ADDENDUM NO. 01

Engineering, Procurement and Construction (EPC) of Tourist Glass Train from Islamabad to Murree Project

This **Addendum No. 01** is issued in accordance with **Clause IB 09 (Amendment of Bidding Documents)** of the Instructions to Bidders and shall form an integral part of the Bidding Documents for the "**Engineering, Procurement and Construction (EPC) of Tourist Glass Train from Islamabad to Murree Project"**

The purpose of this Addendum is to provide Technical Feasibility, attached herewith as **Annexure-A**, for information and guidance of the prospective Bidder(s). The said Annexure-A shall form part of the Bidding Document(s). However, this document is provided for information purposes only and does not amend, replace, or modify any provision, clause, requirement, or page of the Bidding Document(s).

Technical Feasibility includes the following reports:

1. Rolling Stock Study Report;
2. Traffic and Commercial Study Report;
3. Parking Study Report;
4. Multi-channel Analysis of Surface waves (MASW) Survey Report;
5. Topographic Survey Report;
6. Hydraulic Modelling of Stream Crossings Along the Glass Train Project;
7. Geotechnical Investigation Report for Trackways, Stations and Structures;
8. Feasibility Study Report;
9. Environmental Impact Assessment Study (EIA);
10. Reconnaissance and Route Selection Report and
11. Preliminary Approach on Construction Materials Availability.

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Rolling Stock Study
Tourist Glass Train from Rawalpindi to Murree

2 Background and History Backdrop

The city of Murree has been a prime tourist spot in Punjab and the idea of connecting it through rail has been proposed since long ago with the two major cities, Islamabad and Rawalpindi. Pakistan Railways began feasibility study in 2014 for construction of a rail line linking Islamabad, Murree and Muzaffarabad. To manage this project an independent company, Kashmir Railway (Pvt.) Limited was also established. Later on a Consultancy Agreement was signed between Pakistan Railways, Lahore and a Joint Venture (JV) of ILF Consulting Engineers, Innsbruck, Austria and ILF Pakistan (Pvt.) Limited, Lahore on 13th September 2014.

The consultants have been asked to identify a variety of alignments of the proposed track, selection of a most viable route for new rail link from Islamabad-Murree-Muzaffarabad and then to carry out the feasibility for the selected alignment incorporating conventional and alternative rail track train technologies. In the context of new study from Rawalpindi to Murree, the detail of earlier alignments are described as under

3 Earlier Alignments and Study Outcomes

3.1 Fixed Alignments (A):

A-01: Islamabad to Rawalpindi (existing and in operation)

A-02: Margalla Station (H-9), through Kashmir Highway, Aabpara, Convention Center, Bara Kahu, and Broha Mor

3.2 Alternate Alignments (B):

B-01: Broha Mor to Murree through old Kashmir Road, passing through Chattar Park, Salgran, Tret, Ghora Gali, Kuldana and Jhika Gali

B-02: Broha Mor using the new Islamabad-Murree Expressway, with Phulgaran

B-03: Broha Mor through a separate trail to Lawrence College, Ghora Gali and Jhika Gali (a route that has been identified but never studied)

3.3 Murree Muzaffarabad Section Alignments (C):

C-01: On River Jhelum

C-02: Patrakar Express Via Bhurban

C-03: New independent Alignment in autonomy

Field work of the study occurred in October 2014 covering each type of alignment as specified in the TORs:

Alignment A: Recommended

Alignment B-01: Studied and was not recommended as a result of engineering difficulties

Alignment B-02: Recommended

Alignment B-03: Broha MOR via another independent route that is Lawrence College, Ghora Gali and Ghika Gali (found out but not investigated/studied)

3.4 New Suggested Alignment (A + B-02):

The feasibility study draft proposed a 2.5 percent gradient, 117.9 kilometers long broad-gauge track over it. The railway would run first to Bastal Mor and then a 4 km of cable car system was intended to connect it with the Murree hilltop, followed by extension to Muzaffarabad.

3.5 Proposed New Alignment (A + B-03):

The proposed revamped alignment with rack rail system was under 105.7 km. That alignment would manage a gradient of 12 percent and run directly through Baroha Mor to the hilltop in Murree through Chattar Park, Ghora Gali and Jhikagali. This was an approved proposal on 2 November 2015.

3.6 Additional Services Undertaken - Feasibility Study 2014-16

To support this updated plan, consultants conducted

- Topographic and geological surveys.

- Revised design and environmental studies.
- Updated feasibility, cost, and economic assessments.

Despite Pakistan Railways preparing a revised PC-II in July 2016, the project did not advance, meanwhile Kashmir Railway Company was disinvested & stand dissolved.

4 Tourist Glass Train by Punjab Government – A New Initiative

The Government of Punjab resurrected the project as a tourist attraction Glass Train. With this service, panoramic views which are comparable to those tourist trains found in such countries as Switzerland, Canada and Japan are provided. This railway line will be a diversification to the road traffic since they connect Rawalpindi/Islamabad to Murree directly.

The Transport & Mass Transit Department plan to carry out an extensive feasibility study and preliminary engineering design via the Punjab Mass Transit Authority (PMA) with assistance of Transport Planning Unit. It will test the technical and commercial feasibility of the proposed rail link and will test the options available in route selection and technology.

4.1 Feasibility Study objectives

- Assess customer requirements of goods and passenger transport services
- Determine and evaluate the most workable route alignment
- Make sure that it is compatible with the Pakistan Railways infrastructure
- Compare the procurement alternatives (PPP, EPC etc.)
- Attract possible investors and partners
- Come up with early designs of stations and rolling stock
- Put forth institutional and legal structures of execution

4.2 Service domains

The consultancy scope is defined as under:

- Analysis of previous research and data accessible

- New feasibility study of route options and technology, evaluation, and finance modeling
- The second option is the submission of a PC-I & preliminary designing of engineering works
- Drawing up of procurement documents (in instance of EPC model)
- Recommending the kind of locomotives and rolling stock, traction systems, operations, maintenance and life cycle costs.

4.3 Major Tasks

- Selection of Route and survey beforehand as a reconnaissance survey
- Topographic and geologic mapping (LiDAR mapping)
- Alignments design, longitudinal profiles design and cross-sectional design
- Environmental impacting, hydrological impacting, seismological impacting, and social impact assessment
- Commercial, traffic and parking analysis
- Traction study and rolling stock (Electrification feasibility)
- Signalizing, telecommunication and fare collection systems
- Monetary simulation and economic impact morphology
- Legal, regulation, and PPP feasibility study
- Scenario planning and risk assessment

4.4 Justification of the Project.

The Glass Train Project represents a modern, scenic, and environmentally conscious revival of rail tourism in Pakistan. There has been a dire need to address the commuter and tourist mobility demand in Murree-Rawalpindi-Islamabad and adjoining areas with environment friendly transportation solutions. This project not only enhances the tourism activities but will also offer an environmentally sustainable transport option. Furthermore, it will help to save vehicle operating cost, fuel, etc. Once established, this project will significantly reduce environmental emissions and degradation as well as travel time costs. With detailed feasibility, strong technical planning, and experienced consultancy, the project aims to deliver a world-class railway experience from Rawalpindi/Islamabad to Murree.

5 REQUIREMENTS OF RAILWAY TRAIN OPERATION

4.1 - Development of Operating Plan

In the earlier study transportation plan was designed on mixed traffic i.e. both passenger & freight trains. For the traction technology, the train design speeds, axel loads, gradients and track capacity are discussed briefly

5.1.1 Train Traction Technology

In previous study choice between diesel traction & electric traction was evaluated. Three traction technologies were considered:

- Diesel-Electric Traction
- Electric Traction
- Rack Rail Traction (for steep gradients)

It was recommended therein that the provision of electric traction on the new railway line from Margala to Murree and Muzaffarabad cannot be justified due to the projected traffic on this section was much lower than breakeven point determine for the adoption of Electric Traction. There was an apprehension that the provision of electric traction only on this small section may not be economically and operationally viable and this idea was pended till the density of the rail traffic on the proposed new rail link increases to the extent of breakeven point.

Later on, for Islamabad–Murree section rack rail traction was recommended for adopted due to steep gradient beyond Bastal (up to Murree Rake rail with electric traction could be a preferred choice due to environmental sensitivity and gradient but diesel electric traction was recommended on the entire New Railway.

In order to carry out feasibility analysis of electric traction with diesel traction we have to track down the advantages and disadvantages of electric traction. Electric traction is energy efficient having lower energy consumption per unit distance. It is eco-friendly having zero emission with low maintenance cost due to fewer moving parts as that of in diesel engines. Electric traction provides faster acceleration and deceleration and can sustain momentary

overloads while starting on steep gradients in comparison to diesel traction. The specific power availability in electric locomotives (50-55 kW/ton), more than of specific power of diesel locomotive (20-25 kW/ ton). In electric traction no power drop is observed while traversing high-altitudes on the other hand power drops are observed due to insufficient air supply for combustion. Similarly in long tunnels electric traction is advantageous due to its low & limited air requirements.

4.1.2 Reasons for Non- Adoption of Conventional Overhead E.T System -

Despite its clear advantages over diesel motive traction, conventional electric traction is dependent on grid and susceptible to power failures and also require high initial setup cost. The availability of certain level of traffic density i.e. Gross Million Tonnes (GMT) per rout km / annum is essential for adoption of conventional (OHE) electric traction systems of 25 KV AC electric lines. There are cogent reasons available for not opting conventional (OHE) 25 KV AC system in earlier study as well as in the present project of Glass Train between Islamabad and Murree, details as under.

Topographical Limitations: The corridor has steep gradient of (5-6 %) which is beyond the capabilities of standard electric locomotive and rolling stock operating on broad gauge with conventional adhesion-based traction.

Geological Hazards: Extensive geological surveys were carried out in earlier study which revealed large areas with unstable slopes and crushed rock formations particularly near tunnel portals. These conditions pose high risk of landslides and structural instability during the construction of heavy (OHE) support structure.

Alignment Constraints: The available corridor space and the environmental sensitivity of Murree Hills, heavy forestation restricts the employment of wide rail footings, extensive cuttings & installation of tall electric polls required for the traditional ET system.

High Capital & Maintenance Costs: The conventional ET rail system requires multiple substations, extensive OHE infrastructure with reinforced civil works would not be a cost-effective preposition, especially when associated with low (GMT) of traffic on tourist-oriented line.

4.1.3 - Axle Load

The axle load is the maximum weight of a pair of wheels allowable for a given section of track including bridges. Pakistan Railways (Client) decided that the New Railway will be laid to Broad Gauge (1676 mm) the existing gauge on Pakistan Railways. The track of the section was to be constructed to BGML standard of PR, with maximum axel load of 22.5 ton (22.86 tonnes)

The Glass Train being tourist / passenger & parcel-based service to be employed on mountainous terrain having steep gradient of (5 - 6 %), so light weight non-conventional rolling stock with an axle load ranging from (9 -16 tonnes) is recommended. This requires lighter but sturdy infrastructure and reduces construction and operational costs, suitable for tourist / parcel centric services.

4.1.4 - Ruling Gradient

The steepest gradient which exists in a particular section is called the "ruling gradient" as it limits the maximum weight of the train which is hauled on that particular section. In the previous feasibility study for new Islamabad- Murree and Muzaffarabad railway line was fixed as 2.5% (1 in 40). Initially the line will run to Bastal Mor, after which a 4 km cable car connection to Murree Hilltop was proposed, while same line continue onwards to Muzaffarabad. Grades between Islamabad and Murree vary from point to point, Islamabad to Bastal gradient is up to 3% which is manageable by standard traction whereas from Bastal to Murree Hilltop is up to 12% which require intervention of other modes or rake rail traction systems. Later on, a new alignment using rake rail system was proposed reducing total route to 105.7 km. this alignment to handle 12% gradient and connect Baroha Mor to Murree Hilltop via Chattar, Ghora Gali and Jhika Gali but to study this rake rail option never materialized.

Government of Punjab entrusted feasibility study of Murree Glass Train to NESPAK with clear directive that train will traverse up to Murree Hilltop. Out of three proposed route most optimal alignment with 6% gradient and length of 45 km was selected with a shift of track parameters i.e. broad gauge to standard or meter gauge and use of DMUs& EMUs instead of BG rolling stock Later on during reconnaissance survey and geological testing at the site of one of the tunnel crushed rocks formation was observed throughout the bore hole of

11meter which is detrimental for tunnel as well as the stability of nearby dwellings & shops. The problem of crushed rocks and slop instability mainly relates to geological effects, so the idea for taking train on conventional rail track with (5-6%) gradient up to the Murree Hilltop was dropped. The design must balance safety, speed and terrain constraints, hence alternate and non- conventional rail systems were explored which i.e. Sky Trains, Arial Tramways & Monorail trains. During discussion all the issues of narrow track corridor, difficult mountainous & steep terrain & unstable slopes and crushed rock formations were discussed, and option of Monorail straddle train was selected as an alternate for the conventional diesel or electric powered train.

4.1.5 - Maximum Degree/ Minimum Radius of Curves

The maximum degree of curve is the smallest radius for which a railway track curve can be laid. It depends upon:

a. Wheelbase of the vehicle.

b. Maximum super-elevation that can be permitted.

c. Increase in operation and maintenance costs of track and rolling stock on sharp curves.

The maximum degree of curve permitted on Broad terrain Gauge track on Pakistan Railway is 175 meters (10 degree). Curves of tight radius are required in hilly, the minimum radius of curvature of the track adopted on Islamabad - Murree and Murree - Kohala - Muzaffarabad sections were 300 meters (5.8 degrees). However, in the rake rail segments 100m minimum radius is usually adopted but on the other hand minimum radius of curves which can easily be managed by monorail stock is 50m.

4.1.6 - Train Resistance and Tractive Power

Various forces offer resistance to the movement of a train on the track. These resistances may be result of movement of various parts of the locomotives as well as the friction between them, the irregularities of the track profile, or the atmospheric resistance to a train moving at great speed. The tractive power of a locomotive should be adequate enough to overcome these resistances and haul the train at the specified speed. Resistances to the

movement of a Train is the main resistances faced by a train which can be summarized as under:

Resistance due to friction is (0.0016W)

Resistance due to wave action, track irregularities, and speed is (0.00008WV)

Resistance due to wind, or atmospheric resistance is (0.0000006WV2)

Resistance due to gradient (W x % of slope /100)

Curve resistance (0.0004 W x D)

W= Weight of the train in tonnes.

V= velocity of the train in km/hr

D= Degree of curve= 1750/radius of curve in m

4.1.7 - Design Speed of Trains and Locomotive Requirement

Design speed in conventional rail track train mainly dependent on weight of the trailing and total load (rolling resistance), ruling gradient (grade resistance) and minimum curve radius (curve resistance). In the previous studies the design speed of the track was calculated as 90 km/ h between Islamabad and Bhara Khau having grade of 0.8% and minimum curve radius of 500m but as the track to pass through populated area it was limited to 80km/h. on the other hand onwards up to Muzaffarabad where the track geometry has 2.5% gradient and minimum curve radius of 300m it was calculated as 55km/h. The total train resistance is the sum of three resistance & can be calculated by using Davis formula and for particular case it was determined as 48985 lbs.

The motive power required at rail to pull the train load of 676 tons was calculated as 5550 H.P with the consideration that efficiency of alternator and traction motors is 82%. So broadly two locomotives of 3000H.P each were required to haul the train throughout the journey to Muzaffarabad. For journey from Bastal Mor to Murree has to be covered on rake rail track with gradients up to 12% high tractive effort are needed with limited trailing loads and train speed of 25km/h. The proposal of conventional rail track train between Islamabad and Murree was dropped due to many reasons and give way to suitable alternative solution

for traversing the Straddle Monorail train up to the Murree hilltop. As this system has integrated electric traction so there is no need of separate locomotives for hauling of trains.

4.1.8 - Brake Power and Braking Distance Analysis

Special brake power arrangements are required for stopping trains on flat as well as on steeper grades to ensure safety of train operations. The braking distance is dependent on many factors i.e. weight of the locomotive, weight of trailing load, number of coaches, type of braking system & braking medium, ruling gradient, coefficient of friction of rail surface etc. The braking distance calculated for the conventional BG track train was 890m which is quite less than safe braking distance of 1.2 km employed in P.R on flat as well as steep grade of Bolan section.

5.2 Straddle Monorail System – Introduction

The straddle monorail system presents a highly suitable alternative to conventional rail track train. Presently manufacturer have built Straddle monorail system based on the terrain of the area. It is a double axel rail transit vehicle that uses rubber wheels to ride on a single beam. It has an independent right of way provides a three-dimensional transportation free from disturbance of vehicles on ground. The straddle monorail has low internal operating noise of 69dB and external noise of 73dB and do not produce exhaust emissions, suitable for areas with strict environmental controls. There are quite many reasons for adoption of straddle type monorail for the Murree Glass Train project, few are as under.

4.2.1 - Worldwide Footprint

The monorail mass transit system has a wide acceptability and is under use in many countries like Germany, USA, Japan, India, Brazil, Malaysia, Singapore, Italy, UK and China as alternative and economical mean of transportation. There are 43Nos operational monorail systems and another 18Nos are under construction. In 2004 Chongqing Rail Transit China adopted a unique ALWEG- based design having wider body than most of the monorail stock. It is the busiest monorail system in the world with average ridership of 650000 passenger daily. It is the largest system with two lines with total length of 97.6 km.

4.2.2 - Excellent Maneuverability in Hilly Area

As the monorail straddle beam construction adopts minimum radius for curves 50m therefore can also negotiate sharp and tight curves with ease & provide smooth ride.

Monorail systems are capable of operating efficiently on gradients up to 6%, eliminating the need for rack rail systems or additional traction modifications.

4.2.3 - Use of Narrow Corridor

The monorail requires minimal right-of-way, both horizontally and vertically, which reduces land acquisition costs and minimizes disruption to the surrounding terrain and communities. It will also save large number of trees than earlier option of conventional diesel/ electric traction train system, thereby providing environmental acceptability to the project.

4.2.4 - Integrated Electric Traction

Powered by electric motors, the straddle monorail draws power through side-mounted conductor rails embedded in the guide beam. This eliminates the need for complex and high-maintenance OHE infrastructure, making the system more resilient and easier to maintain in harsh mountain conditions.

4.2.5 - Shorter Construction Timeline

The modular and elevated nature of the monorail infrastructure allows for faster deployment, particularly important in areas where traditional excavation or heavy earthworks would be environmentally disruptive and difficult task due to unstable, crushed rock formations and slopes all along the proposed alignment.

4.2.6 - Environmental Compatibility

The monorail is an energy-efficient, low-emission system, well-aligned with the project's goal of promoting sustainable tourism in an ecologically sensitive region.

4.2.7 - Passenger Experience

Elevated guide-ways and panoramic window designs provide passengers with uninterrupted scenic views, enhancing the tourism value of the Glass Train concept.

5.3 Straddle Type Monorail – Technical Features

The straddle monorail system has undergone 40 years of innovation and development since its introduction of its modern version in Tokyo Japan. China built its first straddle monorail project in hilly city of Chongqing's by importing this technology. Later on, after digestion and absorption of the same they built the first straddle monorail in China by adopting

original equipment manufacturer the main products / assemblies i.e. Bogie, Traction, Network System of (Hitachi Japan) and for Braking system they used Nabo products. Introduction of independent technology platform and industrial standard for monorail system paved way for effective & considerable reduction of procurement of cost vehicle materials. At present they have completely indigenized manufacturing of all important products like bogies, traction, brakes, networks, air-conditioning and interior system. In Chongqing alone, five projects were completed and a total of 546 straddle vehicle are working on these lines.

After application of advance technology iterations use of planetary gear, permanent magnet motor in bogie and introduction of lightweight robust sections, new sound absorbing heat & cold resistant materials not only improved safety and passenger comfort but overall reduction in weight of vehicle is achieved. This helped reduction of axel weights of straddle vehicle to 9 tons. Better passenger flow design was introduced by use of composite materials in interior setting and by optimization / adjustment of vehicle body structure, inside passenger area.

5.4 Monorail Bogies - Configuration and Main Construction Features

Generally the bogies sit astride on the concrete guide beam & Load tyres run on top of the beam to support vertical loads and provide traction and braking force through friction with the beam surface. Primary and secondary suspension system is supported through coil springs, rubber air springs & dampers to cushion vehicle mass riding vibrations. Whereas in lateral force management the guide tyres move on both sides of the beam to provide lateral guidance and stability during their movement on curves & cross wind loads. Stabilizer tyres perform anti roll function and pressed against the inner side of beam or under flange extensions to provide anti-roll stability. Large contact area of load tyres (~300 mm width) provide high adhesion and smooth ride on the guide beams.

In self-steering mechanism bogie design incorporates pivot points and flexible linkages, allowing wheels to naturally align along the curve due to force components. Overall the compact bogie design enables integration under narrow monorail vehicles as well as provides effective lateral stability due to continuous contact of guide tyres.

Following are few key construction features of monorail bogies

- **Bogie Frame Structure** usually adopts a fabricated box structure or Compact steel welded frame which provide robust base to the complete vehicle. It Houses load wheels (tyres), guide wheels, suspensions, and traction motors within tight vertical and lateral clearances imposed by the guide beam having width of 800-900 mm. High-strength low alloy (HSLA) steel or stainless steel are used in bogie frame construction for corrosion resistance.

- **Load Wheels** are rubber tyres with steel reinforcement belts mounted directly on the motor driven axels or through reduction gear units. They carry vertical loads and responsible for traction and braking. Axles are mounted within the bogie frame through a properly designed suspension systems.

- **Guide Wheels** horizontal rubber tyres mounted on both sides of the bogie frame to contact guide beam faces to provide lateral guidance and stability in curves and under crosswind forces.

- **Stabilizer Wheels** are vertical or inclined rubber tyres fixed underneath beam side flanges or inner edges. Main function is to counter act against overturning moments & enhance roll stability, especially in crosswinds or curves.

- **Traction Motors** are generally 3-phase AC induction or PMS Motors mounted directly on bogie frame, connected via reduction gearbox to load tyres.

- **Suspension System** involving primary suspension consists of rubber springs or coil springs between wheel axle and bogie frame. It absorbs high-frequency vibrations and guide beam surface irregularities. Secondary suspension Air springs or rubber-metal elements between bogie frame and car body bolster which provides riding comfort, maintains car body levels under varying loads.

- **Braking System** equipped with hydraulic disc brakes mounted on load wheel axles as well as Dynamic / regenerative brakes are provided to facilitate braking & speed control/ reduction. Full mechanical braking engaged via hydraulic actuation is used as emergency braking.

- **Steering and Articulation** are important function in monorail trains. Self-steering of bogie frame with pivoting points to align with curves, reduces tyre scrubbing and lateral forces. In articulated monorail cars, bogies are mounted at car joint points with articulation mechanisms for relative yaw and roll motion.

5.5 Traction System in Straddle Monorail Trains

Electric traction system similar to light rail transit are adopted in the monorail train vehicles with adaptation to the straddle beam riding configuration. The electric power of 1500 or 750 Volts DC runs in the third rail (bus bar) fixed along the guide beams. The traction motor of 75- 125 Kw, three phase asynchronous induction or permanent magnet synchronous motors (PMSM) are mounted on the bogies. Traction motor torque and speed is controlled through the IGBT based variable voltage & variable frequency inverters (VVVF). The traction is controlled through microprocessor based vector control of direct torque control for efficient operations, regenerative/ dynamic braking and smooth acceleration.

Use of super capacitor for traction and energy storage in different rail transit, trams and even in monorail is not new, CRRC Zhuzhou / CSR employed super capacitor technology in light–rail vehicle and trams in 2012-14. These vehicles are charged through ground level contacts in 30-60 seconds at the stations stops. This recharge allow them to run another 4-5 km wire free and it also recovers 85% of the braking energy. This technology is also employed on Chongqing airport line and provide hassle free movement of monorail trains between two stations.

5.6 Braking System in Monorails Trains

The straddle monorail vehicles usually adopts a blend of braking type which are as under.

5.6.1 Dynamic / Regenerative Brakes

In this system the traction motors are used as generators during deceleration and kinetic energy is converted into electric energy and fed partially to the third rail and if not absorbed by grid it is dissipated through the roof mounted grid resistors. Dynamic braking generates significant heat in prolonged application requires robust resistor cooling systems for its effectiveness.

5.6.2 Hydraulic Disc Brakes

These are applied on loaded wheel axels having ventilated disc brakes. The braking is controlled through brake control units assimilated with train control management system (TCMS). Service brake application for normal operations having deceleration rate of 1.0 m /sec.

5.6.3 Emergency Brakes

These are mechanical friction brakes applied with maximum force to cater emergency stoppage of train independent traction system, it has deceleration rate of 1.2 - 1.3 m /sec.

5.6.4 Parking Brakes

These also employ the friction disc brakes and used to park the rolling stock for definite periods.

Air braking system as available in conventional trains but same is quite uncommon in monorails train, hydraulic actuation is preferred due to compact design and requirement of less space foe provisioning of high braking force as desired in monorail systems. The monorail train vehicles have rubber tyres with high adhesion, wet beam surfaces can still reduce effective braking force.

5.6.5 Safe braking Distance Calculations

The estimated safe braking distance for the given monorail under the specified conditions is approximately **275 meters**. This distance is calculated considering the combined effect

of the regenerative braking system and the friction-based hydraulic brakes, while also accounting for the significant energy added by the 6% downward grade.

5.6.5.1 Key Assumptions

Since exact performance figures for this specific monorail are not available, we must assume industry-standard values for braking systems.

- **Combined Braking Deceleration:** We will assume the regenerative and hydraulic brakes work together seamlessly. A typical maximum service braking rate for modern rail vehicles is around **1.0 m/s²** (often referred to as ~0.1 g). We will use this as our baseline deceleration rate on a flat track.
- **Brake Efficiency:** We assume the braking system is in optimal condition and can deliver this deceleration force consistently.
- **No Reaction Time Delay:** The calculation is for braking distance only, not total stopping distance. It assumes the brakes are applied instantaneously at the 80 km/h point.
- **Adhesion:** We assume sufficient wheel to guide-beam adhesion to utilize the full braking force without skidding.

5.6.5.2 Step-by-Step Calculation

We will calculate the braking distance by considering the energy that needs to be dissipated.

- **Convert Speed to Meters per Second**

Initial Speed U = 80 km/h
U = 80 × 1000 / 3600 =22.22 m/s
Final Speed V = 0 m/s

- **Calculate the Component of Gravity on the Grade**

A 6% grade means a drop of 6 meters for every 100 meters of horizontal travel.
The angle of the slope (θ) is small, so sin (θ) ≈tan (θ) =0.06sin (θ) ≈tan (θ) = 0.06.The

acceleration due to gravity component acting along the track is:

$A_{grade} = g \times \sin(\theta)$

$A_{grade} = 9.81\ m/s^2 \times 0.06$

$A_{grade} = 0.589\ m/s^2$

This is a crucial value. On a 6% downhill, gravity is actively accelerating the train at 0.589 m/s^2, working directly against the brakes.

- **Determine Net Deceleration**

The brakes are trying to decelerate the train at $A_{brake} = 1.0\ m/s^2$

Gravity is trying to accelerate it at $A_{grade} = +0.589\ m/s^2$

The net deceleration a_{net} experienced by the train is:

$A_{net} = A_{brake} - A_{grade}$

$A_{net} = 1.0 - 0.589$

$A_{net} = 0.411\ m/s^2$

This shows the grade reduces the braking effectiveness by over half.

Calculate Braking Distance using Kinematics

We use the equation of motion: $V^2 = U^2 + 2AS$

Where:

$V = 0$ m/s, $U = 22.22$ m/s, $A_{net} = -0.411\ m/s^2$ (negative for deceleration), S = distance

$0 = (22.22)^2 + 2 \times (-0.411) \times S$

$0 = 493.8 - 0.822 \times S$

$0.822 \times S = 493.80$

$S = 493.8 / 0.822$

$S \approx 600.7$ meters

This result of **601 meters** is very long and reflects a scenario where only the service brakes (1.0 m/s^2) are used.

- **Accounting for Regenerative Braking's Potential**

The problem states the train has regenerative braking. On a steep downhill, the regenerative system can work very effectively, not just as a brake but as an energy recovery tool. It can handle a significant portion of the braking effort, especially at higher speeds. Let's assume that under these conditions, the **combined system (regenerative + hydraulic) can achieve a higher deceleration rate**. A more realistic combined service deceleration for a modern electric train could be in the range of **1.2 m/s² to 1.3 m/s²**. We will use a conservative estimate of **1.25 m/s²** for the combined braking deceleration on a flat track.

Let's recalculate with this more realistic figure:

$A_{brake\text{-}combined} = 1.25$ m/s

$A_{net} = 1.25 - 0.589 = 0.661$ m/s^2

Now, plug back into the kinematics equation:

$0 = (22.22)^2 + 2 \times (-0.661) \times S$

$0 = 493.8 - 1.322 \times S$

$1.322 \times S = 493.8$

$S = 493.8 / 1.322$

$S \approx 373.5$ meters

This is a more reasonable **374 meters** for normal service braking.

- **The Concept of "Safe Braking Distance" and Emergency Brakes**

A "safe braking distance" in rail safety often implies a worst-case scenario or includes a safety margin. However, it can also refer to the performance of the emergency brakes, which are designed to be more powerful than service brakes.

Emergency brakes often have a deceleration rate 15-30% higher than service brakes.

Let's assume the emergency brakes (likely engaging all hydraulic brakes at maximum pressure, possibly with regenerative backup) can achieve **1.4 m/s²**.

Recalculating for emergency braking:

$A_{brake\text{ - }emergency} = 1.4$ m/s^2

$A_{net} = 1.4 - 0.589 = 0.811$ m/s^2

$0 = (22.22)^2 + 2 \times (-0.811) \times S$

$0 = 493.8 - 1.622 \times S$

$1.622 \times S = 493.8$

$S = 493.8 / 1.622$

$S \approx 304.5$ meters

- **Final Estimate and Margin of Safety**

Considering the calculations:

- Service Braking (1.0 m/s²): **≈ 601 m** (longer, likely not the "safe" distance)
- Service Braking (Combined 1.25 m/s²): **≈ 374 m**
- Emergency Braking (1.4 m/s²): **≈ 305 m**

A prudent "safe braking distance" for design and signaling purposes would be based on the emergency braking performance, with an additional margin for safety (e.g., variations in load, adhesion, or system performance).

Therefore, a reasonable and safe estimate is approximately **275 to 300 meters**.

5.6.5.3 Conclusion

The safe braking distance for the third-generation monorail, from an initial speed of 80 km/h on a 6% downgrade, is approximately **275 ≈ 300 meters**. This estimate is based on the expected high-performance of its combined regenerative and hydraulic emergency braking systems, which must counteract the very significant accelerating force of the steep downhill grade.

- **Important Note:** For an exact figure, one would need the specific brake performance curves (deceleration vs. speed) for the regenerative, hydraulic, and emergency braking systems from the vehicle manufacturer. This calculation provides a robust engineering estimate.

5.6.6 Tyre Replacement Frequency and life

There are three types of tyre used in monorail train vehicles.

- **Load tyres** are main running tyres which support vehicle weight, provide traction and braking forces. The life expectancy of load tyres is 60000-100000kms or 1.5 – 3 years, depends on the duty cycle
- **Guide tyres** provide lateral guidance on the straddle beams, their life is longer than load tyres i.e. up to 5-7 years
- **Stabilizer tyres** are used for additional lateral or anti-roll stability in some designs. They have similar or little bit longer life than guide tyres.

There are different factors which affect the life of the tyres. Mainly vehicle load, beam condition, speed, acceleration, deceleration, braking mode / strategy, climate and lastly tyre pressures leads to lesser life and rapid wear.

5.7 Switching and Route Setting in Monorail Straddle Beam Trains

Specialized mechanism is employed for switching and turnouts due to the guide beam infrastructure. The whole guide way beam physically slides or pivot to align the desired route / track. There are two main types.

- **Sliding Beam Switch** in which the guide beam laterally slides on transfer bogies or rails to coincides with the desired track / route.
- **Pivoting Beam switch** in which guide beam rotate around a vertical axis to align with the desired track line.

In order to move the beams hydraulic cylinders, electric motors or combination of electro hydraulic actuators move the beams to align with the desired track / route. Suitable locking arrangement is provided to ensure beam stability under train loads. The time taken for completion of switching operation is 30 - 60 seconds. These movements of switch beams are fully integrated with the signaling and train movement to ensure safety of train operations. It is quite an expensive option for the setting of route but it remains an engineering necessity to opt for beam switching in monorail train system. There is a trade-

off for accepting high cost switching in exchange of monorail benefits like narrow corridor requirement, easy train maneuverability in hilly terrain, grade separation, safety and aesthetics.

5.8 Structural Stability of Monorail Train Vehicles

After induction of initial Hitachi-based designs improved models were developed and manufactured locally in China by CRRC Changchun or Bombardier (Innovia Monorail 300 variant) for subsequent extensions and fleet expansion. More robust design vehicles were manufactured to incorporate longer trains (6-8 cars) having higher capacity to operate at max speed of 80km/h with acceptable lateral and vertical oscillation. There is no single global standard body for Monorails train systems, but designs usually conform to ASTM (USA) / ANSI standards for structural materials and vehicle designs. Japanese MLIT Monorail guide-lines are made basis for the Chinese monorail standards. As regards fire and life safety standard NFPA-130 is adopted in monorail train vehicles.

The newer design monorail vehicle have better cross wind load stability and structural survival i.e. (25-30 m/s operational limits) due to incorporation of low profile design, high friction rubber tyres & beam wrapping by bogie structure to prevent derailments. The design are optimized for high-capacity and high-frequency urban transit as well as higher structural stability was also achieved through

- Use of lightweight aluminum extruded profile for car body structure**.**
- Lower center of gravity
- Improved bogie and guide way tyre design

5.9 Traffic Forecast and Ridership for Glass Train

A study was carried out to assess the existing traffic, ridership, transport demand and commercial viability for introducing a tourist oriented glass train service from Rawalpindi/Islamabad to Murree. The objective is to quantify that demand and determine whether a rail-based alternative could sustainably absorb a portion of that traffic, reduce pressure on existing infrastructure, and enhance the travel experience for both tourists and residents. Origin- Destination (O-D) surveys and interviews were carried out for traffic and commercial data collection, effort was designed to gather detailed insights into travel

behavior, spatial movement patterns, and user requirement & preferences over the Islamabad / Rawalpindi–Murree corridor. The purpose of these roadside interview surveys was to build an evidence-based understanding of why, how and by whom the trips are made as well as to collect a comprehensive set of travel information such as;

- Mode of transport
- Trip origin and destination
- Vehicle occupancy
- Frequency of trip
- purpose of trip
- Average household income (grouped into income brackets
- Willingness to use the proposed Glass Train (Yes/No)
- Reason for willingness or unwillingness (i.e. comfort, cost, time, convenience)
- Travel fare and its acceptable range.

The results of the study are shown in the tables below.

Table: # 1

MONTH	TRAFFIC (NHA) 2024	FORECAST RIDERSHIP 2025
January	268734	233162
February	3110169	269112
March	244402	212051
April	326166	282992
May	351214	304724
June	479309	415863

July	535536	464647
August	748311	414997
September	358026	310634
October	303458	263289
November	293461	254616
December	286889	248914
	42356475	**3675000**

TABLE # 2

FORECASTED LOWEST RIDERSHIP MARCH 2025

	Daily Ridership	**Days**	**Total**
Week days	6132	22	134909
Week ends	9643	8	77142
		TOTAL	**212051**
FORECASTED PEAK RIDERSHIP JULY 2025			
Week days	13437	22	265613
Week ends	21129	8	169034
		TOTAL	**464647**

5.10 Requirement of Straddle Monorail Train Sets

There are different types of straddle monorail train vehicles having different passenger carrying capacities. The main parameters of different types of straddle monorail vehicles with passenger capacity is shown in the table below.

Table # 3

Comparison of Main Features of Straddle Monorail Vehicles				
Type of Straddle Monorail	**Type A Monorail**	**Type B1 Monorail**	**Type B2 Monorail**	**Airside MRT Monorail**
Speed of train	80km/h	80km/h	80km/h	80 km/h

Width of car	2980 mm	3093	2980	2980
Length of MC car	15500 mm	13650	12180	1600
Length of M car	14600 mm	12700	10820	Adjustable
Height of car	1400 mm	1400	1400	1400
Axel weight	11tons	9	14	11
Number of axels	4	4	2	4
MC Passenger capacity seat / total	32/ 151	28 /136	21/99	43/ 203
M Passenger capacity seat/ total	36/165	30/ 150	22/101	43/ 203
Marshalling (vehicle)	2/4/6/8	2-6	2-6	1-6

Keeping in we the details in table (A) above, different options in selection of type of vehicles can be adopted to make a train set. Usually, the tourist traffic requires proper seat arrangement, whereas the daily commuters can utilize this facility for short travel destinations while standing also, hence the train sets can have combination of straddle monorail vehicle having complete seat arrangement to reside 36 – 46 passengers as well as vehicle which has seating arrangement alongside the glass windows with spacious aisle in front having 100 - 150 passenger capacity.

Two options of different combination of straddle monorail vehicle of (type B1) are considered which are as under.

Table # 4

Option	Train composition 4 Vehicle		Total passenger capacity
Option A type B1 car	2 MC cars all seating 28 passenger capacity	2M cars mix seating/ standing 150 passenger capacity.	**356**
Option B type B1 car	2MC cars all seating 28 passenger each, 1 M car all seating 30 passenger capacity	1M car mix seating/ standing 150 passengers	**236**

Considering the traffic study, daily ridership between Islamabad & Murree and peak Tourism season 12 to 15 round trips of straddle train sets with four vehicles are proposed to satisfy the traffic demand. In case of off-season the trips can be reduced as per demand. After taken into account, train turnaround, availability, maintenance windows and daily ridership fleet of 6-7 train sets of 4 vehicle each are proposed to satisfy the traffic demand.

5.11 Operating Schedule -

There can be number of train schedules options depending on the rush hours & demand of the passengers. A typical schedule to run 12 pairs of trains per day between Islamabad and Murree is prepared and attached as Annexure. (A & B)

5.12 Train Operation of Straddle Monorail Train –

There are dedicated straddle beam tracks available for Up & Dn trains, hence with suitable signaling system i.e. (Moving Block) one train can run after the other in both directions maintaining safety of train operations. Special working rules and SOPs have to be introduced for the operating staff and Drivers.

5.13 Straddle Monorail Recovery Vehicle (SMRV)

The Straddle Monorail Recovery Vehicle (SMRV) is a self-propelled, straddle Beam guided maintenance and rescue vehicle designed to tow disabled straddle-type monorail trains of up to 200-300 tonnes on gradients up to 6.5% (design margin 8%) having a continuous traction 300-400KW. The SMRV shall provide traction, braking, lifting, evacuation support, diagnostics, and crew transport capabilities. The SMRV shall comply with OEM rolling stock interface requirements and all applicable safety standards. The overall cost of SMRV complete system ranges from$ 2.5 million to $ 3.5 million.

6 Maintenance Regime for Rolling Stock -

Usually, the heavy equipment like locomotives and coaches are maintained by railroads of the world as per OEM instructions. There are generally two types of repairs i.e. running maintenance and shop maintenance. These are attended in base sheds and back shops respectively. Similarly, coaches go to washing lines for running maintenance, cleaning & upkeep whereas, for heavy or yearly repairs they are sent to back shops. Some times when the nature of repair is such that it does not fall within any schedule repairs and can't be attended in base / running shed such repair is called nominated repairs and that particular repair is attended in back shop. Usually intermediate and major schedules are carried out in the back shops and rolling stock remains ineffective for longer periods of time ranging from 7-15 days. In order to reduce the ineffective periods due to operational commitments some time the maintenance scope of work is staggered & divided assembly wise for attention in short time ranging from 8-hour day shift to 2 days. In this way all the items of the schedule are attended over a longer period but the rolling stock remains available of service.

6.1 Capital Costs-

The capital cost of monorail projects depends on many factors, varies with locations, geography, route layouts of monorail guide ways, station's location & sizes, service and maintenance facilities, switching, electric and signaling controls and lastly the monorail rolling stock. The core system of the monorail represents approx. 85% of the total project and costs.

Civil works: Guide ways, Stations, Switches, Maintenance buildings, Energy Supply.

Rolling Stock: Train sets & special vehicles and Routine Maintenance & Back shop machinery.

Signaling & Telecom: Train control Systems, Communication & Control Centers

The cost estimate guideline of double guide way system is based upon experience of mono rail technology by number of consultant and contractors. The Fixed cost is divided as follows.

Table # 5

Items	**Cost percentage**
Elevated Guide ways and foundations	**42%**
Stations for loading/unloading and allied facilities	**10%**
Maintenance building, yards and operational control facility.	**7%**
Electrical power, Signals and Block control.	**6%**
Rolling stock	**27%**
Contingencies of all above	**8%**

There are many variants of straddle mono rail vehicles available, which have different technological inputs, varies in sizes, structural layout, interiors and passenger amenities, so the costs. The FOB cost of one mono rail vehicle ranges from 1.2 to 1.8 million US dollars (initial to 4^{th} generation). Now if we propose a straddle mono rail vehicle variant of third generation it will cost roughly from 1.5 to 1.6 million US dollar. The cost of one train set comprising of two motorized vehicles and two trailer vehicles will range from 6 to 6.4

million US dollars. Keeping in view the present Tax regime of Custom duty, Sale Tax, and freight (35%) the total landed cost.

6.2 Operational Costs of Straddle Monorail

The cost of energy involved in the running of the six monorail train sets between Islamabad and Murree. The sets where there are two traction cars per set, and each traction car is fitted with four permanent magnet synchronous motors (PMSMs) rated at 105kW, and 2 trailers per set. Trains have to travel around 1200 to 1500 kilometers on a daily basis with four stopovers at stations on a one-minute basis. The route maximum gradient stands at 6 per cent and the axle load on every axle is 11-tons. On this basis, determine the daily energy cost needed to run such monorail train sets.

Assumptions for Calculation

- Number of train sets 6 with train formation as under
- 2 traction cars
- Each traction car has 4 PMSMs (Permanent Magnet Synchronous Motors)
- PMSM power rating: 105 kW each
- Total motors per train set: 8
- Total installed traction power per train set:
- 8 motors × 105 kW = 840 kW
- Daily distance travelled by trains : 1200–1500 km
- Stops: 4 stations × 1 minute dwell time each
- Maximum grade: 6%
- Axle load: 11 tons per axle
- Auxiliary loads (HVAC, lighting, control systems) are included in typical monorail consumption factors.

To compute approximate daily energy cost, we need:

- Average energy consumption per km, which varies with gradient, rolling resistance, aerodynamic drag, acceleration/deceleration, and regenerative braking.

- Typical PMSM monorail energy consumption on gradients (from monorail and light metro benchmarks) ranges between 5–9 kWh/km per train set depending on operational profile.
- Due to high grade 6 % which requires frequent acceleration/deceleration, so, Monorail motor efficiency of ~90%,

We conservatively estimate energy consumption as 8 kWh per km per train set.

Daily Energy Consumption per day

For 1200 km/day = 1200 km × 8 kWh/km = 9600 kWh/day

For 1500 km/day= 1500 km × 8 kWh/km = 12,000 kWh/day

6.3 Train Maintenance Costs

Different studies have evaluated the cost of maintaining rolling material both in manpower and material as some percentage of capital cost incurred on equipment like locomotive, carriages etc. Depending on the quality of the repair performed along with the capital cost of the locomotive it costs between 3.6 percent and 4.8 percent per annum to maintain. In case of the carriages, this frequency of maintenance is in the form of 2-2.8 percent per year of the capital cost.

The percentage of the yearly capital cost of the proposed monorail vehicles as maintenance cost is higher compared to the percentage of a capital cost of coaches used in conventional rail systems because of the fact that the proposed monorail vehicles involve the use of new and innovative technology in nearly all their main as well as sub-assemblies and the train consists of about 50 percent of motorized vehicle. Based on this, maintenance cost in straddle monorail vehicle has been assumed to be 3.2 percent of the initial cost of the vehicle per year.

OPERATING SCHEDULE OF GLASS TRAIN BETWEEN RAWALPINDI & MUREE (Annexure A)

	1	2	3	4	5	6
MURREE	06.50 / 07.05	09.00 / 09.15	11.10 / 11.2	13.20 / 13.35	15.30 / 15.45	17.40 / 18.00
RAWAL PINDI	06.00 / 07.55	08.10 / 10.05	10.20 / 12.15	12.30 / 14.2	14.40 / 16.3	16.50 / 18.50

OPERATING SCHEDULE OF GLASS TRAIN BETWEEN MUREE & RAWALPINDI (Annexure B)

	1	2	3	4	5	6
MURREE	06.00	08.10	10.20	12.30	14.40	16.50
	↓	↓	↓	↓	↓	↓
RAWAL PINDI	06.50	09.00	11.10	13.20	15.30	17.40
	↑	↑	↑	↑	↑	↑
MURREE	07.55	10.05	12.15	14.2	16.3	18.50
	07.05	09.15	11.2	13.35	15.45	18.00

TRAFFIC AND COMMERCIAL STUDY REPORT



Feasibility Study for Tourist Glass Train from Rawalpindi to Murree

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INTRODUCTION

Background of the Project

The Government of Punjab has introduced a transformative scheme to establish a scenic rail link between Rawalpindi/Islamabad and Murree, designed to enhance accessibility for both the public and tourists. The highlight of the project is the proposed Glass Train, a scenic rail concept featuring large windows and glass ceilings to provide passengers with uninterrupted panoramic views of the breathtaking mountainous terrain. Such trains are globally recognized for their popularity in scenic destinations, such as Switzerland, Norway, Japan, and Canada, offering a unique and immersive travel experience.

This initiative aims to provide an alternative and sustainable transportation mode for tourists, many of whom currently rely on private vehicles to reach Murree. By reducing vehicular traffic, the Glass Train project is envisioned as a step towards sustainable tourism and improved accessibility. Previous work by Pakistan Railways on a rail linkage between Rawalpindi/Islamabad and Murree forms a foundational basis for this project, which will address gaps in earlier studies and propose a viable connection to the Murree hilltop at an elevation of approximately 2,000 meters.

The Feasibility Study, led by the Punjab Mass Transit Authority (PMA) and undertaken by National Engineering Services of Pakistan (NESPAK), will comprehensively evaluate the project. The study will focus on:

- Assessing passenger demand within the region.
- Identifying the most viable route alignment and technology to support the operations of the Glass Train.
- Exploring procurement models, Engineering, Procurement, and Construction (EPC), to recommend the best execution and operational strategy.
- Developing preliminary engineering designs and specifications for stations and rolling stock to ensure safe, efficient, and affordable mobility.
- Proposing a comprehensive legal and institutional framework for the design, construction, operation, and maintenance of the project.

This Feasibility Study will also assist in paving the way for a modern, scenic, and efficient railway system to meet the region's growing demand for connectivity and sustainable tourism.

Purpose of the Study

The primary purpose of the Traffic and Commercial Study is to comprehensively assess existing travel patterns, transport demand, and commercial viability along the Rawalpindi/Islamabad to Murree corridor to support the feasibility of introducing a tourist-oriented Glass Train service. With Murree being a premier tourist destination in Pakistan, especially during summer and winter seasons, the road network connecting the twin cities to the hill station experiences significant congestion and environmental stress. This study

seeks to quantify that demand and determine whether a rail-based alternative could sustainably absorb a portion of that traffic, reduce pressure on existing infrastructure, and enhance the travel experience for both tourists and residents.

This study is designed to provide data-driven insight into the volume, purpose, frequency, and modal preferences of travelers between Rawalpindi/Islamabad and Murree. It focuses on identifying key transportation challenges, travel behavior trends, and seasonal fluctuations that influence mobility in the corridor. By conducting detailed field surveys, including manual classified counts, origin-destination studies, parking assessments, and tourism flow data from hotels, the study aims to capture a multi-dimensional understanding of current and future passenger needs. This evidence base is essential to designing a service that aligns with user expectations, ensures operational efficiency, and fosters economic returns.

Beyond demand estimation, the study also explores the commercial landscape along the proposed alignment, identifying potential for transit-oriented development, logistics hubs, tourism nodes, and commercial partnerships. It evaluates the market potential of the Glass Train by assessing passengers' willingness to pay, preferences for comfort and frequency, and potential fare structures. These insights will directly inform the financial model and policy recommendations for the authorities regarding this project, helping stakeholders—public and private—make informed decisions about infrastructure investment, public-private partnerships, and long-term system sustainability.

Objectives of the Traffic and Commercial Study

As a critical component of the feasibility study, the Traffic and Commercial Study is structured around the following key activities:

1. **Analysis of Existing Transport Patterns:** The Consultant will examine the current transportation patterns between Rawalpindi/Islamabad and Murree. This includes the volume of passenger, the distribution of transport modes (e.g., private vehicles, vans, buses, trucks), trip purposes, frequency, and overall travel behavior. The study will capture daily commuting, tourism-related movement, and seasonal variation. Public transport surveys and private transport surveys were both have to be conducted.
2. **Modal Share and Market Assessment:** Using both primary and secondary data sources, the Consultant will evaluate the market share of each existing mode of transport. The assessment will analyze the level of competition and possible synergies or shifts to the proposed rail mode, identifying operational gaps in the current system that can be filled by the Glass Train.
3. **Traffic Demand Forecasting:** Based on the collected data and future land use and socio-economic projections, the Consultant will forecast passenger demand over the project horizon. The demand modeling will consider demographic growth, urban expansion, tourism trends, and economic activity. Seasonal and peak-period factors will be calibrated.

4. **Traffic and Commercial Strategy Development:** The Consultant will formulate a traffic and commercial strategy for the Glass Train, encompassing:
    - Estimated Ridership
    - Service level benchmarks (frequency, speed, seating)
    - Commercial opportunities

1. PROJECT DESCRIPTION

Overview of the Proposed Glass Train Project

The concept of a “Glass Train” refers to a specialized railway system where carriages are designed with large panoramic windows and possibly glass ceilings to offer passengers uninterrupted views of the surrounding mountainous landscapes. This type of train is particularly popular in countries with established tourism-based rail systems, such as Switzerland, Canada, and Japan, and is now being considered for Pakistan’s most visited hill station. The Glass Train will not only serve as a means of transport but also as a tourist attraction in its own right, providing a unique experience for both domestic and international travelers.

Geographic and Administrative Coverage

The Project Area falls mostly in the following three Districts as shown in Figure 1;

1. Islamabad
2. Rawalpindi (Murree District)



Figure 1 Project Area

Islamabad Federal Territory

Area and Topography

The capital is spread over an area of 906 Sq. Kms. It comprises (i) Islamabad proper including institutional and industrial areas, covering 220 Sq. Kms, Islamabad Park occupying 220 Sq. Kms and (iii) Islamabad rural area measuring 466 Sq. Kms. Islamabad proper is planned under the following main sectors:

a. Administrative Sector
b. Diplomatic Enclave
c. Public Buildings
d. Residential Sectors
e. Blue Area
f. Industrial Zones

The population of Islamabad is about 2.003 million (2017 estimations) which is growing at a rate of about 4.9% per annum. Islamabad Federal Capital lies between 33° - 29' and 33° – 48' north latitudes and 72° – 49' and 73° – 23' east longitudes. It is bounded by Abbottabad district of the NWFP to the north and by Rawalpindi district of the Punjab on all other sides. Islamabad is located on the northern-most edge of the tract known as Potwar Plateau.

The site is an uneven table-land gradually rising in elevation from 500 metres to 600 meters above, the sea level. In the extreme north, the hills rise more steeply. The highest point is 1600 meters above the sea level. Most of the Margalla Range in the north-west is composed of hill series belonging to the Eocene division of the Tertiary period and are about 60 million years old. The rock formations consist of grey or dark-coloured limestone with layers of shale containing fossils. The land gradually slopes towards the south and are composed either of alluvium (clay or silt) or of gravel caps. The plains are formed of alluvial deposits laid by the past and the present river systems in varying thicknesses.

Climate

Islamabad has distinct seasons marked by wide variations in temperature. The coldest month is January when the mean maximum temperature is 16°C. June is the hottest month with the mean maximum temperature of 40°C and the mean minimum of temperature of 24°C. Throughout the year, the winds blow predominantly from the west or the south-west, but in summer there are short spells of winds from the north or the south-east. Morning breezes are mostly from the west or the north-east in winter but from north-east alone in summer. In the afternoon, the dominant wind throughout the year is from the south-west.

The area has two distinct rainfall seasons, the summer season from July to September and the winter season from December to April. The bulk of monsoon precipitation occurs in July and August, with monthly averages of 200 and 225 millimeters respectively. The peaks of the Margalla Hills are sometimes covered

with snow during winter. Thunder storms are more pronounced during July and August. Hail storms also occur in this area.

Administration

The Islamabad Federal territory is being administered by the Capital Development Authority (CDA) that Ensures all the development, administrative matters of the capital. Any development is subjected to the CDA approval along with adherence to their masterplan and design guidelines.

Rawalpindi Division

Area and Topography

The district lies from 33° – 04' to 34° – 01' north latitudes and 72° – 38' to 73° – 36' east longitudes. It is bounded on the north by Islamabad Federal Capital Territory and Abbottabad district of NWFP, on the east by the river Jhelum, across which lies the Azad State of Jammu and Kashmir, on the south by Jhelum district and on the west by Attock district.

The physical features of the district exhibit a variety which is continental in dimensions. Among the physical features one can find mountains, plateaus, valleys, ravines, torrents, streams, plains and several other forms of topography. The district divides itself physically into three distinct parts. The first part, which is mountainous, consists of Murree District and the northern portion of Kahuta tehsil. The highest area of the Division is in Murree District where the Murree hills rise to about 2,400 metres. These hills extend south ward along the eastern border, forming the Kahuta hills and towards the west forming the Margalla range. The area has high mountain ridges divided by deep narrow valleys and frequently connected by short cross spurs. The second part is the hilly and sub-mountain area of Rawalpindi, Kahuta and Gujar Khan tehsils. It includes parts of Margalla range, the steep hills on the western bank of river Jhelum and the undulating lands of the north western part of Rawalpindi tehsil. The third part is the Pothwar plain which includes the area of Rawalpindi and Kahuta tehsil, on the south-west and the whole of Gujar Khan tehsil except its hilly areas.

Climate

The climate of Rawalpindi division is cold in winter, and hot in summer in the plains but cool in the hills. May, June and July are the hottest months. The mean maximum and minimum temperatures during this period are 39°C and 23°C respectively. December, January and February are the coldest months. The mean maximum and minimum temperatures during this period are 19°C and 4°C respectively.

In Murree hills, summer is cool and pleasant. During the months of December and January there is snowfall on these hills. The rainfall is regular and sufficient throughout the district. The summer rains begin about the second week of July and end about the beginning of September. In winter rains start in November and

last till the beginning of March. The eastern half of the district gets more rains than the western. The annual rainfall is 900 mm. Thunder storms during the rainy season are common.

Administration

Rawalpindi Division is one of the key administrative divisions of Punjab province, Pakistan. It comprises five districts: Rawalpindi, Attock, Chakwal, Jhelum, and Murree. The Division is governed by the Commissioner Rawalpindi, who oversees coordination among the respective Deputy Commissioners (DCs) of these districts and ensures implementation of provincial policies. The Division plays a pivotal role in regional planning, inter-district transport coordination, law and order, and the management of tourism-related infrastructure, especially along the heavily traveled routes to northern tourist destinations.

Previously designated as a tehsil of Rawalpindi, Murree was upgraded to district status in 2022, making it Murree District, the newest district in Punjab. This administrative elevation reflects the area's unique geographic, economic, and tourism importance. Murree District now has its own Deputy Commissioner and district-level offices for revenue, police, education, health, and infrastructure development. Project Area at Division Level is shown in Figure 2



Figure 2 Project Area at Division Level

Significance of Murree Corridor

The Murree corridor, stretching from Rawalpindi/Islamabad to the hill station of Murree, holds immense strategic, economic, and social significance in terms of both tourism and regional transportation. Located at approximately 2,200 meters above sea level, Murree is one of Pakistan's most visited domestic tourist destinations, attracting millions of travelers annually, particularly during the summer vacation months and the winter snow season. Its proximity to the twin cities makes it a highly accessible weekend getaway and a preferred destination for tourism. The corridor serves as a vital link between the densely populated Potohar region and the Himalayan foothills.

From a tourism perspective, Murree is not just a destination—it is a seasonal economy. The local economy depends heavily on hotels, restaurants, recreational services, and small-scale businesses that thrive on the continuous inflow of tourists. Key attractions such as Mall Road, Patriata (New Murree), Pindi Point, Kashmir Point, Bhurban, and Galiyat remain active year-round. The volume of visitors places extraordinary demand on the corridor's transport infrastructure, particularly the Murree Expressway (E-75), which remains the principal artery connecting the region. This concentration of tourist traffic during peak periods often leads to severe road congestion, long delays, over-occupancy in parking areas, and environmental degradation caused by high vehicular emissions and unregulated development.

In terms of transportation, the Murree corridor reflects the challenges of a rapidly growing tourism sector without corresponding investment in sustainable mobility options. Travel along the corridor is overwhelmingly road-based, with private vehicles accounting for the majority of trips. Public transport options are limited, informal, and often unreliable or uncomfortable. The lack of a regulated mass transit mode contributes to inefficient movement, traffic bottlenecks at entry and exit points, and safety hazards on narrow, winding hill roads. The absence of multimodal integration and a lack of terminal and parking infrastructure further aggravate the transport inefficiencies.

Given these dynamics, the Murree corridor stands out as a critical candidate for alternative, high-capacity, environmentally sustainable transport solutions. The proposed Glass Train seeks to transform the mobility experience in this corridor by providing a scenic, efficient, and climate-resilient rail-based mode of transport. This initiative not only promises to alleviate pressure on the existing road infrastructure but also aligns with long-term regional goals of eco-tourism, green mobility, and integrated urban-rural connectivity. The corridor's unique blend of tourism potential and mobility challenges makes it a high-priority focus area for investment in sustainable transit infrastructure.

Proposed Alignment and Stations

The proposed alignment for the tourist Glass Train corridor originates from Lake View Park in Islamabad, located within the administrative jurisdiction of the Capital Development Authority (CDA), in accordance with directives issued by the Government of Punjab. This location provides a scenic and accessible

departure point that is well-connected to both urban populations and incoming visitors from Rawalpindi and Islamabad.

From Lake View Park, the alignment traverses toward the Barakahu Bypass, avoiding the heavily congested core of Barakahu. A proposed station at Barakahu is located along this bypass to serve as a primary boarding point for suburban residents and to minimize disruption to densely populated zones. This strategic alignment continues along the natural contours of Shahdara Valley, which allows the train to bypass the urban buildup of Barakahu while still maintaining proximity to the area's population.

The alignment then curves back toward a central zone between Kashmir Road (the old Murree Road) and the E-75 Murree Expressway. From here onwards, the alignment remains roughly equidistant between the two main roadways, gradually ascending through Bahria Golf City and continuing toward Manga, preserving its scenic value while ensuring construction feasibility. At Tret, a station is proposed near the Valley Amusement Park, which serves as both a tourist attraction and a population cluster. This stop would facilitate recreational access and serve as a tourism development node along the alignment.

The alignment then moves through hilly terrain, passing Company Bagh, Nandkot, and Ghora Gali, eventually reaching Murree near the Sunny Bank area. The proposed Murree terminal is approximately 600 meters from the existing Murree Bus Stand, with an elevation gain of 223 meters. This terminal is strategically located to provide access to central Murree while minimizing congestion impacts within the core tourist district. It is expected to function as a gateway for tourists, offering integrated services including last-mile connectivity, tourist facilitation, and panoramic viewpoints. Alignment Plan for proposed Rail link between Islamabad and Murree is shown in Figure 3:

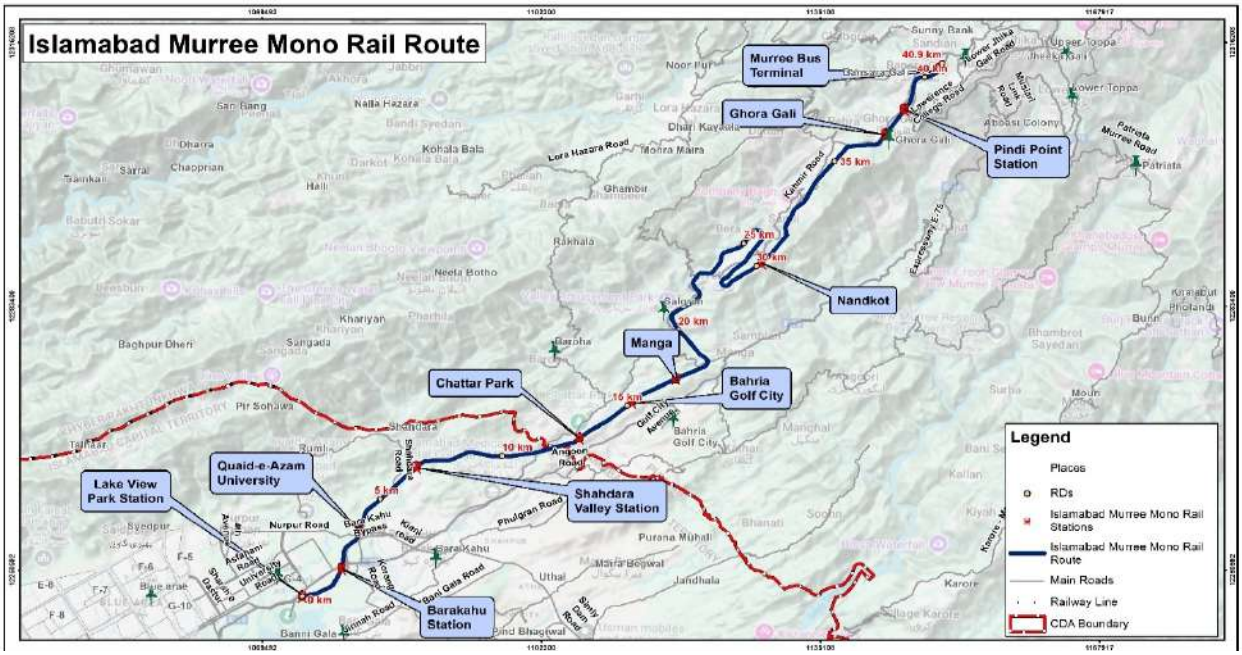


Figure 3 Alignment Plan for proposed Rail link between Islamabad and Murree

In total, the alignment combines technical viability with tourist appeal, traversing diverse terrain while providing critical access to urban peripheries, natural valleys, residential belts, and tourism hotspots. Station locations have been selected based on their potential to serve high-demand catchments, integrate with road-based feeder systems, and promote scenic and environmental value which is a hallmark of Glass Train systems worldwide.

2. METHODOLOGY

This project requires a holistic methodology adopting a well-rounded and systematic approach. The methodology encompasses a review of all relevant previously conducted studies and projects, close and continuous engagement with stakeholders, and extensive data collection aimed at developing an accurate and comprehensive understanding of all dimensions of the project. The collected data provide a robust foundation for detailed analysis, upon which analytical models are developed to estimate ridership across all plausible scenarios. Based on these analyses, projections of future ridership are subsequently derived. The overall methodology adopted for the project is briefly outlined in this chapter, while detailed descriptions of individual steps are presented in their respective dedicated chapters.

Review of Previous Studies

A critical part of the study methodology involved reviewing and analyzing existing data sources and previously conducted studies to build on prior knowledge, validate assumptions, and ensure alignment with regional planning objectives. This approach helped establish a contextual baseline for understanding the existing mobility challenges and tourism dynamics in the Rawalpindi–Murree corridor.

The 2015 ILF feasibility study examined a proposed 118 km broad-gauge railway from Islamabad (Margalla Station) to Muzaffarabad via Murree, commissioned by Pakistan Railways. The study conducted 24-hour classified traffic counts at five locations and 654 vehicle O-D interviews in November 2014, establishing a base year traffic volume of 68,600 passengers/day along the Islamabad-Murree corridor (combining Old Road and Expressway routes). Key findings revealed an 88% private car modal share, predominantly recreational trip purposes (68%), and strong seasonal variation with summer peak factors of 2.2x. The study projected ridership growth from 4,500 passengers/day (2020) to 16,900 passengers/day (2035) for the Islamabad-Murree segment, with rail capturing primarily public transport users rather than private car travelers due to Murree's affluent tourist profile. The study concluded that while passenger demand was viable requiring 8 pairs of trains/day initially—freight transport remained economically unviable due to unbalanced commodity flows (70% empty return trips) and road cost competitiveness.

While the ILF study's alignment differs significantly from the current Glass Train project (Margalla-Aabpara-Baroha Mor route vs. Lake View Park-Barakahu-Tret alignment) and emphasized inter-regional connectivity over tourism experience, its empirical data provides valuable baseline insights for the present study. The 2015 traffic volumes, vehicle occupancy rates (cars: 3.5, wagons: 15, buses: 23), seasonal adjustment factors, and public transport operations from Faizabad terminal (260 departures/day) offer a 10-year historical reference for calibrating current demand projections. Notably, the ILF study's modal shift analysis showing limited private car diversion despite rail's travel time advantage emphasizes the importance of positioning the Glass Train as a premium tourism product rather than purely a transport alternative, which aligns with the current project's focus on scenic value and experiential travel as primary value propositions distinct from conventional commuter rail services.

The study also benefited from the review of several relevant planning documents and data resources from the Capital Development Authority (CDA). These included transport planning frameworks, infrastructure zoning regulations, and master plans covering key areas in and around Islamabad, including Lake View Park, Bhara Kahu, and Shahdara Valley. The insights drawn from these documents helped assess origin-destination flows, the regional role of the E-75 and Kashmir Road corridors, and potential future developments that could affect ridership demand or station placement.

In addition, a GIS-based master plan shared by the Murree District Administration was closely reviewed. This included information on land use zoning, forest reserves, wildlife-protected areas, and urban development boundaries within the Murree region. The data was used in GIS modeling to avoid encroachments into environmentally sensitive areas and to ensure that the proposed rail alignment supports sustainable urban growth and ecological conservation.

The comprehensive review of previous studies and data ensured that the current feasibility study was not developed in isolation. Instead, it builds upon an informed understanding of past assessments, regional planning frameworks, and evolving mobility trends, allowing for an evidence-based, context-sensitive approach to alignment selection, demand forecasting, and commercial viability assessment.

Stakeholder Consultation Approach

Stakeholder consultation is a cornerstone of effective transport planning and infrastructure development, especially in high-sensitivity regions like Murree where land use, tourism, ecology, and mobility converge. Recognizing this, a structured and inclusive stakeholder engagement approach was adopted as part of the Traffic and Commercial Study. The goal was to ensure that the planning process remained aligned with the operational realities, regulatory frameworks, local development priorities, and institutional expectations of the project corridor.

Consultations were carried out at both individual and institutional levels, involving relevant government departments, tourism bodies, and transport authorities. A series of individual meetings were held with key decision-makers and administrators, including:

- Deputy Commissioner (DC) Murree, representing district administration and land management authorities.
- Secretary Regional Transport Authority (RTA), responsible for public transport regulation and inter-district licensing.
- Pakistan Mass Transit Authority (PMA) Manager – Rawalpindi, who provided input on multimodal integration and terminal planning.
- Regional Manager (North) – Tourism Development Corporation of Punjab (TDCP), offering insights on tourist inflow patterns, seasonality, and strategic tourism infrastructure development.

These consultations were vital for verifying field observations, refining survey instruments, and ensuring policy compatibility with local enforcement and planning mechanisms.

In addition to these one-on-one engagements, a high-level multi-stakeholder meeting was conducted on December 24, chaired by the Minister for Transport, Government of Punjab. This meeting brought together representatives from the Transport Department, Tourism Department, District Administrations, CDA, RTA, TDCP, and other key stakeholders involved in planning and approving transport infrastructure across Islamabad, Rawalpindi, and Murree. The project team presented the concept, alignment options, technical overview, and preliminary findings. Stakeholders were invited to share feedback regarding alignment feasibility, station site preferences, integration requirements with existing modes, and potential regulatory constraints.

Participants offered critical observations and expressed broad support for the Glass Train concept, particularly its potential to relieve congestion, improve tourist mobility, and promote sustainable travel in the region. Feedback from this session was recorded and incorporated into the planning refinement process. The meeting also helped build institutional ownership and fostered inter-agency coordination necessary for future implementation phases.

Overall, the consultation approach ensured that the study was not only technically sound but also administratively grounded and politically endorsed, facilitating smoother progression into the design, approval, and execution stages of the project.

Data Collection

A robust and context-sensitive survey planning and sampling strategy is central to any transportation feasibility study, particularly in corridors experiencing seasonal tourism flows and complex travel behaviors. For the Rawalpindi–Murree Glass Train Feasibility Study, a multimodal, multi-scale survey strategy was developed to ensure comprehensive data collection across vehicular, passenger, and commercial movement dimensions. The objective was to gather empirical evidence to support demand estimation, identify potential alignments and station sites, and evaluate the commercial and operational viability of a new electric rail mode.

Survey design was guided by established transportation planning methodologies, such as those outlined in Transport Research Board (TRB) frameworks, which emphasize representative sampling, multi-day coverage, and site-specific adaptability. The approach also integrated local travel characteristics, topography, and the influence of tourism seasonality factors known to heavily skew demand in mountainous corridors like Murree.

One of the key datasets examined was the traffic volume data obtained from the National Highway Authority (NHA) for the Phulgran Toll Plaza, which serves as a major entry point to the Murree Expressway (E-75). This monthly dataset, disaggregated by vehicle class, was instrumental in identifying seasonal variations,

analyzing peak-period volumes, and projecting annual travel demand patterns. It enabled calibration of field-collected data against year-round trends, strengthening the demand forecasting model for the proposed Glass Train service.

The data collection has been completed through performing below described key surveys;

Table 1 Key Surveys

Survey Type	Locations	Duration / Frequency	Notes
Manual Classified Counts (MCC)	6 Strategic Locations catering for incoming and outgoing traffic to Murree	16 hours × 4 days/site	2 Weekdays and 2 Weekends
Origin-Destination (O-D) Surveys	6 Locations *(same as MCC)*	16 hours × 4 days/site	2 Weekdays and 2 Weekends Every 10th Vehicle
Hotel Surveys	100 hotels out of 240 registered hotels in Murree	Monthly average	Across all Murree zones
Public Transport User Interview	Faizabad terminals, 26 no. terminals, Pir Wadhai terminals Rawalpindi, General bus stand Murree	Weekday & weekend, 100 interviews/day	Vehicle types + user profile
Boarding–Alighting Surveys	12 trips/day	2 Weekdays & 2 weekends	Passenger flow analysis
Parking Surveys	7 sites	2 Weekdays & 2 weekends	Peak & off-peak monitoring

Passenger Demand Estimation

The demand forecasting methodology for the proposed Glass Train project was designed to estimate potential ridership using a combination of primary survey data, trip purpose segmentation, mode-wise analysis, and origin–destination (O–D) modeling techniques. The objective was to build a realistic, behaviorally informed model of how existing public and private transport users would shift to the proposed rail service under various conditions, and to quantify ridership by time period (daily, monthly, annual).

Public Transport User-Based Forecasting

For public transport users, the methodology began with vehicle-based counts and user interview surveys at major terminals, with a focus on Faizabad Terminal, the central hub for Murree-bound buses from

Rawalpindi and Islamabad. All buses and vans departing for Murree were counted across weekday and weekend scenarios. Surveys were conducted to capture average vehicle occupancy, boarding/alighting behavior, and passenger willingness to shift to the Glass Train based on factors such as comfort, fare, frequency, and travel time.

A utility function was developed from public transport user interviews, which estimated the percentage of existing users willing to switch to the rail service. The estimated number of public transport travelers was then multiplied by this acceptance percentage, stratified by trip purpose and day type, to calculate daily ridership potential from the public transport segment.

Private Transport User-Based Forecasting

Forecasting from private vehicle users relied heavily on Origin–Destination (O–D) interview data collected at six major locations. These interviews captured key inputs including trip purpose, vehicle occupancy, travel frequency, origin and destination zones, and the traveler's expressed willingness to use the train. Each origin and destination pair was then assigned a Traffic Analysis Zone (TAZ) ID, and a regional O–D matrix was constructed to visualize and quantify trip distributions across the corridor.

The matrix captured both directional flows—Islamabad/Rawalpindi to Murree, and Murree to Rawalpindi/Islamabad, as well as flows from northern regions and Kashmir passing through Murree en-route to Islamabad or Rawalpindi. This zoning approach enabled precise spatial targeting of potential demand and allowed integration with the land use and station accessibility data developed via GIS analysis.

Forecasting for private transport users applied a behaviorally segmented model using trip purpose as a filter. Ridership potential was computed only for those users whose purpose fell within categories likely to consider rail use—specifically, recreation, social visits, home-based travel, and a small proportion of work-based trips. The calculation was applied across all private transport modes (cars, vans, jeeps), with mode-specific utility factors derived from survey responses.

Aggregation and Calibration

The final ridership estimation was obtained by adding the public and private transport-derived rider values, separately computed for weekdays and weekends. These were then used to generate average daily ridership figures, which were scaled to monthly totals using weekday/weekend ratios, and then converted to annual estimates.

To ensure seasonality and broader regional travel patterns were accurately reflected, the annual forecast was calibrated against 2024 monthly traffic volumes provided by the National Highway Authority (NHA) from the Phulgran Toll Plaza. This allowed monthly adjustment factors to be applied, compensating for peak-season spikes (summer and winter) and off-season lulls, ensuring that final annual ridership forecasts represented a realistic, demand-responsive projection.

This combined approach drawing from empirical survey data, trip segmentation, behavioral modeling, and macro-level calibration produced a well-rounded and context-sensitive estimate of potential ridership. It supports robust financial modeling, service frequency planning, and investment decision-making for the Glass Train corridor.

3. DATA COLLECTION

Traffic Volume Counts (Manual Classified Counts - MCC)

The Manual Classified Counts (MCC) and Origin–Destination (O–D) surveys were conducted at six carefully selected strategic locations, each representing a distinct control point for traffic entering or exiting the Murree corridor:

1. Sirinagar–E75 Intersection: The convergence point of all traffic from Islamabad and Rawalpindi onto the E-75 Expressway. This site captures the modal funneling effect and inter-urban traffic convergence toward Barakahu, Murree, and the north.
2. 17 Mile Toll Plaza (Old Kashmir Road): A historic corridor that continues to attract local traffic using the traditional route to Murree, often preferred by smaller vehicles or as an alternate during expressway congestion.
3. Phulgran Toll Plaza (E-75): This modern highway toll plaza records a significant share of Murree-bound and Kashmir-bound vehicles and provides monthly data through the National Highway Authority (NHA), which was also reviewed as secondary validation.
4. Musyari Link Road: The first entry/exit point along E-75 within Murree limits. It enables the measurement of inbound and outbound flows between Murree's urban limits and downstream catchments.
5. Lower Topa Intersection: A transitional node from where traffic either enters Murree's main activity zone or continues northeast toward Azad Kashmir, serving both local access and through-traffic.
6. Kuldanna Chowk: The terminal node for northeast-bound travel toward Nathiagalli and Abbottabad, capturing inter-district dispersal from Murree.

Surveys at these sites were conducted on four days per location—two weekdays and two weekends, with 16-hour continuous observation per day, covering 6:00 AM to 10:00 PM. This timeframe aligns with the proposed operational window for the Glass Train and captures diurnal variation in both commuter and recreational travel.

MCC data were classified by vehicle type (e.g., cars, wagons, Hiace vans, buses, trucks, two-wheelers), direction, and time of day. Simultaneously, O–D surveys were executed using a systematic sampling approach: every 10th vehicle was stopped and interviewed. The survey instrument captured origin and destination, trip purpose (e.g., work, education, recreation), travel frequency, Murree-bound share, and vehicle occupancy—which was especially important to estimate group-based tourist behavior, consistent with literature findings on leisure travel trends in resort corridors.

The MCC consists the vehicles count with a modal split in an interval of every 15 minutes. The MCC Questionnaire and site activity photos has been annexed. The data has been collected for two weekdays and two weekends separately for 16 hours. The count results for all the locations has been described in Table 2 to Table 31 and direction wise MCC is shown in Figure 4 to Figure 13:

1. Srinagar-E 75 Intersection

Table 2 Srinagar - E75 Intersection Traffic counts site description

1	**Site Name**	Sirinagar Road Intersection
2	**Dates on which survey was carried out**	05/03/2025, 06/03/2025, 08/03/2025, 09/03/2025
3	**Day on which survey was carried out**	Wednesday, Thursday, Saturday, Sunday
4	**Approach or Direction i.e. Suitable**	Direction
5	**Traffic A1,A2,A3,A4 from :**	Islamabad
6	**Traffic B1,B2,B3 from :**	Murree
7	**Traffic C1,C2,C3,C4 from :**	Sirinagar Road

Table 3 Srinagar-E75 Traffic Count Summary 5-03-2025 Wednesday

Direction	Traffic From	Type	Volume	% Share
A2	Rawalpindi (Murree Road)	Thro.	9,301	23.05%
B2	Murree	Thro.	19,763	48.98%
C1	Islamabad (Srinagar Road)	Thro.	11,287	27.97%
Total			40,352	100%

Table 4 Srinagar-E75 Traffic Count Summary 6-03-2025 Thursday

Direction	Traffic From	Type	Volume	% Share
A2	Rawalpindi (Murree Road)	Thro.	11028	25.35%
B2	Murree	Thro.	19386	44.57%
C1	Islamabad (Srinagar Road)	Thro.	13082	30.08%
Total			43,496	100%

Table 5 Srinagar-E75 Traffic Count Summary 8-03-2025 Saturday

Direction	Traffic From	Type	Volume	% Share
A2	Rawalpindi (Murree Road)	Thro.	10384	35.62%
B2	Murree	Thro.	17828	61.15%
C1	Islamabad (Srinagar Road)	Thro.	941	3.23%
Total			29,153	100%

Table 6 Srinagar-E75 Traffic Count Summary 9-03-2025 Sunday

Direction	Traffic From	Type	Volume	% Share
A2	Rawalpindi (Murree Road)	Thro.	5455	24.18%
B2	Murree	Thro.	16160	71.64%
C1	Islamabad (Srinagar Road)	Thro.	941	4.17%
Total			22,556	100%

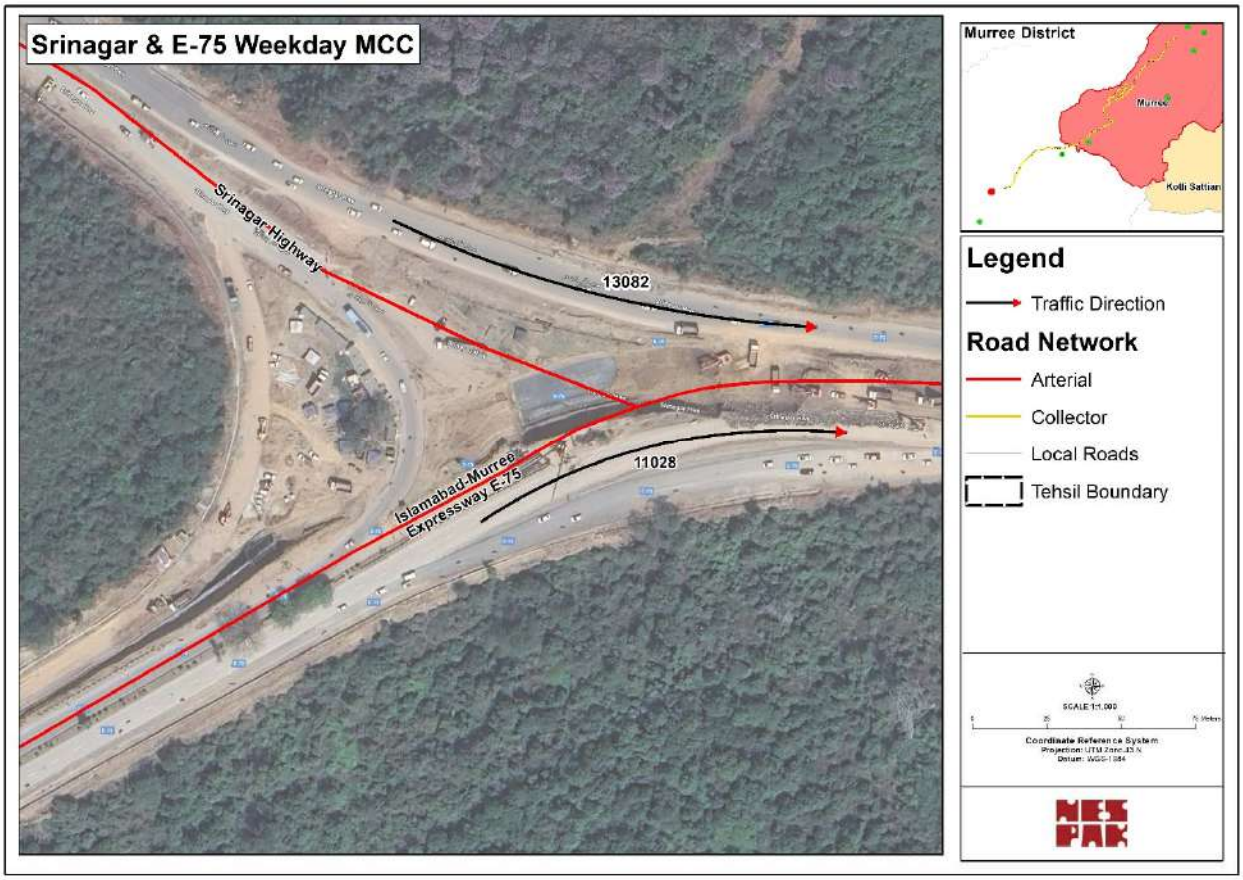


Figure 4 Srinagar-E75 Traffic Count Weekday towards Murree

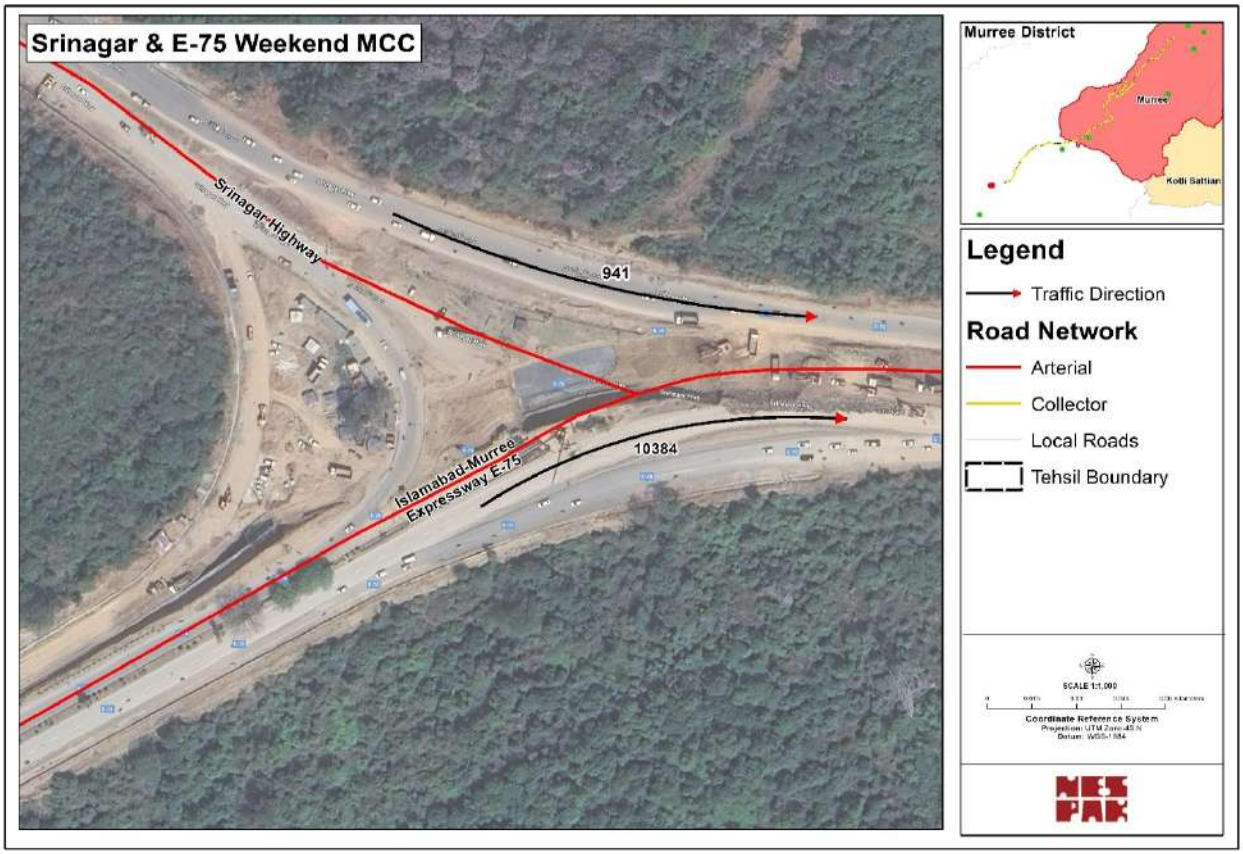


Figure 5 Srinagar-E75 Traffic Count Weekend towards Murree

2. 17 Mile Toll Plaza

The 17 Mile Toll Plaza, located on the historic **Kashmir Road (Old Murree Road)**, serves as a significant access point for traffic heading toward Murree from Rawalpindi and Islamabad.

Table 7 17 Mile Toll Plaza Traffic counts site description

1	**Site Name**	17 Mile Toll Plaza
2	**Dates on which survey was carried out**	22/02/2025, 23/02/2025, 25/02/2025, 26/02/2025
3	**Day on which survey was carried out**	Saturday, Sunday, Tuesday, Wednesday
4	**Approach or Direction i.e. Suitable**	Direction
5	**Traffic A1,A2,A3,A4 from :**	Islamabad
6	**Traffic B1,B2,B3 from :**	Murree

Table 8 17 mile toll plaza Traffic Count Summary 22-02-2025 Saturday

Directional Traffic Movement (PCUs) – 22-02-25 Saturday				
Direction	**Traffic From**	**Type**	**Volume**	**% Share**
A2	Islamabad	Thro.	7018	49.79%
B2	Murree	Thro.	7077	50.21%
Total			14,095	100%

Table 9 17 mile toll plaza Traffic Count Summary 23-02-2025 Sunday

Directional Traffic Movement (PCUs) – 23-02-25 Sunday				
Direction	**Traffic From**	**Type**	**Volume**	**% Share**
A2	Islamabad	Thro.	6494	47.59%
B2	Murree	Thro.	7153	52.41%
Total			13,646	100%

Table 10 17 mile toll plaza Traffic Count Summary 25-02-2025 Tuesday

Directional Traffic Movement (PCUs) – 25-02-25 Tuesday				
Direction	**Traffic From**	**Type**	**Volume**	**% Share**
A2	Islamabad	Thro.	5995	49.08%
B2	Murree	Thro.	6219	50.92%
Total			12,213	100%

Table 11 17 mile toll plaza Traffic Count Summary 26-02-2025 Wednesday

Directional Traffic Movement (PCUs) – 26-02-25 Wednesday				
Direction	**Traffic From**	**Type**	**Volume**	**% Share**
A2	Islamabad	Thro.	5870	47.63%
B2	Murree	Thro.	6455	52.37%
Total			12,325	100%

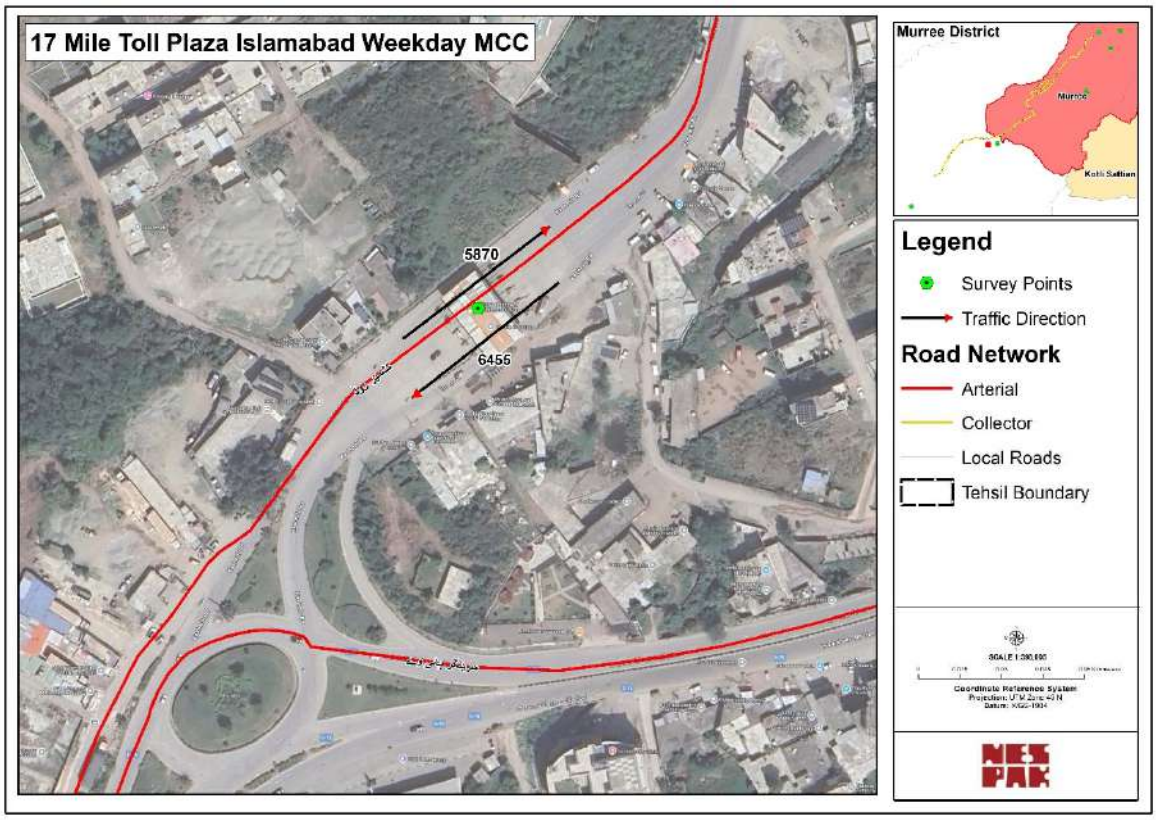


Figure 6 17 Mile Traffic Count Weekdays

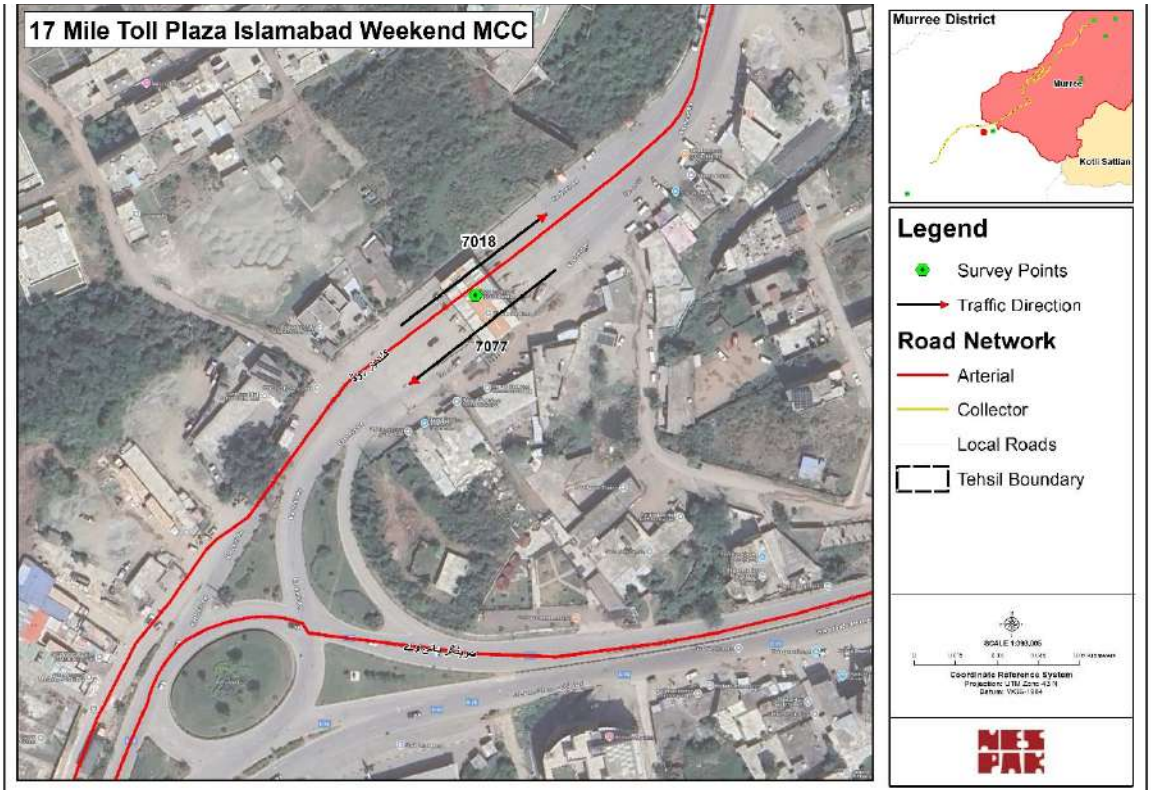


Figure 7 17 Mile Traffic Count Weekends

3. Phulgran Toll Plaza

The **Phulgran Toll Plaza** is a critical traffic monitoring and control point located along the **E-75 Murree Expressway**, which serves as the primary high-speed corridor connecting Islamabad to Murree and beyond to Azad Kashmir. As the first formal tolling point after entering the expressway from Islamabad, Phulgran provides an accurate representation of all northbound vehicular traffic using the new highway alignment. It captures a wide spectrum of travelers, including daily commuters, inter-city passengers, tourist groups, and freight movement.

Table 12 Phulgran Toll Plaza Site Description

1	**Site Name**	Phulgran Toll Plaza
2	**Dates on which survey was carried out**	22/02/2025, 23/02/2025, 25/02/2025, 26/02/2025
3	**Day on which survey was carried out**	Saturday, Sunday, Tuesday, Wednesday
4	**Approach or Direction i.e. Suitable**	Direction
5	**Traffic A1,A2,A3,A4 from :**	Islamabad
6	**Traffic B1,B2,B3 from :**	Murree

Table 13 Phulgran toll plaza Traffic Count Summary 22-02-2025 Saturday

Sr.	Direction	Traffic From	Type	Volume	% Share
1	A2	Islamabad	Thro.	8737	53.66%
2	B2	Murree	Thro.	7546	46.34%
	Total			**16,283**	**100%**

Table 14 Phulgran toll plaza Traffic Count Summary 23-02-2025 Sunday

Sr.	Direction	Traffic From	Type	Volume	% Share
1	A2	Islamabad	Thro.	6960	45.65%
2	B2	Murree	Thro.	8286	54.35%
	Total			**15,247**	**100%**

Table 15 Phulgran toll plaza Traffic Count Summary 25-02-2025 Tuesday

Sr.	Direction	Traffic From	Type	Volume	% Share
1	A2	Islamabad	Thro.	6753	54.41%
2	B2	Murree	Thro.	5657	45.59%
	Total			**12,409**	**100%**

Table 16 Phulgran toll plaza Traffic Count Summary 26-02-2025 Wednesday

Sr.	Direction	Traffic From	Type	Volume	% Share
1	A2	Islamabad	Thro.	6015	48.66%
2	B2	Murree	Thro.	6347	51.34%
	Total			**12,362**	**100%**

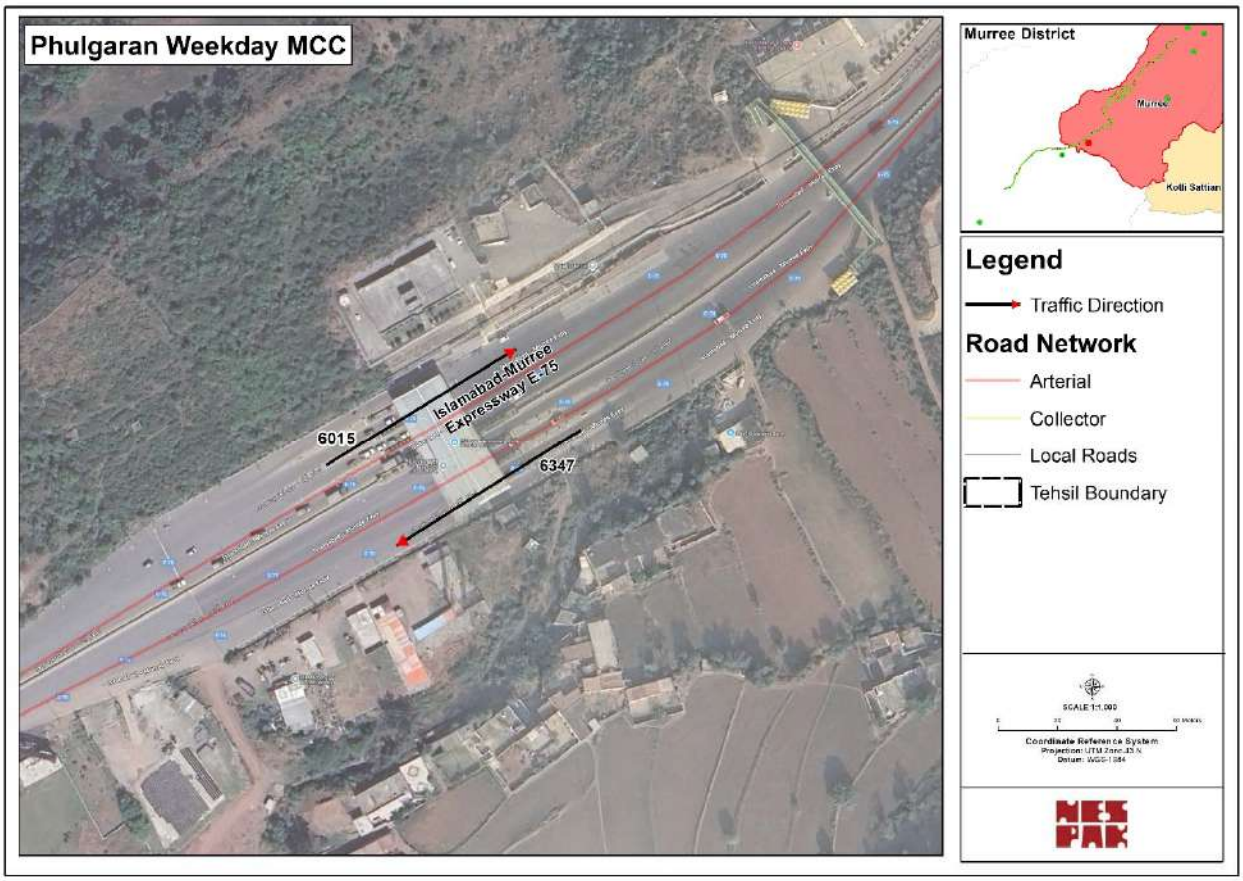


Figure 8 Phulgran Toll Plaza Weekday MCC

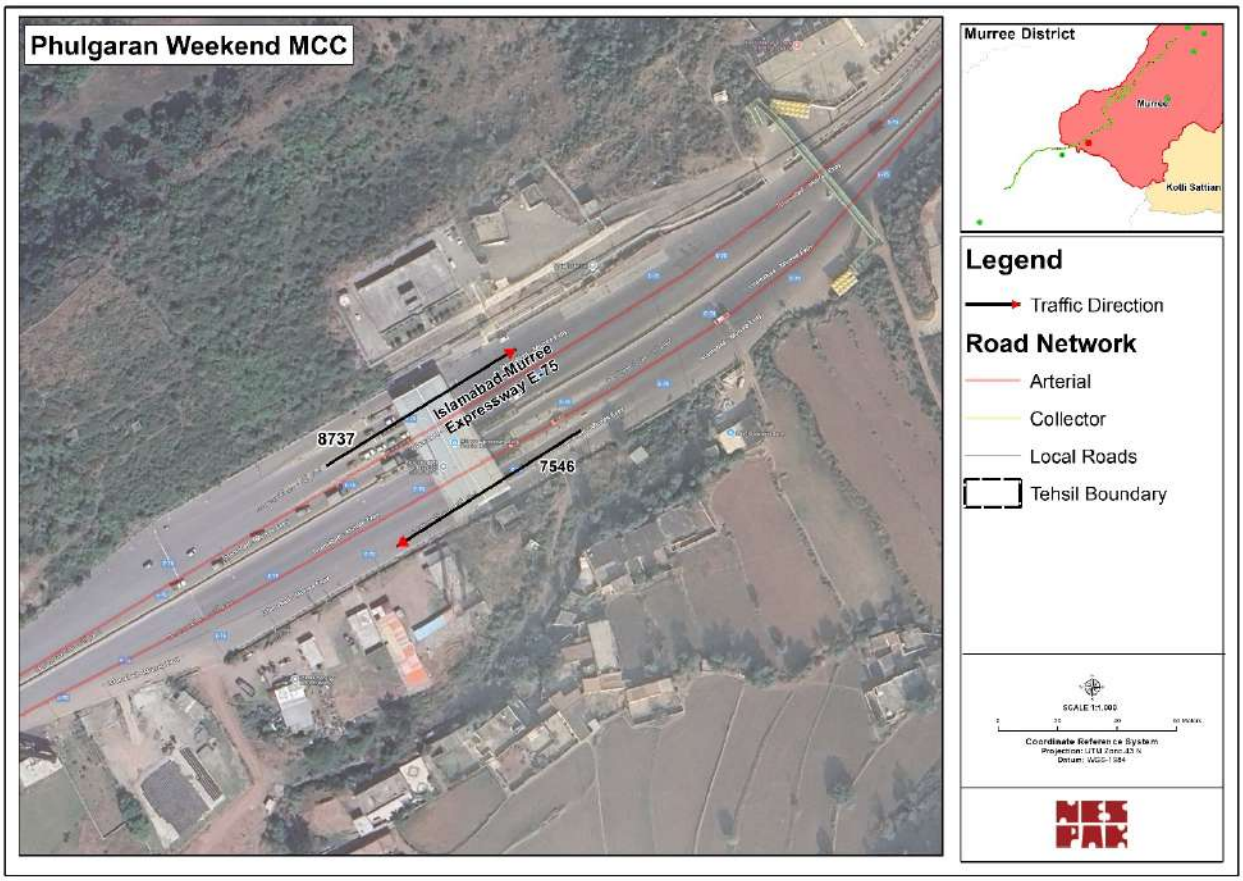


Figure 9 Phulgran Toll Plaza Weekend MCC

4. Musyari Link Road

Table 17 Mussyari Link Road Site Description

1	**Site Name**	Musyari Link Road
2	**Dates on which survey was carried out**	27/02/2025, 01/03/2025, 02/03/2025, 04/03/2025
3	**Day on which survey was carried out**	Thursday, Saturday, Sunday, Tuesday
4	**Approach or Direction i.e. Suitable**	Direction
5	**Traffic A1,A2,A3,A4 from :**	Islamabad
6	**Traffic B1,B2,B3 from :**	Murree
7	**Traffic C1,C2,C3,C4 from :**	Mussyari

Table 18 Mussyari Link Road Traffic Count Summary 01-03-2025 Saturday

Direction	Traffic From	Type	Volume	% Share	
A1	Islamabad	Left Turn	533	4.84%	44.84%
A2		Thro.	4409	40.00%	
B2	Murree (Lower Topa)	Thro.	4251	38.56%	43.42%
B3		Right-Turn	536	4.86%	
C2	Mussaiari	Thro.	220	2.00%	11.74%
C3		Right-Turn	1074	9.74%	
Total			**11022**	**100%**	**100%**

Table 19 Mussyari Link Road Traffic Count Summary 02-03-2025 Sunday

Direction	Traffic From	Type	Volume	% Share	
A1	Islamabad	Left Turn	286	4.87%	44.84%
A2		Thro.	2493	42.45%	
B2	Murree (Lower Topa)	Thro.	2593	44.16%	43.42%
B3		Right-Turn	79	1.35%	
C2	Mussaiari	Thro.	70	1.19%	11.74%
C3		Right-Turn	351	5.98%	
Total			**5872**	**100%**	**100%**

Table 20 Mussyari Link Road Traffic Count Summary 27-02-2025

Direction	Traffic From	Type	Volume	% Share	
A1	Islamabad	Left Turn	340	3.29%	44.84%
A2		Thro.	4449	43.17%	
B2	Murree (Lower Topa)	Thro.	4740	46.00%	43.42%
B3		Right-Turn	138	1.33%	
C2	Mussaiari	Thro.	136	1.32%	11.74%
C3		Right-Turn	503	4.88%	
Total			**10305**	**100%**	**100%**

Table 21 Mussyari Link Road Traffic Count Summary 04-03-2025

Direction	Traffic From	Type	Volume	% Share	
A1	Islamabad	Left Turn	310	5.63%	44.84%
A2		Thro.	2358	42.91%	
B2	Murree (Lower Topa)	Thro.	2338	42.55%	43.42%
B3		Right-Turn	76	1.38%	
C2	Mussaiari	Thro.	82	1.49%	11.74%
C3		Right-Turn	331	6.03%	
Total			**10305**	**100%**	**100%**

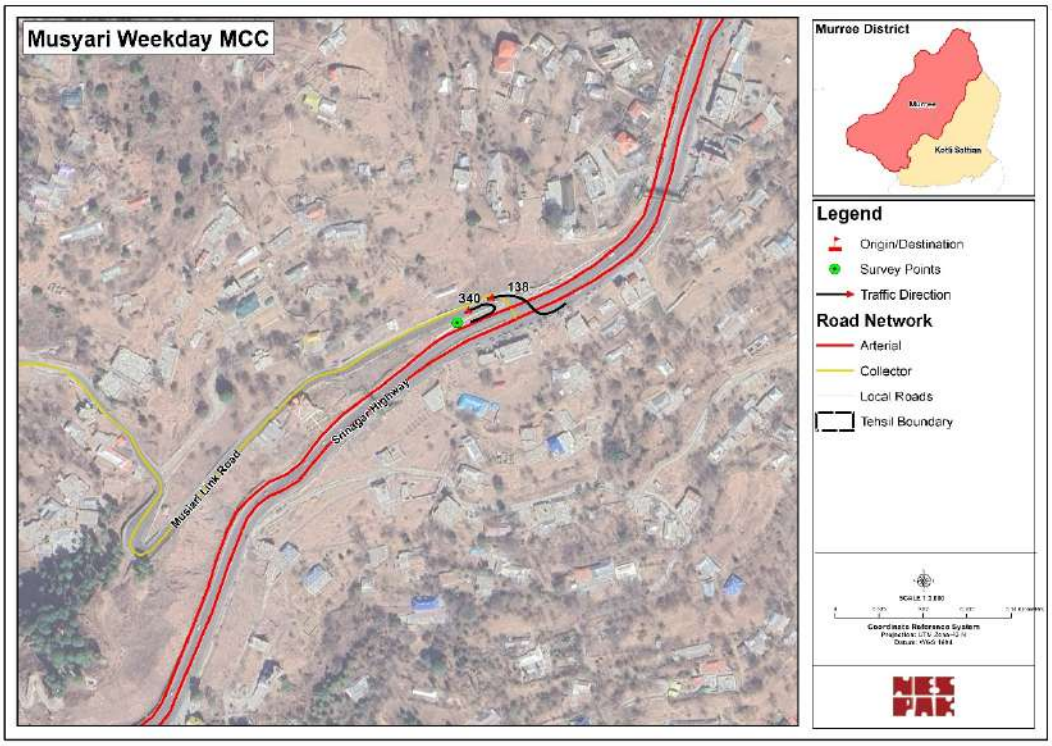


Figure 10 Musyari Link Road Weekday MCC

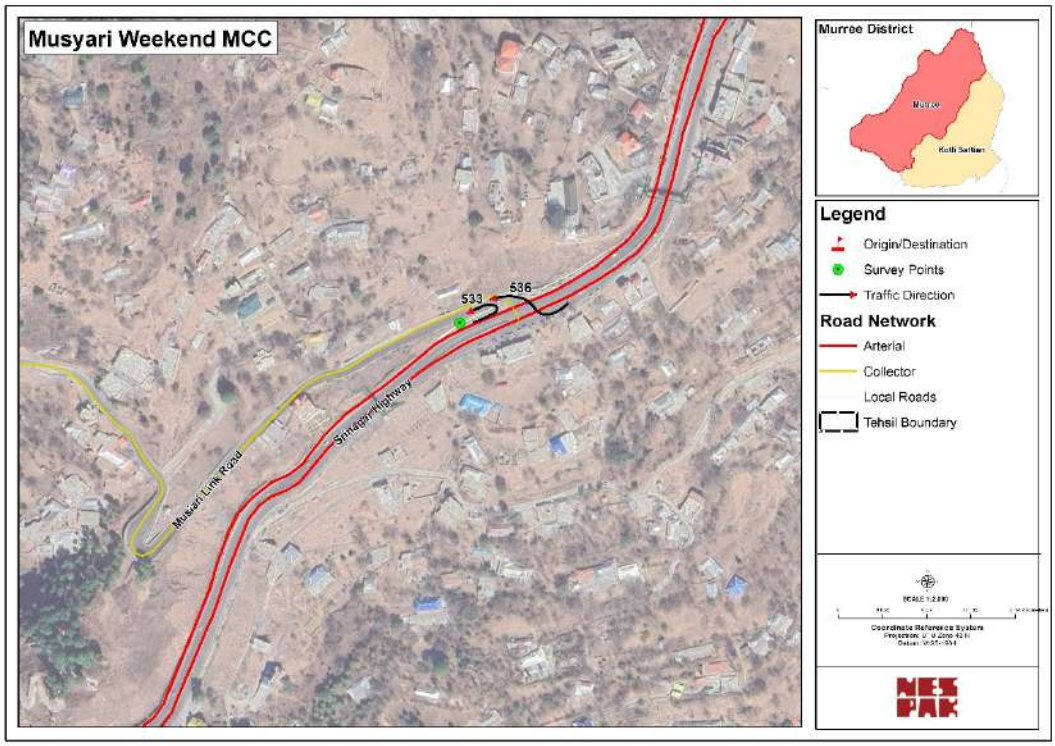


Figure 11 Mussyari Link Road Weekend MCC

5. Kuldanna Chowk

Kuldanna Chowk is a strategically important intersection located on the northeastern edge of Murree, acting as a major dispersal point for traffic moving toward **Nathiagali, Ayubia, Abbottabad**, and other parts of northern Khyber Pakhtunkhwa. It serves as one of the last key junctions within Murree's administrative boundary, where inter-regional travel converges with local movements. Due to its location, Kuldanna Chowk experiences a mix of **through traffic, local tourism, and inter-district connectivity**, making it a valuable site for capturing travel behavior beyond the immediate Rawalpindi–Murree corridor.

Table 22 Traffic Count site description Kuldanna Chowk

1	**Site Name**	Kuldanna Chowk
2	**Dates on which survey was carried out**	01/03/2025, 02/03/2025, 04/03/2025, 05/03/2025
3	**Day on which survey was carried out**	Saturday, Sunday, Tuesday, Wednesday
4	**Approach or Direction i.e. Suitable**	Direction
5	**Traffic A1,A2,A3,A4 from :**	Muzaffarabad RD
6	**Traffic B1,B2,B3 from :**	kashmir RD (Murree)
7	**Traffic C1,C2,C3,C4 from :**	Abbottabad
8	**Traffic D1,D2,D3 from :**	Kuldana RD (Murree)

Table 23 Directional Traffic Movement 01-03-2025 Kuldanna Chowk

Direction	Traffic From	Type	Volume	% Share	
A1	Muzaffarabad RD	Left Turn	2280	19.56%	29.02%
A2		Thro.	1034	8.87%	
A3		Left Turn	69	0.59%	
B1	kashmir RD	Left Turn	1747	14.99%	33.63%
B3		Right-Turn	1958	16.80%	
B4		U-Turn	215	1.85%	
C1	Abbottabad	Right-Turn	230	1.97%	28.96%
C2		Thro.	1402	12.03%	
C3		Right-Turn	1742	14.95%	
D1	Kuldana RD	Left Turn	608	5.21%	8.39%
D2		Thro.	201	1.72%	
D3		Right-Turn	170	1.46%	
Total			**11653**	**100%**	**100%**

Table 24 Directional Traffic Movement 02-03-2025 Kuldanna Chowk

Direction	Traffic From	Type	Volume	% Share	
A1	Muzaffarabad RD	Left Turn	1883	27.11%	29.02%
A2		Thro.	349	5.02%	
A3		Left Turn	37	0.53%	
B1	kashmir RD	Left Turn	1047	15.07%	33.63%
B3		Right-Turn	2339	33.67%	
B4		U-Turn	145	2.08%	
C1	Abbottabad	Right-Turn	54	0.77%	28.96%
C2		Thro.	309	4.45%	
C3		Right-Turn	309	4.45%	
D1	Kuldana RD	Left Turn	337	4.85%	8.39%
D2		Thro.	77	1.11%	
D3		Right-Turn	63	0.91%	
Total			**6947**	**100%**	**100%**

Table 25 Directional Traffic Movement 04-03-2025 Kuldanna Chowk

Direction	Traffic From	Type	Volume	% Share	
A1	Muzaffarabad RD	Left Turn	1320	26.25%	29.02%
A2		Thro.	145	2.87%	
A3		Left Turn	58	1.15%	
B1	kashmir RD	Left Turn	448	8.92%	33.63%
B3		Right-Turn	1469	29.21%	
B4		U-Turn	267	5.30%	
C1	Abbottabad	Right-Turn	39	0.77%	28.96%
C2		Thro.	148	2.94%	
C3		Right-Turn	506	10.06%	
D1	Kuldana RD	Left Turn	493	9.81%	8.39%
D2		Thro.	41	0.81%	
D3		Right-Turn	96	1.91%	
Total			**5027**	**100%**	**100%**

Table 26 Directional Traffic Movement 05-03-2025 Kuldanna Chowk

Direction	Traffic From	Type	Volume	% Share	
A1	Muzaffarabad RD	Left Turn	1659	25.65%	29.02%
A2		Thro.	231	3.57%	
A3		Left Turn	61	0.94%	
B1	kashmir RD	Left Turn	683	10.56%	33.63%
B3		Right-Turn	1819	28.13%	
B4		U-Turn	290	4.49%	
C1	Abbottabad	Right-Turn	61	0.94%	28.96%
C2		Thro.	235	3.63%	
C3		Right-Turn	681	10.53%	
D1	Kuldana RD	Left Turn	536	8.28%	8.39%
D2		Thro.	58	0.89%	
D3		Right-Turn	156	2.41%	
Total			**6465**	**100%**	**100%**

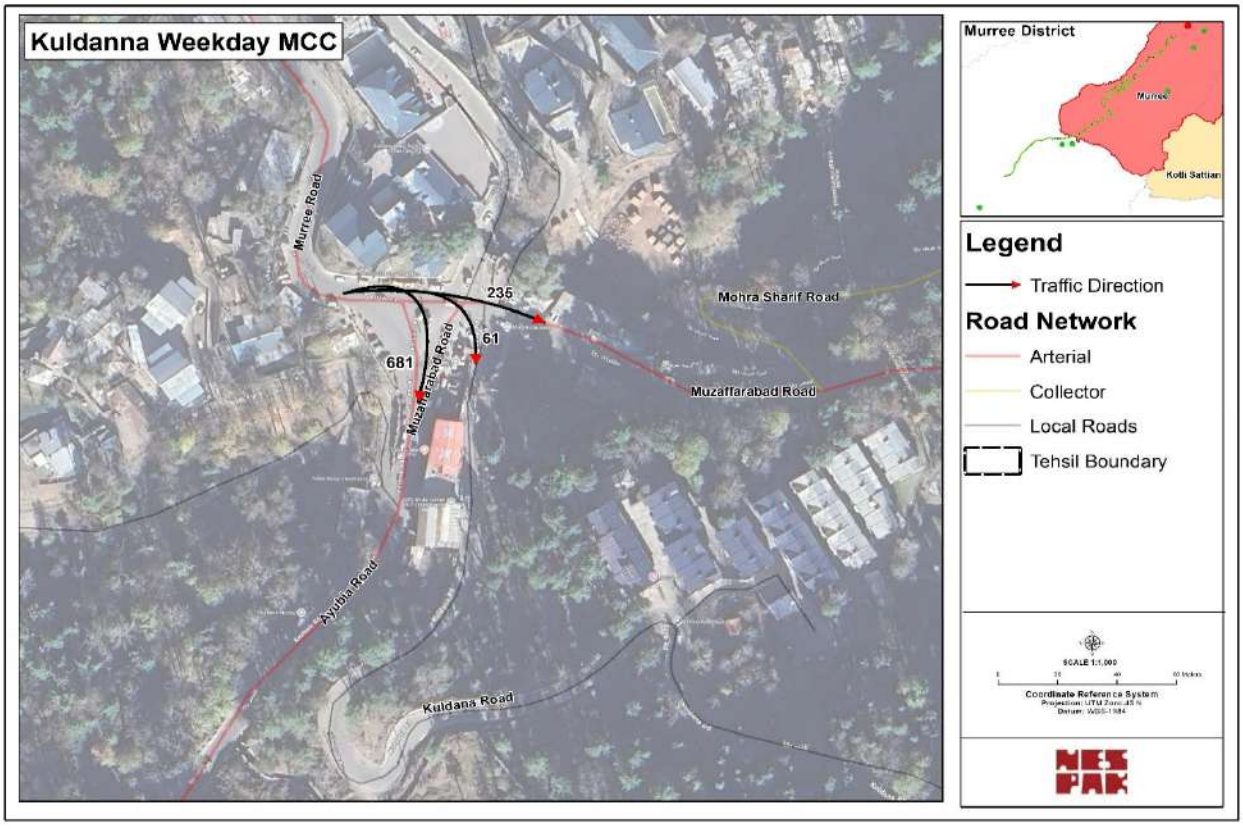


Figure 12 Kuldanna Chowk Weekday MCC Towards Murree

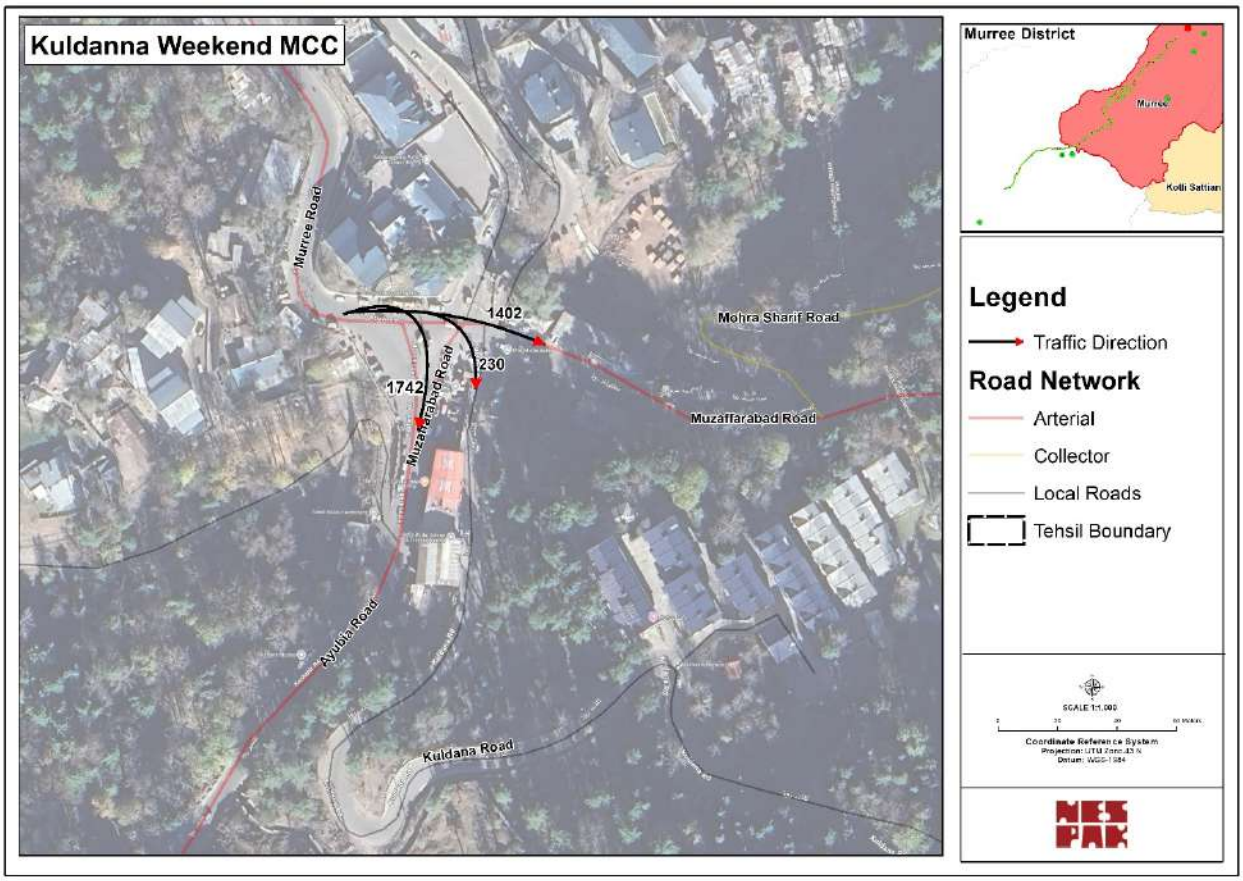


Figure 13 Kuldanna Chowk Weekend MCC Towards Murree

6. Lower Topa Intersection

The **Lower Topa Intersection** is a key mobility node situated near the southern edge of Murree, functioning as one of the final access points for vehicles entering the hill station via the E-75 Expressway. It also provides a critical junction for traffic heading further north toward **Kashmir and Galiyat regions**, making it both a **destination and transition point** within the corridor. Due to its elevation and connectivity, Lower Topa serves not only tourism-based travel but also accommodates logistics movement and inter-provincial traffic. The MCC and O–D surveys conducted at this location revealed high volumes of Murree-bound vehicles, as well as onward traffic to regional destinations.

Table 27 Traffic Count site description Lower Topa Intersection

1	**Site Name**	Lower Topa Intersection
2	**Dates on which survey was carried out**	27/02/2025, 01/03/2025, 02/03/2025, 04/03/2025
3	**Day on which survey was carried out**	Thursday, Saturday, Sunday, Tuesday

4	**Approach or Direction i.e. Suitable**	Direction
5	**Traffic A1,A2,A3,A4 from :**	Islamabad
6	**Traffic B1,B2,B3 from :**	Muzaffarabad
7	**Traffic C1,C2,C3,C4 from :**	Murree

Table 28 Directional Traffic Movement 27-02-2025 Lower Topa

Direction	Traffic From	Type	Volume	% Share	
A1	Islamabad	Left Turn	1346	21.33%	42.64%
A2		Thro.	1345	21.31%	
B2	Muzafarabad	Thro.	1381	21.89%	25.34%
B3		Right-Turn	218	3.46%	
C1	Murree	Left Turn	419	6.64%	32.02%
C3		Right-Turn	1601	25.37%	
Total			**6310**	**100%**	**100%**

Table 29 Directional Traffic Movement 01-03-2025 Lower Topa

Direction	Traffic From	Type	Volume	% Share	
A1	Islamabad	Left Turn	2318	25.97%	42.64%
A2		Thro.	1527	17.11%	
B2	Muzafarabad	Thro.	2722	30.50%	25.34%
B3		Right-Turn	170	1.90%	
C1	Murree	Left Turn	532	5.96%	32.02%
C3		Right-Turn	1657	18.56%	
Total			**8924**	**100%**	**100%**

Table 30 Directional Traffic Movement 02-03-2025 Lower Topa

Direction	Traffic From	Type	Volume	% Share	
A1	Islamabad	Left Turn	1543	24.50%	42.64%
A2		Thro.	1813	28.79%	
B2	Muzafarabad	Thro.	1530	24.30%	25.34%
B3		Right-Turn	142	2.25%	
C1	Murree	Left Turn	766	12.16%	32.02%
C3		Right-Turn	504	8.01%	
Total			**6296**	**100%**	**100%**

Table 31 Directional Traffic Movement 04-03-2025 Lower Topa

Direction	Traffic From	Type	Volume	% Share	
A1	Islamabad	Left Turn	812	16.54%	42.64%
A2		Thro.	1230	25.06%	
B2	Muzafarabad	Thro.	1595	32.48%	25.34%
B3		Right-Turn	80	1.62%	
C1	Murree	Left Turn	609	12.40%	32.02%
C3		Right-Turn	584	11.90%	
Total			**4909**	**100%**	**100%**

Origin-Destination (O-D) Surveys

Origin–Destination (O–D) surveys were a central component of the traffic and commercial data collection effort, designed to gather detailed insights into travel behavior, spatial movement patterns, and user preferences across the Rawalpindi–Murree corridor. The purpose of these roadside interview surveys was to build an evidence-based understanding of why, how, and by whom trips are made in the region, with a particular focus on Murree-bound travel.

O–D interviews were conducted at six strategic survey locations—Sirinagar–E75 Intersection, 17 Mile Toll Plaza, Phulgran Toll Plaza, Musyari Link Road, Lower Topa Intersection, and Kuldanna Chowk—during both weekdays and weekends. At each site, interviews were carried out over 16-hour periods for four separate days, with vehicles sampled systematically (every 10th vehicle) to ensure a broad representation of users.

Each interview collected a comprehensive set of travel characteristics, including:

- Mode of transport (e.g., car, van, public bus, motorcycle)
- Vehicle occupancy (number of passengers)
- Trip origin and destination (both district and specific locality)
- Trip frequency (daily, weekly, monthly, occasional)
- Trip purpose (e.g., recreation, work, education, social visit, shopping)
- Home area (to understand commuter versus tourist flows)
- Average household income (grouped into income brackets)
- Willingness to use the proposed Glass Train (Yes/No)
- Reason for willingness or unwillingness (e.g., comfort, cost, time, convenience)
- Fare preference or acceptable fare range

The OD survey questionnaire has been annexed with the report for review. This data was critical not only for building the regional Origin–Destination Matrix (OD Matrix) but also for segmenting potential users by

income group, purpose of travel, and willingness to shift modes. For instance, tourists showed higher interest in using the train for recreational purposes, while work-based commuters were more sensitive to travel time and fare structures.

The collected O–D data also enabled spatial analysis of trip generation and attraction zones, which supported the delineation of Traffic Analysis Zones (TAZs) across the study corridor. These zones were later used in modeling exercises to forecast demand, identify catchment areas for proposed stations, and quantify the ridership potential based on real-world origin-destination relationships.

In summary, the O–D survey provided a rich, multi-dimensional dataset that directly informed the alignment planning, service design, and commercial strategy of the proposed Glass Train, ensuring that future service provisions are aligned with the expectations and mobility behavior of the corridor's diverse traveler base.

All the Origin-Destination data for 4 days (2 weekdays and 2 weekends) at 6 locations on all directions has enabled to gather data of more than 7900+ travelers in the region.

The results and corresponding analysis are presented in the next chapter.

Bus Terminal Surveys

To assess the operational performance, capacity, and ridership behavior of existing public transport services along the Rawalpindi–Murree corridor, a detailed **Bus Terminal Survey** was conducted at the **Faizabad Terminal**, which functions as the **primary dispatch point for Murree-bound vehicles** from both Rawalpindi and Islamabad. This terminal was selected for its centrality and strategic role as the convergence hub for public transport fleets originating from **26 Number Terminal**, **Pirwadhai**, and other urban terminals before embarking toward Murree and surrounding hill stations.

The survey was conducted over both **weekdays and weekends**, capturing variations in service frequency and passenger load due to **daily commuting** and **tourism-driven demand**, respectively. Information was collected directly from operators on **bus frequency, vehicle type, seating capacity, average occupancy, fare levels, and travel times**. Six key routes were observed, covering major Murree destinations including **Old Murree, New Murree, Phugwari, Patriata, Upper Dewal, and Nathia Galli**.

Weekday Survey Findings:

- A total of **254 trips per day** were operated by 6 transport providers, using **Hiace vans** with an average capacity of **18 passengers** per vehicle.
- The **average occupancy** was 100% across all routes, with slight variations observed on the **New Murree route** (83% occupancy).

- The **total weekday ridership** recorded was **4,476 passengers per day**.
- **Fares ranged from PKR 280 to 500**, depending on destination distance, with an **average travel time of 1:20 to 2:00 hours**.

The Bus Terminal Survey Data for Weekdays is shown in Table 32:

Table 32 Bus Terminal Survey Data (Weekdays)

S.NO	ORIGIN	DESTINATION	NAME OF TRANSPORT OPERATOR	NUMBER OF BUSES PER DAY	VEHICLE TYPE	CAPACITY OF VEHICLE	Average number of passenger per vehicle	TOTAL PASSENGERS PER DAY	Average FARE PER PASSENGER	Average TRAVEL TIME (hrs)
1	Faizabad	Phugwari	Imtiaz Abbasi	32	Hiace	18	18	576	350	1:20
2	Faizabad	Nathia	Naeem	38	Hiace	18	18	684	500	2:00
3	Faizabad	Old Murree	Iftaiz Abbasi	85	Hiace	18	18	1530	300	1:20
4	Faizabad	New Murree	M.Shafique	40	Hiace	18	18	720	280	1:30
5	Faizabad	Upper Dewal	Gul Zaman	35	Hiace	18	18	630	300	1:25
6	Faizabad	Patriata	Ghulam Hussain	32	Hiace	18	18	576	280	1:20
				262				4716		

Weekend Survey Findings:

- On weekends, the **total number of trips increased to 262**, reflecting higher demand due to recreational and leisure travel.
- Vehicle occupancy reached full capacity (18 passengers per vehicle) across all routes, including the previously underloaded New Murree route.
- The **total weekend ridership** rose to **4,716 passengers per day**, indicating an approximate **5.4% increase over weekday volumes**.
- Fare structures remained consistent, but **trip frequency on key routes such as New Murree and Nathia Galli was notably higher**, indicating their popularity among tourists.

The Bus Terminal Survey Data for Weekend is shown in Table 33:

Table 33 Bus Terminal Survey Data (Weekend)

S.NO	ORIGIN	DESTINATION	NAME OF TRANSPORT OPERATOR	NUMBER OF BUSES PER DAY	VEHICLE TYPE	CAPACITY OF VEHICLE	Average number of passenger per vehicle	TOTAL PASSENGERS PER DAY	Average FARE PER PASSENGER	Average TRAVEL TIME (hrs)
1	Faizabad	Phugwari	Imtiaz Abbasi	32	Hiace	18	18	576	350	1:20
2	Faizabad	Nathia	Naeem	38	Hiace	18	18	684	500	2:00
3	Faizabad	Old Murree	Iftaiz Abbasi	85	Hiace	18	18	1530	300	1:20
4	Faizabad	New Murree	M.Shafique	32	Hiace	18	15	480	280	1:30
5	Faizabad	Upper Dewal	Gul Zaman	35	Hiace	18	18	630	300	1:25
6	Faizabad	Patriata	Ghulam Hussain	32	Hiace	18	18	576	280	1:20
				254				4476		

Key Observations:

Old Murree remains the most frequently served destination, with **85 weekday trips and 85+ on weekends**, reflecting its role as the traditional core of tourist activity.

Nathia Galli, despite being the farthest and most expensive destination (PKR 500 fare), saw high occupancy and frequency, especially on weekends, reinforcing its appeal for longer leisure trips.

The uniform vehicle type—**Hiace vans**—indicates a lack of service diversity and limited capacity per trip, which contributes to congestion and does not accommodate group travelers or high-volume demand effectively.

The data suggests significant **latent demand for a higher-capacity, reliable, and comfortable mode of travel** such as the proposed Glass Train, especially during peak tourism periods.

The Bus Terminal Survey demonstrates that **existing public transport is nearing saturation on weekends**, and its constrained capacity and limited comfort are key barriers for many higher-income or family-based travelers. These insights reinforce the strategic value of the Glass Train in **absorbing tourism surges**, **reducing road congestion**, and **improving overall passenger experience** between Islamabad/Rawalpindi and Murree.

Public Transport User Interview Surveys

To complement the quantitative traffic counts and operational data collected from public transport terminals, a focused **Public Transport User Interview Survey** was conducted to gain qualitative insights into the behavior, preferences, and expectations of current public transport users along the Rawalpindi–Murree corridor. The objective of this survey was to assess the **socio-economic profile**, **travel motivation**, and **willingness to shift** of public transport passengers in relation to the proposed Glass Train service.

The survey was carried out at **four major terminals**, including **Faizabad**, which serves as the primary departure point for Murree-bound vans and buses from Rawalpindi and Islamabad. It was also conducted at General Bus Stand Murree, 26 Number Bus stand and Pirwadhai bus stands in Rawalpindi. A sample of **100 users per day** was interviewed on both **weekdays and weekends**, ensuring coverage of both regular commuters and recreational travelers.

The survey collected the following key variables:

- **Trip Purpose** (e.g., work, education, recreation, social, shopping)
- **Trip Frequency** (daily, multiple daily, weekly, monthly, occasional)
- **Vehicle Ownership** (to determine reliance on public transport by necessity or choice)
- **Reason for Using Public Transport** (e.g., affordability, no personal vehicle, convenience, direct access)
- **Average Waiting Time for Bus** (to evaluate service reliability and scheduling gaps)
- **Usability of Proposed Train Service** (Yes/No response to whether the user would prefer the Glass Train)
- **Reason for Usability Response** (e.g., time-saving, comfort, cost, convenience, accessibility, skepticism)
- **Fare Preference** (maximum fare user is willing to pay for the train)

This interview-based approach allowed for deeper understanding of **user attitudes**, particularly around **perceived shortcomings of existing services** (e.g., long wait times, discomfort, overloading) and **expectations from the Glass Train** (e.g., faster journey, more comfortable travel, better reliability). It also helped segment users based on **income level, trip frequency, and ownership status**, which are critical factors in **forecasting modal shift potential**.

Responses from the survey were coded and analyzed to derive behavioral trends, which were later integrated into the **utility function and ridership forecasting models**. These findings also support the **fare strategy and service design recommendations** included in the commercial analysis.

A copy of the complete **survey form** used for interviews is annexed to this report for reference.

Boarding-Alighting Survey

To better understand the **passenger flow patterns**, **stop-level demand**, and **intermediate travel behavior** along the Rawalpindi–Islamabad to Murree public transport corridor, a targeted **Boarding–Alighting Survey** was conducted. This survey aimed to map how passengers enter and exit public transport vehicles throughout the trip rather than only at terminal stations, providing crucial data for identifying **midway demand clusters** and **potential train station sites** for the proposed Glass Train.

The survey was conducted on public transport vans and minibuses operating on the Murree–Islamabad route. A total of **two trips per day** were surveyed:

This approach captured variations between **regular commuter travel** and **weekend recreational demand**.

The trips selected for observation originated from the following three major terminals in Islamabad:

1. **Faizabad Terminal**
2. **Pirwadhai Terminal**
3. **26 Number Terminal** (Peshawar Mor area)

Surveys were conducted in both directions:

- From these **Islamabad terminals to Murree**
- And from the **Murree Bus Stand back to Islamabad**

Each vehicle was observed from **origin to destination**, with surveyors noting the **boarding and alighting locations of each passenger**, along with the **stop name or nearest identifiable landmark**. The surveys also noted:

- Total number of passengers per trip
- Occupancy at different points of the route
- Intermediate stops that had significant boarding/alighting activity

Key Objectives

The purpose of this survey was to:

- Identify **intermediate stops with high passenger turnover**, such as Bhara Kahu, Satra Meel, Phulgran, and Lower Topa.
- Evaluate the **potential demand at locations between terminals** that is often missed in terminal-based surveys.
- Assess **trip completeness** for various passenger segments (full-trip riders vs. short-distance riders).

- Support the **planning and selection of intermediate stations** for the Glass Train, ensuring it captures the most active demand nodes.

Hotels Tourist Survey

Given Murree's identity as a tourism-dependent economy, hotel-based data collection was critical. A stratified sample of 100 hotels was drawn from across the town, representing different zones (Mall Road, Bhurban, Lower Topa, GPO, and Patriata) and hotel categories (budget, mid-range, boutique). The surveys collected data on monthly occupancy rates, average room rent, parking capacity, guest origin, and expected seasonal variations.

Importantly, qualitative inputs were gathered on stakeholder perception of the proposed Glass Train. Operators were asked about potential business opportunities—such as integrated ticketing, station-side investment, or bundled hotel-and-rail packages—reflecting global trends in rail-tourism synergies (World Tourism Organization, 2020). The names of the hotel were not recorded keeping the anonymity of the hotel owners. The data was collected from the Bhurban, Hall road, Mall road, and General Bus Stand (GBS) Murree area. The hotels surveyed are shown in Figure 5:

As part of the broader commercial and tourism-related assessment for the proposed Murree Glass Train project, a detailed Hotels Survey was conducted to collect insights from hospitality operators regarding tourist volumes, operational challenges, transportation preferences of guests, and the potential for integration with the new train service. Given that Murree is a seasonal hill station heavily reliant on tourism, the behavior of hotel operators and their guests plays a critical role in shaping the demand model for the corridor.

A total of 100 hotels were selected for the survey from various key tourism zones of Murree, including:

- Mall Road / GPO Area
- Lower Topa
- Bhurban and New Murree (Patriata)
- Company Bagh and Sunny Bank
- Peripheral areas such as Upper Dewal and Kashmir Point

The sample represented a cross-section of small, mid-sized, and large hotels, including guesthouses, lodges, and resorts. The survey was administered through in-person interviews using a structured questionnaire, which is annexed to this report.

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Survey Structure and Data Collected

The hotel survey covered the following broad categories:

1. Hotel Operations and Visitor Profile

- Location of the hotel
- Average room rent for domestic and international guests
- Number of rooms available
- Monthly visitor data **for a 14-month period (Jan 2024 to Feb 2025)**
- Share of domestic vs. international guests
- City of origin of majority of guests
- Length of stay and luggage volume
- Check-in and check-out times

This section aimed to help the study team understand **seasonal tourism fluctuations**, guest demographics, and operational patterns that influence accommodation demand throughout the year.

Number of Visitors in each month and Domestic and International Tourists % are shown in Table 34 and Table 35:

Table 34 Number of Visitors in each month

Months	Number of Visitors
24-Jan	30,625
24-Feb	22,487
24-Mar	19,122
24-Apr	21,809
24-May	27,340

24-Jun	41,446
24-Jul	43,316
24-Aug	38,656
24-Sep	26,767
24-Oct	22,740
24-Nov	23,048
24-Dec	30,666
25-Jan	30,652
25-Feb	22,144

Table 35 Domestic and International Tourists %

Domestic Tourists (%)	International Tourists (%)
98%	2%

2. Transport Behavior of Guests

- Preferred **mode of travel to Murree** (e.g. private cars, public vans, ride-sharing, tour buses)
- General **transport access issues**, including parking conditions and vehicle congestion

These inputs are valuable in assessing the **current transport burden**, and how much of it may be shifted to a rail-based option.

3. Perceptions of the Murree Glass Train Project

- Opinion on whether the train project would impact their hotel business positively, negatively, or neutrally
- Expected benefits from the project (e.g. increased bookings, better guest access, improved infrastructure)
- Concerns regarding the project (e.g. congestion, environmental impacts, business competition)

This component provides direct **stakeholder feedback** and highlights **potential risks and opportunities** for integration of hospitality with the train service.

4. Fare and Commercial Partnership Preferences

The survey collected information on two aspects:

- the ticket fare ranges suggested by respondents for the proposed train service, and
- the willingness of hotel businesses to participate in stay-and-travel partnerships with the train operator, such as bundled packages and coordinated marketing.

These findings are directly relevant for the commercial structuring of the project, as they provide guidance on setting passenger fares and indicate the potential for private-sector collaboration to strengthen service uptake and revenue generation.

5. Parking Facilities

- Number of parking spots available at the hotel
- Occupancy level of parking (e.g. low, moderate, high, or seasonal fluctuation)

This information is useful for evaluating the **parking load** during tourism peaks and for assessing how the train might help **reduce parking pressure** in congested zones.

6. Freight and Supply Chain Logistics

- Types of commodities received regularly (e.g. food, linen, utilities)
- Primary source of supplies (Murree-based, Islamabad/Rawalpindi, or other cities)
- Current mode of transporting supplies (local vendor transport, private trucks, logistics providers)
- Frequency and volume of deliveries (e.g. weekly, bi-weekly, monthly)
- Openness to using **train-based freight transport** as an alternative (conditional on cost and convenience)

This section provides essential input for assessing the **logistical potential** of integrating light freight services into the Glass Train's operating model, particularly for hotels and food service providers.

The hotel survey served as a vital component of the commercial and tourism-related data collection effort, allowing the project team to understand the **operational realities, seasonal trends, and stakeholder perspectives** that shape Murree's hospitality sector. The collected data supports multiple aspects of the feasibility study including **ridership estimation, commercial integration planning, station access considerations,** and potential **freight service use cases**.

4. Data Analysis

Overview

The data analysis phase constituted a critical component of the Rawalpindi Murree Glass Train Feasibility Study, translating field-collected information into quantifiable insights for ridership estimation, corridor performance assessment, and future scenario modelling. The analytical framework combined manual traffic counts, origin–destination interviews, and public transport passenger surveys, integrating them within a geospatial and behavioural context. The central objective was to capture the complex interaction between private and public travel behaviour, corridor capacity, and tourism-induced temporal variation.

Given the corridor's dual nature serving both regular intercity commuters and seasonal leisure travellers data analysis had to adopt a multi-layered approach. Each dataset was systematically processed, validated, and interpreted to produce consistent and representative metrics reflecting both average and peak-season conditions. The following subsections present a detailed account of the analytical process applied to primary and secondary data sources.

Data Cleaning, Validation, and Quality Assurance

Upon completion of field surveys, all datasets underwent a rigorous multi-step validation procedure to ensure completeness, reliability, and internal coherence. Field supervisors performed initial cross-checks to identify missing or inconsistent entries in MCC and O–D survey forms. Subsequently, digital data cleaning was conducted using spreadsheet-based quality filters and logical consistency checks (e.g., verifying that vehicle entry and exit flows were balanced at paired locations).

Secondary validation was carried out using toll collection data obtained from the National Highway Authority (NHA) for Phulgran Plaza. By comparing recorded daily vehicle volumes with MCC counts, an error margin of less than ±5% was established considered acceptable under TRB and AASHTO transportation survey standards. Anomalous spikes observed during isolated survey hours (mostly in weekend evening peaks) were adjusted using linear interpolation techniques to maintain temporal continuity in hourly flow patterns.

Data Structuring and Classification Framework

Following validation, the data were systematically categorized to facilitate subsequent analysis. Traffic volume data were classified by vehicle type (car, van, Hiace, coaster, bus, truck, motorcycle), direction (upstream toward Murree and downstream toward Islamabad/Rawalpindi), and time interval (hourly, four-hourly, and daily aggregates). This structured data matrix provided a granular basis for constructing temporal and directional profiles of corridor usage.

For O–D surveys, responses were digitized and coded according to Traffic Analysis Zones (TAZs) representing source and destination regions, including Rawalpindi, Islamabad, Murree, Patriata, Nathiagalli, Abbottabad, and Muzaffarabad. Trip purposes were grouped into five standardized categories

recreational, social, work-related, educational, and others. This classification ensured analytical uniformity across datasets and allowed precise segmentation during forecasting.

Traffic Composition and Modal Dominance

The consolidated MCC results revealed that private transport modes overwhelmingly dominated the corridor, accounting for nearly 58% of total daily vehicle flow. Vans and Hiace-type shared vehicles formed the second-largest category (22%), followed by buses (10%) and freight carriers (7%). The low percentage of freight traffic underscored the corridor's primarily passenger-oriented character.

The strong presence of personal cars reflects Murree's identity as a domestic tourism destination, where family and group travellers often prefer the flexibility of private transport. This modal pattern holds significant implications for the proposed Glass Train service, which must be designed as an attractive, comfortable, and time-competitive alternative to private vehicles.

Temporal Distribution and Diurnal Travel Patterns

Traffic volume analysis by hour revealed a distinctive temporal profile consistent with tourism corridors. The morning period (6:00 AM to 10:00 AM) registered the highest outbound traffic toward Murree, coinciding with the start of daily excursions. The afternoon and evening periods (2:00 PM to 8:00 PM) showed dominant return flows, as visitors completed same-day recreational trips.

Weekends exhibited significantly higher traffic intensity approximately 1.8 times weekday volumes reflecting short-duration leisure travel by urban residents. Temporal distribution charts constructed from the data show smooth, symmetrical peaks for weekend days, indicating well- defined recreational demand patterns rather than erratic commuter movements.

Seasonal Variability and Tourism Influence

Long-term validation using NHA's 2024 monthly toll data demonstrated that Murree's traffic volumes are highly seasonal. Summer months (June–August) and winter holidays (December–January) exhibited vehicle flows nearly double those of shoulder months. These findings were consistent with known tourism behaviour linked to school vacations and climatic conditions.

The pronounced seasonality necessitated incorporating monthly adjustment factors in ridership forecasting to avoid overestimation of base demand. Therefore, each month's estimated train ridership was weighted according to its relative share of annual traffic, derived from the NHA dataset.

Origin–Destination Pattern Analysis

O–D survey results provided deep insight into spatial connectivity within the corridor. Approximately 83% of surveyed trips originated from the Rawalpindi–Islamabad metropolitan area, confirming it as the principal generator of Murree-bound travel. Another 10% represented through-traffic from the north (Abbottabad,

Muzaffarabad, and Bagh) traveling toward Islamabad or using Murree as a stopover. The remaining 7% originated from smaller settlements along the E-75 corridor.

In terms of purpose, 68% of trips were recreational, 18% were social or family visits, 9% were work-related, and 5% fell into other categories (educational or commercial). These distributions clearly established the corridor's leisure-dominated profile, reinforcing the rationale for a scenic, comfort-oriented rail mode such as the Glass Train.

Mode of Transport

The mode of the users was recorded to make the correlations required for the mode. The mode of Transport Distribution is shown in Table 36:

Table 36 Mode of Transport Distribution

Vehicle	Number of Respondents	Percentage of Respondents
Motor Cycle (M)	2032	26%
Rickshaw (R)	1	0%
Car (C)	4559	57%
Taxi (TX)	223	3%
Wagon/Van (W)	367	5%
Mini Bus (MB)	112	1%
Bus (B)	280	4%
School Bus (SB)	1	0%
Pick up (PK)	385	5%
Total	7960	100%

The results of the mode of transport are shown in Figure 14:

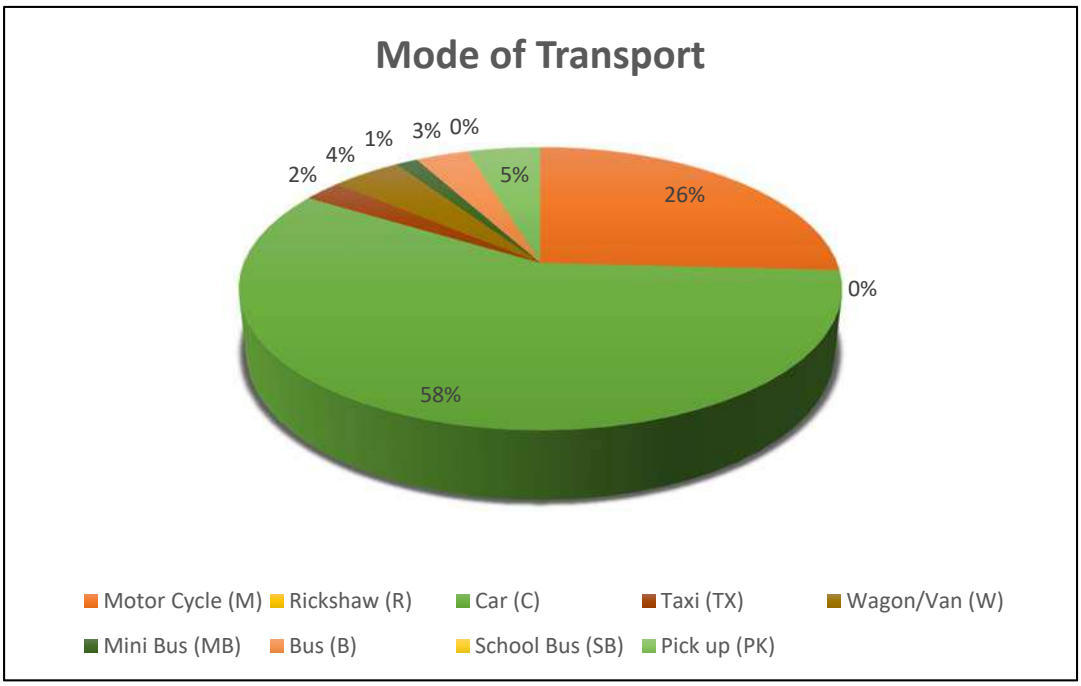


Figure 14 Mode share of Vehicles (Modes) in Project Region

The mode shares analysis reveals that **private vehicles dominate travel in the corridor**, with **cars accounting for approximately 50%** of all observed traffic, followed by **motorcycles at 26%**. In contrast, **public transport usage remains significantly low**, with **wagons comprising just 4%** and **buses only 3%** of the modal split. This highlights a pronounced imbalance between private and public transport modes, underscoring the need for a high-capacity, reliable alternative to attract users away from private vehicle dependency.

Vehicle Occupancy

Vehicle occupancy was recorded for every surveyed vehicle during the O–D interviews to understand travel group sizes and assess transport efficiency across different modes. This metric is particularly important in tourism corridors like Rawalpindi–Murree, where recreational and group travel are common. The data revealed distinct occupancy patterns across modes, with **public transport modes such as wagons and buses generally exhibiting higher average occupancies**, while **private cars and motorcycles tended to carry fewer passengers per vehicle**. This information is critical for estimating person-trip volumes and evaluating the potential ridership shift to the proposed Glass Train. A detailed table summarizing **average occupancy by mode** is presented as Table 37 for reference and use in subsequent demand modeling.

Table 37 Average Occupancies of Modes

Vehicle	Average Occupancy
Motor Cycle (M)	2
Rickshaw (R)	2
Car (C)	3
Taxi (TX)	4
Wagon/Van (W)	11
Mini Bus (MB)	14
Bus (B)	29
School Bus (SB)	18
Pick up (PK)	6

The results of vehicle occupancy are shown in Figure 15:

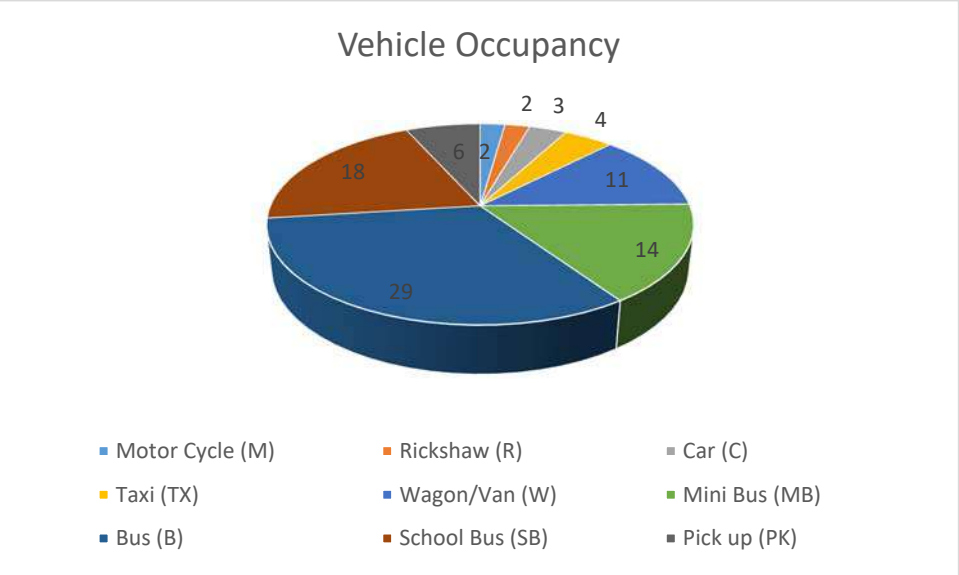


Figure 15 Vehicle Occupancy Distribution

Trip Frequency

Trip frequency was recorded as part of the O–D survey to assess not only the intensity of travel within the Rawalpindi–Murree corridor but also for through traffic originating from or destined to regions such as Azad Kashmir, Abbottabad, and the broader northern belt. Respondents were asked to categorize their trip frequency into five distinct groups: Once Daily, Multiple Daily, Weekly, Monthly, and Occasionally. This data provided critical insights into both regular commuter movement and infrequent, often tourism-related, travel.

Frequent travelers (daily and weekly) were primarily associated with work, education, and essential services, particularly between Rawalpindi/Islamabad and surrounding residential zones. In contrast, monthly and occasional trips were largely made for recreational, social, or seasonal purposes, often by families or tourist groups traveling from distant locations such as Muzaffarabad, Bagh, Abbottabad, and Mansehra. This frequency segmentation was essential in distinguishing between core commuter demand and periodic leisure travel, which directly influenced ridership modeling, service design, and the peak-period operational strategy of the proposed Glass Train. Trip Frequency Distribution is shown in Table 38:

Table 38 Trip Frequency Distribution

Trip Frequency	Number of Respondents	Percentage of Respondents
Once daily	3803	48%
Multiple Daily	1208	15%
Weekly	889	11%
Monthly	773	10%
Occasionally	1239	16%
Empty	48	1%
Total	7960	100%

The detailed distribution of responses by frequency category is presented in the Figure 16:

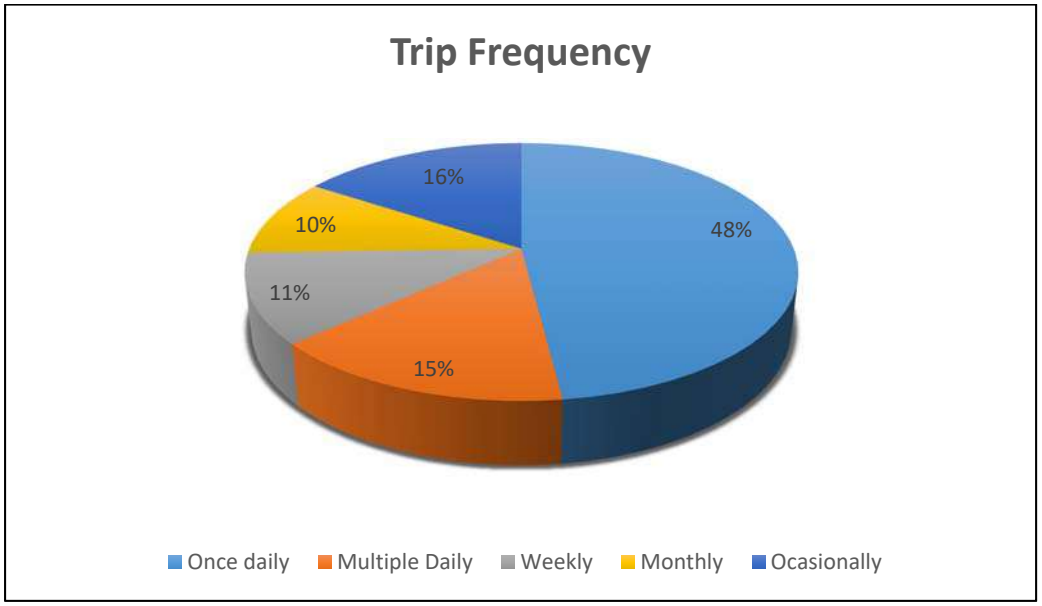


Figure 16 Trips Frequency Distribution

The results reveal that 48% of trips are made on a daily basis, reflecting strong commuter and routine travel activity. An additional 15% of travelers reported making multiple trips per day, indicating high-frequency usage, mostly by commercial drivers, local service providers, or intra-regional commuters. In contrast, 16%

of all trips were classified as occasional, typically undertaken for recreational, social, or seasonal purposes. These included travelers from Muzaffarabad, Bagh, Abbottabad, and Galiyat, highlighting Murree's role not only as a destination but also as a transit corridor.

This frequency breakdown provides a critical input for segmenting potential Glass Train ridership between regular commuters and tourism-based users. It also supports service planning decisions related to train frequency, fare structuring, and peak-period capacity management. A full tabulation of trip frequency responses is included in the analysis section.

Trip Purpose

Trip purpose was a key variable collected through the O–D survey to understand the motivations behind travel across the study corridor, including movement between Rawalpindi/Islamabad, Murree, and surrounding regions such as Azad Kashmir and Abbottabad. The survey responses indicate a diverse range of trip purposes, reflecting the corridor's dual role as both a commuter route and a tourism-recreational spine.

The data shows that work-related trips dominate the corridor, accounting for 40% of total trips, followed by home-based trips at 30%, which include return journeys or intra-regional local travel. These figures point to a significant commuter market, especially among residents of Barakahu, Bhara Kahu, and adjacent suburban zones who frequently travel to Islamabad or Murree for employment or daily needs.

Recreational travel makes up 11% of the total trips, underscoring the tourism significance of Murree and the surrounding Galiyat region. Social visits account for 8%, often overlapping with family or leisure travel, especially during weekends and holidays. Other purposes include business trips (7%), education-related travel (3%), and shopping (1%), indicating lower but still notable levels of functional and occasional travel. These trip purpose distributions are crucial for forecasting train ridership potential, as recreational, social, and home-based travelers are more likely to shift to the proposed scenic train service, compared to regular work or education commuters. The results also informed service design and fare strategy, allowing for targeted planning to attract modal shift among tourism-prone user groups. Trip Purpose Distribution is shown in Table 39:

Table 39 Trip Purpose Distribution

Trip Purpose	Number of Respondents	Percentage of Respondents
Home	2373	30%
Work	3156	40%
Business	546	7%
Education	257	3%
Social	647	8%
Recreational	904	11%
Shopping	50	1%
Empty	27	0%
Total	7960	100%

The results of Trip Purpose are shown in Figure 17:

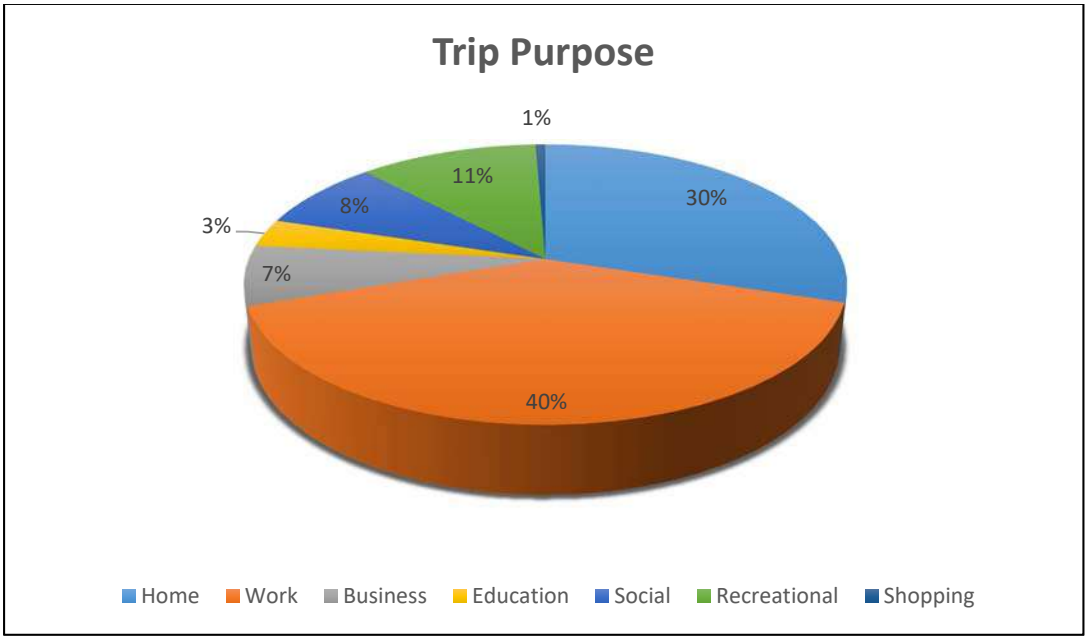


Figure 17 Trip Purpose Distribution

Household Income

Household income data was collected during the Origin–Destination (O–D) surveys to assess the socio-economic profile of travelers using the Rawalpindi–Murree corridor and its adjoining routes from Azad Kashmir, Abbottabad, and other northern regions. Understanding income distribution is a key input for determining fare affordability, target market segmentation, and the potential modal shift to the proposed Glass Train service.

Out of the 7,921 respondents, the majority 47.5% reported a monthly household income between PKR 0 to 40,000, indicating a large share of lower-income travelers, most of whom depend on public transport and informal shared mobility options. The second-largest group (33%) fell within the PKR 40,001 to 80,000 range, generally representing the lower-middle and middle-income segments who often alternate between private and public modes depending on trip purpose and affordability.

It is important to note that in household income surveys, especially in face-to-face roadside interviews, respondents often tend to underreport their actual income due to privacy concerns or social perception. Therefore, the actual income distribution may skew slightly higher than reported, particularly for self-employed or business-class travelers.

The upper-middle-income group (PKR 80,001 to 120,000) made up 12% of the sample, while only 7.3% reported incomes above PKR 120,000. These higher-income travelers, though fewer in number, predominantly use private vehicles but showed openness to using the Glass Train for leisure and tourism-based travel, provided the service offers comfort, convenience, and reliability.

This income stratification was critical for developing a tiered fare strategy for the Glass Train—balancing affordability for lower-income users and enhanced service offerings for higher-paying segments. It also supported the identification of ridership clusters most likely to convert from road to rail, especially within the middle-income recreational travel market. Household Income Distribution is shown in Table 40:

Table 40 Household Income Distribution

Average Household Income	Number of Respondents	Percentage of Respondents
0-40,000 PKR	3763	47%
40,001-80,000 PKR	2619	33%
80,001-120,000 PKR	961	12%
120,001-150,000 PKR	411	5%
150,001-higher	169	2%
Empty	37	0%
Total	7960	100%

The results of Household income are shown in Figure 18:

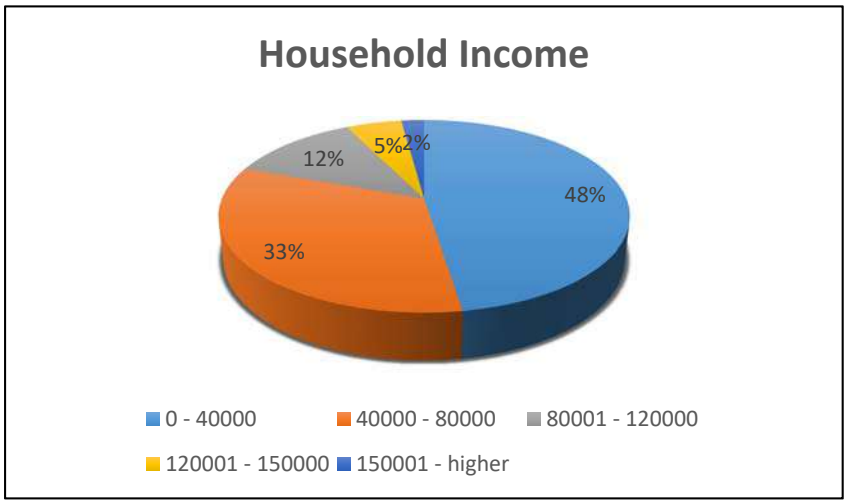


Figure 18 Household Income Distribution

Utility function for using the proposed Train

As part of the Origin–Destination (O–D) surveys, respondents were asked whether they would be willing to use the proposed Glass Train service, and if so, what factors would influence their decision. The objective was to assess market receptiveness, understand mode shift potential, and identify key service attributes that drive user preferences.

Out of a total of 7,719 respondents, an overwhelming 87% (6,732) indicated a willingness to use the Glass Train, while only 13% (987) stated they would not consider using it. This high level of interest signals a strong latent demand for rail-based alternatives, especially in a corridor currently dominated by private vehicles and informal public transport options. Train Usage Distribution is shown in Table 41:

Table 41 Train Usage Distribution

Train Usage	Number of Respondents	Percentage of Respondents
Yes	6862	86%
No	1088	14%
Empty	10	0%
Total	7960	100%

Train Usability Distribution among the commuters is shown in Figure 19:

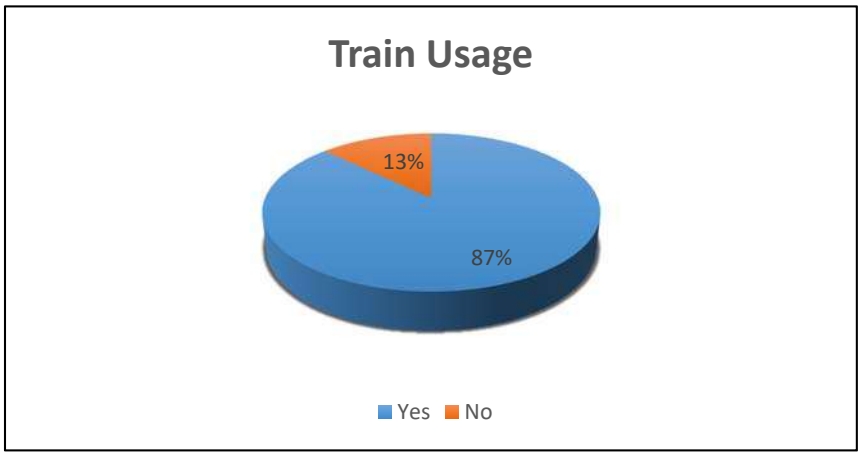


Figure 19 Train Usability Distribution among the commuters

Among those willing to shift to the train, the most cited reasons were cost efficiency (38%) and time savings (38%), followed by convenience (11%), accessibility (6%), and flexibility (3%). A small portion (4%) selected other reasons, including environmental concerns, scenic value, and comfort. This pattern indicates that while the train is seen as a premium travel mode, its affordability and reliability remain the primary decision-making factors for most users especially middle- and lower-income travelers. The results of Train Usage (Yes) are shown in Figure 20:

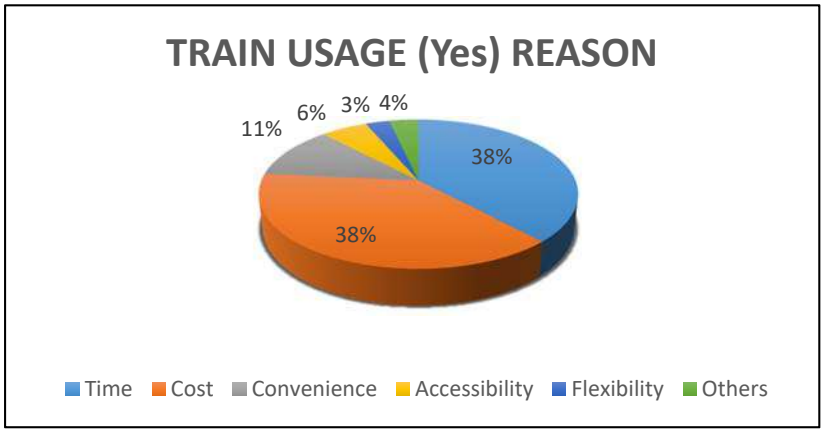


Figure 20 Reasons of Those who are willing to use the Train

On the other hand, those who expressed unwillingness to shift to the train (13% of respondents) provided different reasoning. Among them, 32% cited time-related concerns, implying a perception that the train may not be faster or as responsive as their current mode. 21% were concerned about cost, suggesting that a segment of users especially from the lower-income bracket may still find the fare structure unaffordable. Other factors included convenience (14%), accessibility (7%), and flexibility (7%), while a notable 20% selected 'other reasons', which included a general preference for personal vehicles or skepticism about the project's implementation and reliability. The results of Train Usage (No) are shown in Figure 21:

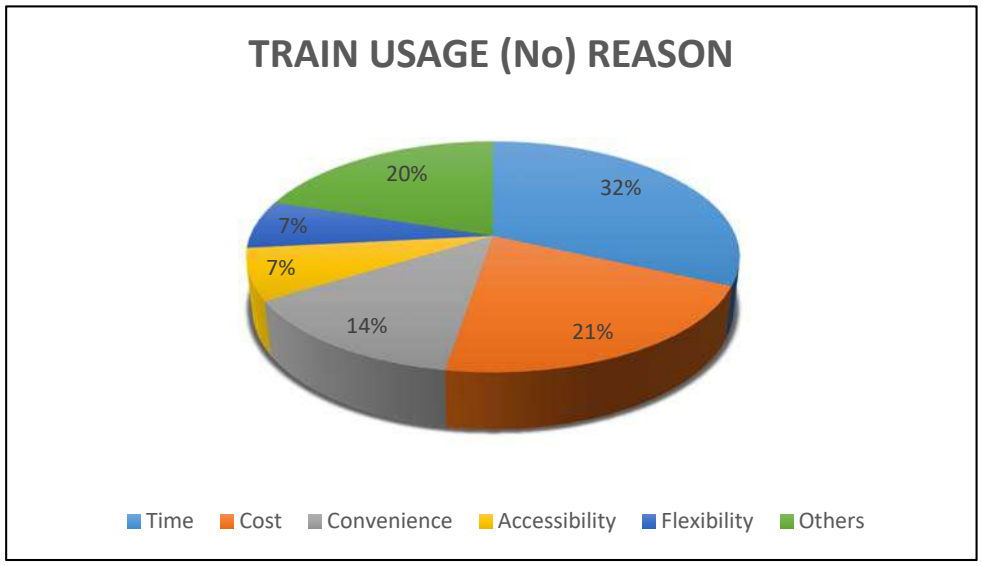


Figure 21 Reasons of Those who are not willing to use the Train

These findings offer valuable insights for designing the operational and commercial framework of the proposed service. For example:

- Fare pricing should reflect cost competitiveness with private car usage, particularly to attract tourists and leisure travelers rather than daily commuters.
- Journey time should be optimized to remain competitive with car travel, especially on the Rawalpindi–Murree stretch.
- Stations and services must be planned with easy access and seamless modal integration to mitigate concerns around last-mile connectivity.

The high willingness to shift, coupled with a clear understanding of motivators and barriers, provides a strong foundation for shaping a user-focused, commercially viable rail service. These insights will directly inform the fare policy, marketing strategy, and passenger experience design of the Glass Train project.

Fare Preference

As part of the user interview component of the O–D surveys, respondents were asked to indicate the maximum fare they would be willing to pay for the proposed Glass Train service. This information was critical for developing a realistic fare structure that aligns with the income levels, travel motivations, and perceived value of the train service among different user groups.

The data reveals that the majority of respondents approximately 73% (5,773 out of 7,920)—indicated a fare preference in the range of PKR 300 to 500. This range aligns closely with current travel costs for public transport vans and coasters along the Rawalpindi–Murree corridor, suggesting that fare affordability will be a key determinant of ridership adoption, particularly among middle- and lower-income travelers.

An additional 20% (1,610 respondents) were willing to pay between PKR 501 to 700, which reflects a moderate willingness to pay more for improved comfort, safety, or travel time reliability. These users often belong to the upper-middle-income bracket or are tourists who prioritize convenience over minimal cost.

At higher price points, only 5% of respondents (407 people) were comfortable paying PKR 701 to 1,000, while 113 respondents (1.4%) preferred fares up to PKR 1,500, and a minimal 0.2% (17 respondents) were open to paying beyond PKR 1,500. These latter segments typically include higher-income travelers or tourists seeking premium or value-added experiences such as scenic viewing coaches or lounge-class seating.

The clear skew toward lower fare preferences supports the need for a tiered pricing model, where standard seating remains affordable to the majority while premium options are offered for higher-paying customers. It also highlights the importance of pricing the service competitively with existing modes, especially to encourage mode shift from public vans and low-occupancy private cars.

These fare sensitivity insights are instrumental in defining the revenue model, setting ridership assumptions, and ensuring that the train is positioned as both a financially viable and socially inclusive transport solution.

Fare Preference Distribution is shown in Table 42:

Table 42 Fare Preference Distribution

Fare Preference	Number of Respondents	Percentage of Respondents
300-500 PKR	5773	73%
501-700 PKR	1610	20%
701-1,000 PKR	407	5%
1001-1,500 PKR	113	1%
1501-higher	22	0%
Empty	35	0%
Total	7960	100%

The results of Fare Preference Distribution of Travelers are shown in Figure 22:

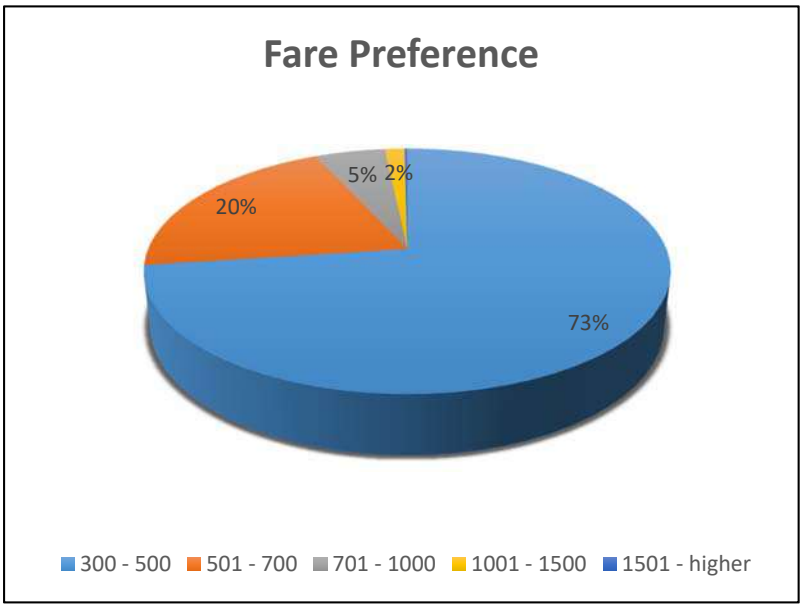


Figure 22 Fare Preference Distribution of travelers

Origin–Destination Travel Matrix (Weekday Travel Patterns)

The Origin–Destination (O–D) Matrix developed from weekday survey data presents a detailed picture of interregional and intra-corridor travel behavior across the Rawalpindi–Murree region and its adjacent zones, including **Azad Kashmir**, **Abbottabad and northern Khyber Pakhtunkhwa**, and **southern cities such as Lahore and Gujranwala**. This matrix is instrumental in identifying **dominant movement patterns**, **potential ridership concentrations**, and **key flow corridors** for the proposed Glass Train service.

The most significant directional flows originate from **Islamabad and Rawalpindi**, which together contribute a large share of trips toward Murree and beyond. Specifically, **18.15% of weekday trips originate in Islamabad destined for Murree**, while **5.74% originate from Rawalpindi to Murree**, highlighting the core tourism and commuting demand that currently relies on private cars and vans along the E-75 corridor. These flows represent the **primary ridership base** for the proposed train service, particularly for recreational, social, and home-based trips.

The return movement is also evident, with **6.76% of Murree-origin trips heading to Rawalpindi** and **9.9% toward Islamabad**, confirming the bidirectional demand and supporting the viability of **both outbound and inbound train operations**. Notably, Murree also generates **through traffic** toward regions such as **Abbottabad (3.11%)**, **Nathiagalli (1.18%)**, and **Azad Kashmir (0.48%)**, suggesting its role as a **regional transit point**, not just a terminal destination.

Other noticeable patterns include:

Travel from Islamabad to Abbottabad (3.61%) and Kashmir (0.81%), which further validates the significance of the E-75 and Murree corridor as a **gateway to northern Pakistan**.

Rawalpindi also shows significant movement toward Kashmir (1.09%), reinforcing the corridor's multi-regional utility.

There is modest travel between northern and southern cities such as **Lahore and Gujranwala**, with Murree and Islamabad serving as intermediate hubs, reflected in smaller but relevant percentages across the matrix (e.g., 4.19 % from southern cities to Murree).

Overall, the O–D matrix reveals a **radial flow structure**, with **Murree at the center**, strongly linked to Rawalpindi and Islamabad, and connected outward to Kashmir, Abbottabad, and the southern Punjab region. These patterns provide crucial input for determining **train routing, intermediate station placement**, and **service frequency**, and also validate Murree's role as a **central node in regional mobility**. The weekday-centric matrix will be further analyzed against weekend travel patterns to capture the effect of tourism spikes and leisure travel fluctuations. Trips Distribution O-D Matrix for Weekday is shown in Table 43 and Table 44:

Table 43 Trips Distribution O-D Matrix for Weekday

O/D	Murree	Nathiagalli	Towards Kashmir	Abottabad and beyond in KPK	Rawalpindi	Islamabad	Other cities towards south(Lahore, Gujranwala, etc)
Murree	964	174	72	538	2727	4286	1282
Nathiagalli	100	0	0	18	161	46	160
Towards Kashmir	155	0	37	0	376	186	423
Abottabad and beyond in KPK	489	23	69	160	485	328	777
Rawalpindi	1537	114	213	483	60	228	40
Islamabad	5456	249	170	644	895	3024	367
Other cities towards south (Lahore, Gujranwala, etc)	1489	160	330	820	192	179	149

Table 44 Trips Distribution (%) O-D Matrix for Weekday

O/D	Murree	Nathiagalli	Towards Kashmir	Abottabad and beyond in KPK	Rawalpindi	Islamabad	Other cities towards south(Lahore, Gujranwala, etc)
Murree	6.22%	1.18%	0.48%	3.11%	6.76%	9.90%	2.91%
Nathiagalli	0.67%	0.00%	0.00%	0.12%	0.51%	0.09%	0.33%
Towards Kashmir	0.71%	0.00%	0.14%	0.00%	1.76%	0.71%	1.14%
Abottabad and beyond in KPK	2.67%	0.05%	0.14%	1.09%	2.43%	1.69%	1.61%
Rawalpindi	5.74%	0.77%	1.09%	2.31%	0.19%	0.49%	0.09%
Islamabad	18.15 %	0.81%	0.81%	3.61%	2.31%	6.98%	1.07%
Other cities towards south (Lahore, Gujranwala, etc)	4.19%	0.33%	1.14%	1.90%	0.55%	0.63%	0.40%

Origin–Destination Travel Matrix (Weekend Travel Patterns)

The weekend Origin–Destination (O–D) matrix provides valuable insight into the shifting dynamics of travel behavior across the Rawalpindi–Murree corridor and its wider regional connections during high-tourism periods. Compared to weekdays, **weekend travel reflects significantly higher leisure and recreational movement**, which directly influences demand patterns for the proposed Glass Train service.

The data shows that **Islamabad and Rawalpindi remain the primary origin zones for Murree-bound trips**, with **14.49 % of trips originating from Islamabad to Murree** and **7.01 % from Rawalpindi to Murree**. These figures represent a clear increase from weekday levels, confirming that **weekends trigger a surge in recreational and social travel** to hill stations. Return flows are similarly elevated, with **7.56 % of trips originating from Murree to Rawalpindi** and **12.07 % toward Islamabad**, highlighting the bidirectional nature of weekend excursions.

Murree continues to act as a **central travel node**, with spillover movement toward adjacent tourist destinations such as **Nathiagalli (0.49%)**, **Abbottabad and northern KPK (2.75%)**, and **Kashmir-bound areas (0.11%).**

While these percentages are relatively modest, they reflect Murree's role as a **staging point** for onward travel toward **Galiyat, Ayubia, and Muzaffarabad**, especially for weekend tourists extending their journey.

The weekend data also shows increased inter-regional tourism from **southern Punjab cities such as Lahore, Gujranwala, and Sialkot**, with **7.81% of all trips originating from this region to Murree**,

compared to 3.25% during weekdays. This significant rise underscores Murree's attraction as a **weekend destination for longer-distance travelers**, further validating the potential for long-haul train passengers or bundled transport-tourism packages.

Islamabad-originating trips continue to dominate multiple directions: not only to Murree, but also to **Kashmir (2.26%)**, **Abbottabad and northern KPK (2.52%), and Southern cities (0.19%).** These flows reinforce Islamabad's position as a **primary urban hub and transit distributor**, critical to both outbound and returning weekend travel.

Other key patterns include:

- Increased weekend travel from Murree to **Rawalpindi (8.59%) and Islamabad (12.07%)**, indicating day trips or return movement after overnight stays.
- A marginal rise in flows from Murree to **southern Punjab cities (2.08 %)**, reflecting tourist departures post-weekend stays.
- Noticeable inter-regional movement between **southern cities and the north**, routed via Rawalpindi–Murree, which strengthens the case for **Murree as a regional connector**.

In summary, the weekend O–D matrix captures a clear shift from work-based and functional weekday travel toward **recreational and tourism-driven flows**. The data confirms that the **proposed Glass Train is most likely to see peak ridership on weekends**, particularly from the Islamabad–Murree and Rawalpindi–Murree segments. These patterns also justify the inclusion of flexible train scheduling, weekend frequency scaling, and targeted fare/tourism promotions aligned with high-volume weekend travel trends. Trips Distribution O-D Matrix for Weekend is shown in Table 45 and Table 46:

Table 45 Trips Distribution O-D Matrix for Weekend

O/D	Murree	Nathiagalli	Towards Kashmir	Abottabad and beyond in KPK	Rawalpindi	Islamabad	Other cities towards south(Lahore , Gujranwala, etc)
Murree	2055	116	22	665	3056	5955	1112
Nathiagalli	29	0	0	29	126	123	304
Towards Kashmir	330	0	44	25	359	316	619
Abottabad and beyond in KPK	440	0	25	239	304	442	784
Rawalpindi	2398	356	614	524	174	897	0
Islamabad	5294	311	536	784	725	2506	67

Other cities towards south (Lahore, Gujranwala, etc)	4041	413	825	1150	191	113	0

Table 46 Trips Distribution (%) O-D Matrix for Weekend

O/D	Murree	Nathiagalli	Towards Kashmir	Abottabad and beyond in KPK	Rawal pindi	Islamabad	Other cities towards south(Lahore, Gujranwala, etc)
Murree	8.59%	0.49%	0.11%	2.75%	7.56%	12.07%	2.08%
Nathiagalli	0.12%	0.00%	0.00%	0.12%	0.21%	0.28%	0.51%
Towards Kashmir	1.61%	0.00%	0.21%	0.04%	1.59%	1.24%	1.31%
Abottabad and beyond in KPK	0.95%	0.00%	0.04%	0.62%	0.51%	1.02%	1.30%
Rawalpindi	7.01%	1.08%	2.51%	1.57%	0.36%	2.07%	0.00%
Islamabad	14.49%	0.99%	2.26%	2.52%	1.67%	5.03%	0.19%
Other cities towards south (Lahore, Gujranwala, etc)	7.81%	0.76%	1.58%	2.00%	0.47%	0.28%	0.00%

Public Transport User Interview Surveys

Public Transport User Interview Surveys are shown in Table 47 to Table 55:

Table 47 Household Income Summary

Household Income	Number of Respondents	Percentage of Respondents
< Rs.5000	5	1%
Rs. 5001-Rs. 10,000	1	0%
Rs.10,001-Rs. 15,000	0	0%
Rs. 15,001-Rs.20,000	66	16%
Rs.20,001-Rs.25,000	23	6%
Rs.25,001-Rs.30,000	15	4%
Rs.30,001-Rs,35,000	175	44%
> Rs.35,000	100	25%
No income	16	4%
Total	401	100%

Table 48 Trip Purpose Summary

Trip Purpose	Number of Respondents	Percentage of Respondents
Home	73	18%
Work	38	9%
Education	69	17%
Health	27	7%
Social	117	29%
Others	77	19%
Total	401	100%

Table 49 Trip Frequency Summary

Trip Frequency	Number of Respondents	Percentage of Respondents
Everyday	105	26%
Once a month	60	15%
Once a week	141	35%
More than once a month	95	24%
Total	401	100%

Table 50 Vehicle Ownership Summary

Vehicle Ownership	Number of Respondents	Percentage of Respondents
Yes	184	46%
No	217	54%
Total	401	100%

Table 51 Reason for Using Public Transport Summary

Reason for Using Public Transport	Number of Respondents	Percentage of Respondents
Accessibility	20	5%
Availability	58	14%
Reliability	87	22%
Affordability	134	33%
Travel Time	102	25%
Total	401	100%

Table 52 Average Waiting time for Bus Summary

Average waiting Time for Bus	Number of Respondents	Percentage of Respondents
5	13	3%
10	101	25%

15	155	39%
20	68	17%
25	17	4%
30	28	7%
60	11	3%
90	8	2%
Total	401	100%

Table 53 Usage of Glass Train Summary

Usage of Glass Train	Number of Respondents	Percentage of Respondents
Yes	319	80%
No	82	20%
Total	401	100%

Table 54 Reason for Using Glass Train Summary

Reason	Number of Respondents	Percentage of Respondents
Accessibility	61	15%
Availability	141	35%
Reliability	88	22%
Affordability	86	21%
Travel Time	25	6%
Total	401	100%

Table 55 Willingness to Pay Fare Summary

Willingness to Pay Fare	Number of Respondents	Percentage of Respondents
PKR 300-500	232	58%
PKR 500-700	138	34%
PKR 700-1000	26	6%
PKR 1000-1500	2	0%
PKR > 1500	3	1%
TOTAL	401	100%

Based on the Public Transport User Interview Surveys (Tables 45–53), the key socio-economic characteristics, travel behavior, and user perceptions are summarized below in a consolidated narrative form suitable for inclusion in a technical report.

The household income profile of respondents (Table 45) indicates that the majority of public transport users belong to low- to middle-income groups. About 44% of respondents reported a monthly household income

between Rs. 30,001 and Rs. 35,000, while 25% earn more than Rs. 35,000. Approximately 16% fall in the Rs. 15,001–Rs. 20,000 income bracket, and 6% earn between Rs. 20,001 and Rs. 25,000. Very few respondents (around 1%) reported income below Rs. 5,000, and 4% indicated having no income. This income distribution suggests that public transport primarily serves economically active and middle-income households.

The trip purpose distribution (Table 46) shows that social trips constitute the largest share, accounting for 29% of all trips. Education-related trips represent 17%, while trips to and from home account for 18%. Work-related trips make up 9%, and health-related trips account for 7%. The remaining 19% fall under other purposes. This indicates that public transport is used for a wide variety of trip purposes, with a notable emphasis on social and education-related travel.

Trip frequency data (Table 47) reveals that public transport usage is relatively regular among respondents. About 35% of users travel once a week, while 26% use public transport on a daily basis. Around 24% travel more than once a month, and 15% use public transport only once a month. This pattern reflects a mixed user base comprising both regular and occasional public transport users.

Vehicle ownership patterns (Table 48) show that a slight majority of respondents (54%) do not own any private vehicle, while 46% reported owning at least one vehicle. This highlights the continued dependence on public transport among a significant proportion of the population, even in households where private vehicle ownership exists.

The reasons for using public transport (Table 49) are dominated by affordability, cited by 33% of respondents. Travel time is the second most important factor (25%), followed by reliability (22%). Availability accounts for 14%, while accessibility is cited by only 5% of respondents. These findings emphasize the importance of cost, time efficiency, and service reliability in influencing public transport usage.

Average waiting time for buses (Table 50) indicates that most users experience moderate waiting times. Approximately 39% of respondents reported an average waiting time of 15 minutes, while 25% wait around 10 minutes. About 17% experience a 20-minute wait, and smaller proportions reported waiting times of 30 minutes or more. Only a very small share of user's experience extremely long waiting times of 60 to 90 minutes, suggesting relatively acceptable service frequency overall.

With regard to the usage of the Glass Train (Table 51), a large majority of respondents (80%) reported that they use the service, while 20% indicated that they do not. This reflects a strong level of acceptance and utilization of the Glass Train among public transport users in the study area.

The primary reasons for using the Glass Train (Table 52) are availability (35%) and reliability (22%), followed closely by affordability (21%). Accessibility accounts for 15%, while travel time is cited by only 6% of users. These results suggest that consistent service availability and dependable operations are the key drivers of Glass Train usage.

Finally, willingness to pay fare (Table 53) indicates that most respondents are price-sensitive. Around 58% are willing to pay a fare between PKR 300 and 500, while 34% are willing to pay between PKR 500 and 700. Only a small proportion (about 7%) are willing to pay fares exceeding PKR 700. This highlights the need to maintain affordable fare structures to ensure continued ridership and social inclusivity of the proposed service.

Boarding and Alighting Survey

Summary of Boarding and Alighting Survey is shown in Table 56 to

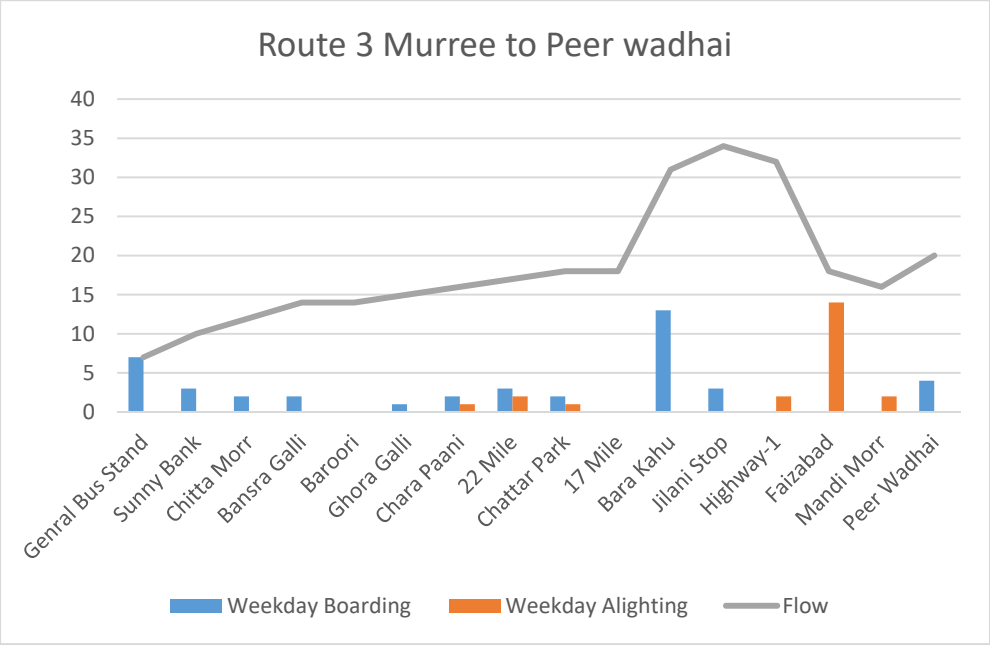


Figure 34 Weekday B & A Route 3 Murree to Peer wadhai

Table 62 and Figure 23 to Figure 34:

Table 56 26 no. stop to Murree Boarding & Alighting Summary

Route 1				
Direction	26 no. Stop to Murree			
Stops Name	Weekend Boarding	Weekend Alighting	Weekday Boarding	Weekday Alighting
26 No Stop	7	0	5	0
Nori	3	1	0	0
Dental Hospital	0	0	2	1
G-8 Markaz	1	2	0	0
Develop Park	0	0	1	0
G-9 Markaz	0	1	0	0
Police Foundation	3	0	3	3
Collage Mor	0	2	1	0

G-10 Markaz	3	1	0	1
Tanki	0	4	0	0
G-10 / G-11	2	1	0	2
IMC	0	0	0	0
G-11 Markaz	0	1	0	0
Meharbadi	0	6	0	4
BUS CHANGE				
High Cort	8	0	3	0
NHA	0	1	0	1
Faiz Ahmad	2	0	0	0
Khayaban E Johar	1	3	1	0
Potohar	0	1	0	0
IJP	3	0	0	3
Faizabad	0	14	4	0
Faizabad	25	0	4	0
BUS CHANGE				
CDA	0	1	0	4
Aabpara	0	0	2	0
Foreign Office	2	0	0	1
Lake View Park	1	3	1	2
Malpur	3	0	0	0
Bara Kahu	0	5	2	7
17 Mile	1	0	0	0
Chattar Park	3	1	4	3
Valley Park	0	1	4	3
Gharamb	1	2	0	0
Tret	3	3	0	1
Bankoth	0	1	0	0
Samli	4	2	3	0
Malot	1	1	0	0
Phera	0	1	1	0
Ghora Galli	2	4	0	2
Bansra Galli	3	1	0	3
Samli	3	1	3	0
Murree	0	23	7	5

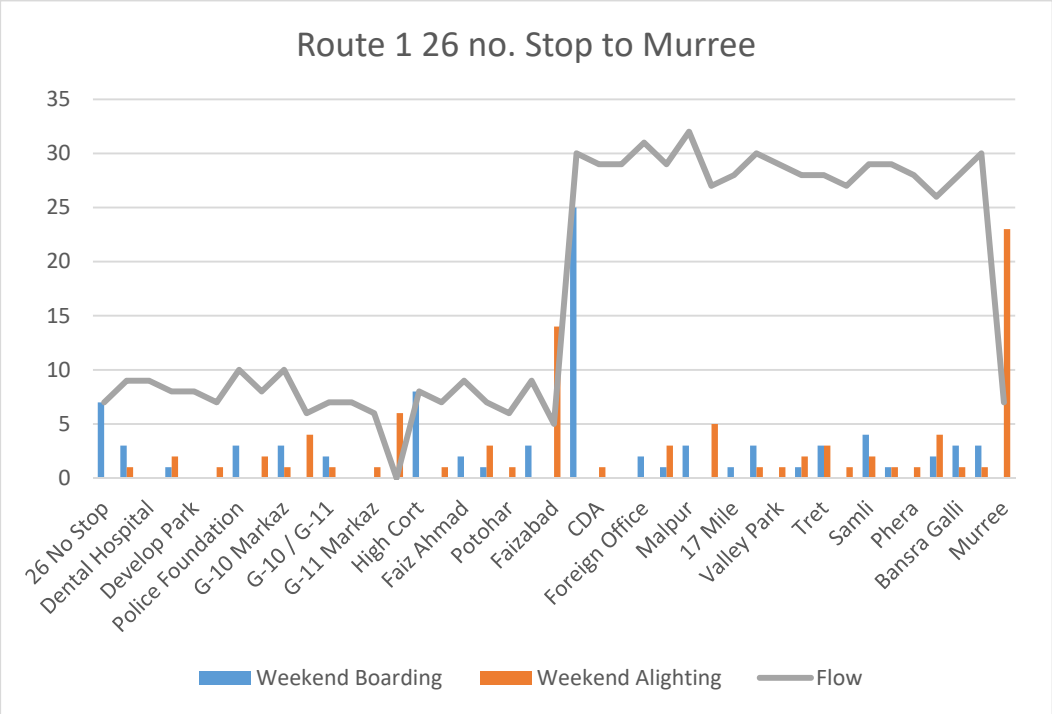


Figure 23 Weekend B & A Route 1 26 no. Stop to Murree

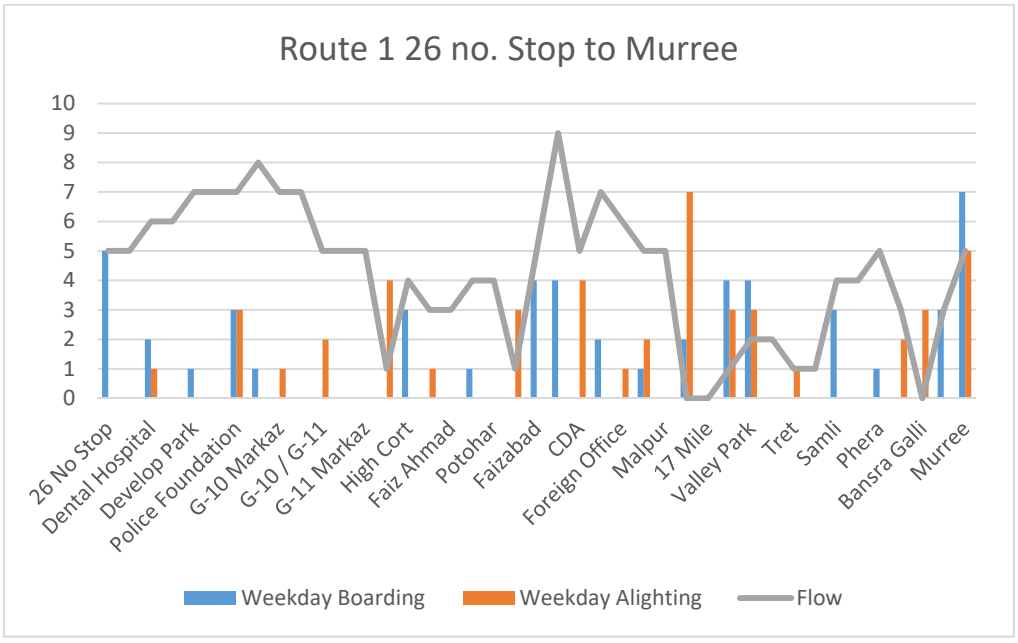


Figure 24 Weekday B & A Route 1 26 no. Stop to

Table 57 Murree to 26 no. stop Boarding & Alighting Summary

Route 1

Direction	Murree to 26 no. Stop			
Stops Name	Weekend Boarding	Weekend Alighting	Weekday Boarding	Weekday Alighting
Murree	13	0	13	0
Sunny Bank	0	1	0	1
Company Bagh	7	0	7	0
Shimla	1	1	1	1
NandKot	2	3	2	3
Tret	0	1	0	1
Pel Factory	1	0	1	0
Chattar Park	1	4	1	4
17 Mile	4	2	4	2
Bara Kahu	1	0	1	0
Lake View Park	2	5	2	5
Faizabad	0	14	0	14
Potohar	13	0	13	0
Khayaban E Johar	0	1	0	1
IMS	1	1	1	1
College Mor	0	2	0	2
Dental Hospital	1	0	1	0
Nori	0	1	0	1
26 No Stop	0	6	0	6

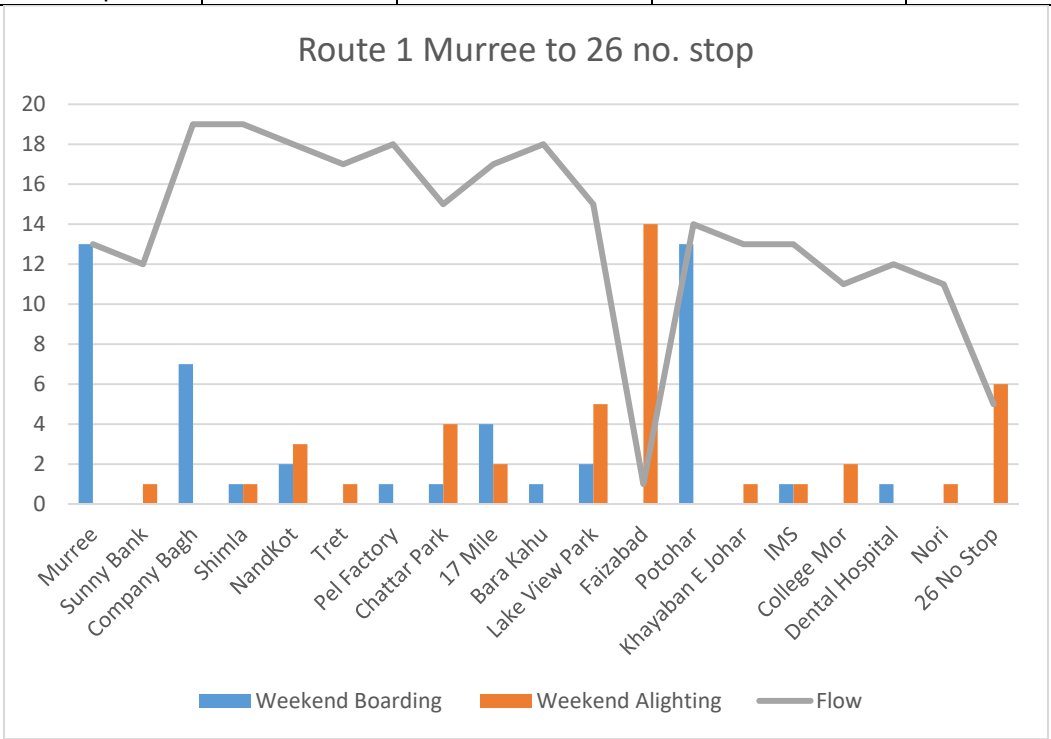


Figure 25 Weekend B & A Route 1 Murree to 26 no. stop

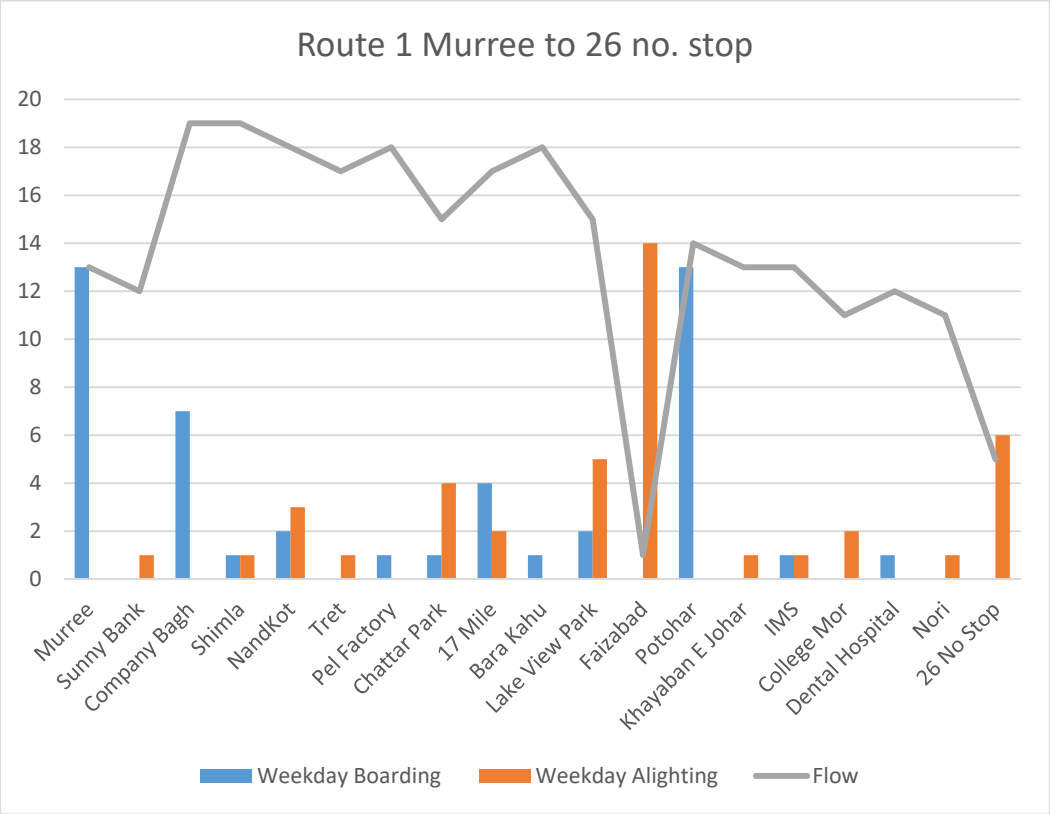


Figure 26 Weekday B & A Route 1 Murree to 26 no. stop

Table 58 Faizabad to Murree Boarding & Alighting Summary

Route 2				
Direction	Faizabad to Murree			
Stops Name	Weekend Boarding	Weekend Alighting	Weekday Boarding	Weekday Alighting
Faizabad	21	0	23	0
Rawal Dam	0	2	0	0
Lake View Park	3	0	0	2
Malpur	0	1	4	0
Bara Kahu	1	0	0	1
Akbar Niazi	0	3	3	0
17 Mile	2	0	0	3
Chattar Park	0	5	0	1
Karlot	4	0	2	1
Village Tarmana	0	7	0	2
Valley Park	5	0	1	0
Manga	0	1	0	1
Tret	1	0	1	0
Takiya	0	3	0	3

Malot	2	0	3	0
Phera	0	1	0	2
Ghora Galli	3	2	1	0
Chitta Morr	0	7	0	1
Sunny Bank	1	1	1	0
Kuldana	3	3	1	1
Bansra Galli	4	0	0	2
Murree	7	5	0	20

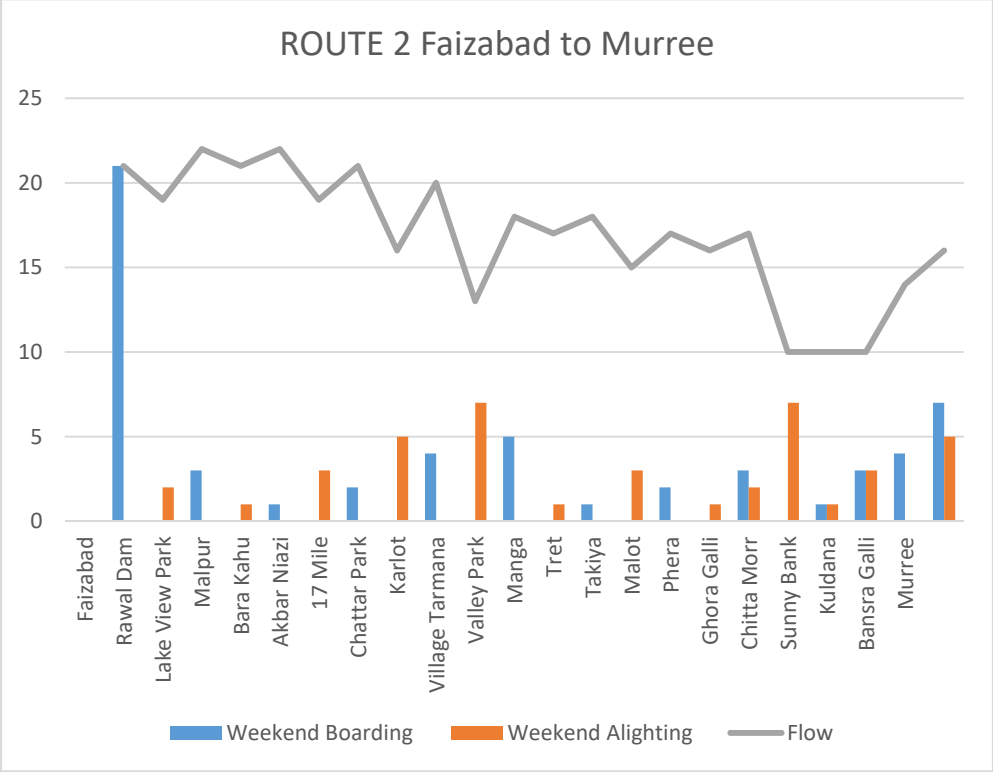


Figure 27 Weekend B & A ROUTE 2 Faizabad to Murree

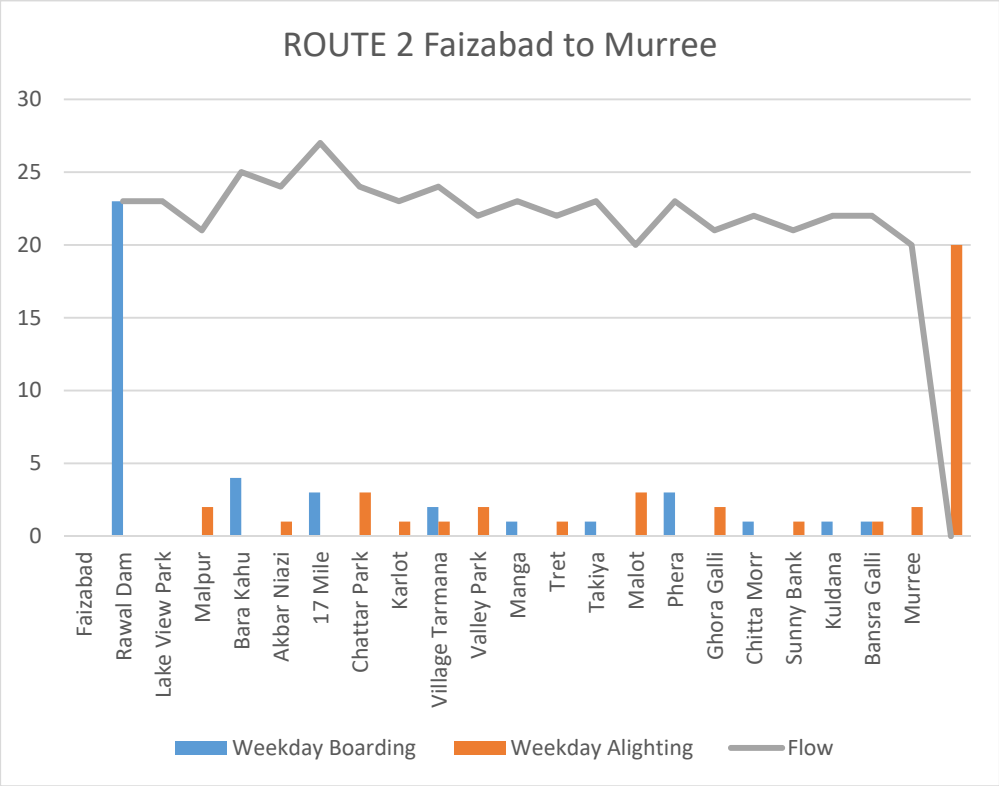


Figure 28 Weekday B & A ROUTE 2 Faizabad to Murree

Table 59 Murree to Faizabad Boarding & Alighting Summary

Route 2				
Direction	Murree to Faizabad			
Stops Name	Weekend Boarding	Weekend Alighting	Weekday Boarding	Weekday Alighting
Murree Bus Stand		0	13	
Sunny Bank		1	1	
Chitta Morr		0	2	
Bansra Galli		1	1	
Ghora Galli	2	3	3	2
Company Bagh		1	1	
Samli	1	0		1
Nandkot	2	4		2
Takiya		2		
Tret		0	2	
22 Mile		5	3	
Chattar Park	1	14		1
17 Mile		0	5	
Bara Kahu	17	1	21	17
Jilani Stop	1	1		1

Tokri Stop	1	2		1
Rawal Dam	4	0	3	4
Highway	7	1		7
Faizabad		6	19	

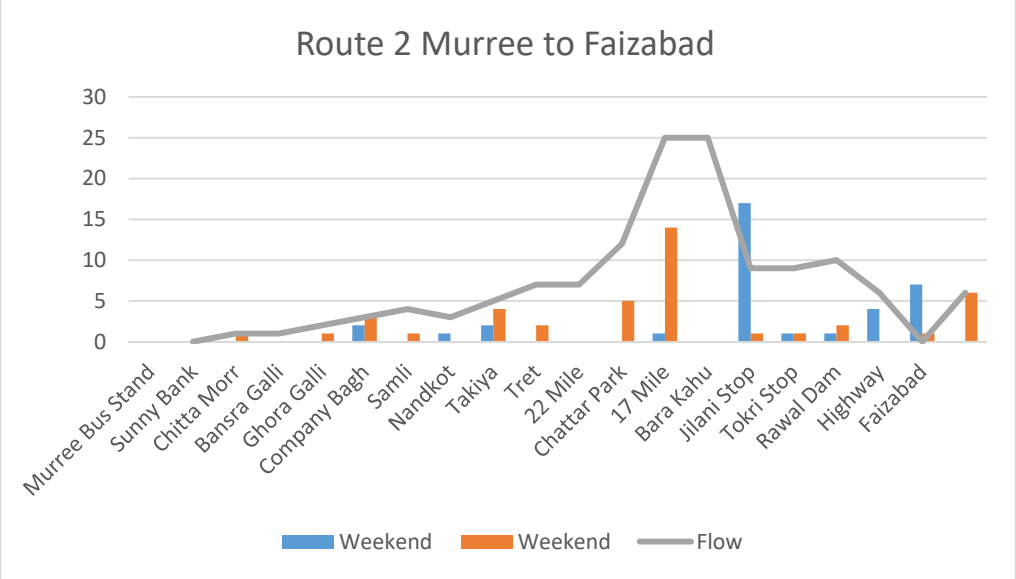


Figure 29 Weekend B & A Route 2 Murree to Faizabad

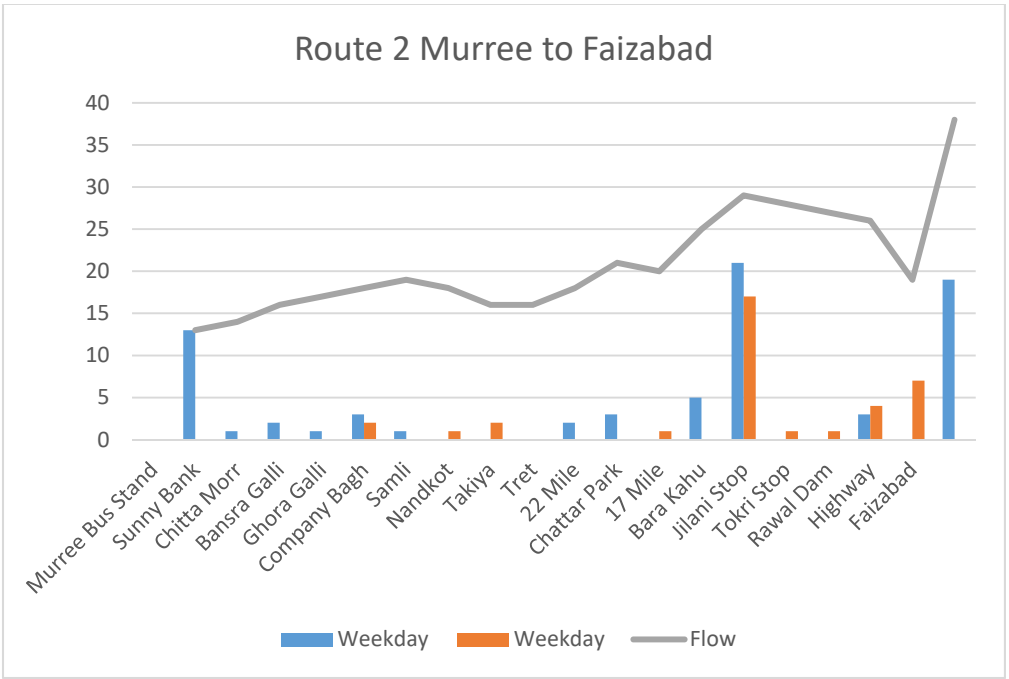


Figure 30 Weekday B & A Route 2 Murree to Faizabad

Table 60 Peer wadhai to Murree Boarding & Alighting Summary

Route 3				
Direction	Peer wadhai to Murree			
Stops Name	Weekend Boarding	Weekend Alighting	Weekday Boarding	Weekday Alighting
Peer Wadhai Bus Stand	3	0	6	0
Faizabad	24	0	3	0
Rawal Dam	2	3	17	0
Abbasi Hotel	0	0	0	1
Thaal Chowk	2	0	2	0
Bara Kahu	20	20	24	19
Chattar Park	0	2	0	3
Salsrain	0	2	1	0
Vallay Park	0	1	0	4
Tret	0	2	2	0
Nandkot	1	0	0	1
Chara Pani	0	2	0	3
Company Bagh	1	2	0	2
Ghora Galli	1	4	3	0
Bansra Galli	0	5	1	7
Chitta Mor	0	1	3	9
Sunny Bank	0	2	0	4
Bus Stand Murree	0	8	9	0

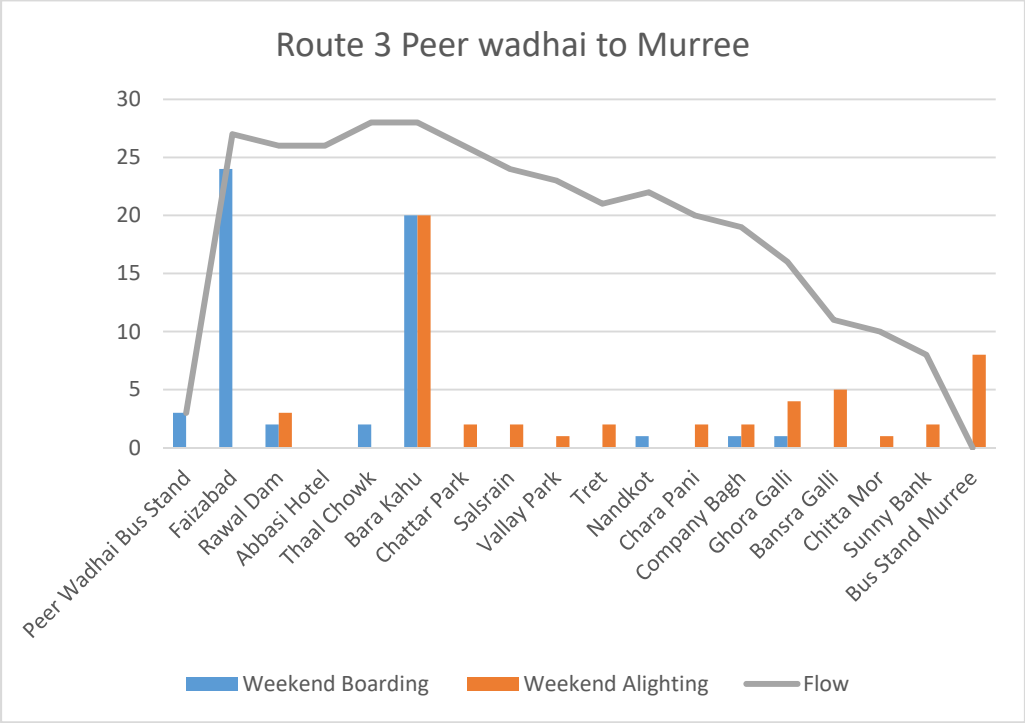


Figure 31 Weekend B & A Route 3 Peer wadhai to Murree

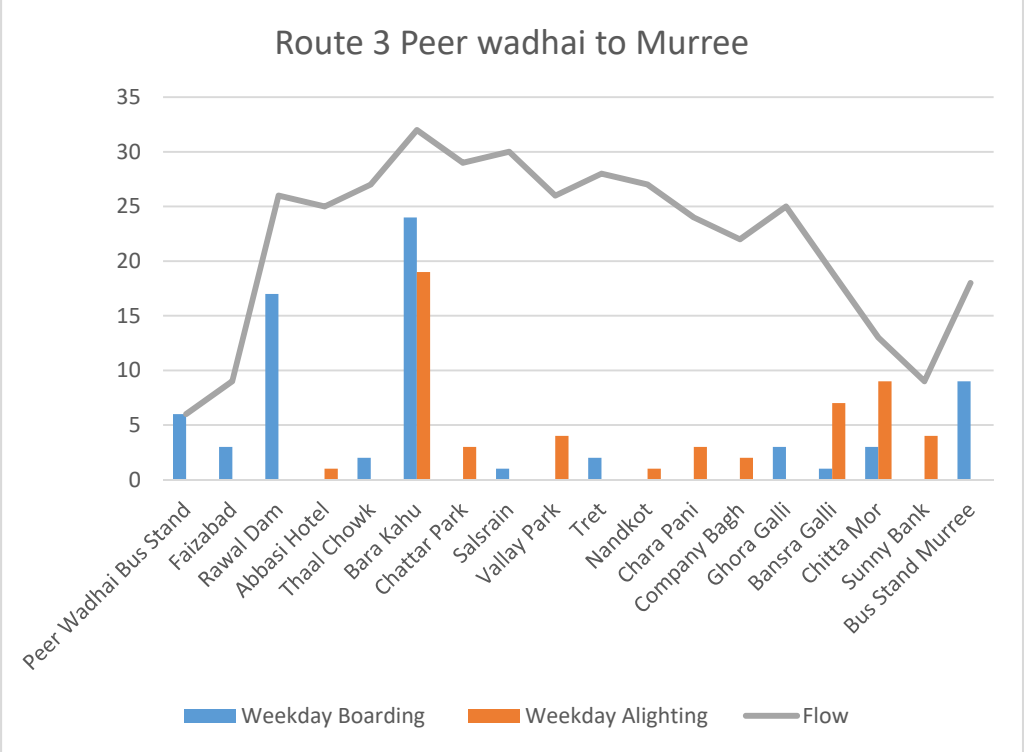


Figure 32 Weekday B & A Route 3 Peer wadhai to Murree

Table 61 Murree to Peer wadhai Boarding & Alighting Summary

Route 3				
Direction	Murree to Peer wadhai			
Stops Name	Weekend Boarding	Weekend Alighting	Weekday Boarding	Weekday Alighting
Genral Bus Stand	7		7	
Sunny Bank	3		3	
Chitta Morr	2		2	
Bansra Galli	2		2	
Baroori				
Ghora Galli	1		1	
Chara Paani	2	1	2	1
22 Mile	3	2	3	2
Chattar Park	2	1	2	1
17 Mile				
Bara Kahu	13		13	
Jilani Stop	3		3	
Highway-1		2		2
Faizabad		14		14
Mandi Morr		2		2
Peer Wadhai	4		4	

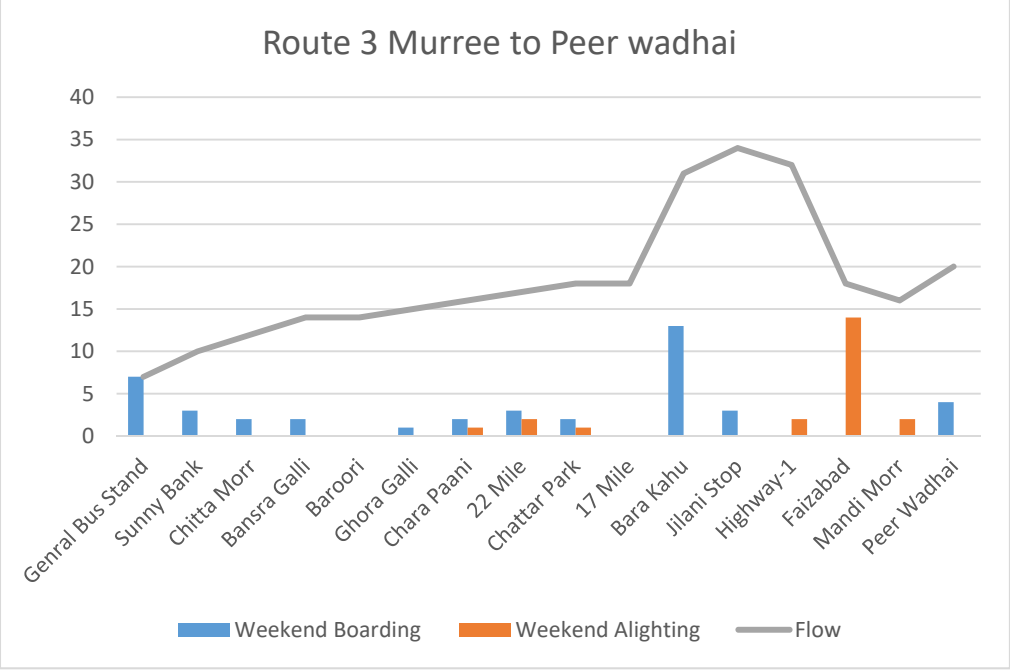


Figure 33 Weekend B & A Route 3 Murree to Peer wadhai

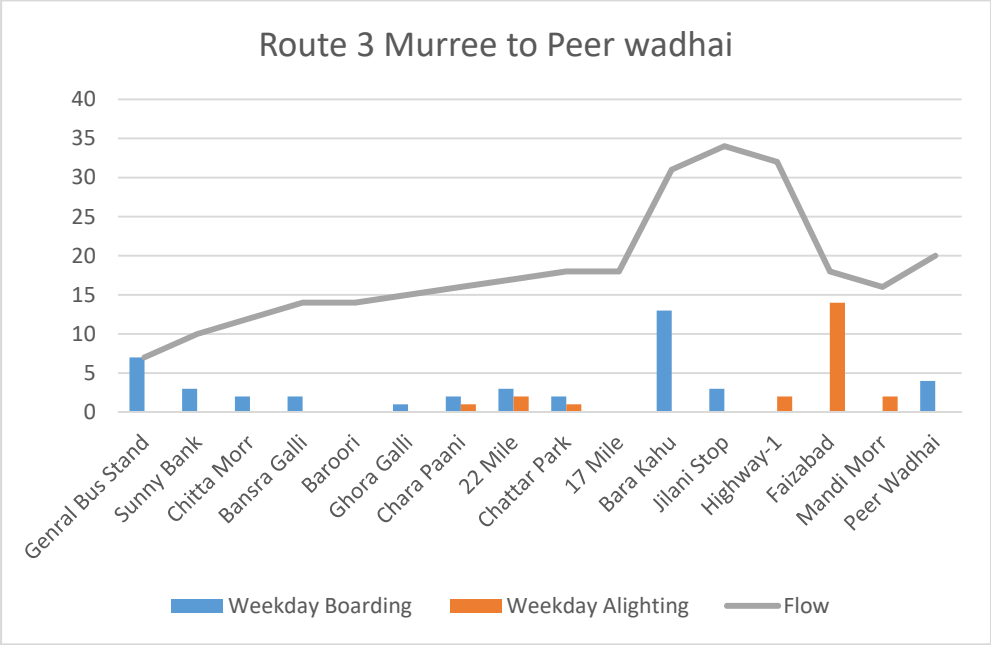


Figure 34 Weekday B & A Route 3 Murree to Peer wadhai

Table 62 Boarding and Alighting Summary Data

Route	Direction	Day	Total Boardings	Total Alighting	Net Load	Peak Boarding Stop	Peak Alighting Stop
1	26 no. stop to Murree	Weekend	85	88	-3	Faizabad	Murree
		Weekdays	48	46	2	Murree	Bara Kahu
	Murre to 26 no. stop	Weekend	47	42	5	Potohar	Faizabad
		Weekdays	47	42	5	Potohar	Faizabad
2	Faizabad to Murre	Weekend	57	41	16	Faizabad	Chitta Morr & Village Tramana
		Weekdays	40	40	0	Faizabad	Murree
	Murre to Faizabad	Weekend	74	36	38	Bara Kahu	Bara Kahu
		Weekdays	74	36	38	Bara Kahu	Bara Kahu
3	Peer Wadhai to Murree	Weekend	54	54	0	Faizabad	Bara Kahu
		Weekdays	71	53	18	Bara Kahu	Bara Kahu
	Murree to Peer Wadhai	Weekend	42	22	20	Bara Kahu	Faizabad
		Weekdays	42	22	20	Bara Kahu	Faizabad

Hotels Tourist Survey

The key findings of the Hotel Tourist Survey are summarized below.

Customer Travel Pattern Summary is shown in Table 63:

Table 63 Customer Travel Patterns to Murree

Customer Travel Patterns to Murree					
	Private Cars	Public Buses	Ride-Sharing Services	Tour Buses	Other Transport
Yes	87%	38%	2%	12%	0%
No	13%	62%	98%	88%	0%

Perceptions of the Murree Glass Train Project Summary Tables are shown in Table 64 to Table 66:

Table 64 Positive Impact of Murree Glass Train Project on Hotel Businesses

Positive Impact of Murree Glass Train Project on Hotel Businesses	Number of Respondents	Percentage of Respondents
Yes	163	71%
No	9	4%
Maybe	58	25%
	230	100%

Table 65 Benefits from Murree Glass Train Project

Benefits from Murree Glass Train Project					
	Increased Tourist Footfall	Better Connectivity for Guests	Higher Hotel Bookings	Improved Local Infrastructure	Other
Yes	76%	58%	73%	49%	0%
No	24%	42%	27%	51%	0%

Table 66 Concerns Regarding Project

Concerns Regarding Project				
	Increased Traffic Congestion	Environmental Impact	Higher Competition for Local Businesses	Other
Yes	47%	62%	38%	0%
No	53%	38%	62%	0%

Fare and Commercial Partnership Preference Summary is shown in Table 67 and Table 68:

Table 67 Reasonable Price Range for Murree Glass Train

Reasonable Price Range	Number of Respondents	Percentage of Respondents
< PKR 500	152	66%
PKR 500-1000	74	32%
> PKR 1000	5	2%
	230	100%

Table 68 Customers Interested in Stay-and-Travel Packages

Interested in Stay-and-Travel Packages	Number of Respondents	Percentage of Respondents
Yes	205	89%
No	25	11%
Maybe	0	0%
	230	100%

Parking Facilities Summary is shown in Table 69:

Table 69 Average Parking Occupancy in Hotels

Average Parking Occupancy	Number of Respondents	Percentage of Respondents
High	18	8%
Moderate	51	22%
Low	25	11%
High during Peak Season, Low during off-peak Season	113	49%
Blanks	23	10%
	230	100%

The Freight and Supply Chain Logistics Summary Tables are shown in Table 70 to Table 73:

Table 70 Freight Primary Supply Source

Primary Supply Source	Number of Respondents	Percentage of Respondents
Local Vendor from Murree	140	61%
Suppliers from Islamabad/Rawalpindi	87	38%
Suppliers from other cities	2	1%
	230	100%

Table 71 Hotel Supplies Transport Mode for Freight

Hotel Supplies Transport Mode	Number of Respondents	Percentage of Respondents
Local transport in Murree from Vendor	196	85%
Private Trucks	28	12%
Third-Party Logistics	7	3%
Other	0	0%
	230	100%

Table 72 Freight Bulk Supply Delivery Frequency

Bulk Supply Delivery Frequency	Number of Respondents	Percentage of Respondents
Daily	48	21%
Weekly	106	46%
Bi-Weekly	53	23%
Monthly	21	9%
Seasonally	2	1%
	230	100%

Table 73 Interest in Train Freight Service

Interest in Train Freight Service	Number of Respondents	Percentage of Respondents
Yes	120	52%
No	32	14%
Maybe depending on Cost and Convenience	78	34%
	230	100%

The Hotel Tourist Survey provides comprehensive insights into travel patterns, business perceptions, pricing expectations, parking conditions, and freight logistics associated with tourism in Murree.

The customer travel pattern data (Table 63) indicates that private cars are the dominant mode of travel to Murree, with 87% of hotel respondents reporting that their guests primarily arrive by private vehicles. Public buses are used by 38% of tourists, while tour buses account for 12%. Ride-sharing services contribute a negligible share at 2%, and no respondents reported the use of other transport modes. This highlights a strong dependence on private vehicles, which contributes to congestion, especially during peak tourist seasons.

Perceptions regarding the Murree Glass Train Project (Tables 64–66) are largely positive among hotel stakeholders. As shown in Table 64, about 71% of respondents believe that the project will have a positive impact on hotel businesses, while only 4% expressed a negative view. Approximately 25% were uncertain, indicating cautious optimism. In terms of anticipated benefits (Table 65), increased tourist footfall is the most commonly expected outcome, supported by 76% of respondents. Higher hotel bookings are expected by 73%, while 58% anticipate improved connectivity for guests. Nearly half of the respondents (49%) also expect improvements in local infrastructure as a result of the project. However, respondents also expressed certain concerns (Table 66), with environmental impact being the most significant, cited by 62% of respondents. Increased traffic congestion is a concern for 47%, while 38% fear higher competition for local businesses, indicating the need for careful environmental and traffic management planning.

The fare preference and commercial partnership responses (Tables 67 and 68) reveal strong price sensitivity and business collaboration potential. As shown in Table 67, a majority of hotel respondents (66%) consider a fare below PKR 500 to be reasonable for the Glass Train, while 32% support a fare range between PKR 500 and 1,000. Only 2% favor fares above PKR 1,000, emphasizing the importance of affordable pricing. Furthermore, Table 68 shows strong interest in integrated tourism offerings, with 89% of respondents expressing willingness to participate in stay-and-travel packages, indicating significant potential for public-private partnerships between hotels and the Glass Train service.

Parking facility conditions at hotels (Table 69) reflect seasonal demand pressures. Nearly half of the respondents (49%) reported high parking occupancy during peak tourist seasons and low occupancy during off-peak periods. About 22% reported moderate occupancy levels, while 8% experience consistently high parking demand. These findings underscore the strain on parking infrastructure during peak periods and highlight the potential role of the Glass Train in reducing reliance on private vehicles.

The freight and supply chain logistics assessment (Tables 70–73) shows that most hotels rely on local and regional supply networks. As per Table 70, 61% of hotels source their supplies from local vendors within Murree, while 38% depend on suppliers from Islamabad and Rawalpindi. Only 1% source supplies from other cities. Table 71 indicates that hotel supplies are predominantly transported using local transport within Murree (85%), with limited use of private trucks (12%) and third-party logistics services (3%). Bulk supply deliveries are mainly conducted on a weekly basis (46%), followed by bi-weekly (23%) and daily deliveries (21%), as shown in Table 72.

Finally, interest in using train-based freight services (Table 73) is relatively strong, with 52% of respondents expressing clear interest. An additional 34% indicated conditional interest depending on cost and convenience, while only 14% were not interested. This suggests that, if designed efficiently and competitively, a freight component of the Murree Glass Train could support hotel supply chains and reduce road congestion.

Data Integration and Model Preparation

The cleaned and coded datasets were integrated within a Geographic Information System (GIS) environment, linking O–D pairs, survey locations, and potential Glass Train stations. Each O–D pair was assigned to a Traffic Analysis Zone, and a base-year trip matrix was generated for both directions.

This structured database provided the foundation for mode-choice analysis and demand forecasting. The next stage involved applying these empirical relationships vehicle volumes, trip purposes, occupancy levels, and willingness-to-shift percentages into a quantitative framework to derive ridership estimates under various operational scenarios.

5. Market and Commercial Analysis Framework

Understanding the market dynamics and commercial potential of the proposed Glass Train is essential to evaluate its long-term financial viability and attractiveness for private investment or public–private partnership (PPP) models. The commercial analysis in this study was structured around four key pillars: (1) tourism demand profiling, (2) income group segmentation, (3) user willingness-to-pay, and (4) commercial development opportunities along the corridor. This multi-pronged approach draws directly from primary hotel data, survey-based user behavior analytics, and land-use insights gathered during the planning phase. All are these explained in the respective chapter.

Tourism Market Profiling

The tourism-driven nature of Murree's economy makes visitor demand the most influential variable in the commercial viability of the proposed train. As part of the study, data was collected from 100 hotels, representing approximately 42% of the registered establishments in Murree. Hotels were selected to cover all major zones, including Mall Road, GPO, Bhurban, Lower Topa, and New Murree. The survey captured monthly guest occupancy, origin of visitors, parking availability, and seasonal fluctuations in bookings.

The hotel data confirmed that tourism in Murree is highly seasonal, with sharp peaks during summer (May–July) and winter (December–January), corresponding with school vacations and snowfall. On average, occupancy rates exceeded 80% during peak months, while dropping to below 30% in off-peak months. These insights validated the high fluctuation in travel demand and supported the need for a scalable and seasonally responsive train operation model.

The hotel managers were also surveyed on their perceptions of the Glass Train, with a majority expressing optimism regarding its potential to attract high-end tourism and ease congestion. Many showed interest in collaborative ventures, including bundled hotel–train ticket packages, digital promotion partnerships, and on-site kiosks at terminal stations. These preferences directly inform potential revenue diversification strategies.

Income Group Segmentation and Fare Affordability

The commercial model also required understanding the income-level distribution of current travelers, which was captured during O–D and public transport user interviews. Respondents were segmented into income brackets (low, lower-middle, upper-middle, and high income), allowing an estimation of fare elasticity and service expectation across groups.

The findings indicated that:

- Low-income and lower-middle-income travelers (~40–45%) were mostly public transport users, price-sensitive, and generally unwilling to pay more than existing fares without improvements in service quality.

- Upper-middle-income travelers (~35%) showed a strong preference for a scenic, safe, and congestion-free experience, and were willing to pay moderate premiums over conventional fares, especially for leisure trips.
- High-income groups (~20%) typically traveled in private vehicles, but a significant share expressed a willingness to shift to rail if it offered premium services—onboard comfort, panoramic views, secure parking, and reliable travel times.

Based on this segmentation, tiered ticketing models were conceptualized, with base fares targeting the commuter market and premium services aimed at tourists and families in the higher-income brackets. Fare willingness was triangulated against vehicle operating cost (fuel + toll) to gauge the economic attractiveness of mode shift for each user class.

Willingness-to-Pay and Modal Shift Probability

During the public transport and O–D interviews, respondents were explicitly asked whether they would shift to the train, and under what conditions (fare, travel time, comfort, safety). A utility function was derived from this data to calculate the probability of shift from each mode (public van, private car, coaster, wagon) based on fare levels and service attributes.

This enabled a mode-wise market capture estimate, which directly informed revenue forecasts and ridership projections. For example, the highest conversion likelihood was observed in upper-middle- income tourists using public vans, while the lowest was among daily wage workers using informal transport. These values were further tested under various sensitivity assumptions during financial modeling.

Commercial Development Potential

Beyond fare revenue, the Glass Train offers potential for ancillary commercial income through station area development, advertising, retail concessions, and tourism services integration. Key terminal locations such as Lake View Park (origin) and Sunny Bank (Murree) are planned as high-footfall hubs, ideal for commercial kiosks, food courts, souvenir shops, and tourism facilitation centers.

Additionally, intermediate stations such as 17 Mile, Valley Amusement Park, and Lower Topa offer potential for public-private ventures in parking, shuttle linkages, themed rest areas, and even eco-lodges. These developments could be structured under long-term leases or revenue-sharing arrangements, significantly enhancing the financial attractiveness of the project.

This comprehensive market and commercial framework grounded in hotel data, income segmentation, and land-use realities which lays the foundation for a multi-stream revenue model, diversifying income sources and reducing dependency on farebox recovery alone. It also strengthens the business case for engaging private investors, operators, and tourism stakeholders in the development and long-term operation of the Glass Train.

6. Survey Results and Demand Forecasting Outcomes

Overview

This chapter presents the results of the multimodal survey analysis and the outcomes of the ridership forecasting model for the proposed Rawalpindi–Murree Glass Train. The results integrate findings from MCC, O–D, and passenger interview surveys, structured to depict how existing travel patterns could transform with the introduction of a new electric rail service. The analysis highlights vehicular flow characteristics, user behaviour, potential modal shifts, and seasonally adjusted annual ridership estimates that form the empirical foundation for the project's technical and financial evaluation.

Vehicular Flow Results and Corridor Load Profiles

Data from the four primary analysis sites—17 Mile Toll Plaza, Phulgran Toll Plaza, Lower Topa Intersection, and Kuldana Chowk—were aggregated to derive representative traffic load profiles. Average daily traffic across these sites ranged between 34,000 and 39,000 vehicles, with weekend peaks surpassing 42,000.

Phulgran Toll Plaza recorded the highest average daily throughput, handling nearly 60% of total Murree-bound traffic. This confirmed the E-75 Expressway as the primary conduit for tourist and local travel. Comparatively, the 17 Mile Toll Plaza exhibited higher shares of small private vehicles, while Lower Topa and Kuldana sites reflected more mixed traffic, including light commercial vehicles serving local businesses and hotels.

Passenger Demand Estimation

Overview of Approach

The estimation of potential ridership for the proposed Glass Train service was conducted using a segmented direct demand model with trip-purpose-based modal shift analysis. This approach combines empirical traffic data collection with behavioral adjustment factors derived from stated preference surveys, following established practices in transport demand forecasting for new transit corridors.

The methodology segments potential users into two distinct markets:

1. Public Transport (PuT) Users – passengers currently using buses, wagons, and Hiace vehicles
2. Private Transport (PrT) Users – passengers traveling by private modes.

For each segment, a multi-step process was applied to estimate the proportion of existing travelers likely to shift to the proposed rail service, accounting for trip purpose, origin-destination patterns, and stated willingness-to-use.

Public Transport User Demand Estimation

Data Source and Base Volume

Public transport demand estimation was based on Bus Terminal Survey data collected at Faizabad Terminal, the primary dispatch point for Murree-bound public transport services from Rawalpindi/Islamabad.

The survey captured:

- Number of daily departures by operator and route
- Vehicle type and seating capacity
- Average occupancy rates

Fare structure and travel times

From Tables 43-44, the total daily public transport passenger volume to Murree was calculated as:

Total PuT passengers/day = Σ (Vehicles × Average Occupancy)

= 254 vehicles × 17.6 average occupancy

= 4,476 passengers/day (weekday average)

This figure represents the bidirectional flow between Islamabad/Rawalpindi and Murree, as return trip patterns show similar volumes considering the private transporters only operate at maximum occupancy with temporal distribution differences.

Public transport users represent a captive market segment with limited modal alternatives and higher sensitivity to service quality improvements (Cervero, 2013). Based on the Public Transport User Interview Survey (Tables 45-53):

- 80% expressed willingness to use the Glass Train (Table 51)
- Primary motivations: reliability (35%), availability (35%), affordability (21%), and accessibility (15%)

However, direct application of the 80% stated preference would overestimate modal shift due to:

- Hypothetical bias in stated preference surveys
- Operational constraints such as train frequency, station accessibility, and first/last-mile connectivity
- Fare competitiveness relative to existing informal transport operators

Following TRB guidance on stated preference calibration, a conservative adjustments applied on both weekday and weekend PuT passenger flow and taken into as a part of estimated ridership attracted from the existing public transport mode users.

Private Transport User Demand Estimation

Methodology Framework

Private transport demand estimation employed a spatially disaggregated origin-destination (O-D) analysis using data collected at four strategic Manual Classified Count (MCC) and O-D survey locations:

- 17 Mile Toll Plaza (Old Murree Road)
- Phulgran Toll Plaza (Murree Expressway)
- Lower Topa Intersection (Murree-Kohala junction)
- Kuldanna Chowk (Murree-Abbottabad/Nathiagalli divergence)

The estimation involves the following sequestional procedures that estimates the attraction of ridership from PrT users of the corridor to proposed rail link.

Origin-Destination Matrices Formulation

O-D matrices were constructed separately for private modes such as cars and motorcycles based on roadside interview data (n = 7,960 interviews across all survey locations). Each interviewed vehicle was classified by:

- Origin zone (district and locality)
- Destination zone (district and locality)
- Trip purpose (home, work, education, social, recreational, shopping)
- Vehicle occupancy
- Willingness to use train (yes/no)
- Stated reasons for willingness/unwillingness

Volume Expansion and Person-Trip Conversion

The percentage-based O-D matrices were expanded to absolute vehicle volumes using MCC data collected at the same locations.

Expansion Formula:

$$V(i,j) = ADTMode \times OD\%(i, j)$$

Where:

V(i,j) = Daily vehicle trips from zone i to zone j

ADTMode = Total annual daily traffic of mode at survey location

OD%(i,j) = Percentage of trips from i to j observed in survey

Vehicle trips were then converted to person-trips using average occupancy rates derived from survey observations (Table 33):

Person-Trip Conversion:

$$P(i,j) = V(i,j) \times \text{Occupancy rate}$$

Where:

P(i,j) = Daily person-trips from zone i to zone j

Occupancy rate : derived from survey for each mode

This process was repeated for all O-D pairs at all four survey locations, generating location-specific person-trip matrices. Same process has been applied to the weekend data for estimation of weekend statistics.

Spatial Filtering for Corridor-Relevant Trips

All trips captured at survey point were not aligned with the proposed corridor, hence the spatial filtering is very important in this regard. A spatial filtering process was applied to isolate only those O-D pairs where rail service would be a viable alternative.

Filtering Criteria by Location is represented as below;

A. Phulgran and 17 Mile Toll Plazas:

Include: Rawalpindi/Islamabad and cities towards south (with transfer penalty) ↔ Murree (both directions)

Exclude: Through-traffic (e.g., Lahore → Kashmir), local trips within Islamabad

These locations represent the core Islamabad-Murree corridor where the train alignment directly competes with road travel.

B. Kuldanna Chowk:

Include: Northern cities (Abbottabad, Nathiagalli, Mansehra) ↔ Islamabad/Rawalpindi

These trips will include a transfer hence the transfer penalty has been applied to cap the trips at a conservative level.

While the Glass Train terminates at Murree, travelers from northern regions may use it as the first segment of their journey to Islamabad, particularly if integrated ticketing and seamless transfer facilities are provided.

C. Lower Topa Intersection:

Include: Kashmir/Muzaffarabad ↔ Islamabad/Rawalpindi

These trips will include a transfer hence the transfer penalty has been applied to cap the trips at a conservative level.

Similar rationale as Kuldanna has been used. The train offers potential time savings and comfort advantages for the Murree-Islamabad segment, but the need for onward travel to Kashmir limits appeal.

The estimate is conservative, assuming only highly motivated travelers (e.g., tourists prioritizing comfort) would opt for the multi-modal trip.

Trip Purpose-based Segmentation

Modal shift propensity varies significantly by trip purpose. Recreational and social travelers exhibit greater flexibility in mode choice and higher valuation of comfort and scenic attributes, while commuters prioritize travel time and schedule reliability.

The corridor-relevant person-trips were disaggregated by trip purpose using the distribution observed in O-D survey responses as presented in the survey results chapter.

Trip Purpose Disaggregation Formula:

$$P(i,j,purpose) = P(i,j,total) \times Purpose\%$$

Where:

P(i,j,purpose) = Person-trips from zone i to zone j for specific purpose

Purpose% = Proportion of trips for that purpose (from survey)

Purpose-Specific Modal Shift Application

Modal shift rates were differentiated by trip purpose, reflecting both stated willingness-to-use and realistic behavioral adjustment factors.

A. High-Propensity Purposes (Social + Recreational):

Survey data showed 86% stated willingness to use the train among private vehicle users. However, for social and recreational travelers—who exhibit the strongest affinity for the Glass Train's unique attributes (scenic views, comfort, novelty)—a higher realization rate was justified.

B. Low-Propensity Purposes (Work, Home, Education, Shopping, Other):

For utilitarian trip purposes, direct application of the 86% stated willingness would significantly overestimate actual modal shift. Analysis of stated reasons for not using the train (Table 52) revealed that time constraints (32%), accessibility concerns (7%), and flexibility requirements (7%) disproportionately affect work, education, and routine travel patterns.

A more conservative and realistic shift rate was derived by applying a utility function based on these stated behavioral constraints rather than hypothetical willingness alone. This rate reflects travelers who, despite the practical limitations of their trip purpose, can accommodate train schedules and station access requirements such as those without destination vehicle dependency or those able to integrate the train into multi-modal trip chains.

This factor was validated against observed mode choice patterns in the O-D survey data, where work and education travelers showed strong revealed preference for private vehicles even when lower-cost public transport alternatives existed, indicating deeply embedded behavioral and logistical constraints that limit rail adoption for these trip types.

Combined Ridership Estimates

As described above ridership estimation methodology employed a disaggregated multi-Layered framework combining empirical traffic data, stated preference surveys, and behavioral adjustment factors calibrated to international best practices. The resulting base year estimate of 6,132 passengers/day (March weekday). As the nature of the region is a regular tourism based, hence separate data for weekend has also been collected and similar model applied on it that yields a weekend ridership 9,643 passengers/day (March weekend).

Subsequent sections adjust this baseline for seasonal variation, weekend patterns, and future year growth to generate comprehensive ridership forecasts across the project evaluation horizon.

Monthly and Seasonal Adjustment Factors

The Rawalpindi-Murree corridor exhibits pronounced seasonal variation in travel demand, driven primarily by Murree's role as Pakistan's premier hill station and year-round tourist destination. As established in the project description (Section 2), the region experiences two distinct tourism cycles that fundamentally shape transportation demand patterns:

Summer Tourism Peak (May–August): Murree attracts visitors seeking respite from the intense heat of the plains, with peak activity during school summer vacations (June-July). Daily temperatures in Murree range between 15-25°C during this period, compared to 35-45°C in Rawalpindi/Islamabad, creating strong demand for recreational travel. This period coincides with extended family vacations, educational institution closures, and the traditional Pakistani tourism season.

Winter Tourism Peak (December–January): The region experiences significant visitor influx during the winter months, particularly when snowfall occurs. December-January represents the primary snow season in Murree, attracting domestic tourists seeking winter recreational experiences. This peak intensifies during the Christmas-New Year holiday period and extends through January when snowfall is most reliable.

Shoulder and Off-Peak Periods (March-April, September-November): These months experience moderate tourism activity, with primarily weekend-based recreational travel and steady weekday commuter flows. February represents the lowest demand period, with reduced tourism due to post-winter conditions and economic factors following the Eid-ul-Fitr expenditure cycle.

This dual-peak seasonal pattern creates substantial variation in corridor traffic volumes, with summer and winter peaks potentially exceeding off-peak demand by factors of 2.0-2.5×. Understanding and quantifying

this seasonality is critical for accurate annual ridership projection, service planning, and financial forecasting.

To calibrate the base ridership estimates derived from the March 2025 survey period, monthly traffic volume data from the National Highway Authority (NHA) Phulgran Toll Plaza was obtained and analyzed. The Phulgran Toll Plaza, located on the Murree Expressway (E-75) approximately 22 km from Islamabad and 38 km from Murree, serves as a critical control point capturing the majority of vehicular traffic entering the Murree corridor from the twin cities.

Phulgran Toll Plaza data was selected as the calibration benchmark for the following reasons:

- **Comprehensive Coverage:** The toll plaza operates 24/7 with automated classification systems, capturing all vehicle movements by type (cars, wagons, buses, trucks) without sampling bias.
- **Spatial Representativeness:** Located on the expressway alignment parallel to the proposed Glass Train corridor, the toll plaza traffic composition closely mirrors the potential train ridership market, particularly private vehicles and public transport traveling between Islamabad and Murree.
- **Temporal Continuity**: NHA maintains continuous monthly records, enabling analysis of full annual cycles and multi-year trend validation. Data for calendar year 2024 (latest complete annual dataset) was utilized.
- **Policy Neutrality:** Unlike survey data, which may be influenced by survey timing or respondent bias, toll plaza data represents revealed behavior across all market segments and weather conditions.

Monthly traffic volume data from Phulgran Toll Plaza reveals distinct seasonal patterns consistent with Murree's dual tourism cycle. Table 74 presents the 2024 monthly vehicle volumes and percentage variation relative to the annual average:

Table 74 monthly vehicle volumes and percentage variation

MONTH (2024)	TRAFFIC (NHA)
January	268,734
February	310,169
March	244,402
April	326,166
May	351,214
June	479,309

July	535,536
August	478,311
September	358,026
October	303,458
November	293,461
December	286,889

Key Observations from NHA Phulgran Toll Plaza Traffic Data

Pronounced Summer Peak:

The highest traffic volumes are observed during the summer tourism season, with July emerging as the peak month, recording approximately 159% of the annual average traffic, corresponding to a 1.59× seasonal multiplier. June and August also exhibit significantly elevated demand levels at approximately 1.48× and 1.38×, respectively. This pattern reflects strong recreational travel to Murree during peak summer months.

Secondary Winter Tourism Peak:

A secondary demand peak is evident during the winter season, particularly in December and January, which register approximately 1.31× and 1.18× of the annual average traffic, respectively. While winter demand remains substantial, it is comparatively lower and more volatile than summer peaks, largely due to weather-related uncertainty and intermittent road accessibility.

Representativeness of Survey Month (March):

The survey month of March aligns closely with the annual average traffic level, recording approximately 99% of the annual mean. This confirms March as a neutral and statistically representative baseline period, suitable for developing survey-based demand estimates without systematic seasonal bias.

Off-Peak Demand Trough:

February represents the lowest demand period of the year, with traffic volumes declining to approximately 71% of the annual average. The resulting peak-to-trough ratio of approximately 2.24:1 (July relative to February) highlights the extreme seasonality characterizing travel demand on the corridor.

Stable Shoulder Season Demand:

The months of April, September, and November fall within a relatively stable shoulder season, with traffic levels ranging between approximately 78% and 93% of the annual average. These months represent moderate and predictable demand conditions, which are particularly relevant for routine operations, maintenance planning, and baseline service scheduling.

Based on March Daily Weekday (6132) and weekend (9,643) ridership, monthly ridership for month of march has been estimated as 212,051. This has been calibrated with the march traffic of NHA, 244,042 and the estimated monthly ridership for year 2025 has been presented as below;

Table 75 Estimated monthly ridership for year 2025

MONTH	MONTHLY FORECASTED RIDERSHIP
January	233,162
February	269,112
March	212,051
April	282,992
May	304,724
June	415,863
July	464,647
August	414,997
September	310,634
October	263,289
November	254,616
December	248,914
Total	**3,675,000**

7. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Traffic and Commercial Study for the proposed Tourist Glass Train between Rawalpindi/Islamabad and Murree was conducted to assess existing travel demand, modal characteristics, user behavior, and commercial viability within the project corridor. The analysis was based on extensive primary data collection, including manual classified traffic counts, origin–destination surveys, public transport user interviews, bus terminal surveys, boarding–alighting surveys, hotel surveys, and secondary traffic data from the National Highway Authority. The findings provide a robust empirical basis for evaluating the feasibility of the proposed service.

The analysis confirms that travel along the Rawalpindi/Islamabad–Murree corridor is dominated by tourism and recreational trips, with pronounced weekend and seasonal peaks. Traffic volume counts and O–D survey results show substantial passenger movement toward Murree, particularly during weekends, reflecting the corridor's role as a primary tourism artery. Hotel survey results further corroborate the strong and sustained inflow of visitors throughout the year, with significant monthly variation aligned with summer and winter tourism seasons.

The study identifies a heavy reliance on private vehicles, particularly cars and small vans, which constitute the dominant share of traffic on both the Murree Expressway (E-75) and the old Murree Road. Public transport services, while fully utilized, are limited in capacity, comfort, and service quality. Bus terminal and boarding–alighting surveys indicate that existing services operate at or near full occupancy during both weekdays and weekends, demonstrating limited ability to absorb future demand or provide improved travel conditions within the existing road-based system.

Origin–Destination surveys and public transport user interviews reveal a clear willingness among travelers to shift to a rail-based alternative, particularly for tourism and leisure trips. The analysis shows that comfort, safety, scenic experience, and avoidance of road congestion are the primary factors influencing potential modal shift. Fare preference analysis indicates that a significant proportion of users are willing to pay fares comparable to or moderately higher than existing public transport fares, provided that the service offers superior reliability and travel experience.

Passenger demand forecasting, developed through a combination of public transport and private vehicle user analysis, origin–destination matrices, trip purpose segmentation, and seasonal calibration using NHA toll plaza data, indicates a viable ridership potential for the proposed Glass Train. The results demonstrate that demand is sufficient to support a passenger-focused rail service, particularly when service levels are aligned with observed weekday–weekend and seasonal variations.

The commercial analysis confirms that the viability of the project is driven almost entirely by passenger transport demand. Hotel surveys and freight-related responses indicate limited and inconsistent potential

for freight movement, reinforcing the conclusion that the Glass Train should be planned exclusively as a tourism-oriented passenger service rather than a mixed-use rail corridor.

Overall, the Traffic and Commercial Study concludes that the proposed Tourist Glass Train is justified from a transport demand perspective, demonstrates clear market acceptance, and is commercially viable as a passenger-focused, tourism-driven rail service, subject to appropriate service design and operational planning.

Recommendations

Based on the findings and analytical outcomes of the Traffic and Commercial Study, it is recommended that the project proceed to the next stages of feasibility, including detailed engineering design, financial analysis, and environmental assessment. The results of the traffic surveys and demand forecasting provide sufficient justification to advance the project beyond the conceptual level.

The Glass Train should be planned and operated strictly as a passenger-oriented, tourism-focused service. Rolling stock design, station facilities, and service standards should prioritize comfort, safety, and scenic value, reflecting the preferences identified in user surveys and willingness-to-pay analysis. Freight operations should not be included in the project scope, as demand analysis does not support their commercial viability.

Service planning should adopt a demand-responsive operating strategy. Train frequencies and operating hours should be aligned with the observed travel patterns identified in the study, with higher service levels during weekends and peak tourism seasons and optimized operations during off-peak periods to ensure operational efficiency and financial sustainability.

Fare structures should be developed within the acceptable ranges identified through passenger surveys, ensuring competitiveness with existing road-based public transport while reflecting the enhanced service quality offered by the Glass Train. Fare policy should be simple, transparent, and aligned with tourism travel behavior rather than daily commuter pricing models.

Adequate last-mile connectivity should be ensured at all stations, particularly at the Murree terminal, to facilitate smooth passenger dispersal and minimize localized congestion. Integration with feeder services and appropriate terminal area management should be incorporated into subsequent planning stages.

Future project development should continue to respect environmental, land-use, and planning constraints identified within the study corridor. Detailed environmental and social assessments should build upon the alignment and station locations assessed in this study to ensure sustainable implementation in the ecologically sensitive Murree region.

8. ANNEXURES

OD Survey Performa

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

O-D Survey (Public Vehicles)

Road Name:	_____	**Link No**	_____	**Day/Date**	_____
Direction:	_____	**From Node**	_____	**Surveyor Name**	_____
Latitude:	_____	**To Node**	_____	**Sheet No.**	_____
Longitude:	_____				

Sr.NO	TIME OF INTERVIEW	VEHICLE CODE	NO. OF PASSENGERS	TRIP ORIGIN	TRIP DESTINATION	TRIP FREQUENCY	TRIP PURPOSE	HOME AREA (ZIP)	AVERAGE HOUSEHOLD INCOME	TRAIN USAGE*	REASON	FARE PREFERENCE

*Will you use glass train with travel time approx 90 mins and market competetive fare ?

Vehicle Codes : Motor Cycle (M), Rickshaw (R), Car (C), Taxi (TX), Wagon/Van (W), Mini Bus (MB), Bus (B), School Bus (SB), Pick up (PK), Truck-2 Axle (2T),Truck - 3 Axle (3T), Truck – 4 Axle (4T), Truck - 5 Axle (5T), Truck- 6 Axle (6T), Tractor/Trolleys (TT)

Trip Purpose: 1-Home, 2-Work, 3-Business, 4-Education, 5-Social, 6-Recreational, 7-Shopping

Trip Frequency: 1-Once daily 2- Multiple Daily 3- Weekly 4-Monthly, 5-Ocasionally

Average Household Income: 1-Less than 40,000 PKR, 2-40,000-80,000 PKR, 3-80,000-120,000 PKR, 4-120,000 PKR-150,000 PKR, 5->150,000 PKR

Reason: 1-Time, 2-Cost, 3-Convenience, 4-Accessiblity, 5-Flexibility, 6-Others

Train Usage: Y-Yes, N-No

Fare Preference: 1-300-500 PKR, 2-500-700 PKR, 3-700-1000 PKR, 4-1000-1500 PKR, 5->1500 PKR

The Punjab Masstransit Authority
Government of Punjab

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

Bus Terminal Survey Questionnaire for Estimating Passengers to Murree

Section A: Operator & Vehicle Information

1. **Name of Transport Operator**

2. **Number of Buses Operating to Murree per day**
   - **Weekday (Mon–Fri):** _____
   - **Weekend (Sat–Sun):** _____
3. **Type(s) of Vehicles Used** a) Coaster b) Hiace c) Bus d) Pickup e) other _____
4. **Seating Capacity of Each Vehicle Type** _____
5. **Service Type**
   ☐ Non-stop ☐ Local (with intermediate stops)
   If **local**, please list major stops: _____

Section B: Service Frequency and Occupancy

6. **Average Number of Passengers per Vehicle**
   - **Weekday:** _____
   - **Weekend:** _____
7. **Estimated Total Passengers to Murree Per Day**
   - **Weekday:** _____
   - **Weekend:** _____

Section C: Fares and Operational Info

10. **Average Fare per Passenger (to Murree):** Rs. _____
11. **Average Travel Time to Murree:** _____ minutes
12. **Do You Record or Track Passenger Data?**
    ☐ Yes ☐ No
    If yes: Can you provide average monthly ridership? _____

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Government of Punjab

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

PUBLIC TRANSPORT QUESTIONNAIRE

Survey Site / Location _____

Surveyor Name _____

Date _____ Day _____

1. **Age**
   a) 10 to20 c) 20 to 30 e) 30 to 40 g) 40 to 50
   b) 50 to 60 d) 60 to 70 f) 70 to 80 h) Others

2. **Questionnaire Control Information**

a) Bus Operator/Company Name _____

b) Bus No _____

c) Bus Route No/Location _____

3. **Household Income/month**

1.< Rs. 5000	4. Rs.15,001-Rs.20,000	7. Rs.30,001-Rs.35,000
2.Rs.5001-Rs.10,000	5.Rs.20,000-Rs.25,000	8.> Rs.35,000
3.Rs.10,001-Rs.15,000	6. Rs.25,001-Rs.30,000	9. No income

4. **Your origin**

_____

5. **Your Destination**

_____

6. **Purpose of this Trip.**

1. Home	3.Education	5. Social
2. Work	4. Health	6. Others

7. **How many times do you use public transport?**
   1. Everyday 3. Once a week
   2. Once a month 4. More than once a month

8. **Do you have your own vehicle**
   1. Yes 2. No

   If yes then how many
   a. No of Bicycle _____
   b. No of Motorcycle _____
   c. No of cars _____

9. Why you prefer public transport over private transport

1. Accessibility 2. Availability 3. Reliability 4. Affordability 5. Travel Time

10. How much time (minutes) you have to wait at the Bus stop

1. 5	2. 10	3. 15	4. 20
5. 25	6. 30	7. 60	8. 90

11. Please rank your satisfaction with the existing bus/wagon service in the following areas

1. Route system	0	1	2	3	4	5
2. Operating hours	0	1	2	3	4	5
3. Frequency	0	1	2	3	4	5
4. Punctuality	0	1	2	3	4	5
5. Safety	0	1	2	3	4	5
6. Bus/Wagon fare	0	1	2	3	4	5
7. Access to bus stop	0	1	2	3	4	5
8. Bus stop facilities	0	1	2	3	4	5
9. Affordability	0	1	2	3	4	5
10. Security	0	1	2	3	4	5
11. Driver / conductor's attitude	0	1	2	3	4	5

12. Will you be using a Glass Train originating from Margalla Station H-9, having a travel time of 100 minutes?

1. Yes 2. No

13. Reason for choosing or not choosing the Train?

1. Accessibility 2. Availability 3. Reliability 4. Affordability 5. Travel Time

14. How much you are willing to pay as a Fare for a Glass Train towards Murree?

1. PKR 300-500 2. PKR 500-700 3. PKR 700-1000 4. PKR 1000-1500 5. > PKR 1500

The Punjab Masstransit Authority
Government of Punjab

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

BOARDING & ALIGHTING SURVEY

Surveyor Name:									
Route No/Name:									
Vehicle Type:									
Vehicle Company:									
Registration No:									
Vehicle Capacity (Seats):									
Survey Direction: From:	**To:**								
Date:				-			-		
Position:									

Stop No.	Bus Stop Name	Number of Alighting Persons	Number of Boarding Persons	Arrival Time (Minutes)	Departure Time (Minutes)
Start					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Note: Passengers alighting or boarding at locations between stop must be added to the next stop

Murree Glass Train Project – Hotel Survey Questionnaire

(To be filled by Hotel Manager or Equivalent)

General

1. Hotel Location (Area in Murree): _____
2. Average Room Rent (Domestic) : _____
3. Average Room Rent (International) : _____
4. Number of Rooms Available: _____

Visitors Volume

5. Number of Visitors in each month in last year;

Months	Number of Visitors
January-24	
February-24	
March-24	
April-24	
May-24	
June-24	
July-24	
August-24	
September-24	
October-24	
November-24	
December-24	
January-25	
February-25	

6. What approximate percentage of your guests are:
   - Domestic Tourists: _____%
   - International Tourists: _____%
7. How do most of your customers travel to Murree?
   - ☐ Private Cars
   - ☐ Public Buses
   - ☐ Ride-Sharing Services (Careem, Uber, etc.)
   - ☐ Tour Buses
   - ☐ Other (Specify): _____

Glass Train Project-Related

8. Do you believe the Murree Glass Train Project will have a positive impact on your hotel business?

   a). Yes b). No c). Maybe Supporting Reason: _____

9. What kind of benefits do you expect from this project? (Select all that apply)

- ☐ Increased Tourist Footfall
- ☐ Better Connectivity for Guests
- ☐ Higher Hotel Bookings
- ☐ Improved Local Infrastructure
- ☐ Other (Specify): _____

10. Do you have any concerns regarding the project?

- ☐ Increased Traffic Congestion
- ☐ Environmental Impact
- ☐ Higher Competition for Local Businesses
- ☐ Other (Specify): _____

Tourist Arrival Regularity

11. What is the average length of stay of your guests?
☐ 1 night ☐ 2-3 night's ☐ More than 3 night's

12. How much luggage do visitors typically carry during their stay?
a). Small (1-2 bags) b). Medium (3-4 bags) c). Large (5+ bags) d). don't carry luggage

13. From which city most tourists come from
a). Lahore b). Rawalpindi/Islamabad c). Karachi d)others, specify _____

14. What time of the day do most of your guests check-in and check-out?
Check-in: _____ Check-out: _____

Commercial Point-of-View

15. What price range would be reasonable for a one-way ticket on the Murree Glass Train?"
(☐ <500 PKR ☐ 500-1000 PKR ☐ 1000+ PKR)

16. Would your hotel be interested in offering stay-and-travel packages with the Murree Glass Train?" (☐ Yes ☐ No ☐ Maybe)

Parking

17. Number of available Parking Spots at your Hotel: _____

18. What is average occupancy of your hotel parking?
a). High b). Moderate c). Low d) High during peak season, low during off-peak season

Freight Supply Chain

19. What commodities are included in your supplies? : _____

20. Where do you primarily source your hotel supplies from?
    a). Local Vendor from Murree b). Suppliers from Islamabad/Rawalpindi c). Suppliers from other cities (please specify: _____)

21. How are your hotel supplies currently transported?
    a). Local transport in Murree from Vendor b). Private Trucks c). Third-Party Logistics d). Other (please specify)

22. How frequently do you receive bulk supply deliveries?
    a). Daily b). Weekly c). Bi-Weekly d). Monthly e). Seasonally (specify _____)

23. On average, how much freight does your hotel receive per delivery?
    a). Less than 100kg b). 100-500 kg c). 500-1000kg (1 ton) d). 1-5 tons e). More than 5 tons

24. Would you consider using a train freight service for hotel supplies if available on equivalent cost?
    a). Yes b). No c). Maybe depending on cost and convenience (specify _____)



PARKING STUDY REPORT

Draft

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

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INTRODUCTION

Project Background

The Government of Punjab has introduced a transformative scheme to establish a scenic rail link between Rawalpindi/Islamabad and Murree, designed to enhance accessibility for both the public and tourists. The highlight of the project is the proposed Glass Train, a scenic rail concept featuring large windows and glass ceilings to provide passengers with uninterrupted panoramic views of the breathtaking mountainous terrain. Such trains are globally recognized for their popularity in scenic destinations, such as Switzerland, Norway, Japan, and Canada, offering a unique and immersive travel experience.

This initiative aims to provide an alternative and sustainable transportation mode for tourists, many of whom currently rely on private vehicles to reach Murree. By reducing vehicular traffic, the Glass Train project is envisioned as a step towards sustainable tourism and improved accessibility. Previous work by Pakistan Railways on a rail linkage between Rawalpindi/Islamabad and Murree forms a foundational basis for this project, which will address gaps in earlier studies and propose a viable connection to the Murree hilltop at an elevation of approximately 2,000 meters.

The Feasibility Study, led by the Punjab Mass Transit Authority (PMA) with support from the Transport Planning Unit under the Transport and Mass Transit Department, will comprehensively evaluate the project.

As part of the comprehensive feasibility study, a Parking Study has been undertaken to assess the existing parking infrastructure along the proposed alignment and to determine the future requirements for supporting the project through efficient park-and-ride systems. The integration of strategically located parking facilities is a key element for enhancing accessibility, promoting modal shift, and ensuring seamless connectivity for commuters and tourists.

Objectives of the Parking Study

The objectives of this Parking Study are as follows:

- To evaluate the current availability, usage, and operational characteristics of parking facilities near the proposed rail alignment.
- To analyze the potential for integrating existing parking facilities into a comprehensive park-and-ride system.
- To estimate future parking demand in light of projected ridership and modal shift assumptions.
- To identify suitable locations for new parking infrastructure based on land availability, accessibility, and connectivity.
- To propose parking design features aligned with international best practices and user expectations.
- To support the overall feasibility and success of the tourist glass train project through a robust parking strategy.

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Study Area Description

The parking study focuses on two primary geographical clusters: **Murree Town and its surrounding tourism belt**, and the **Rawalpindi/Islamabad entry and feeder zones**. These areas were selected based on their strategic importance to tourist travel patterns and their direct interaction with the proposed glass train alignment.

In **Murree**, the study concentrated on high-pressure zones that consistently experience intense vehicular inflow, particularly during weekends and peak tourism seasons. Areas such as **Mall Road and the GPO vicinity** serve as the town's primary commercial and pedestrian zones, attracting a high footfall throughout the year. These locations witness a high demand for short-term parking, especially from day-trippers and families visiting the central shopping district. Additionally, scenic viewpoints like **Kashmir Point, Pindi Point, and the Bhurban Approach** attract tourists who often park for brief periods, leading to rapid turnover and congestion.

The entry corridors to Murree, including **Lower Topa, Kuldana Chowk, and Musyari Link Road**, often experience **spillover parking** during holidays and festive seasons, as vehicles are forced to stop short of the town due to full capacity within. Moreover, the numerous **hotel zones, guesthouses, and hill lodges** in and around Murree frequently lack purpose-built off-street parking facilities, resulting in the use of adjacent streets and vacant land parcels for informal parking. These conditions contribute to **non-uniform and inefficient parking patterns**, compounded by **seasonal spikes**, a lack of organized regulation, and weak enforcement mechanisms.

On the other end of the corridor, the **Rawalpindi/Islamabad feeder zones** were studied for their potential to act as **interchange points or park-and-ride hubs** for the glass train. Key locations include the **Faizabad Interchange**, a major confluence point between Islamabad and Rawalpindi, and the **Pirwadhai Bus Terminal**, which serves as a central node for intercity bus operations. The **Murree Road Corridor**, stretching from **Zero Point to Bhara Kahu**, represents a linear zone with multiple access points to the train route and opportunities for intermediate stops or auxiliary parking development.

Other potential feeder locations include **Margalla Railway Station** and the **surrounding land parcels**, which offer space for structured park-and-ride development. Similarly, the **Islamabad Expressway connector zones** were assessed for their accessibility and potential to divert vehicular traffic away from Murree by offering well-located train boarding options. Collectively, these sites are envisioned to serve as **transfer nodes**, enabling tourists to **switch from private vehicles to the glass train**, thereby significantly **reducing vehicular congestion and parking demand** within Murree's constrained road network.

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STUDY APPROACH

3.1 Steps Taken in the Assessment Process

The approach adopted for this study is structured, phased, and data-driven. It begins with a comprehensive desk review to understand the existing conditions, previous studies, and background information. This foundational understanding informs the development of a targeted field survey strategy. Based on the insights from the desk study, following parking sites along or near the proposed alignment were shortlisted for detailed investigation.

Table 1 Selected Parking sites for Data Collection

S/No.	Location	Parking Capacity	Remarks
1	Valley Park	150	
2	Lake View Parking	300	
3	Abpara Market	80	Marked =20 Open = 60
4	Abpara Market-2	70	Shop owners Parking
5	Jasmine Garden	200	
6	Shaker Parian	550	Monument = 250+TKR 300
7	Railway Parking Area	45	
8	Parking Stand Adjacent to dry Port	60	
9	GPO Carparking	30	
10	Paid Car parking Club Road	25	
11	TMA Car parking	20	

These sites were then assessed through full-day field surveys (both on weekdays and weekends) to capture real-time data on vehicle entries and exits, which provided key indicators such as accumulation and occupancy rates. The findings were further analyzed to determine the suitability of existing facilities for integration into the train's park-and-ride system.

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The following images, extracted from Google Maps, showcase the current parking sites in the study area, providing insight into their locations and layouts:

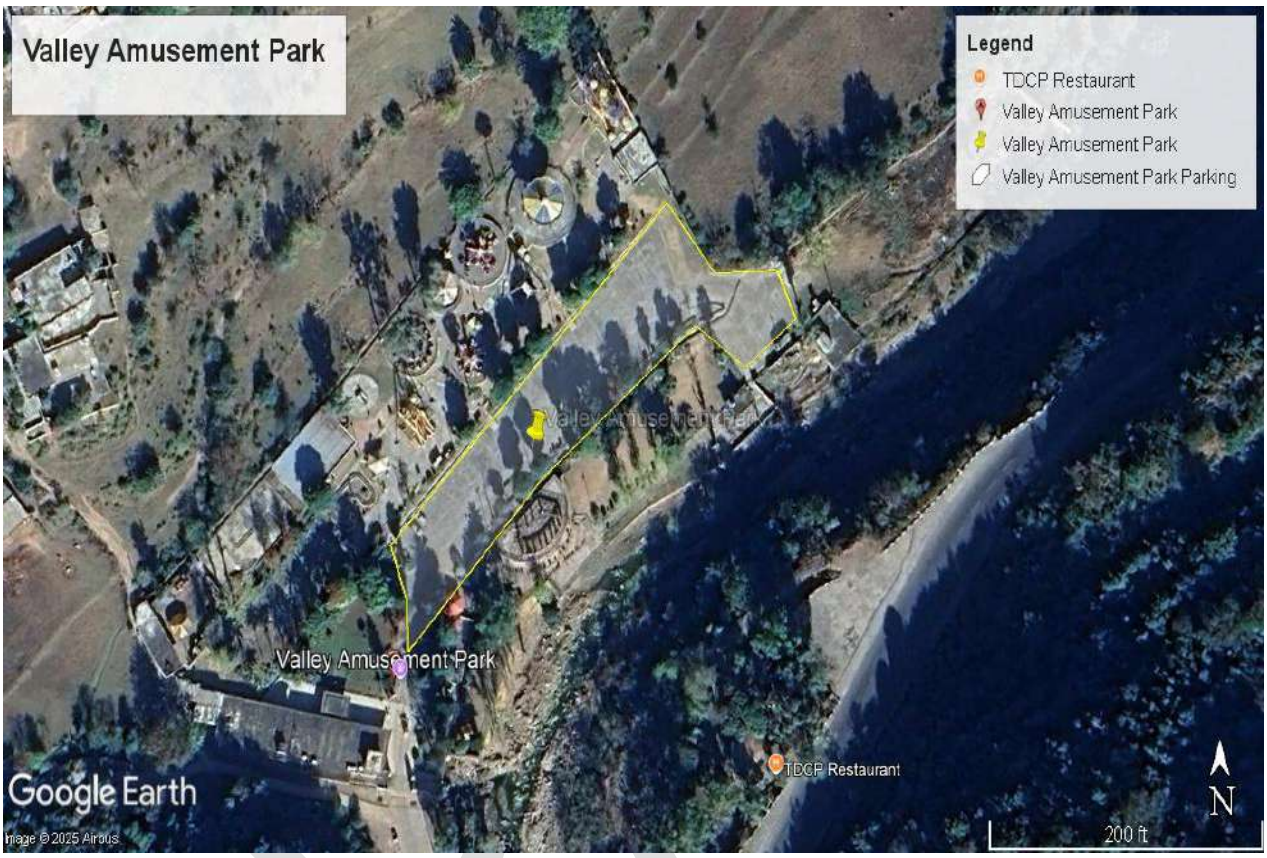


Figure 1 Valley Amusement Park

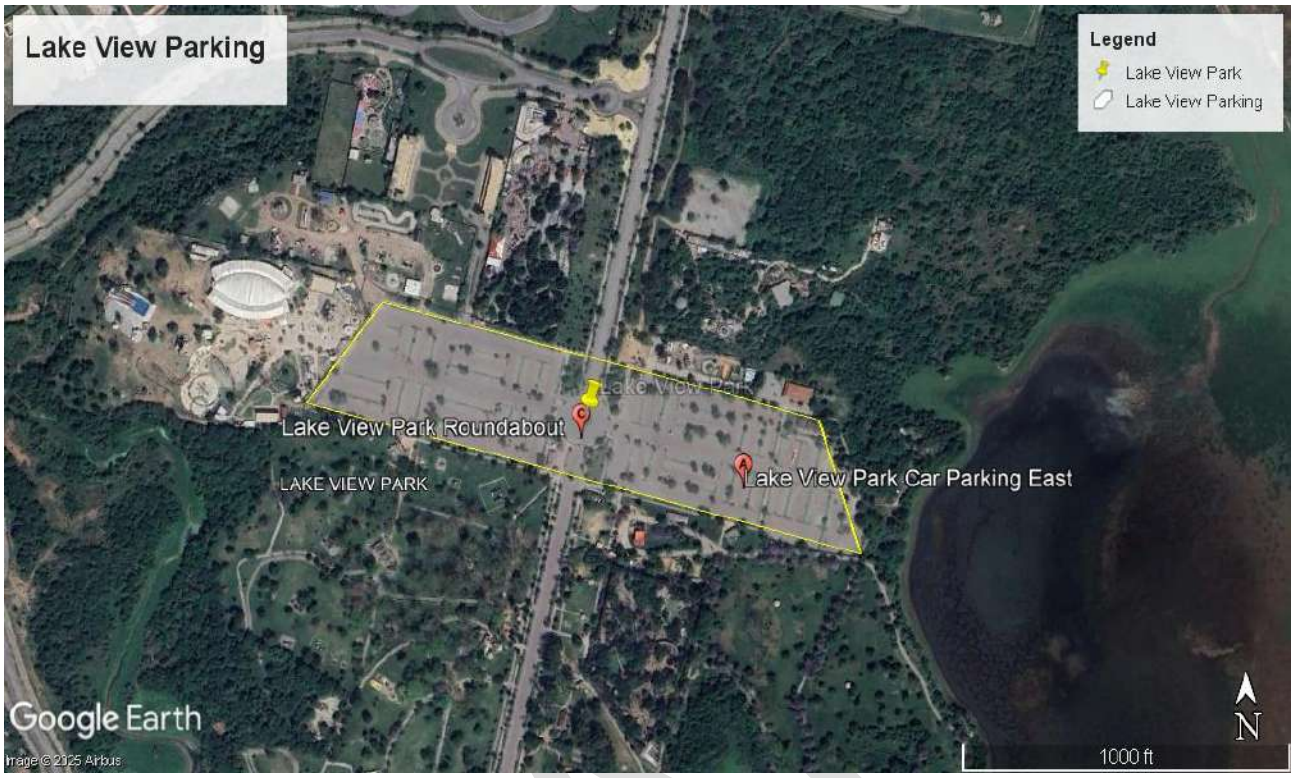


Figure 2 Lake View Parking



Figure 3 Abpara Market Parking



Figure 4 Jasmine Garden Parking



Figure 5 Shakar Parian Parking



Figure 6 Railway Parking Area

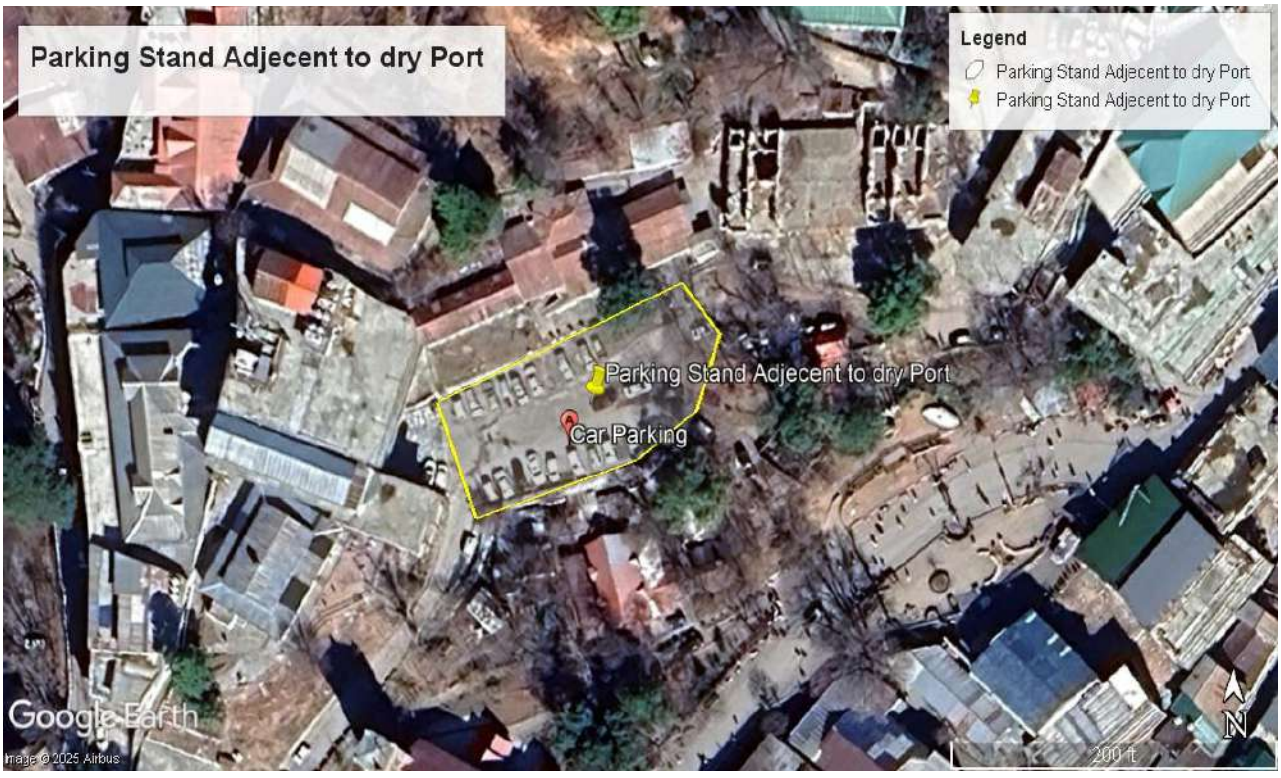


Figure 7 Parking Stand Adjacent to Dry Port



Figure 8 GPO Car Parking



Figure 9 Paid Car Parking Club Road



Figure 10 TMA Parking

Future demand projections were generated using ridership estimates derived from the main feasibility study. These projections were cross-referenced with current parking supply data to identify gaps and propose future solutions. Design principles and recommendations were framed based on global best practices to ensure modern, efficient, and user-friendly parking systems.

3.2 Integration with Main Alignment Planning and Ridership Projections

The parking study is closely aligned with the broader feasibility study, especially the alignment planning and ridership projections. The selection of existing sites and identification of potential future locations are based on their spatial relationship with proposed train stations and expected passenger flows. Ridership forecasts play a critical role in determining the scale and location of required parking facilities.

By integrating this study with mainline infrastructure planning, the proposed solutions aim to create a unified and functional multimodal system that enhances accessibility while minimizing urban congestion and environmental impact.

METHODOLOGY

Analysis of Existing Parking Facilities

As an essential first step in the parking study, a thorough assessment of existing parking facilities located near or along the proposed alignment of the Murree–Islamabad Tourist Glass Train was undertaken. The objective of this analysis was to understand the current parking infrastructure landscape and evaluate its potential to support the future park-and-ride requirements of the glass train service.

This evaluation focused on several key aspects:

- **Capacity:** The total number of parking spaces available at each site.
- **Utilization:** The extent to which these spaces are occupied throughout the day.
- **Operational Characteristics:** Management practices, access control, pricing (if any), and general functionality of the parking facility.
- **Geographical Distribution:** The physical location of each facility in relation to the proposed train alignment and major access roads.
- **Accessibility:** The ease with which users can access each site by private vehicle and their potential connectivity with nearby train stations.

To gather this information, day-long manual parking surveys were conducted at each shortlisted parking facility. The surveys were carried out by trained field staff, who recorded vehicle entry and exit counts on an hourly basis from morning to evening. This data collection enabled the calculation of important metrics such as:

Parking Accumulation: Accumulation refers to the number of vehicles parked in a facility at a specific point in time. It represents the total count of occupied spaces during a survey at regular intervals (usually hourly) and helps in understanding the pattern of parking usage throughout the day.

Occupancy (%): Occupancy is the ratio of the number of occupied parking spaces to the total number of available spaces, usually expressed as a percentage. It indicates how efficiently a parking facility is being utilized.

Formula:

Occupancy (%) = (Number of parked vehicles / Total parking spaces) × 100

This empirical data provided a clear picture of how each facility performs under current conditions and helped to identify gaps such as overcrowding, underutilization, or limited access. Moreover, this analysis laid the groundwork for assessing which of these existing facilities could be feasibly integrated into the glass train system as park-and-ride hubs and which sites may require upgrades or alternative solutions.

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Demand and Supply Studies

A comprehensive demand and supply analysis was conducted to assess the current utilization of parking facilities and to estimate future parking requirements associated with the introduction of the Murree–Islamabad Tourist Glass Train. This analysis served two primary objectives:

- To understand the present parking dynamics along the proposed alignment.
- To project how demand will evolve, particularly in response to the expected modal shift toward the tourist train service.

Current Demand Estimation

To evaluate existing demand**,** manual field surveys were conducted over the course of a full operating day (typically from 08:00 AM to 19:00 PM) at each identified parking location. Surveyors recorded hourly vehicle entries and exits, which allowed for the computation of key indicators such as:

- **Hourly Demand Trends**: Fluctuations in the number of parked vehicles over the course of the day, helping identify the most active and inactive periods.
- **Peak Occupancy Levels**: The maximum number of vehicles present at any given hour, indicating the highest level of utilization.
- **Turnover Rates**: How frequently parking spaces were vacated and reoccupied, giving insights into short-term versus long-term usage.

From this data, the existing supply (total capacity) and actual demand (space usage) were matched to detect surpluses or deficits at each site. Facilities with consistently high occupancy and limited availability were flagged as high-demand areas, whereas those with low utilization indicated either overcapacity or poor accessibility.

Future Parking Demand Forecasting

To project future parking needs, the analysis incorporated:

- **Ridership Projections**: Data from the main feasibility study was used to estimate the number of passengers expected to switch to the train once operational.
- **Modal Shift Assumptions**: Reasonable assumptions (based on regional travel behavior studies and international benchmarks) were applied to estimate what proportion of future train users would arrive by private vehicle and require parking.
- **Growth Factors**: Anticipated increases in private vehicle ownership, tourism trends, and seasonal travel variations were also factored in to ensure realistic long-term forecasting.

These projections were then translated into estimated future parking space requirements at various nodes along the train corridor—particularly near major stations and proposed park-and-ride locations. The

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comparison of future demand with existing supply provided a clear picture of expected shortfalls, guiding the identification of new facility locations and the need for capacity enhancement.

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DATA COLLECTION

For the purpose of understanding travel patterns and traffic volumes along the proposed alignment, a “Number Plate Survey” was conducted at strategically selected locations. These locations were chosen based on their proximity to the proposed alignment and their relevance in capturing vehicle movements entering and exiting the corridor. The survey was carried out by trained enumerators over the course of two shifts, starting from 7:00 AM in the morning until 10:00 PM in the evening, ensuring a comprehensive coverage of daily traffic activity, including both peak and off-peak hours.

Each enumerator was equipped with a standardized data recording sheet, and the methodology remained consistent across all sites to ensure uniformity and reliability of data.

At each site, the number plates of all entering and exiting vehicles were manually recorded. This allowed for the identification of unique vehicle movements across different sites. In addition to number plate details, the mode of transport for each vehicle was also recorded, encompassing all categories such as motorcycles, cars, wagons, vans, coasters, buses, mini-trucks, and heavy trucks, among others. This allowed for a comprehensive classification of traffic by vehicle type.

To account for variations in traffic flow between different days of the week, the survey was conducted on both weekdays and weekends. This approach ensured that any fluctuations in travel patterns due to work-related commuting or recreational travel could be accurately captured and analyzed.

A standard data sheet was used across all sites and days, designed to capture the following information:

- Date and day of survey
- Survey location
- Time of entry and exit
- Vehicle number plate
- Vehicle type (mode)
- Direction of movement (entering or exiting)

This systematic data collection process provided a robust dataset for subsequent analysis of traffic patterns, trip purposes, and vehicle movements relevant to the feasibility and planning of the proposed project.

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RESULTS

The collected data for each site was being analyzed at each site for the whole day and the Accumulation (%) per hour and occupancy (%) has been calculated for both weekdays and weekends. The data has been attached below:

Lake View Park

Weekend

Table 2 Parking Collection Data and results at Lake View Park-Weekend

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
8:00	9:00	25	6	19	19	6%
9:01	10:00	57	26	31	50	17%
10:01	11:00	102	52	50	100	33%
11:01	12:00	39	50	-11	89	30%
12:01	13:00	30	40	-10	79	26%
13:01	14:00	31	30	1	80	27%
14:01	15:00	28	22	6	86	29%
15:01	16:00	30	21	9	95	32%
16:01	17:00	22	18	4	99	33%
17:01	18:00	58	25	33	132	44%
18:01	19:00	58	28	30	162	54%
19:01	20:00	8	0	8	170	57%
20:01	21:00	0	0	0	170	57%
21:01	22:00	0	0	0	170	57%
22:01	23:00	0	0	0	170	57%
23:01	0:00	19	19	0	170	57%
		507	337			

Mode Share		
1	Motorcycle	138
2	cars	347
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	4
5	Mazda / Coaster	19
6	Trucks	0

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Weekdays

Table 3 Parking Collection Data and results at Lake View Park-Weekdays

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
8:00	9:00	26	5	21	21	7%
9:01	10:00	35	21	14	35	12%
10:01	11:00	36	32	4	39	13%
11:01	12:00	26	23	3	42	14%
12:01	13:00	27	28	-1	41	14%
13:01	14:00	22	27	-5	36	12%
14:01	15:00	27	30	-3	33	11%
15:01	16:00	35	37	-2	31	10%
16:01	17:00	32	32	0	31	10%
17:01	18:00	35	35	0	31	10%
18:01	19:00	41	41	0	31	10%
19:01	20:00	76	16	60	91	30%
20:01	21:00	0	2	-2	89	30%
21:01	22:00	0	0	0	89	30%
22:01	23:00	0	0	0	89	30%
23:01	0:00	0	0	0	89	30%
		418	329			

Table 4 Mode shift at Lake view park - weekdays

Mode Shift		
1	Motorcycle	167
2	cars	220
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	5
5	Mazda / Coaster	13
6	Trucks	0

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TMA Parking Murree

Weekend

Table 5 Parking Collection Data and results at TMA Parking Murree-Weekend

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
7:00	8:00	0	0	0	0	0%
8:01	9:00	4	0	4	4	14%
9:01	10:00	6	4	2	6	21%
10:01	11:00	27	10	17	23	82%
11:01	12:00	14	14	0	23	82%
12:01	13:00	13	15	-2	21	75%
13:01	14:00	13	8	5	26	93%
14:01	15:00	21	25	-4	22	79%
15:01	16:00	14	15	-1	21	75%
16:01	17:00	0	4	-4	17	61%
17:01	18:00	2	6	-4	13	46%
18:01	19:00	1	1	0	13	46%
19:01	20:00	3	13	-10	3	11%
20:01	21:00	2	5	-3	0	0%
21:01	22:00	0	0	0	0	0%
22:01	23:00	0	0	0	0	0%
23:01	0:00	0	0	0	0	0%
		120	120			

Table 6 Mode shift at TMA Car Parking - Weekday

Mode Shift		
1	Motorcycle	14
2	cars	2
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	13
5	Mazda / Coaster	0
6	Trucks	0
7	Others	24

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Weekday

Table 7 Parking Collection Data and results at TMA Car Park Murree-Weekdays

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
7:00	8:00	5	3	2	2	7%
8:01	9:00	4	1	3	5	18%
9:01	10:00	2	2	0	5	18%
10:01	11:00	3	0	3	8	29%
11:01	12:00	3	1	2	10	36%
12:01	13:00	2	3	-1	9	32%
13:01	14:00	1	2	-1	8	29%
14:01	15:00	2	2	0	8	29%
15:01	16:00	2	3	-1	7	25%
16:01	17:00	3	3	0	7	25%
17:01	18:00	2	2	0	7	25%
18:01	19:00	2	1	1	8	29%
19:01	20:00	1	2	-1	7	25%
20:01	21:00	2	1	1	8	29%
21:01	22:00	1	2	-1	7	25%
22:01	23:00	1	1	0	7	25%
23:01	0:00	0	0	0	7	25%
		36	29			

Table 8 Mode shift at TMA Car Parking - Weekends

Mode Shift		
1	Motorcycle	0
2	cars	36
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	0
5	Mazda / Coaster	0
6	Trucks	0

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H-9 Railway Station

Weekday

Table 9 Parking Collection Data and results at H-9 Railway Station -Weekdays

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
7:00	8:00	8	1	7	7	16%
8:01	9:00	0	1	-1	6	13%
9:01	10:00	0	0	0	6	13%
10:01	11:00	0	0	0	6	13%
11:01	12:00	0	0	0	6	13%
12:01	13:00	0	0	0	6	13%
13:01	14:00	1	0	1	7	16%
14:01	15:00	27	23	4	11	24%
15:01	16:00	6	11	-5	6	13%
16:01	17:00	7	3	4	10	22%
17:01	18:00	4	12	-8	2	4%
18:01	19:00	0	0	0	2	4%
19:01	20:00	0	0	0	2	4%
20:01	21:00	0	0	0	2	4%
21:01	22:00	0	0	0	2	4%
22:01	23:00	0	0	0	2	4%
23:01	0:00	0	0	0	2	4%
		53	51			

Table 10 Mode Share at H-9 Railway Station -Weekdays

Mode Share		
1	Motorcycle	14
2	cars	35
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	0
5	Mazda / Coaster	0
6	Trucks	0

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Weekend

Table 11 Parking Collection Data and results at H-9 Railway Station -Weekends

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
7:00	8:00	7	0	7	7	16%
8:01	9:00	8	3	5	12	27%
9:01	10:00	4	6	-2	10	22%
10:01	11:00	7	7	0	10	22%
11:01	12:00	6	5	1	11	24%
12:01	13:00	7	6	1	12	27%
13:01	14:00	6	6	0	12	27%
14:01	15:00	5	8	-3	9	20%
15:01	16:00	7	4	3	12	27%
16:01	17:00	5	7	-2	10	22%
17:01	18:00	7	5	2	12	27%
18:01	19:00	5	8	-3	9	20%
19:01	20:00	5	9	-4	5	11%
20:01	21:00	0	1	-1	4	9%
21:01	22:00	0	0	0	4	9%
22:01	23:00	0	0	0	4	9%
23:01	0:00	0	0	0	4	9%
		79	75			

Table 12 Mode Share at H-9 Railway Station -Weekends

Mode Share		
1	Motorcycle	11
2	cars	62
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	2
5	Mazda / Coaster	0
6	Trucks	0

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Shakarpariyan Car Park

Weekday

Table 13 Parking Collection Data and results at Shakarpariyan -Weekdays

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
7:00	8:00	0	0	0	0	0%
8:01	9:00	1	0	1	1	0%
9:01	10:00	3	2	1	2	1%
10:01	11:00	9	8	1	3	1%
11:01	12:00	21	9	12	15	5%
12:01	13:00	12	9	3	18	6%
13:01	14:00	32	20	12	30	10%
14:01	15:00	12	23	-11	19	6%
15:01	16:00	16	20	-4	15	5%
16:01	17:00	9	11	-2	13	4%
17:01	18:00	26	23	3	16	5%
18:01	19:00	31	26	5	21	7%
19:01	20:00	22	27	-5	16	5%
20:01	21:00	0	9	-9	7	2%
21:01	22:00	0	7	-7	0	0%
22:01	23:00	0	0	0	0	0%
23:01	0:00	0	0	0	0	0%
		194	194			

Table 14 Mode Share at Shakarpariyan - Weekdays

Mode Share		
1	Motorcycle	1
2	cars	44
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	0
5	Mazda / Coaster	5
6	Trucks	1
7	others	8

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Weekend

Table 15 Parking Collection Data and results at Shakarpariyan -Weekends

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
7:00	8:00	2	0	2	2	1%
8:01	9:00	2	3	-1	1	0%
9:01	10:00	2	2	0	1	0%
10:01	11:00	2	1	1	2	1%
11:01	12:00	10	8	2	4	2%
12:01	13:00	6	3	3	7	3%
13:01	14:00	3	5	-2	5	2%
14:01	15:00	4	5	-1	4	2%
15:01	16:00	4	3	1	5	2%
16:01	17:00	3	4	-1	4	2%
17:01	18:00	4	4	0	4	2%
18:01	19:00	3	3	0	4	2%
19:01	20:00	0	5	-5	-1	0%
20:01	21:00	0	0	0	-1	0%
21:01	22:00	0	0	0	-1	0%
22:01	23:00	0	0	0	-1	0%
23:01	0:00	0	0	0	-1	0%
		45	46			

Table 16 Mode Share at Shakarpariyan - Weekends

Mode Share		
1	Motorcycle	23
2	cars	23
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	0
5	Mazda / Coaster	0
6	Trucks	0

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GPO Car Parking

Weekdays

Table 17 Parking Collection Data and results at GPO Car Park -Weekdays

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
7:00	8:00	3	2	1	1	3%
8:01	9:00	3	2	1	2	7%
9:01	10:00	2	0	2	4	13%
10:01	11:00	3	1	2	6	20%
11:01	12:00	1	3	-2	4	13%
12:01	13:00	3	2	1	5	17%
13:01	14:00	5	3	2	7	23%
14:01	15:00	7	1	6	13	43%
15:01	16:00	6	4	2	15	50%
16:01	17:00	5	5	0	15	50%
17:01	18:00	10	8	2	17	57%
18:01	19:00	2	5	-3	14	47%
19:01	20:00	4	7	-3	11	37%
20:01	21:00	1	0	1	12	40%
21:01	22:00	2	0	2	14	47%
22:01	23:00	3	0	3	17	57%
23:01	0:00	0	0	0	17	57%
		60	43			

Table 18 Mode Share at GPO car park - Weekdays

Mode Shift		
1	Motorcycle	0
2	cars	52
3	. Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	0
5	Mazda / Coaster	0
6	Trucks	0
7		0

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Weekends

Table 19 Parking Collection Data and results at GPO Car Park -Weekends

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
7:00	8:00	0	0	0	0	0%
8:01	9:00	0	0	0	0	0%
9:01	10:00	0	0	0	0	0%
10:01	11:00	10	9	1	1	3%
11:01	12:00	10	9	1	2	7%
12:01	13:00	41	42	-1	1	3%
13:01	14:00	30	30	0	1	3%
14:01	15:00	35	34	1	2	7%
15:01	16:00	15	13	2	4	13%
16:01	17:00	13	6	7	11	37%
17:01	18:00	14	14	0	11	37%
18:01	19:00	19	25	-6	5	17%
19:01	20:00	10	11	-1	4	13%
20:01	21:00	0	3	-3	1	3%
21:01	22:00	0	0	0	1	3%
22:01	23:00	0	0	0	1	3%
23:01	0:00	0	0	0	1	3%
		197	196			

Table 20 Mode Share at GPO car park - Weekends

1	Motorcycle	45
2	cars	97
3	. Rickshaw / Qingqi	1
4	Wagon/Suzuki/Mini-Bus	50
5	Mazda / Coaster	1
6	Trucks	0
7	Other	2

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ANALYSIS

As part of the Parking Study for the Murree–Islamabad Tourist Glass Train Project, a focused analysis was conducted to estimate parking flux—the volume and pattern of vehicle inflow and outflow at potential parking nodes along the alignment. The purpose of this analysis was to quantify hourly and daily parking demand that would result from increased train ridership, and to design an effective park-and-ride (PnR) strategy that supports the anticipated modal shift.

Estimation of Parking Flux

To estimate the parking flux, the study relied on a combination of:

- **Ridership Projections:** Derived from the main feasibility study, this data provided estimates of the number of passengers expected to use the Glass Train service daily, including breakdowns by direction and station.
- **Modal Split Assumptions:** Based on local travel patterns, stakeholder consultations, and global best practices for similar tourist train systems, assumptions were made regarding the percentage of riders likely to arrive at stations via private vehicles.
- **Temporal Distribution Factors**: Historical traffic patterns, tourism trends, and seasonal variations were analyzed to distribute projected demand across time intervals (e.g., hourly), enabling the identification of peak periods for parking demand.

Proposal for Park-and-Ride Facilities

Based on the estimated parking flux, the study proposed a series of strategically located park-and-ride (PnR) facilities along the train corridor. These facilities are intended to:

- **Support seamless multimodal integration** by enabling travelers to park their vehicles and transfer to the train system with ease.
- **Relieve traffic congestion** in Murree and other high-density zones by capturing vehicle traffic at peripheral or intermediate nodes.
- **Enhance accessibility** to the train service, especially for tourists and commuters coming from suburban or outlying areas.

The proposed park-and-ride locations were identified based on:

- Proximity to major train stations and feeder roads
- Land availability for parking infrastructure
- Connectivity to local transport modes
- Current and projected parking demand levels

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Each proposed site was evaluated for its suitability to host adequate parking capacity during peak hours, and preliminary sizing recommendations were made accordingly. In addition to conventional surface parking layouts, the study considered the need for multi-level parking structures in high-demand areas and suggested features.

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PUNJAB MASS TRANSIT AUTHORITY (PMA) GOVT OF THE PUNJAB

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM ISLAMABAD TO MURREE



MULTICHANNEL ANALYSIS OF SURFACE WAVES (MASW) SURVEY REPORT

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DISCLAIMER

This report was prepared by National Engineering Services Pakistan Private Limited (NESPAK) for the project titled "Consultancy Services for Feasibility Study for Tourist Glass Train from Islamabad to Murree, Punjab, Pakistan". The information in this report reflects the results of multichannel analysis of surface waves on actual field data collected from January 18, 2025 to February 14, 2025. These results are intended to be used for the investigated MASW profile locations at the site and cannot be practiced to incur subsurface information at locations other than those mentioned in this report.

This report and the information presented are exclusively for the use of the authorized recipient. Any use that a third party makes of this report or any reliance on decisions to be based on it, is prohibited.

The findings of this report are a result of discrete investigations conducted according to normal practices. Under no conditions, however, do these findings represent the actual state of ground conditions at all points across the project area.

The construction activity may alter the conditions from those prevailing at the time; this report was prepared or may reveal somewhat different conditions. NESPAK does not accept any responsibility for the changes; if revealed in the subsurface geophysical conditions provided in this report.

MULTICHANNEL ANALYSIS OF SURFACE WAVES (MASW) SURVEY REPORT

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LIST OF ABBREVIATIONS / ACRONYMS

GOP	Government of Punjab
GPS	Global Positioning System
MASW	Multichannel Analysis of Surface Waves
NESPAK	National Engineering Services Pakistan Private Limited
PMA	Punjab Mass Transit Authority

EXECUTIVE SUMMARY

The Government of Punjab has introduced a transformative scheme to establish a scenic rail link between Rawalpindi/Islamabad and Murree, designed to enhance accessibility for both the public and tourists. The highlight of the project is the proposed Glass Train, a scenic rail concept featuring large windows and glass ceilings to provide passengers with uninterrupted panoramic views of the breathtaking mountainous terrain. Such trains are globally recognized for their popularity in scenic destinations, such as Switzerland, Norway, Japan, and Canada, offering a unique and immersive travel experience.

As part of the consultancy agreement, non-destructive geophysical investigation consisting of Multichannel Analysis of Surface Waves (MASW) survey was carried out to determine the shear wave velocity profile up to 30 meters depth (Vs_{30}), at the selected locations of proposed Glass Train Route from Islamabad to Murree. Shear Wave Velocity (Vs and Vs30) is a mandatory requirement as an input parameter for the following studies (as per international standards and guidelines like Building Code of Pakistan-Seismic Provision 2007, Universal Building Codes etc.)

1) Seismic hazard assessment of the project.
2) Geological/geotechnical studies like

Site characterization/soil profile type and to meet other related geotechnical/geological objectives e.g;

- Stiffness of material,
- Cyclic liquefaction
- Dynamic Parameters
- Bearing Capacity, etc.

This current MASW report will provide a ground truthing scientific base to the above mentioned studies effectively.

A total of Seventy one (71) MASW Survey Profiles were performed by NESPAK geophysicists. The estimated depth of investigation for each MASW profile is 30.0 meters. The location of each MASW survey profile is shown in Figure 1a to 1h.

The site specific results of the Multichannel Analysis of Surface Waves (MASW) Survey have been calculated for each MASW survey profile location, which are shown in Figures 3 to 73.

As per MASW survey results from the site, shear wave velocity derived Vs30 is 560 m/sec. As per Building Code of Pakistan-Seismic Provision 2007, the subsoil has been categorized as “Sc” as per requirements provided in Section 5 of this report.

1. INTRODUCTION:

Multichannel Analysis of Surface Waves (MASW) survey is carried out to provide the input parameter of shear wave velocity and Vs30.

Shear Wave Velocity (Vs and Vs30) is a mandatory requirement as an input parameter for the following studies (as per international standards and guidelines like Building Code of Pakistan-Seismic Provision 2007, Universal Building Codes etc.)

1) Seismic hazard assessment of the project.
2) Geological/geotechnical studies like

Site characterization/soil profile type and to meet other related geotechnical/geological objectives e.g;

- Stiffness of material,
- Cyclic liquefaction
- Dynamic Parameters
- Bearing Capacity, etc.

This current MASW report will provide a ground truthing scientific base to the above mentioned studies effectively. The shear wave velocity (Vs30) profile up to 30-meters depth was calculated at selected locations along the proposed route of glass train.

The NESPAK geophysicists proceeded for field visit to perform MASW survey on January 18, 2025. Before the execution of the MASW survey, a site reconnaissance survey was carried out for better understanding of the proposed route of glass train, planning and selection of the MASW survey points. A total of Seventy one (71) MASW survey profiles were executed at selected locations along the proposed route of glass train. These MASW survey profiles are designated as MASW-1 to MASW-71 and their locations are shown in Figure 1a to 1h. According to observation of surface geology during MASW survey silty clay/gravel/boulders/alternate beds of shale/sandstone etc. are present at surface.

The coordinates of the center point of each MASW Survey profile were taken by a handheld GPS during the execution of the survey as shown in Table-1.

Table-1: Coordinates of Multichannel Analysis of Surface Waves Observation Points

MASW NO.	LOCATION	EASTING (m)	NORTHING (m)	SURFACE GEOLOGY
MASW-01	H9/Margala Station	33.663517°	73.047939°	Silty clay/clayey silt was present along the profile
MASW-02	H9/Margala Station	33.663699°	73.047949°	Silty clay/clayey silt was present along the profile
MASW-03	Existing Bridge In front of NUML	33.666803°	73.054374°	Silty clay/clayey silt was present along the profile
MASW-04	Khyaban e Johar Station	33.668227°	73.057315°	Silty clay/clayey silt was present along the profile
MASW-05	Khyaban e Johar Station	33.670734°	73.062121°	Silty clay/clayey silt was present along the profile
MASW-06	Near Existing Bridge In front of Al Shifa	33.673083°	73.066337°	Silty clay/clayey silt was present along the profile
MASW-07	Existing Bridge Near Faizabad Chowk	33.668241°	73.088968°	Silty clay/clayey silt was present along the profile
MASW-08	Along the Proposed Route option no.4	33.675353°	73.093401°	Silty clay/clayey silt was present along the profile
MASW-09	Along the Proposed Route option no.4	33.681188°	73.098337°	Silty clay/clayey silt was present along the profile
MASW-10	WAPDA Colony Station	33.686256°	73.110597°	Silty clay/clayey silt was present along the profile
MASW-11	WAPDA Colony Station	33.690759°	73.111610°	Silty clay/clayey silt was present along the profile

MASW-12	Lake View Park Station	33.717329°	73.124547°	Silty clay/clayey silt/gravel and boulder was present along the profile
MASW-13	Near Existing Bridge Jinnah Stream	33.720106°	73.129358°	Silty clay/clayey silt was present along the profile
MASW-14	Along the Proposed Route option no.4	33.729394°	73.138311°	Silty clay/clayey silt was present along the profile
MASW-15	Existing Bridge along QAU road	33.736067°	73.144944°	Silty clay/clayey silt was present along the profile
MASW-16	Existing Bridge along QAU road	33.736581°	73.145905°	Silty clay/clayey silt was present along the profile
MASW-17	Along the Proposed Route Shahdra Valley	33.751734°	73.160989°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-18	Along the Proposed Route Shahdra Valley	33.755810°	73.166232°	Silty clay/clayey silt was present along the profile
MASW-19	Bharakhu Station	3.759919°	73.172771°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-20	Bharakhu Station	33.760568°	73.172448°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-21	Along the Proposed Route Shahdra Valley	33.764257°	73.179356°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-22	Along the Proposed Route Shahdra Valley	33.759899°	73.183931°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-23	Along the Proposed Route Shahdra Valley	33.754157°	73.187764°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-24	Existing Bridge	33.754872°	73.203869°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-25	Proposed Bridge Bharakhu	33.765975°	73.214586°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-26	Along the Proposed Route	33.767489°	73.220989°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-27	Existing Bridge Korang river	33.772525°	73.236997°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-28	Chatar park Station	33.777006°	73.243408°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-29	Chatar park Station	33.777217°	73.242808°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-30	Bahria Golf City Station	33.794731°	73.276631°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-31	Bahria Golf City Station	33.795092°	73.276142°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-32	Proposed Bridge	33.805655°	73.294044°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-33	Manga Station	33.809453°	73.295736°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-34	Manga Station	33.809629°	73.295351°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-35	Shakarparian Station	33.681943°	73.075331°	Silty clay/clayey silt was present along the profile
MASW-36	Shakarparian Station	33.681816°	73.076116°	Silty clay/clayey silt was present along the profile
MASW-37	Aabpara Station	33.705282°	73.087353°	Silty clay/clayey silt was present along the profile
MASW-38	Aabpara Station	33.704099°	73.087100°	Silty clay/clayey silt was present along the profile
MASW-39	Barakhu Station	33.732047°	73.147767°	Silty clay/clayey silt was present along the profile
MASW-40	Barakhu Station	33.731173°	73.148597°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-41	Qauid e Azam University Station	33.744415°	73.158701°	Silty clay/clayey silt was present along the profile
MASW-42	Qauid e Azam University Station	33.744191°	73.159091°	Silty clay/clayey silt was present along the profile
MASW-43	Shahdara Valley Station	33.766126°	73.180359°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-44	Shahdara Valley Station	33.766295°	73.179946°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-45	Proposed Cut near Shahdara Valley	33.772069°	73.186410°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-46	Proposed Tunnel (Inlet) near Shahdara Valley	33.781377°	73.191620°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-47	Proposed Tunnel (center) near Shahdara	33.784701°	73.203598°	Silty clay/clayey silt and gravel/boulder was present along the profile

	Valley			
MASW-48	Proposed Tunnel (outlet) near Shahdara Valley	33.787189°	73.200613°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-49	Proposed Bridge adjacent to Judicial colony	33.800825°	73.242911°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-50	Proposed Tunnel (inlet) near Judicial colony	33.800531°	73.254146°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-51	Proposed Tunnel (center)	33.800327°	73.255493°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-52	Proposed Tunnel (outlet) near Judicial colony	33.806814°	73.263716°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-53	Proposed Bridge near Judicial colony	33.806597°	73.265145°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-54	Tret Valley Amusement Park Station	33.814683°	73.281501°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-55	NandKot station	33.840803°	73.318324°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-56	NandKot station	33.840319°	73.317473°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-57	Track Crossing from Road at Nandkot	33.841483°	73.320670°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-58	Proposed Cut	33.856666°	73.335896°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-59	Proposed Tunnel (inlet)	33.857903°	73.337030°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-60	Proposed Tunnel (center)	33.858593°	73.338401°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-61	Proposed Tunnel (outlet)	33.860202°	73.339114°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-62	Proposed Cut	33.874746°	73.345365°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-63	Ghora Gali Station	33.881161°	73.360590°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-64	Ghora Gali Station	33.881190°	73.360974°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-65	Pindi Point Station	33.881190°	73.360974°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-66	Pindi Point Station	33.893340°	73.367751°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-67	Proposed Tunnel (inlet) near Pindi Point	33.895135°	73.368376°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-68	Proposed Tunnel (center) near Pindi Point	33.893825°	73.374468°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-69	Proposed Tunnel (outlet) near Pindi Point	33.892928°	73.378508°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-70	Murree Terminal	33.906942°	73.382416°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-71	Murree Terminal	33.908300°	73.382661°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile

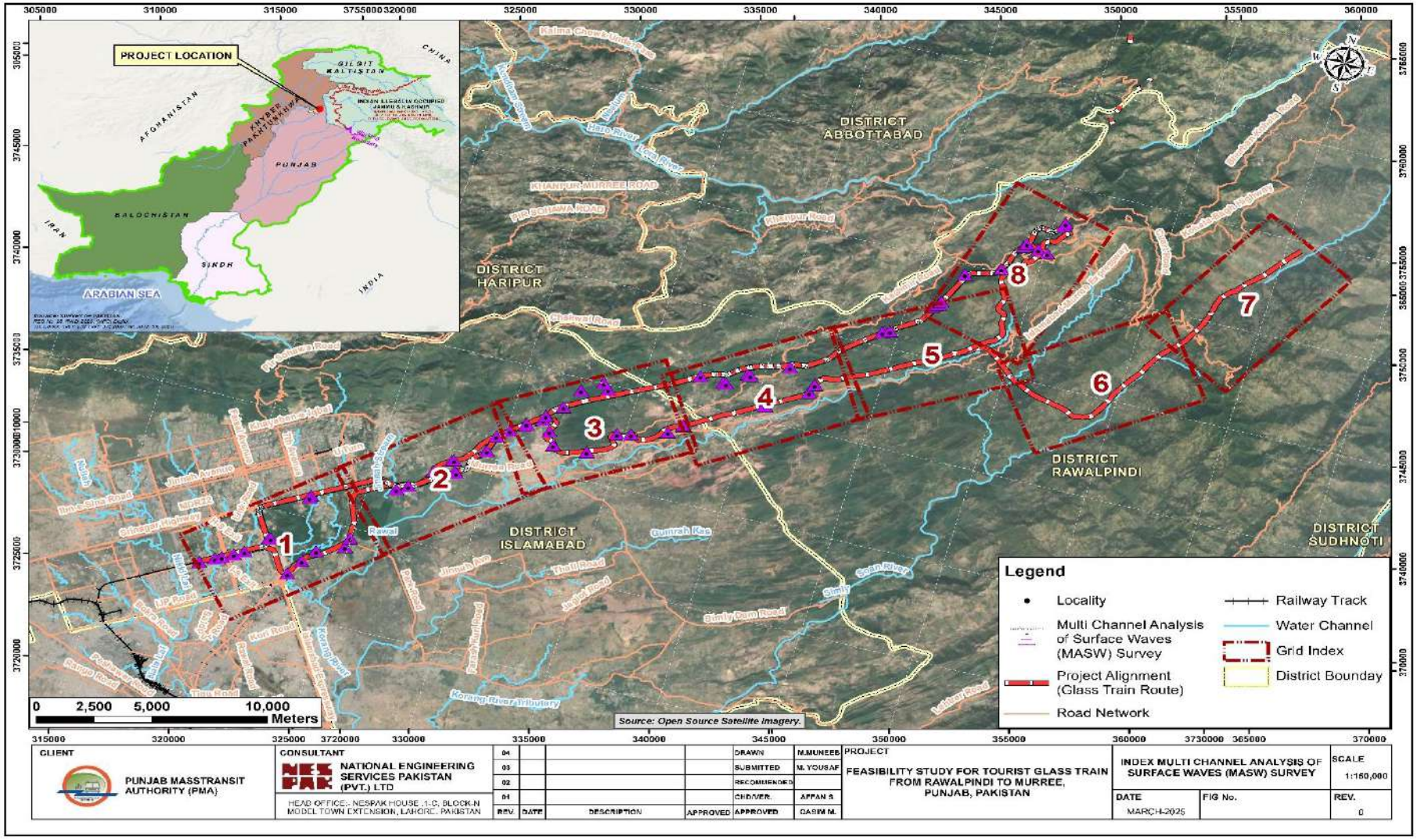


Figure 1: Satellite Image Exhibiting the Spread of MASW Survey Profile Locations for Glass Train Project from Islamabad to Murree

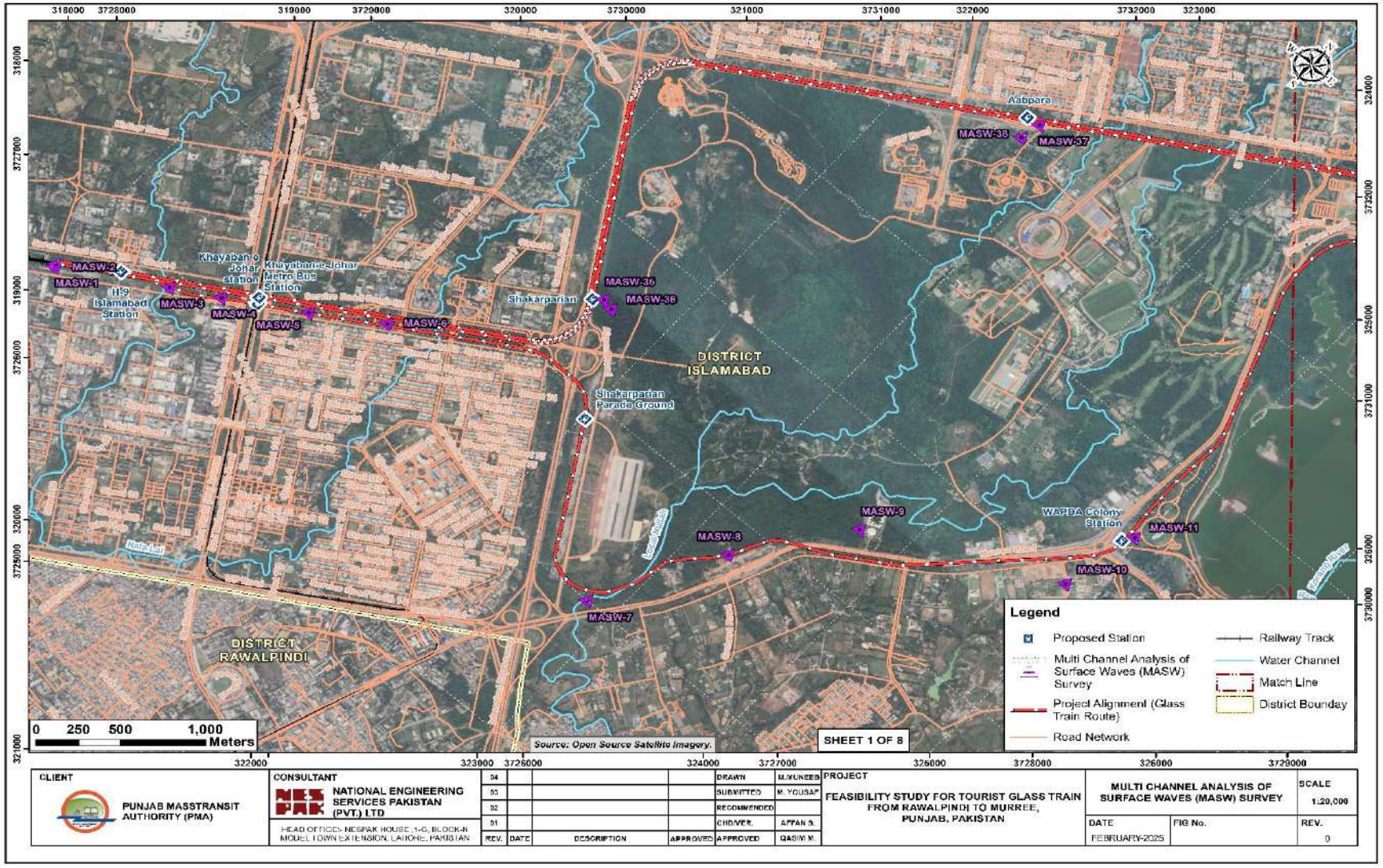


Figure 1a: Satellite Image Exhibiting the Spread of MASW Survey Profile Locations for Glass Train Project from Islamabad to Murree

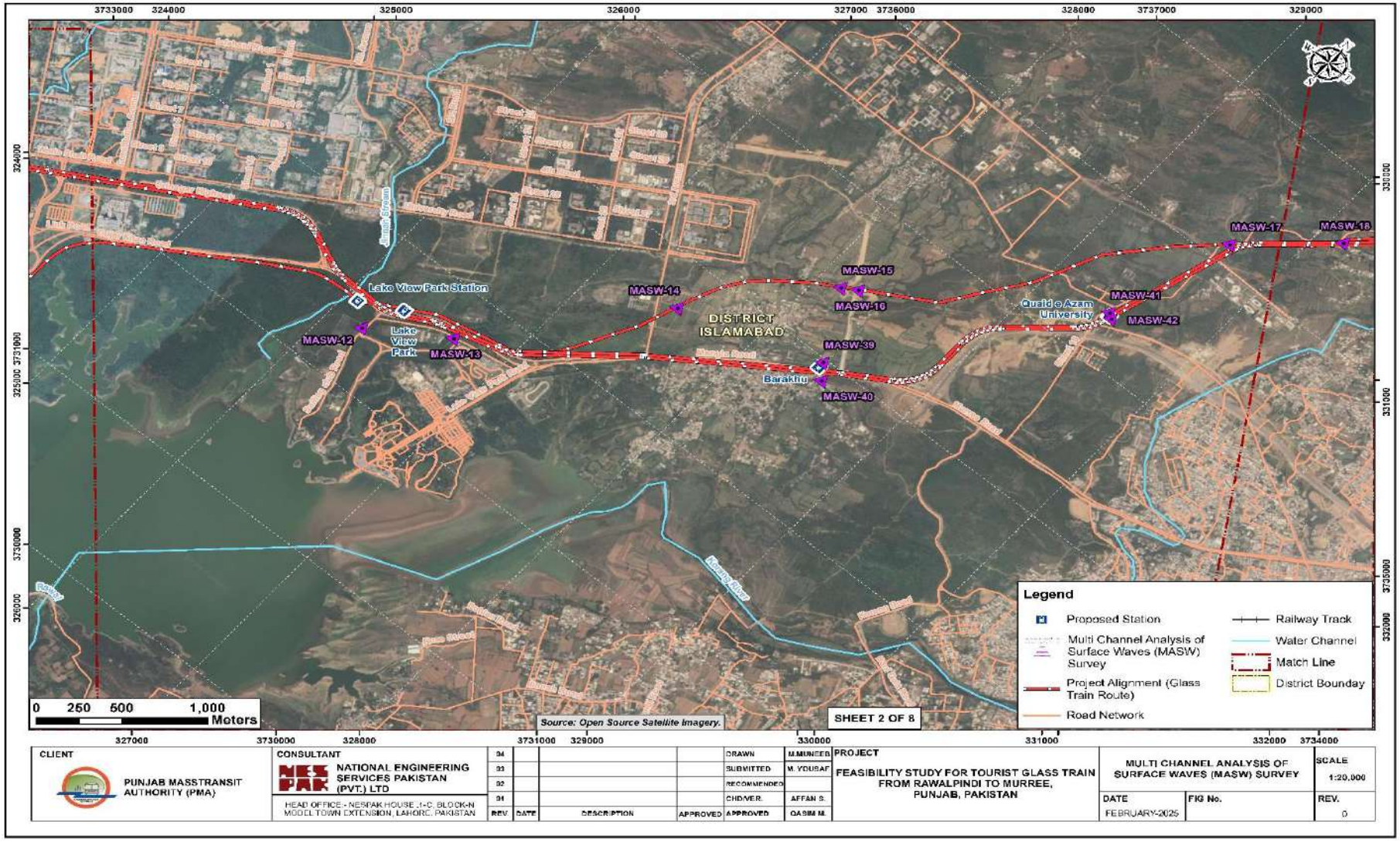


Figure 1b: Satellite Image Exhibiting the Spread of MASW Survey Profile Locations for Glass Train Project from Islamabad to Murree

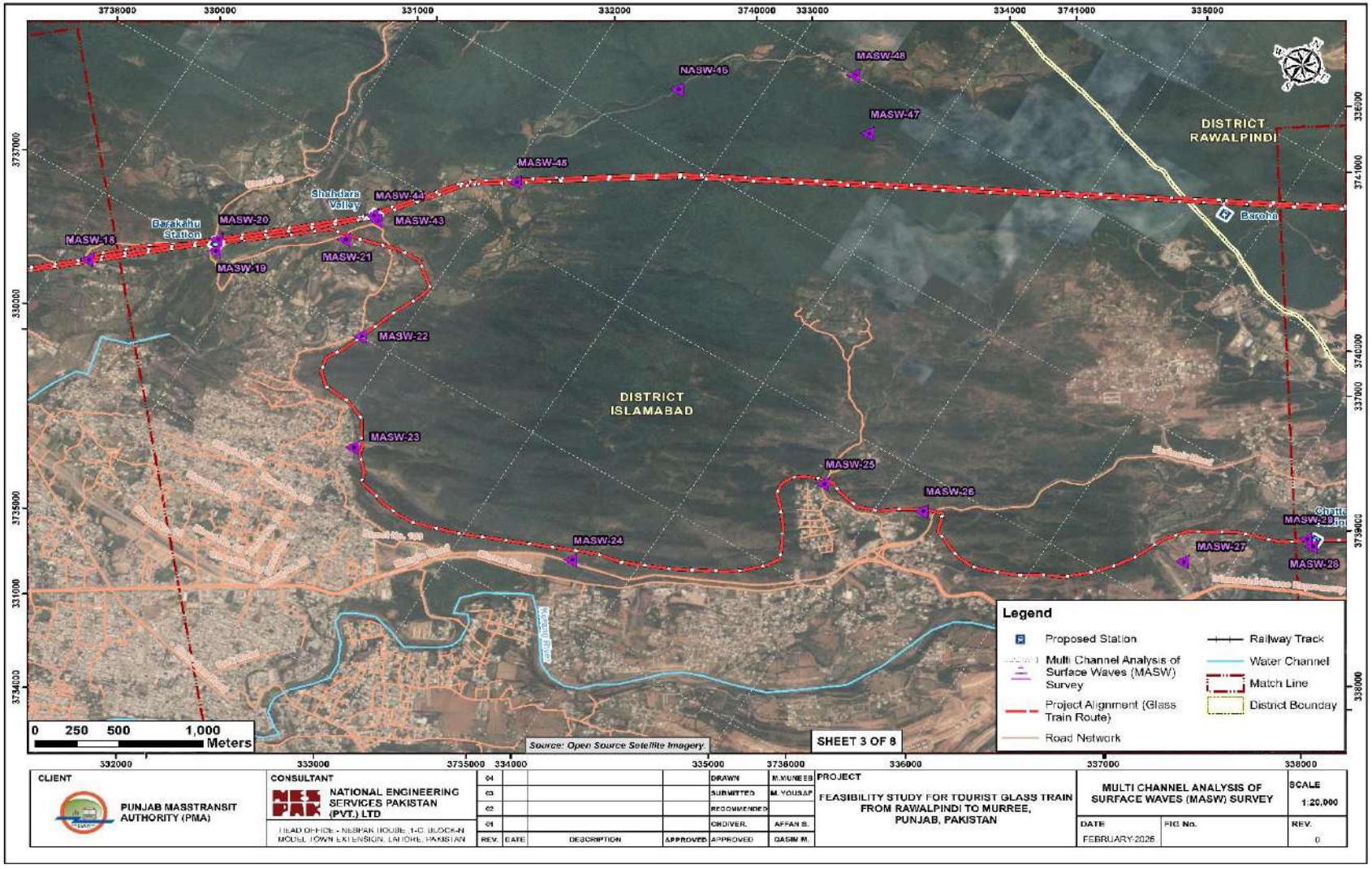


Figure 1c: Satellite Image Exhibiting the Spread of MASW Survey Profile Location for Glass Train Project from Islamabad to Murree

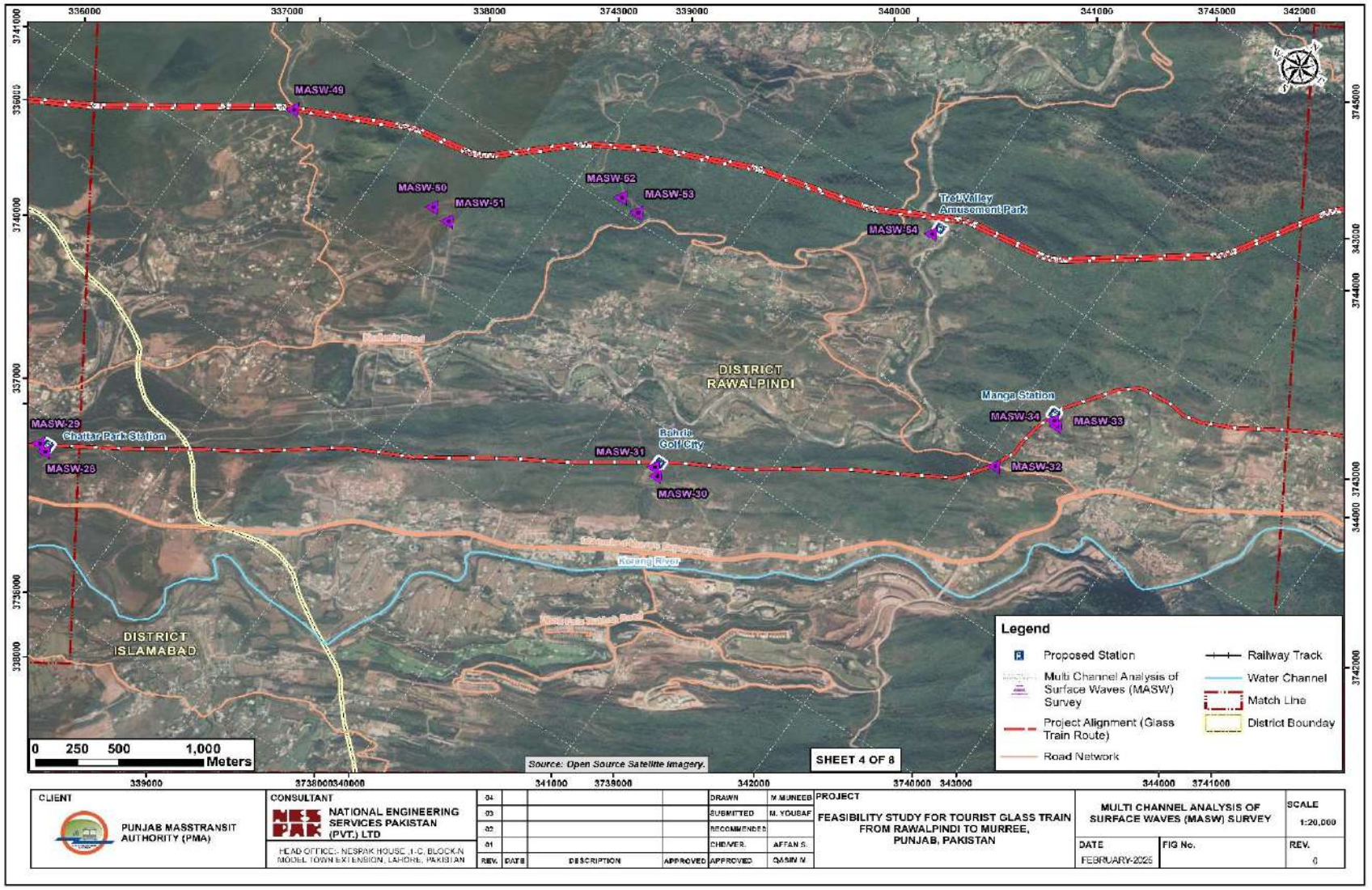


Figure 1d: Satellite Image Exhibiting the Spread of MASW Survey Profile Locations for Glass Train Project from Islamabad to Murree

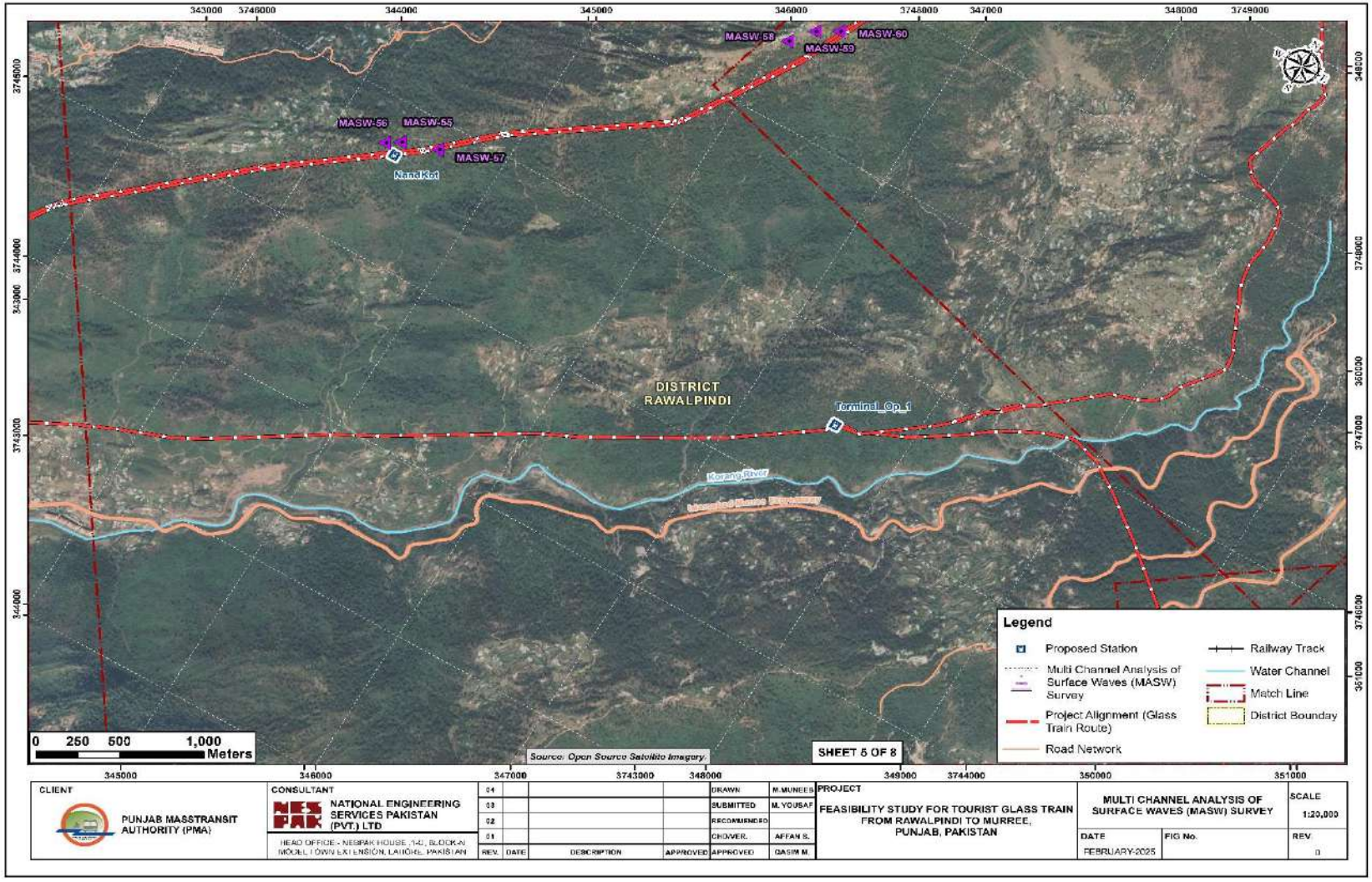


Figure 1e: Satellite Image Exhibiting the Spread of MASW Survey Profile Locations for Glass Train Project from Islamabad to Murree

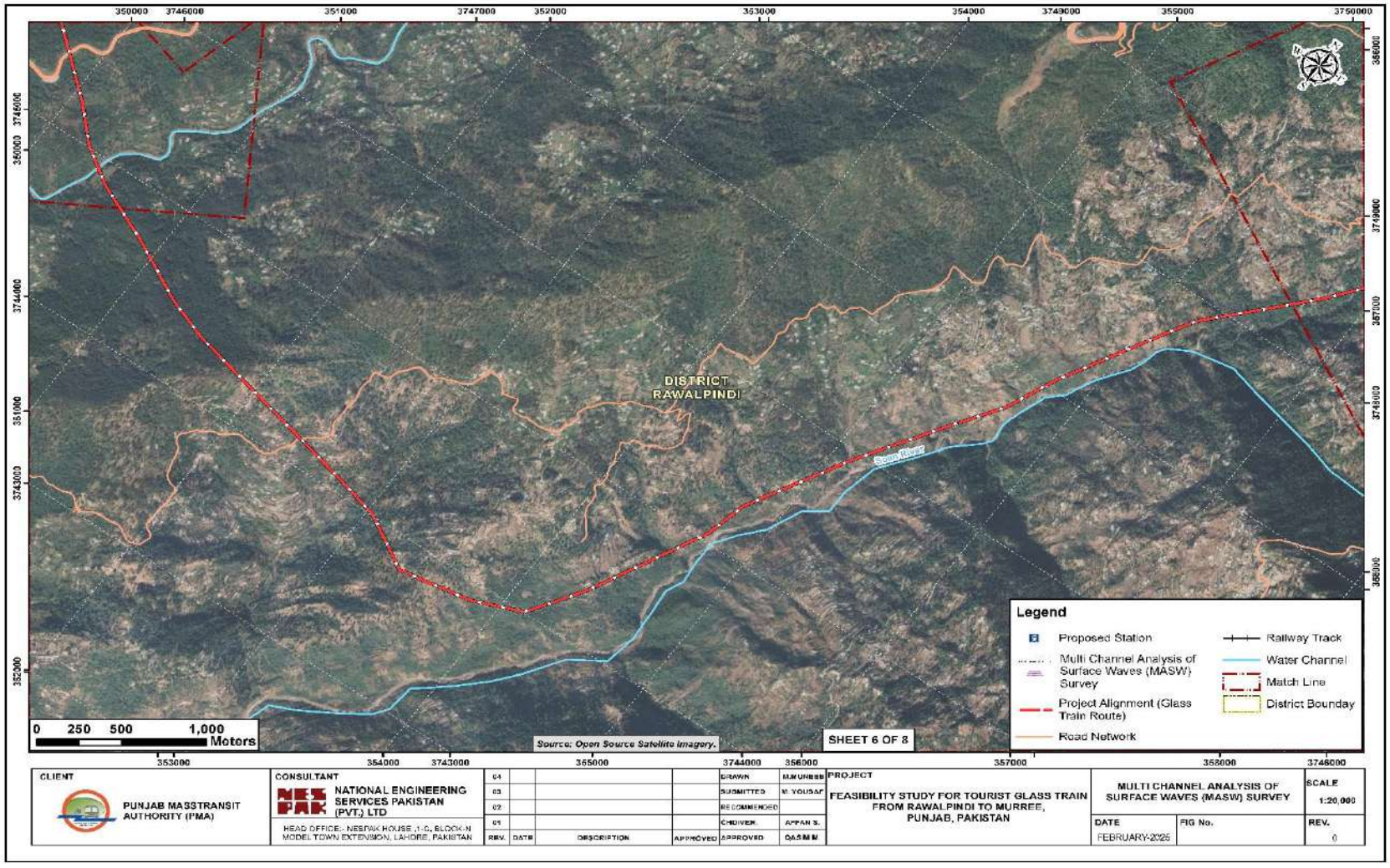


Figure 1f: Satellite Image Exhibiting the Spread of MASW Survey Profile Locations for Glass Train Project from Islamabad to Murree

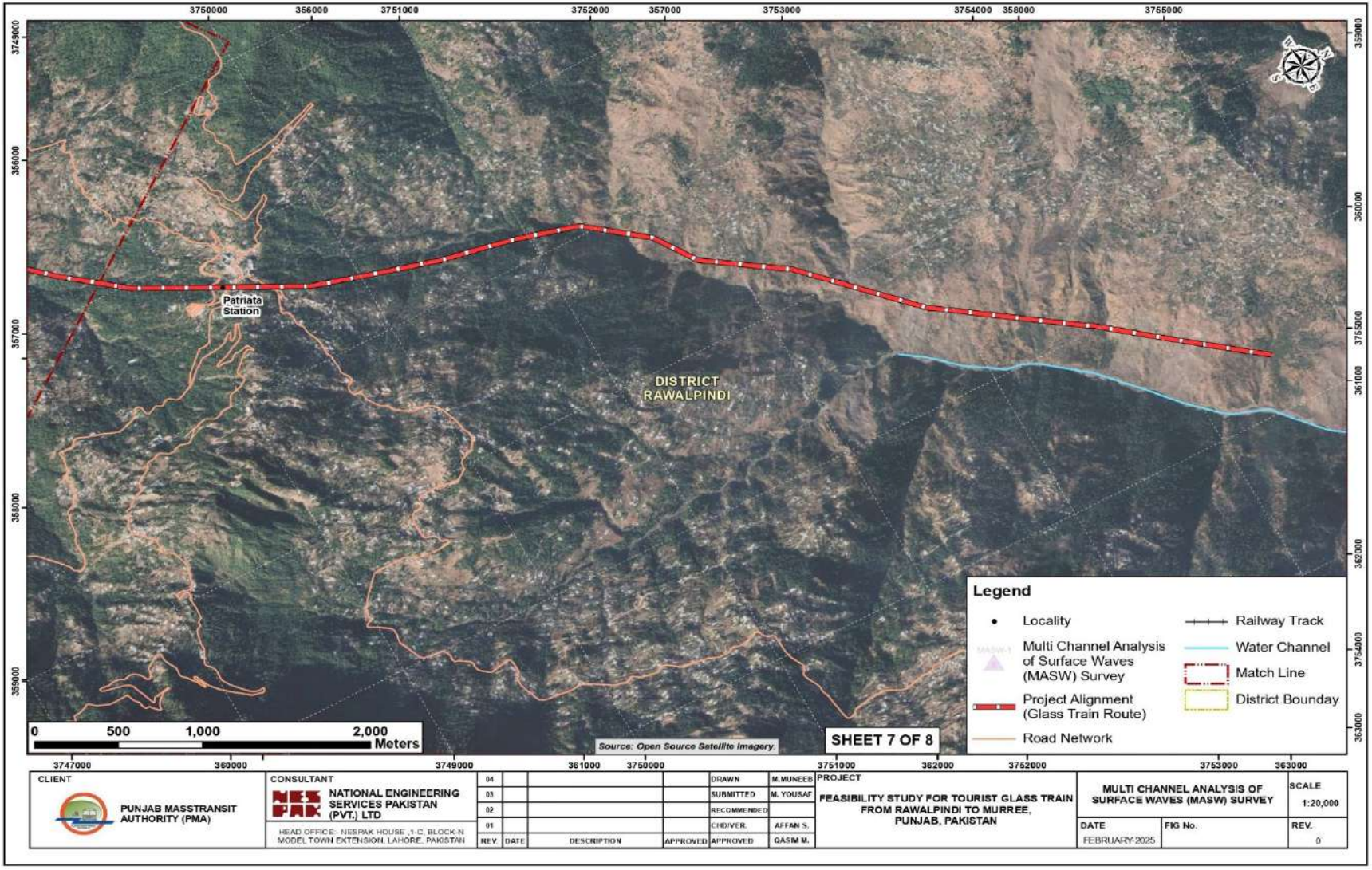


Figure 1g: Satellite Image Exhibiting the Spread of MASW Survey Profile Locations for Glass Train Project from Islamabad to Murree

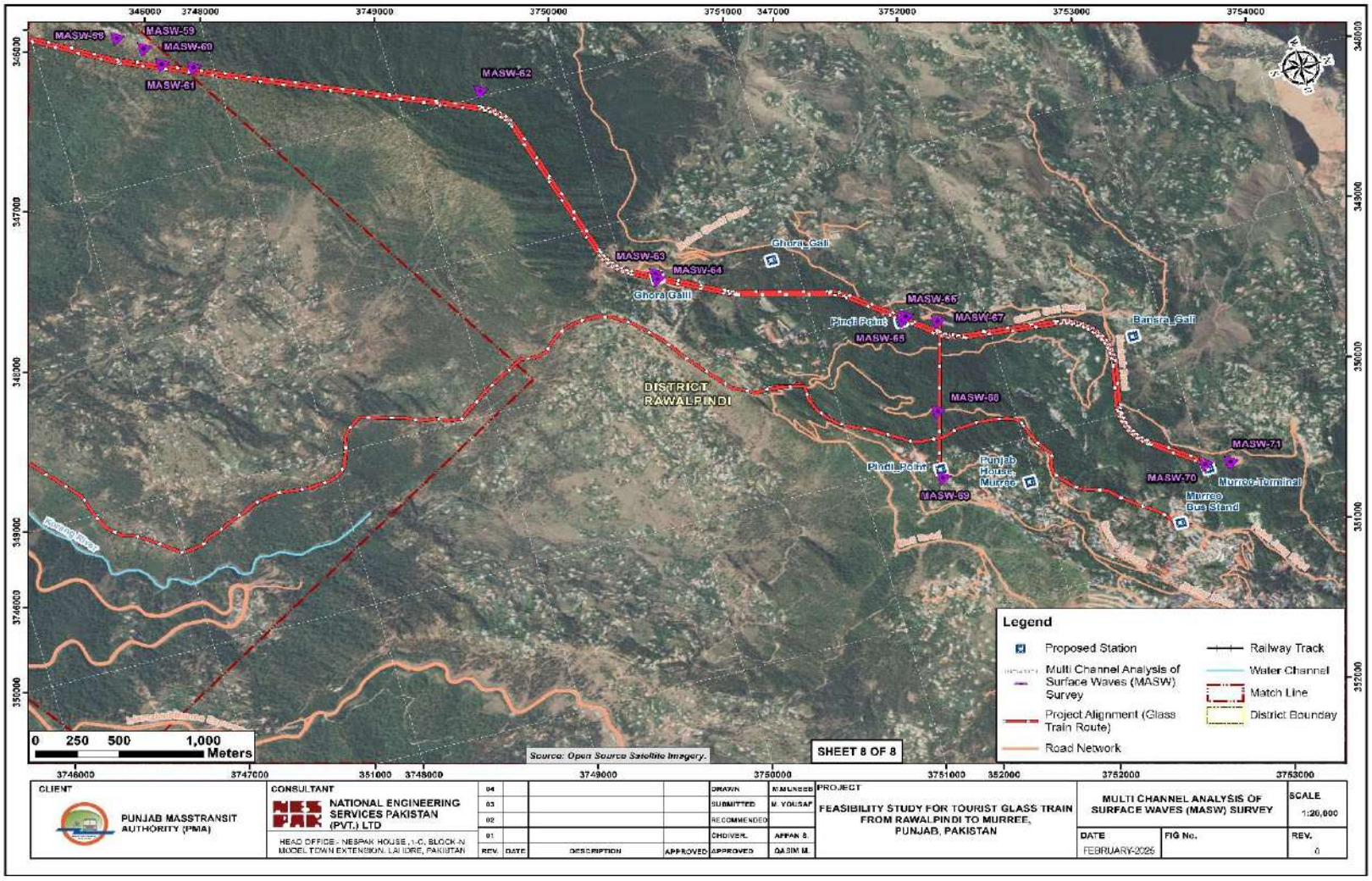


Figure 1h: Satellite Image Exhibiting the Spread of MASW Survey Profile Locations for Glass Train Project from Islamabad to Murree

2. SCOPE OF WORK

In order to investigate the shear wave velocity profile up to 30 meters depth (Vs_{30}), the following scope of services is envisaged:

a) Site reconnaissance to assess the site conditions and selection of MASW Survey profile locations along the proposed glass train.
b) Data acquisition at selected locations which were proposed by the seismologist.
c) Processing, analysis and inversion of shear wave data recorded at the site.
d) Preparation of site specific MASW Survey report, including;
    - Inverted cross sections of shear wave velocities with respect to depth at each MASW Survey profile location up to a depth of investigation of 30.0 m.
    - Site characterization/soil profile type of the project area as per Building Code of Pakistan-Seismic Provisions 2007, which will further support to Geotechnical expert/studies.

3. PRINCIPLE OF MULTICHANNEL ANALYSIS OF SURFACE WAVES (MASW) SURVEY

The MASW method utilizes the surface waves propagating parallel to the earth's surface without dissipating or spreading energy in the earth's interior. The surface waves have the strongest energy (more than two-thirds of the total energy is carried by the surface waves) and hence Rayleigh waves appear as dominant events in seismic records. Therefore, Rayleigh waves, the principal component of ground rolls are used as they permit a simpler acquisition.

The MASW method is based on the following fundamental postulates:

(a) The seismic waves propagate with different velocities in different geological strata.
(b) The contrasts between the seismic wave velocities across the geological boundaries are large.

The active MASW adopts the conventional seismic refraction mode of survey using receivers and an active seismic source such as steel plate/sledge hammers, weight drops etc. placed in a straight line, which is called in-line profiling system. The impact of the ground motion on the detectors is transformed into an electric current and the signal (in the form of current) is transmitted by seismic cables to a seismograph, which comprises an amplifying unit and a multichannel recorder. The instant of the explosion or the impact from a mechanical energy source is also recorded by the seismograph through a trigger device.

The MASW method consists of measuring (along the ground surface) the seismic waves (Rayleigh waves) generated by the impulsive energy source. The arrival of the waves at the receiving stations after propagation through the earth is recorded by detectors (low frequency geophones 4.5 Hertz vertical) sensitive to vibration. Dispersion nature of Rayleigh waves is imaged through wave-field transformation of seismic record by frequency wave-number (f-k) or slowness-frequency (p-f) transform. From the dispersion image, a dispersion curve of the fundamental mode of Rayleigh waves is selected, which is then inverted for a 1D Vs Profile.

The interpretation giving the depths and velocities can be carried out by data processing. The reliability in the determination of the depths and layer velocities increases if the seismic signals are recorded in both directions along the detector spread. The schematic diagram of MASW Survey is shown in Figure 2.

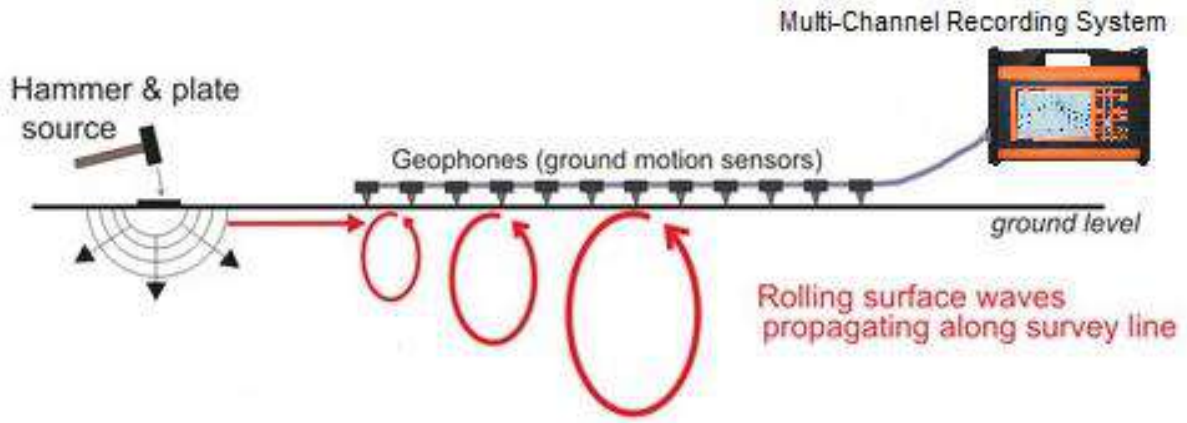


Figure 2: Schematic Diagram of MASW Survey

4. FIELD PROCEDURE

A twenty-four (24) channel Signal Enhancement Seismograph "TERRALOC Pro-2" of ABEM, Sweden was used in the field for the recording of the arrival time of seismic waves. For the multichannel analysis of surface waves, twenty four (24) geophones (4.5 Hertz vertical) were placed on the ground surface in a straight line at different intervals of about 2, 2.5 and 3 meters along the profile line. The seismic waves were produced at the source point by striking a sledge-hammer on a steel plate. The number of impacts (i.e. stacks) at each shooting point was taken five (5) to increase the signal-to-noise ratio to improve the data quality. Variable number of shots at offset distances of 4m, 5m, 6m, 7m, 8m, 9m and 12m were taken at one side of the spread. The method of reverse shooting was adopted in which seismic waves are produced on both ends of the geophones spread and the Rayleigh waves are recorded from both directions at the same offset distance.

The coordinates of the MASW Survey profiles locations were taken by a handheld GPS during the execution of the survey as given in Table-1. The MASW survey data acquisition parameters are given in Table-2.

Since the working conditions at site were very bad in terms of signal to noise ratio disturbed by heavy traffic, loose surface material and noise generated by blowing wind, therefore best possible maximum efforts were made to improve the signal to noise ratio for acquiring good quality data at site. Further, best efforts were also made during data processing/interpretation process to achieve the optimum results.

Table-2: MASW Data Acquisition Parameters

Geophone	24 (4.5 hertz, vertical)
Stack	5
Geophone Distance	2, 2.5 and 3 meters
Length of Spread	46, 57.5 and 69 meters
Shot Position	4, 5, 6, 7, 8, 9 and 12 meters offset
Sampling Interval	1000 micro seconds

5. DATA EVALUATION

Seismic Pro 9.3 Inversion licensed software package of Geogiga Technology Incorporation was used to process the MASW data.

The data were subjected to analyzing the over tone image of each shot gather, which represents the phase velocity versus frequency. The fundamental mode of the surface wave was used for the analysis. The calculation of the phase velocities within the specified frequency range was run several times using different values and sets of input parameters for the output curves until the highest signal-to-noise ratio (*S*/N*)* was achieved.

Each dispersion curve was individually inverted to generate a 1D shear-wave velocity profile. The inversion program run starts by searching for a Vs_{30} profile, whose theoretical dispersion curve matches with the experimental dispersion curve obtained from the dispersion analysis, with a lowest root–mean square error (RMSE) between the two curves.

This 1D shear wave velocity profile (Vs_{30}) up to thirty (30) meters appears to be the most representative of the material directly below the middle of a geophone spread.

The results obtained from data acquired in the field is correlated with the Building Code of Pakistan Seismic Provisions-2007 in order to identify the soil profile type. Soil profile types are defined as follows: BCP SP-2007 CH-04 4-2

S_A: Hard rock with measured shear wave velocity, vs > 1500 m/s (4,920 ft/sec).

S_B: Medium hard rock with 750 m/s < vs < 1500 m/s (2,460 ft/sec < vs < 4,920 ft./sec).

Sc: Very dense soil and soft rock with 350 m/s < vs < 750 m/s (1,150 ft/sec < vs < 2,460 ft/sec) or with either N > 50 or su > 100 kPa (2,088 psf).

S_D: Stiff soil with 175 m/s < vs < 350 m/s (575 ft/sec < vs < 1,150 ft/sec) or with 15 < N < 50 or 50 kPa < su < 100 kPa (1,044 psf < su < 2,088 psf).

S_E: A soil profile with vs < 175 m/s (575 ft/sec) or with N 20, wmc > 40 percent and su < 25 kPa (522 psf).

S_F: Soils requiring site-specific evaluation:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils
2. Peats and/or highly organic clays [H > 3 m (10 ft) of peat and/or highly organic clay where H = thickness of soil]
3. Very high plasticity clays [H > 7.5 m (25 ft) with PI > 75] 4. Very thick soft/medium stiff clays [H > 37 m (120 ft)]

6. RESULTS

The following results are inferred from the Multichannel Analysis of Surface Waves (MASW) Survey based on their locations:

1. Surface Geology: Soil

- The Vs_{30} for the MASW-1 location is interpreted as 332 meters/second.

- The Vs_{30} for the MASW-2 location is interpreted as 360 meters/second.
- The Vs_{30} for the MASW-3 location is interpreted as 397 meters/second.
- The Vs_{30} for the MASW-4 location is interpreted as 333 meters/second.
- The Vs_{30} for the MASW-5 location is interpreted as 353 meters/second.
- The Vs_{30} for the MASW-6 location is interpreted as 333 meters/second.
- The Vs_{30} for the MASW-7 location is interpreted as 340 meters/second.
- The Vs_{30} for the MASW-8 location is interpreted as 395 meters/second.
- The Vs_{30} for the MASW-9 location is interpreted as 336 meters/second.
- The Vs_{30} for the MASW-10 location is interpreted as 441 meters/second.
- The Vs_{30} for the MASW-11 location is interpreted as 376 meters/second.
- The Vs_{30} for the MASW-13 location is interpreted as 418 meters/second.
- The Vs_{30} for the MASW-14 location is interpreted as 428 meters/second.
- The Vs_{30} for the MASW-15 location is interpreted as 519 meters/second.
- The Vs_{30} for the MASW-16 location is interpreted as 580 meters/second.
- The Vs_{30} for the MASW-18 location is interpreted as 554 meters/second.
- The Vs_{30} for the MASW-35 location is interpreted as 310 meters/second.
- The Vs_{30} for the MASW-36 location is interpreted as 348 meters/second.
- The Vs_{30} for the MASW-37 location is interpreted as 340 meters/second.
- The Vs_{30} for the MASW-38 location is interpreted as 411 meters/second.
- The Vs_{30} for the MASW-39 location is interpreted as 385 meters/second.
- The Vs_{30} for the MASW-41 location is interpreted as 491 meters/second.
- The Vs_{30} for the MASW-42 location is interpreted as 607 meters/second.
- The Vs_{30} for the MASW-45 location is interpreted as 465 meters/second.
- The Vs_{30} for the MASW-46 location is interpreted as 566 meters/second.
- **The average Vs_{30} for soil profiles is interpreted as 416.6 meters/second (say 420 m/sec.)**

2. Surface Geology: Rock

- The Vs_{30} for the MASW-12 location is interpreted as 589 meters/second.
- The Vs_{30} for the MASW-17 location is interpreted as 741 meters/second.
- The Vs_{30} for the MASW-19 location is interpreted as 620 meters/second.
- The Vs_{30} for the MASW-20 location is interpreted as 1012 meters/second.
- The Vs_{30} for the MASW-21 location is interpreted as 785 meters/second.
- The Vs_{30} for the MASW-22 location is interpreted as 819 meters/second.
- The Vs_{30} for the MASW-23 location is interpreted as 861 meters/second.
- The Vs_{30} for the MASW-24 location is interpreted as 862 meters/second.
- The Vs_{30} for the MASW-25 location is interpreted as 803 meters/second.
- The Vs_{30} for the MASW-26 location is interpreted as 751 meters/second.
- The Vs_{30} for the MASW-27 location is interpreted as 739 meters/second.
- The Vs_{30} for the MASW-28 location is interpreted as 940 meters/second.
- The Vs_{30} for the MASW-29 location is interpreted as 860 meters/second.
- The Vs_{30} for the MASW-30 location is interpreted as 929 meters/second.
- The Vs_{30} for the MASW-31 location is interpreted as 618 meters/second.
- The Vs_{30} for the MASW-32 location is interpreted as 743 meters/second.
- The Vs_{30} for the MASW-33 location is interpreted as 695 meters/second.
- The Vs_{30} for the MASW-34 location is interpreted as 714 meters/second.
- The Vs_{30} for the MASW-40 location is interpreted as 841 meters/second.
- The Vs_{30} for the MASW-43 location is interpreted as 719 meters/second.
- The Vs_{30} for the MASW-44 location is interpreted as 678 meters/second.

- The Vs_{30} for the MASW-47 location is interpreted as 620 meters/second.
- The Vs_{30} for the MASW-48 location is interpreted as 680 meters/second.
- The Vs_{30} for the MASW-49 location is interpreted as 906 meters/second.
- The Vs_{30} for the MASW-50 location is interpreted as 712 meters/second.
- The Vs_{30} for the MASW-51 location is interpreted as 753 meters/second.
- The Vs_{30} for the MASW-52 location is interpreted as 649 meters/second.
- The Vs_{30} for the MASW-53 location is interpreted as 833 meters/second.
- The Vs_{30} for the MASW-54 location is interpreted as 889 meters/second.
- The Vs_{30} for the MASW-55 location is interpreted as 763 meters/second.
- The Vs_{30} for the MASW-56 location is interpreted as 754 meters/second.
- The Vs_{30} for the MASW-57 location is interpreted as 678 meters/second.
- The Vs_{30} for the MASW-58 location is interpreted as 718 meters/second.
- The Vs_{30} for the MASW-59 location is interpreted as 592 meters/second.
- The Vs_{30} for the MASW-60 location is interpreted as 696 meters/second.
- The Vs_{30} for the MASW-61 location is interpreted as 658 meters/second.
- The Vs_{30} for the MASW-62 location is interpreted as 599 meters/second.
- The Vs_{30} for the MASW-63 location is interpreted as 514 meters/second.
- The Vs_{30} for the MASW-64 location is interpreted as 566 meters/second.
- The Vs_{30} for the MASW-65 location is interpreted as 542 meters/second.
- The Vs_{30} for the MASW-66 location is interpreted as 494 meters/second.
- The Vs_{30} for the MASW-67 location is interpreted as 508 meters/second.
- The Vs_{30} for the MASW-68 location is interpreted as 473 meters/second.
- The Vs_{30} for the MASW-69 location is interpreted as 740 meters/second.
- The Vs_{30} for the MASW-70 location is interpreted as 440 meters/second.
- The Vs_{30} for the MASW-71 location is interpreted as 373 meters/second.
- **The average Vs30 for rock profile is interpreted as 705.84 meters/second meters/second (say 700 m/sec.)**

Both the Soil and Rock profiles lies under soil profile type "Sc" as per BCP-SP 2007, So, overall, the average Vs30 for the project area is interpreted as 558 (Say 560 meters/second)

7. CONSLUCIONS

As per MASW survey results from the site, shear wave velocity derived is Vs30 570 m/sec. As per Building Code of Pakistan 2007, the subsoil has been categorized as "Sc" as per requirements provided in Section 5 of this report.

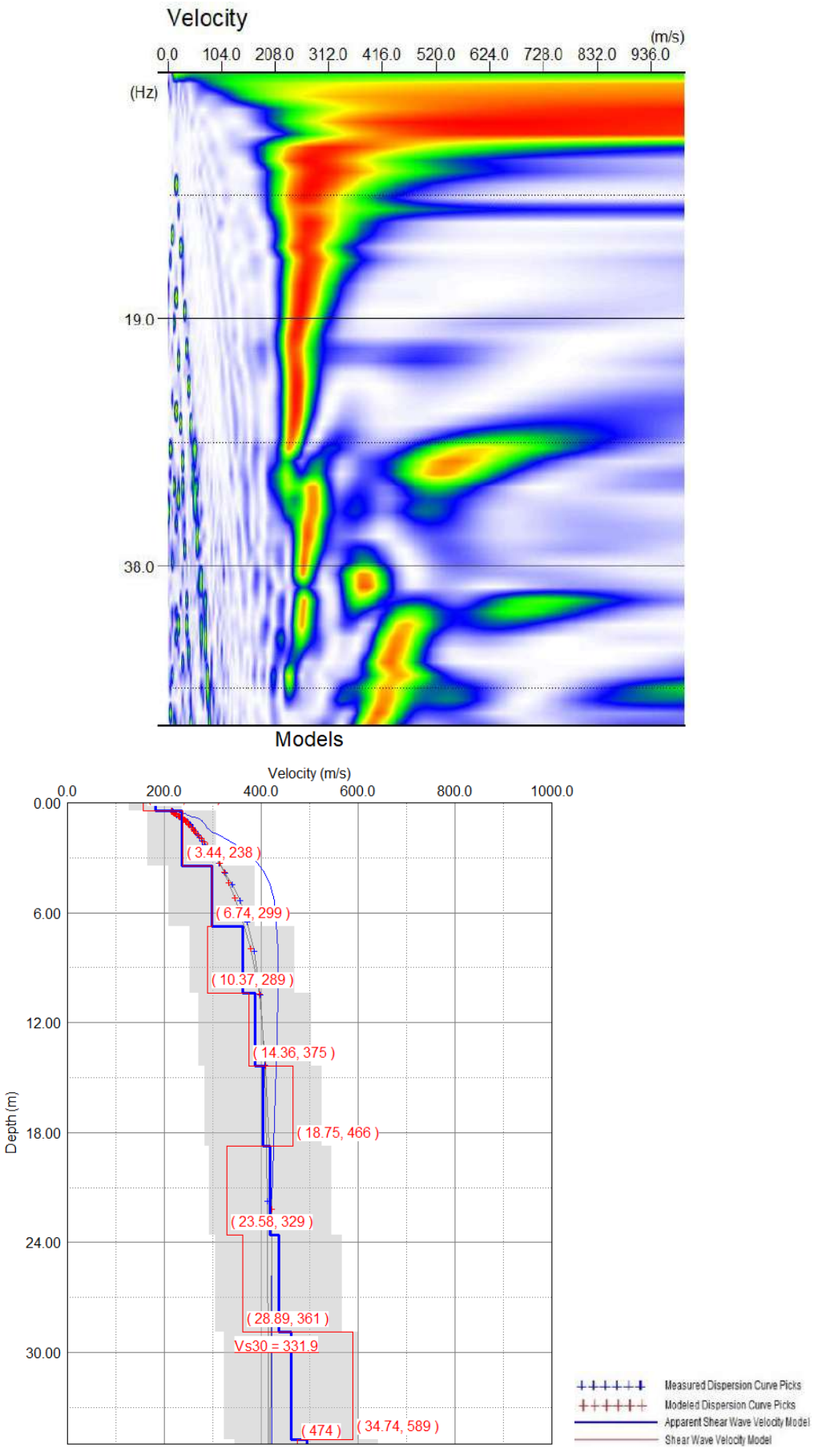


Figure 3: Dispersion Curve and inverted S-wave Velocity Model of MASW-1

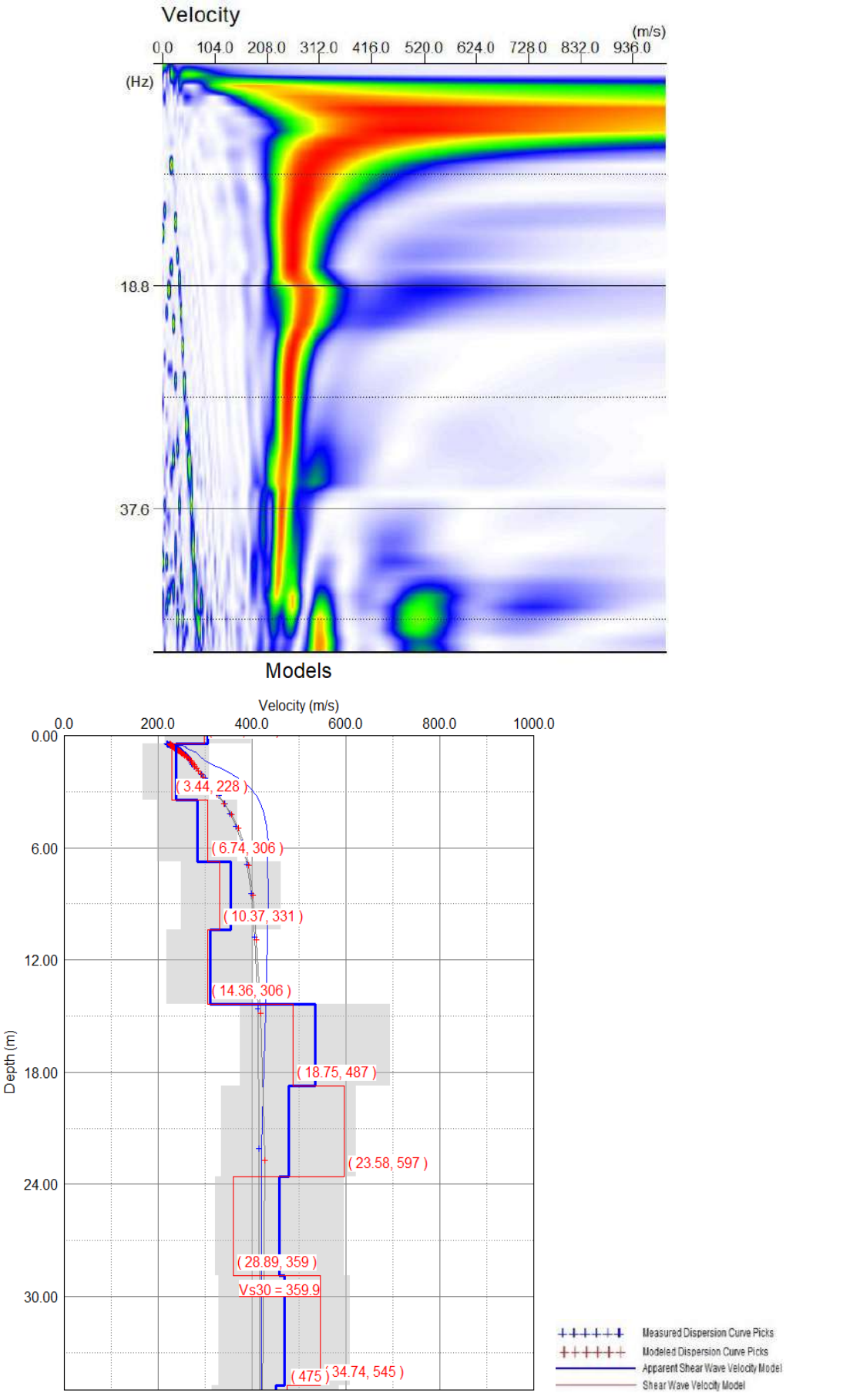


Figure 4: Dispersion Curve and inverted S-wave Velocity Model of MASW-2

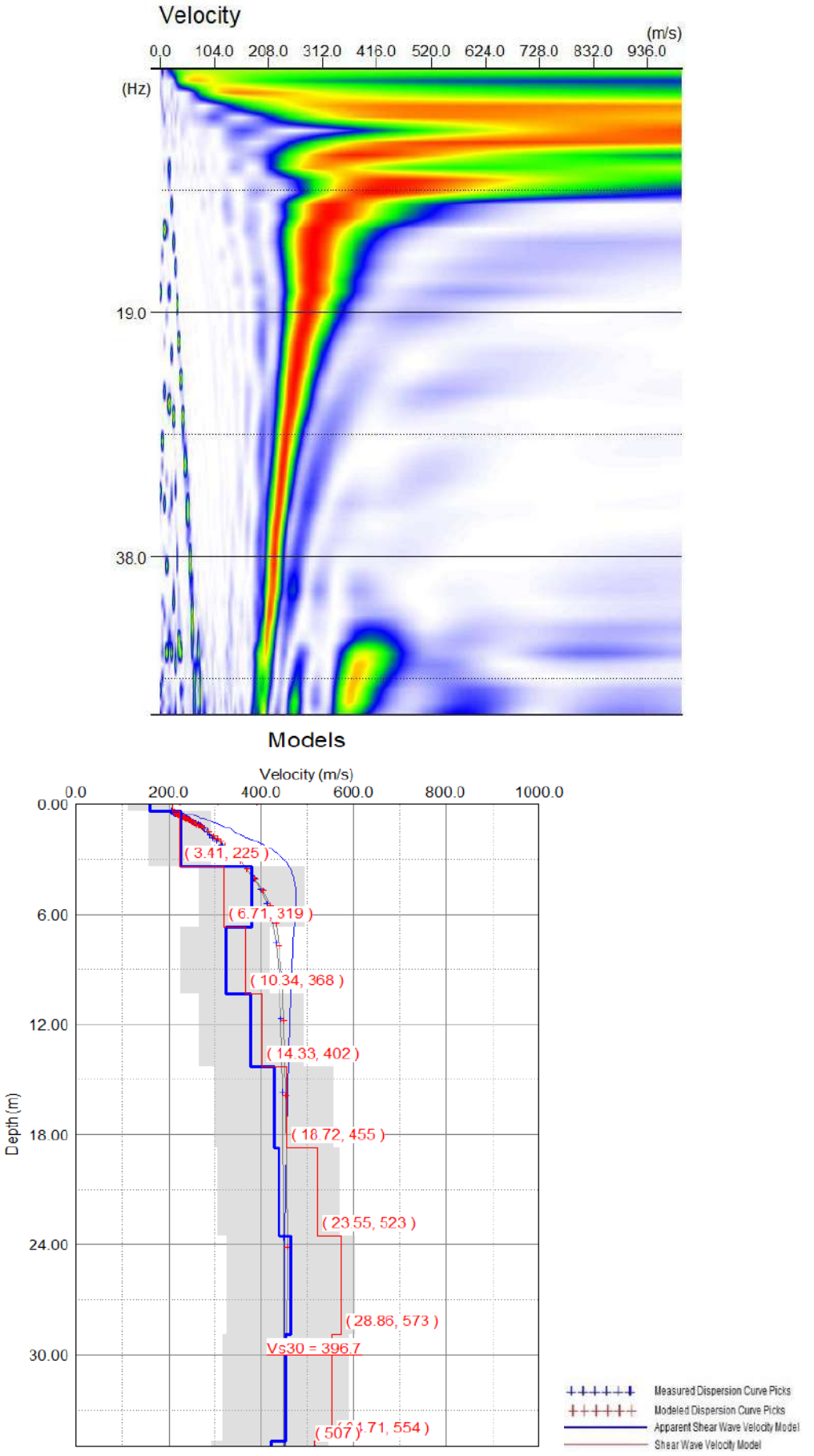


Figure 5: Dispersion Curve and inverted S-wave Velocity Model of MASW-3

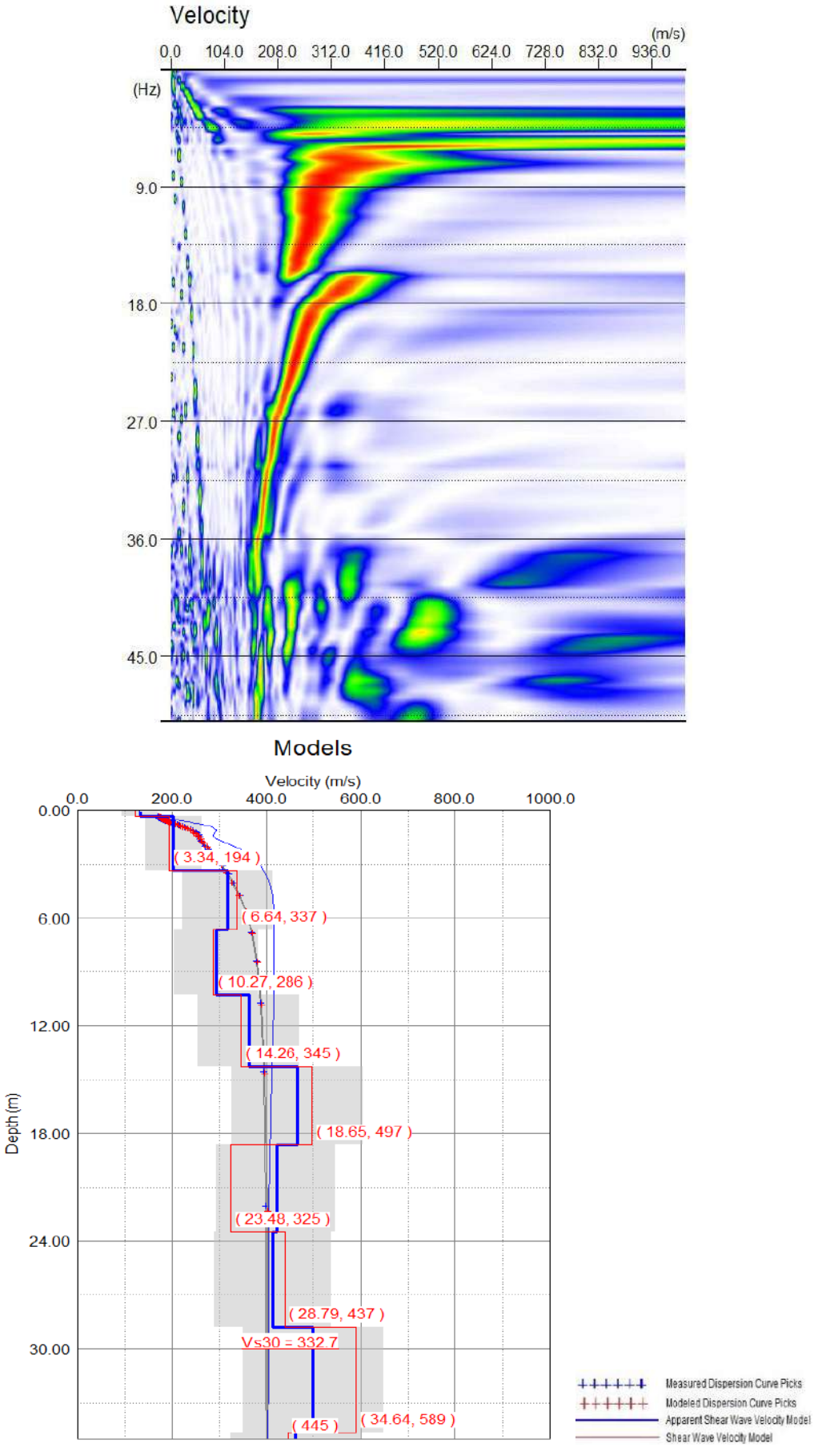


Figure 6: Dispersion Curve and inverted S-wave Velocity Model of MASW-4

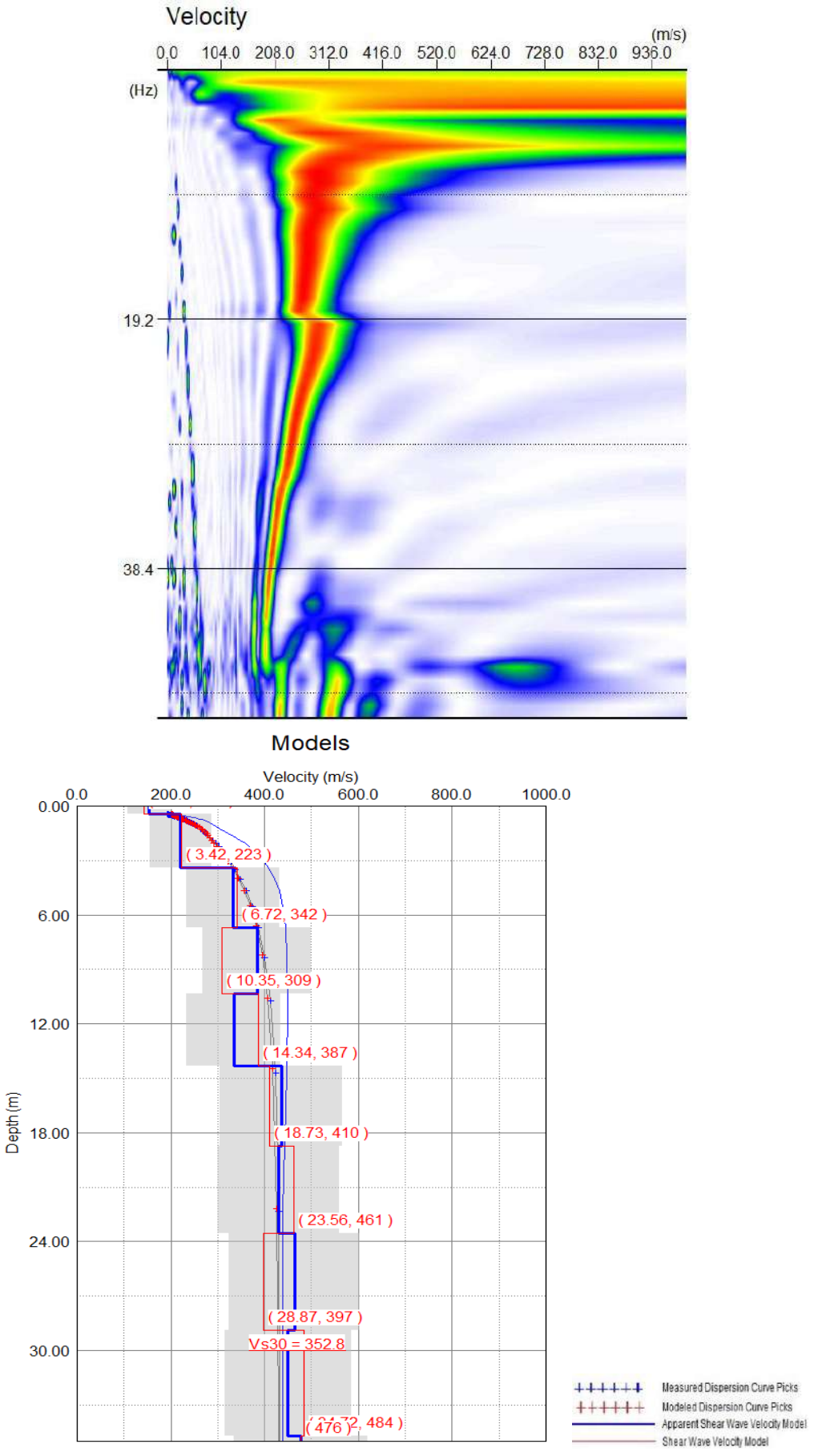


Figure 7: Dispersion Curve and inverted S-wave Velocity Model of MASW-5

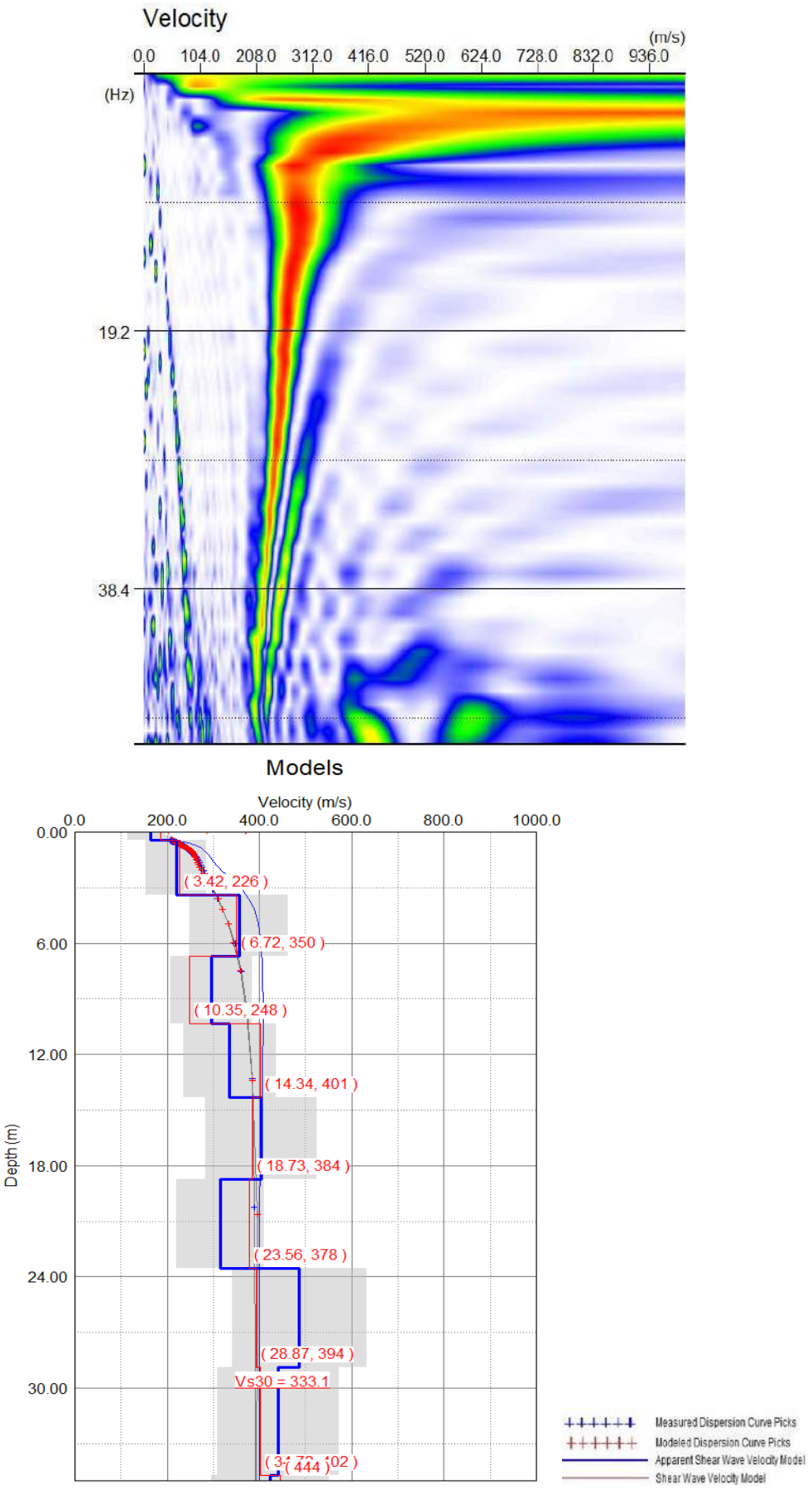


Figure 8: Dispersion Curve and inverted S-wave Velocity Model of MASW-6

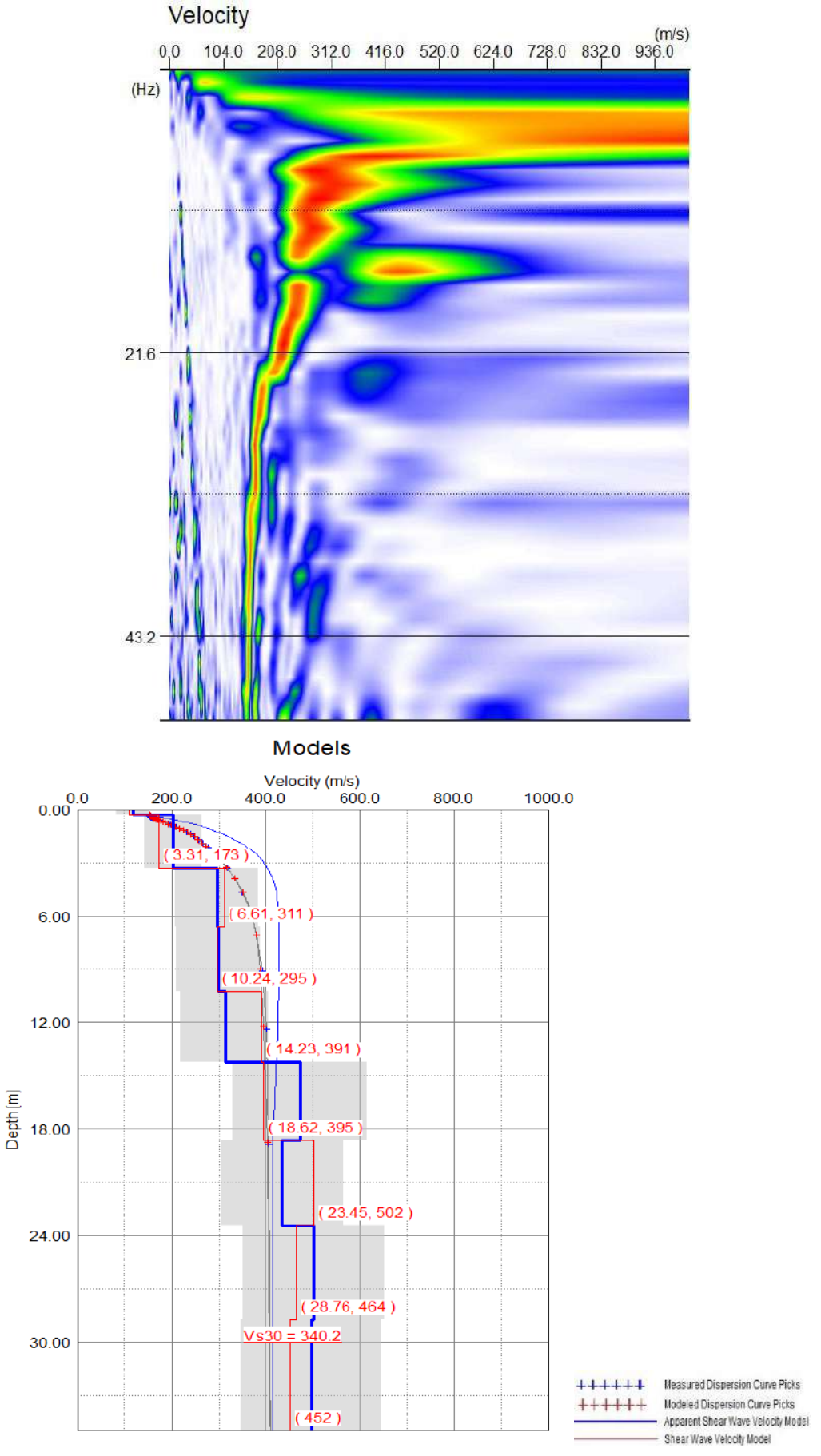


Figure 9: Dispersion Curve and inverted S-wave Velocity Model of MASW-7

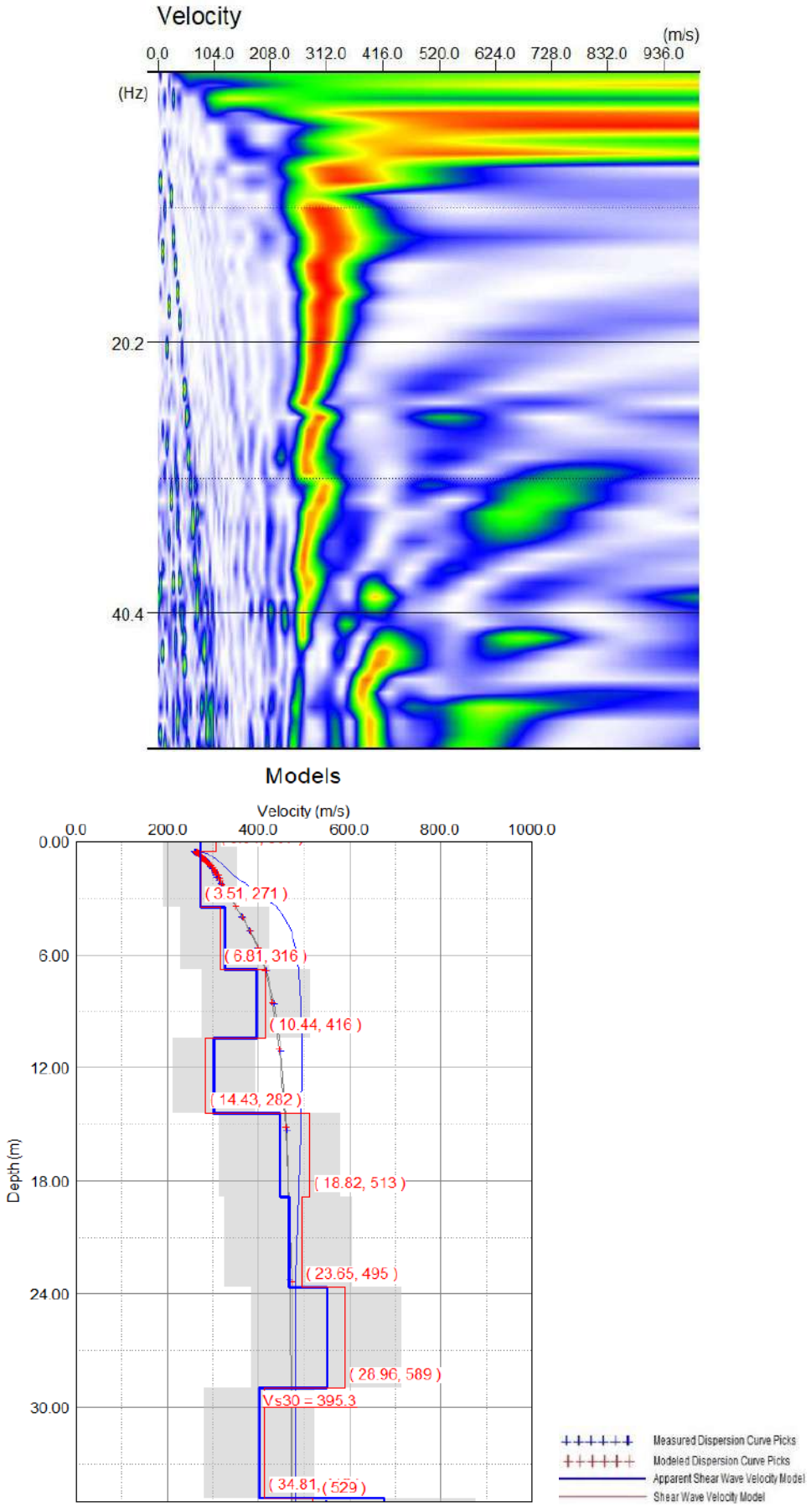


Figure 10: Dispersion Curve and inverted S-wave Velocity Model of MASW-8

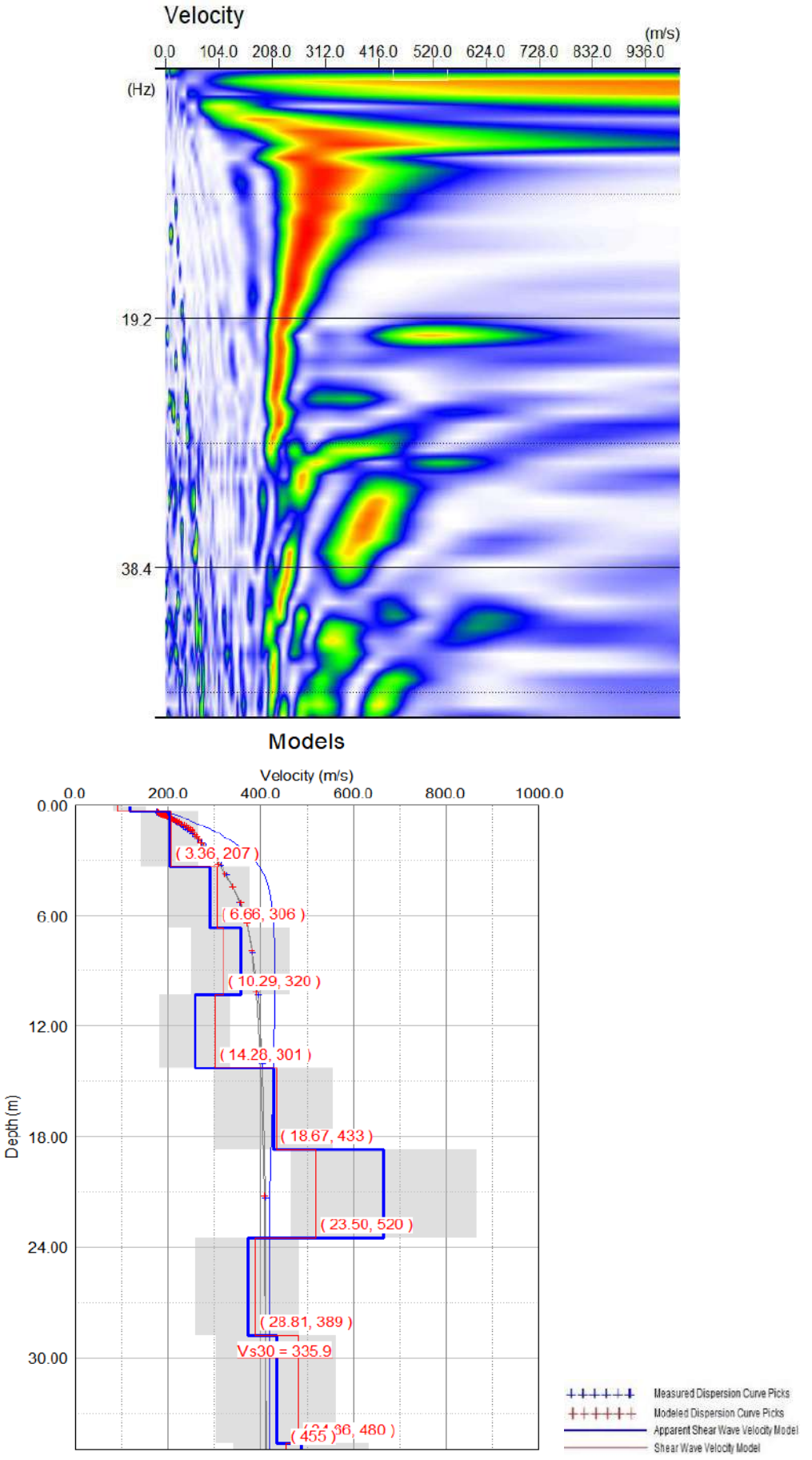


Figure 11: Dispersion Curve and inverted S-wave Velocity Model of MASW-9

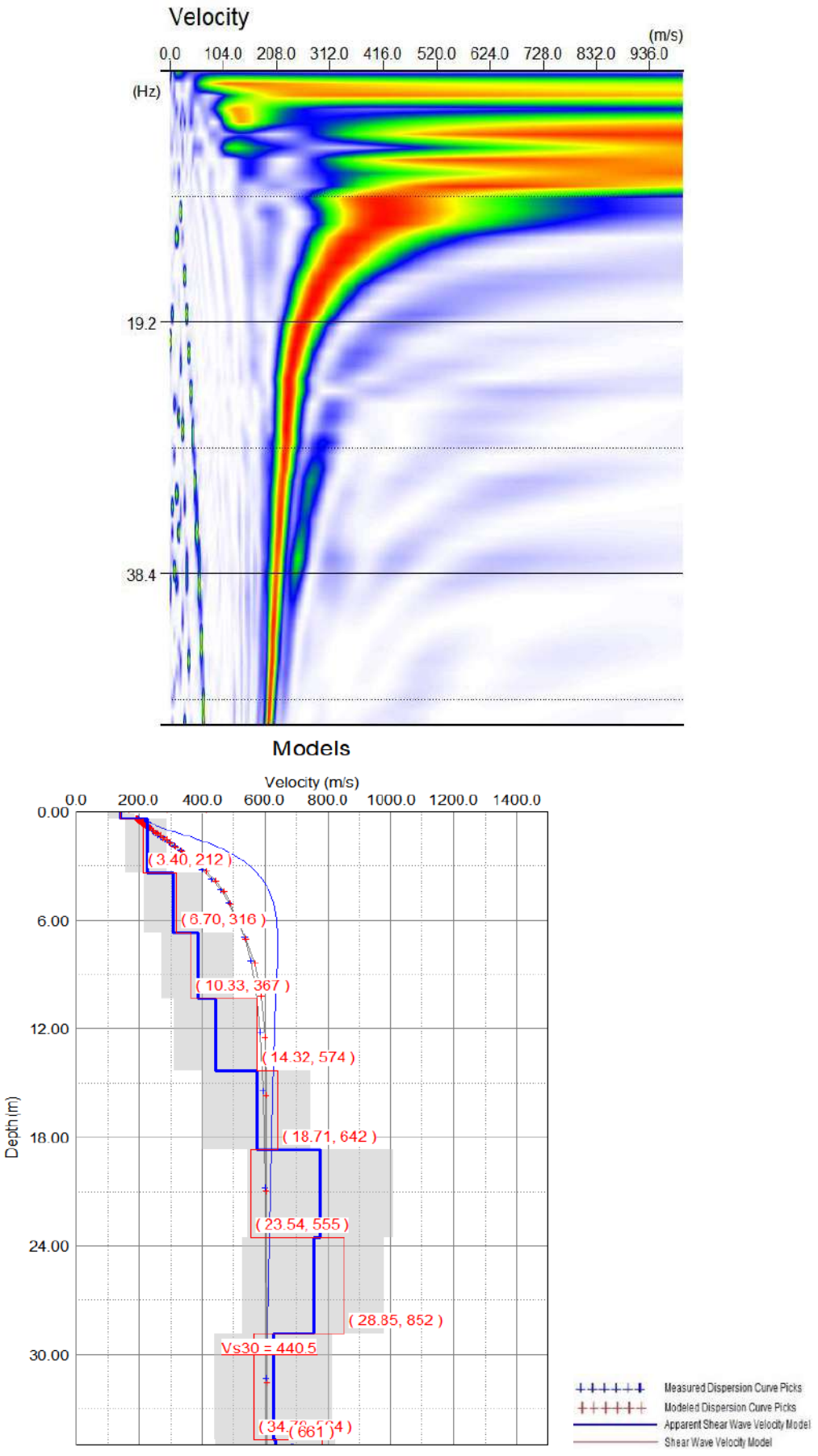


Figure 12: Dispersion Curve and inverted S-wave Velocity Model of MASW-10

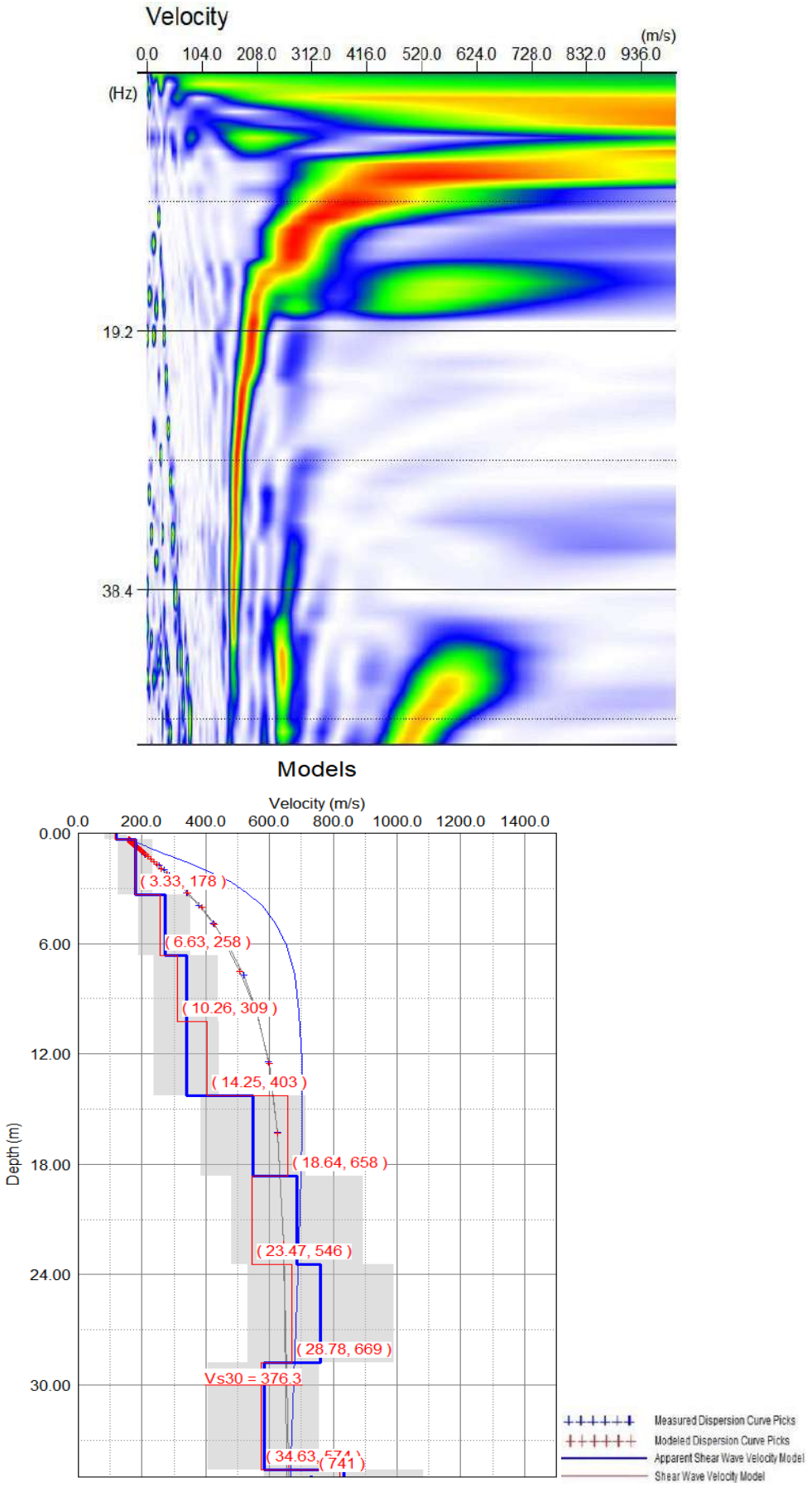


Figure 13: Dispersion Curve and inverted S-wave Velocity Model of MASW-11

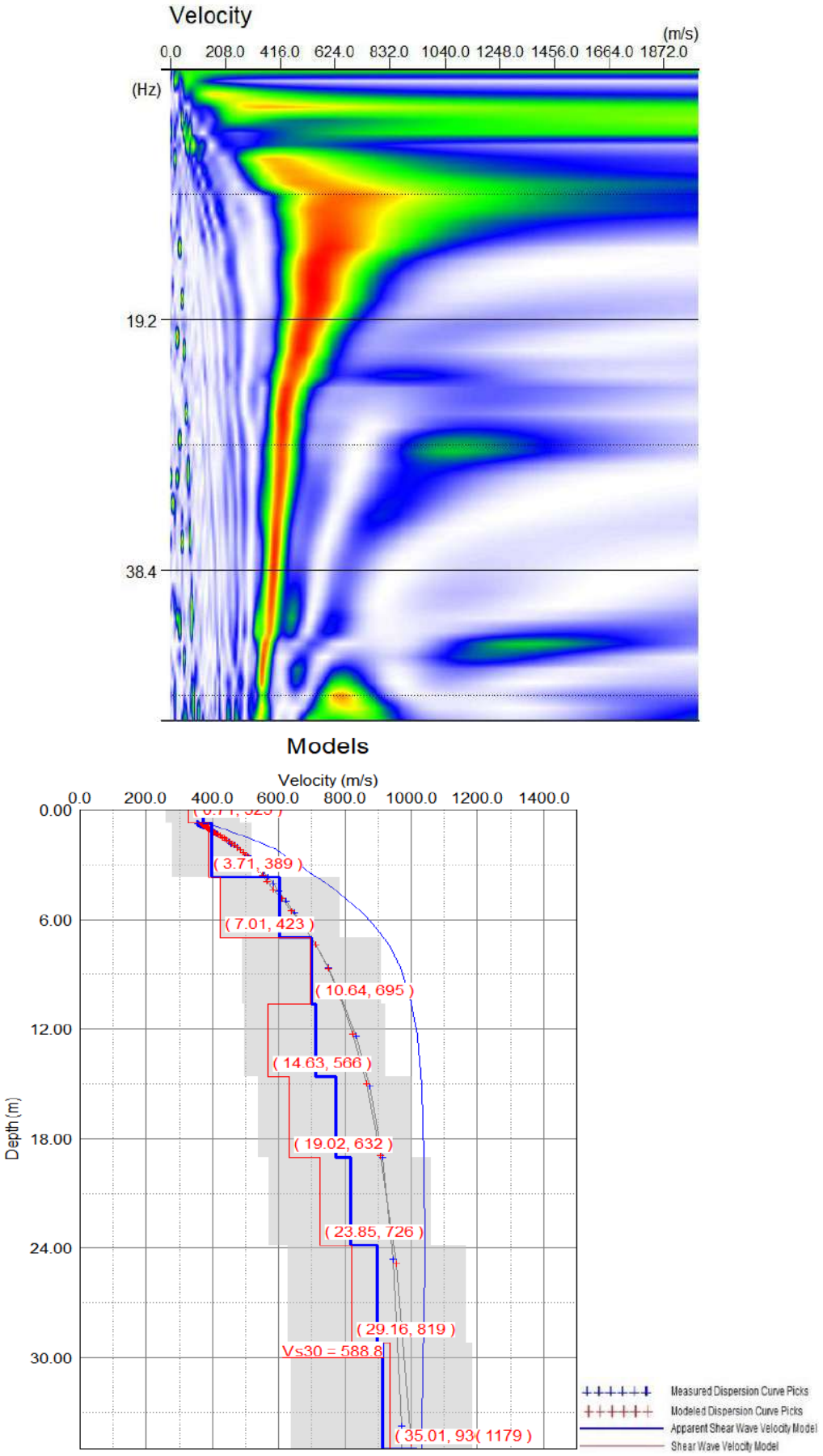


Figure 14: Dispersion Curve and inverted S-wave Velocity Model of MASW-12

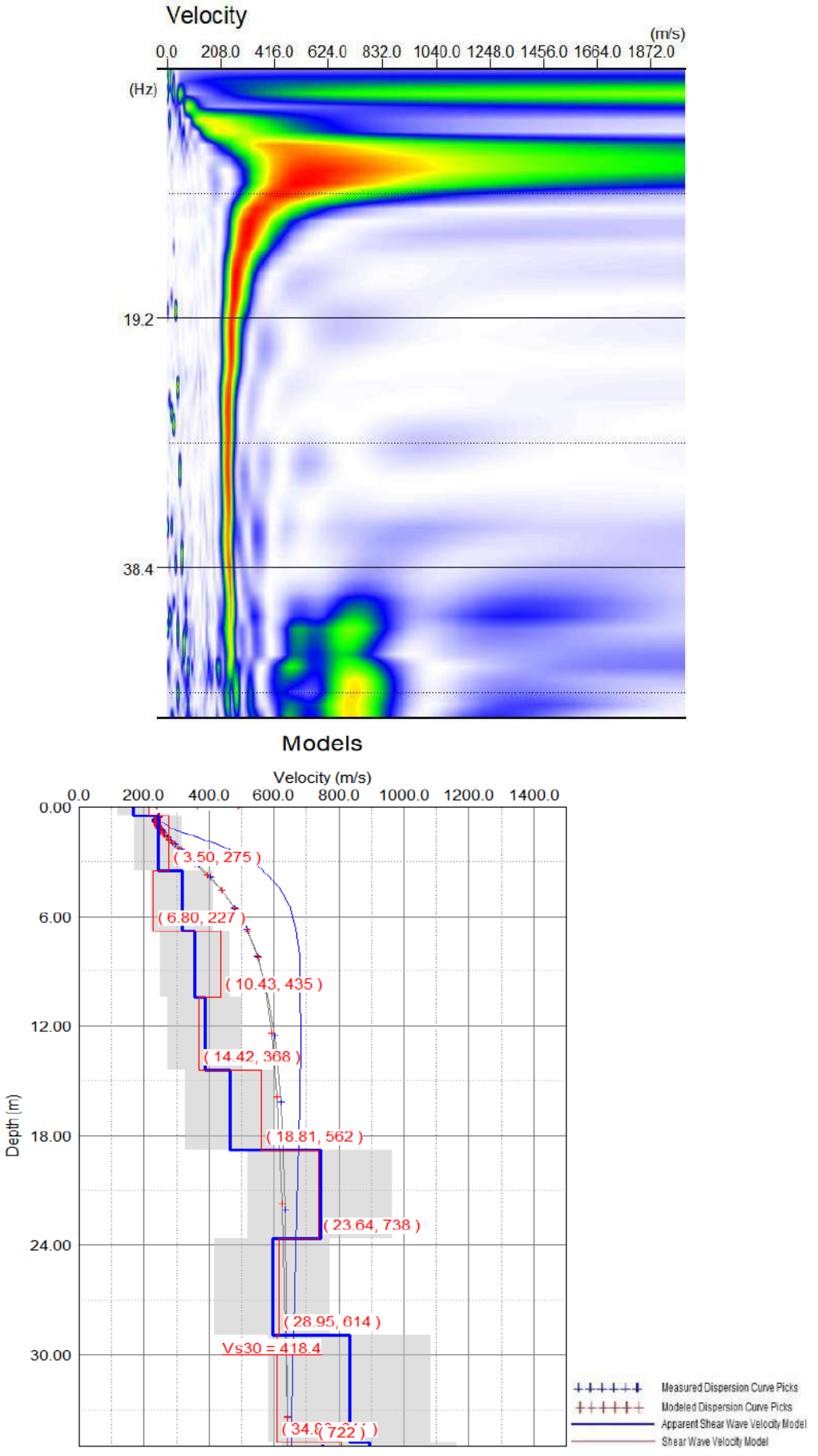


Figure 15: Dispersion Curve and inverted S-wave Velocity Model of MASW-13

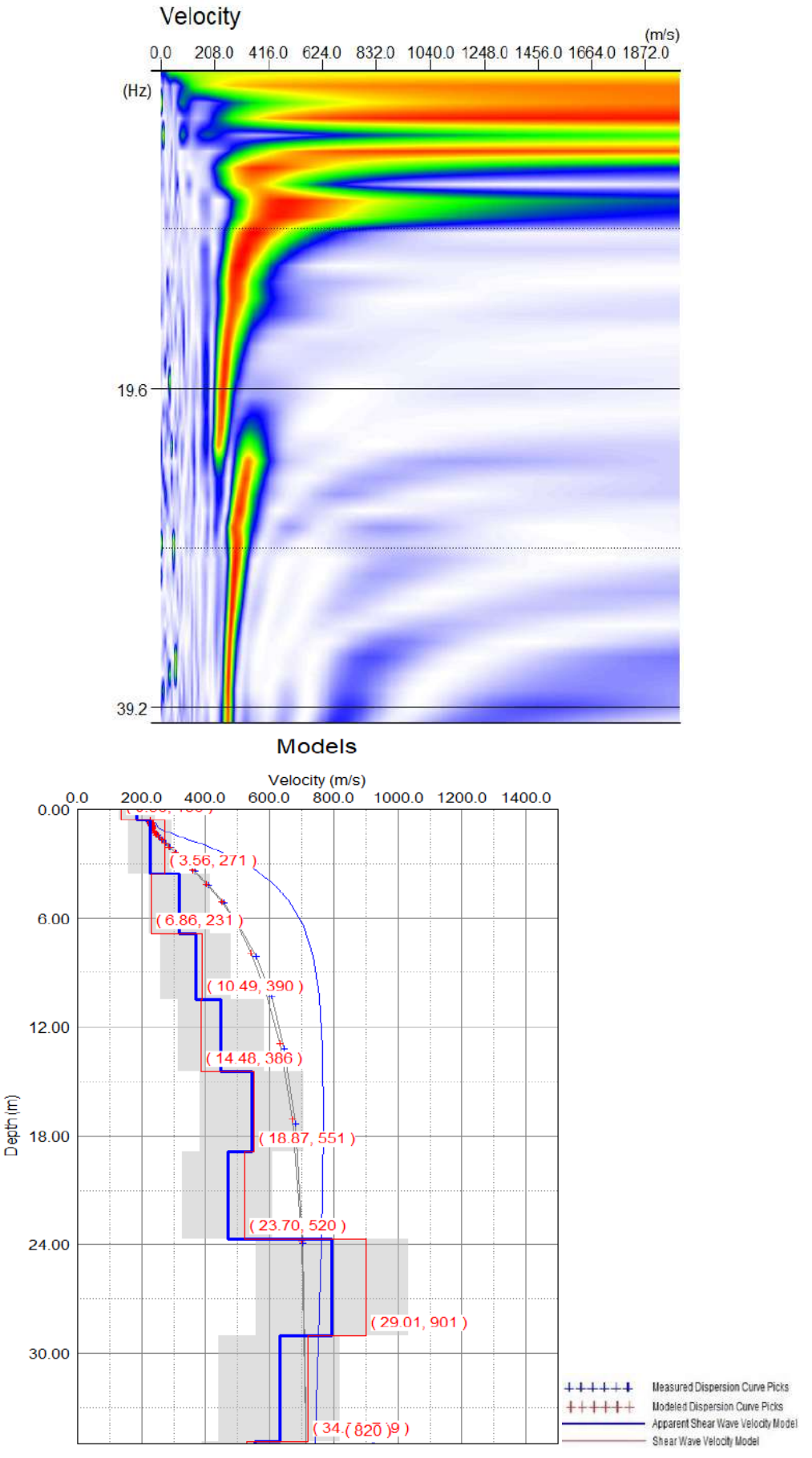


Figure 16: Dispersion Curve and inverted S-wave Velocity Model of MASW-14

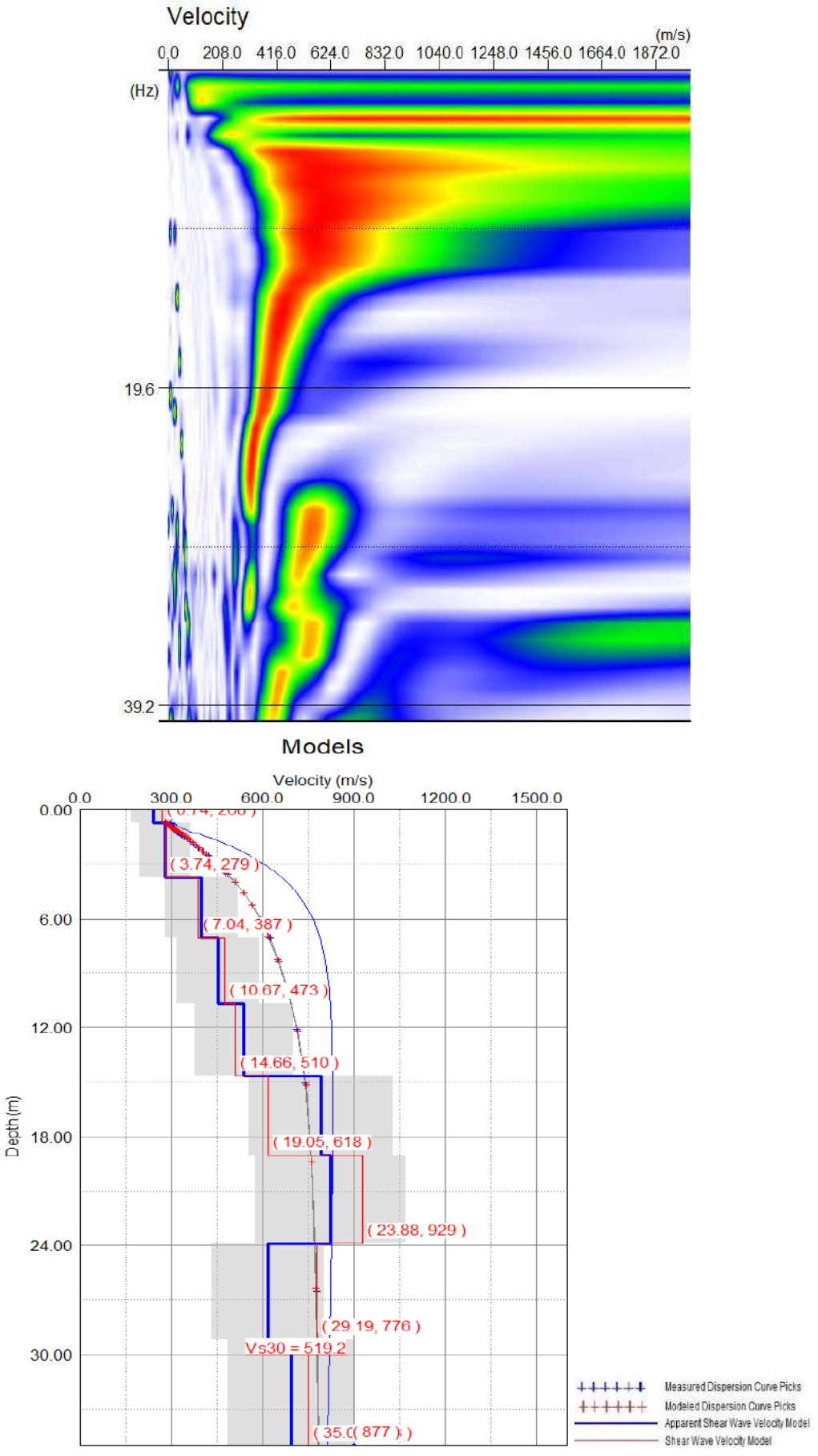


Figure 17: Dispersion Curve and inverted S-wave Velocity Model of MASW-15

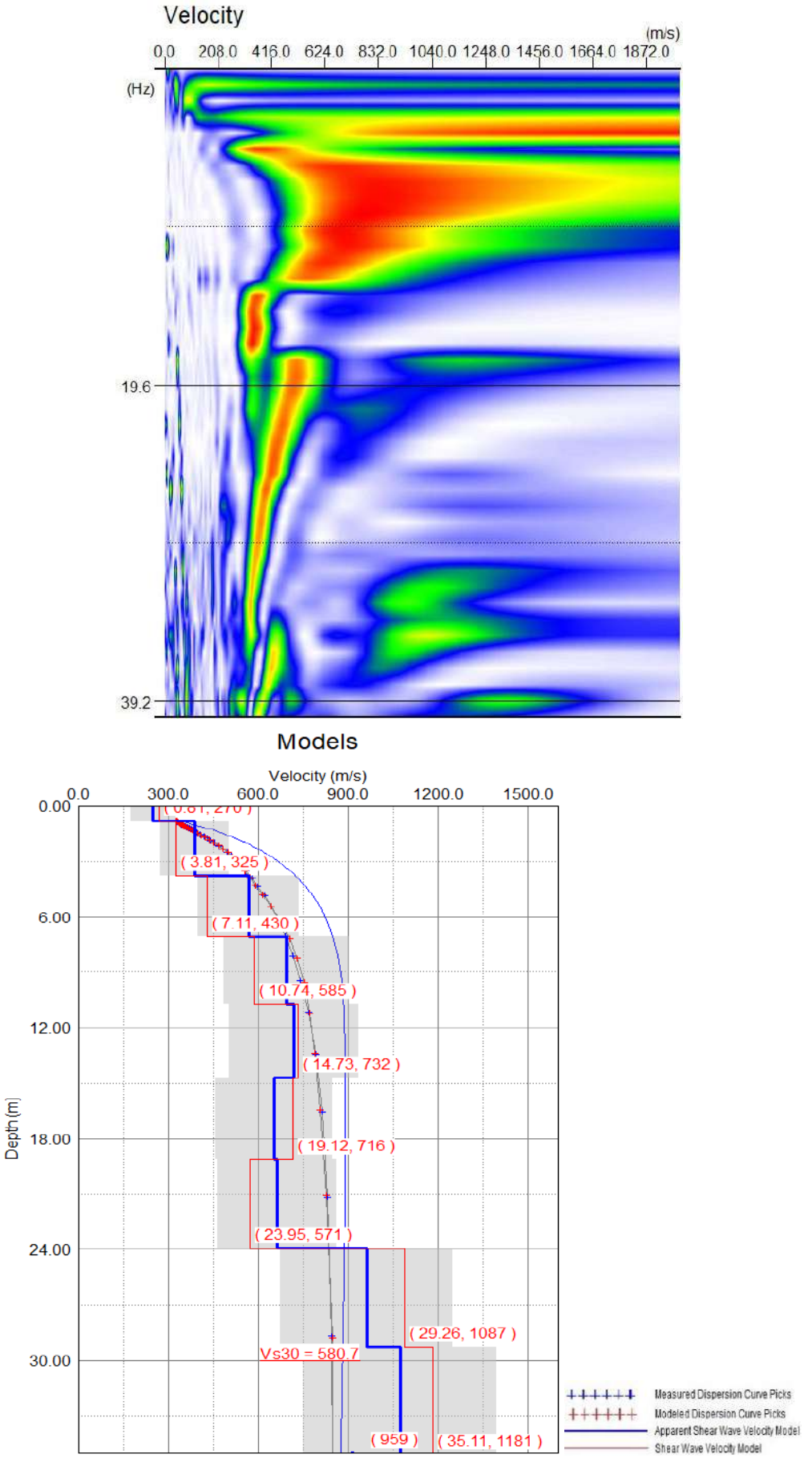


Figure 18: Dispersion Curve and inverted S-wave Velocity Model of MASW-16

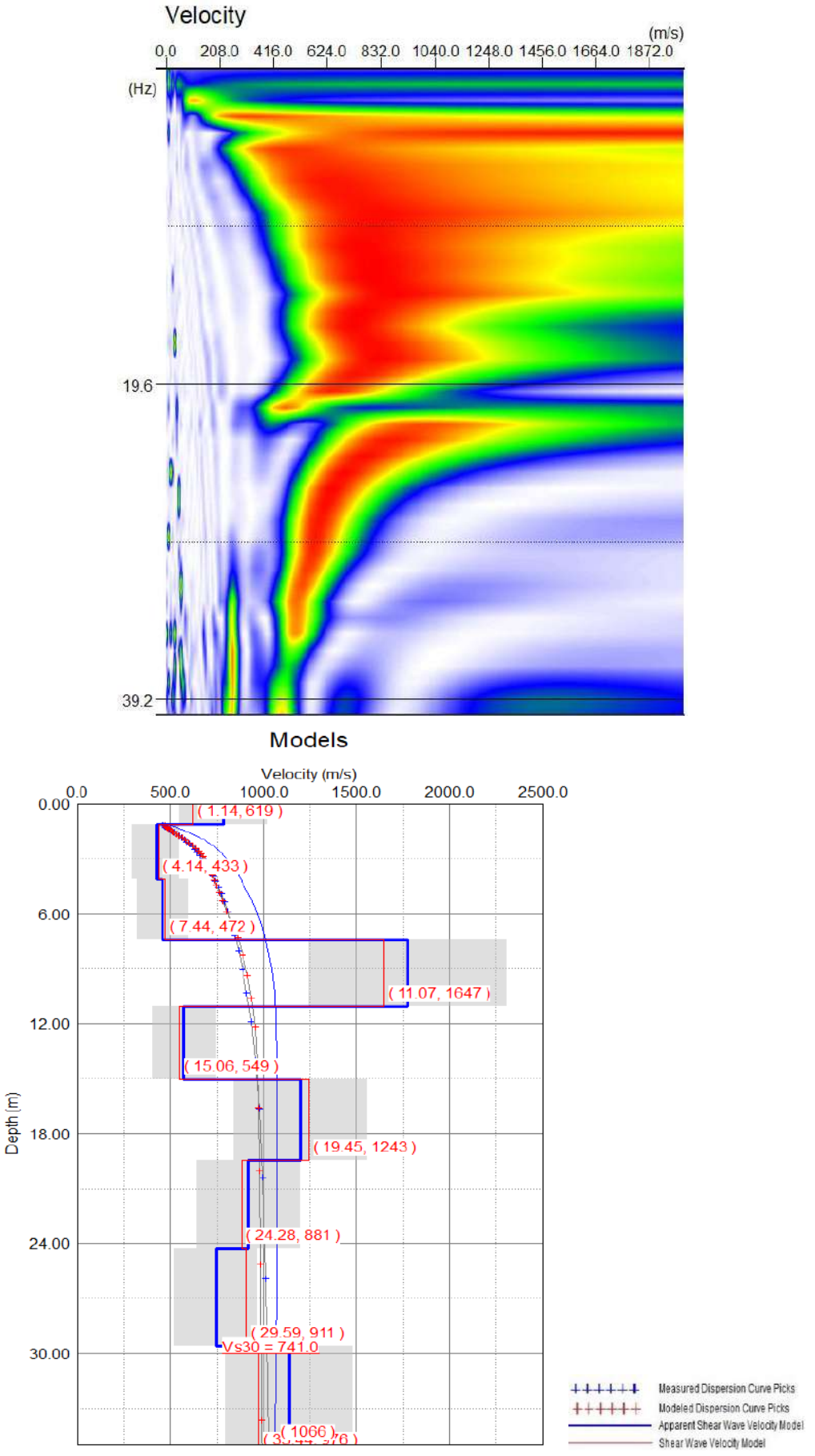


Figure 19: Dispersion Curve and inverted S-wave Velocity Model of MASW-17

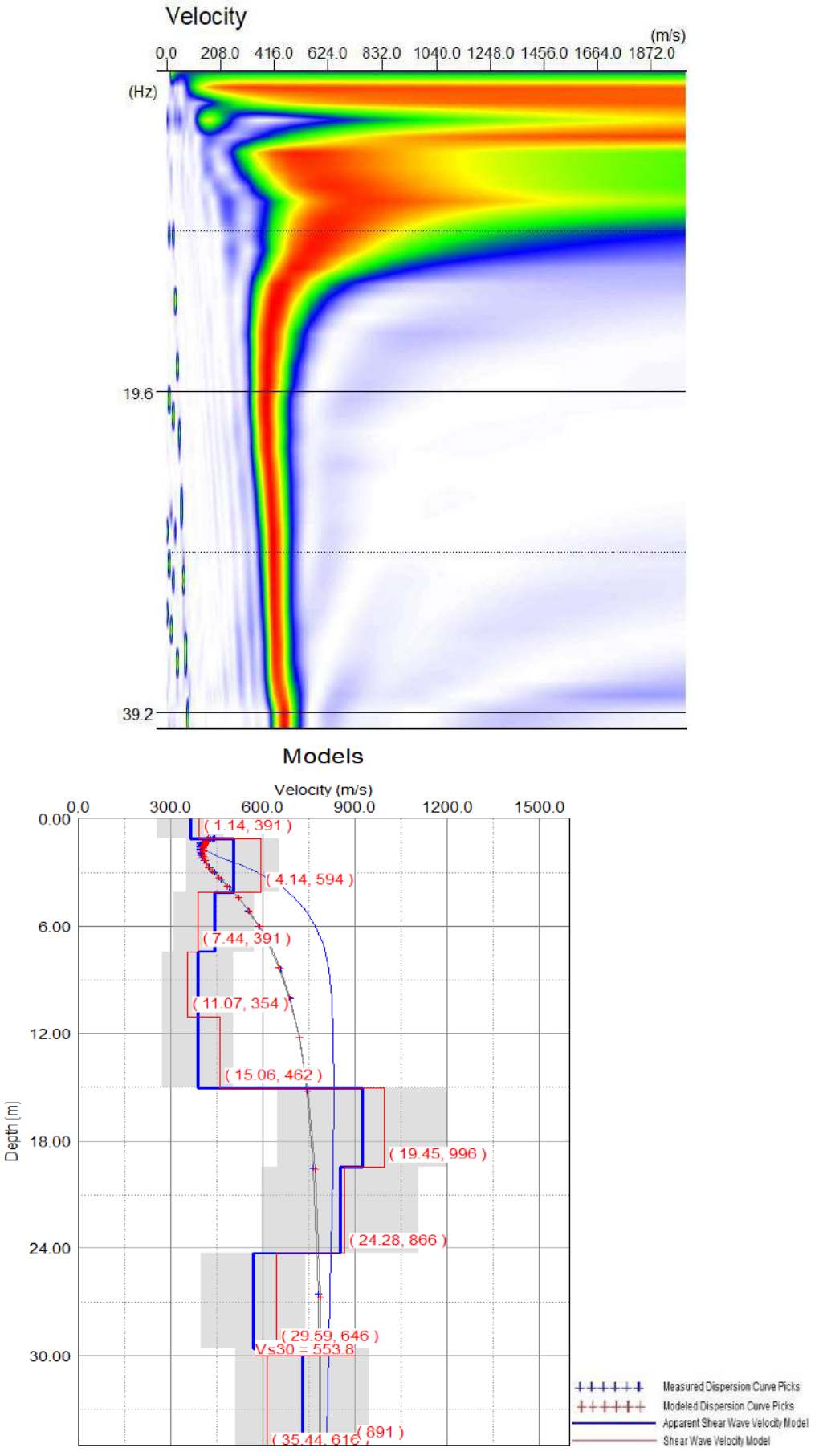


Figure 20: Dispersion Curve and inverted S-wave Velocity Model of MASW-18

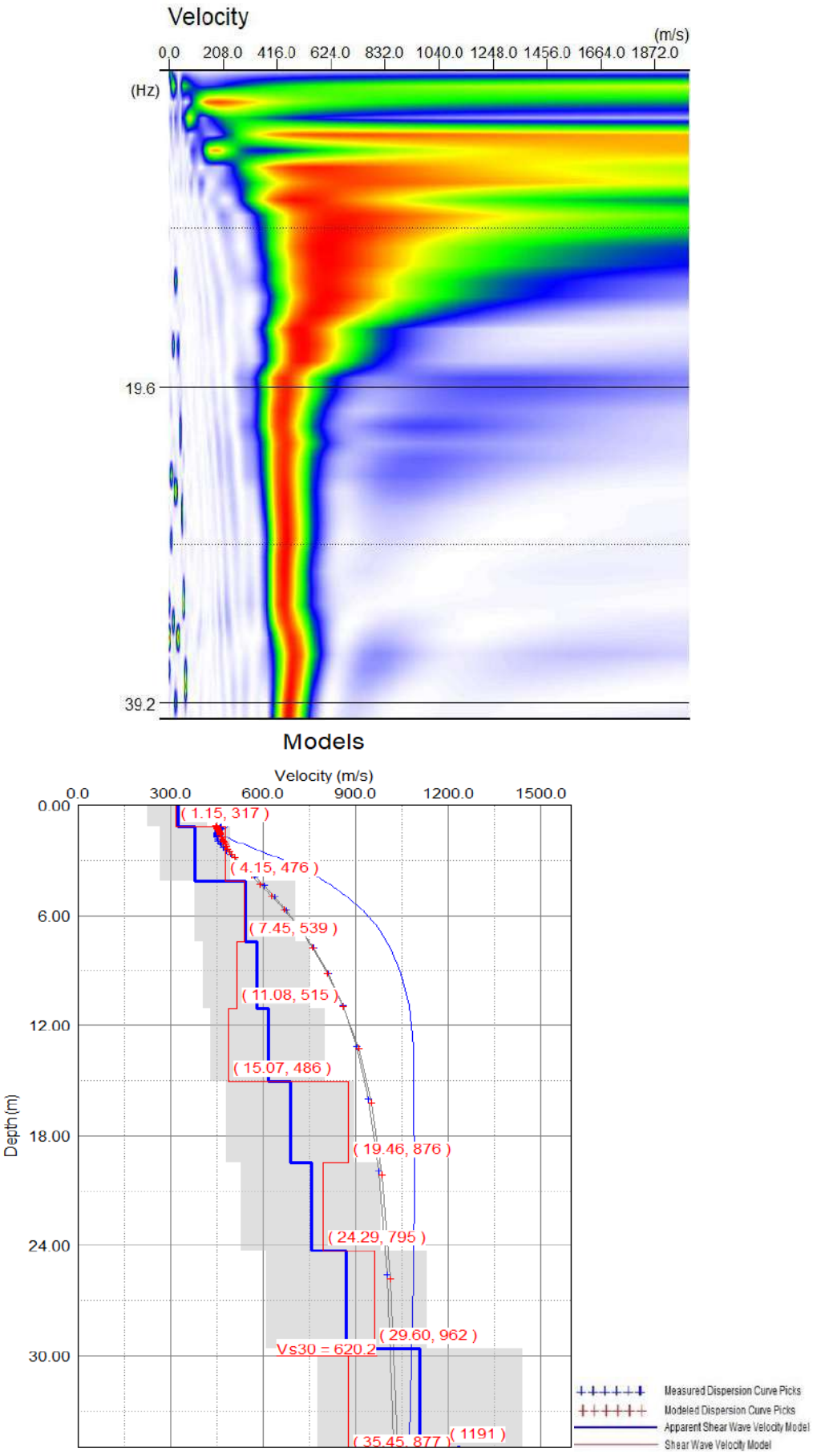


Figure 21: Dispersion Curve and inverted S-wave Velocity Model of MASW-19

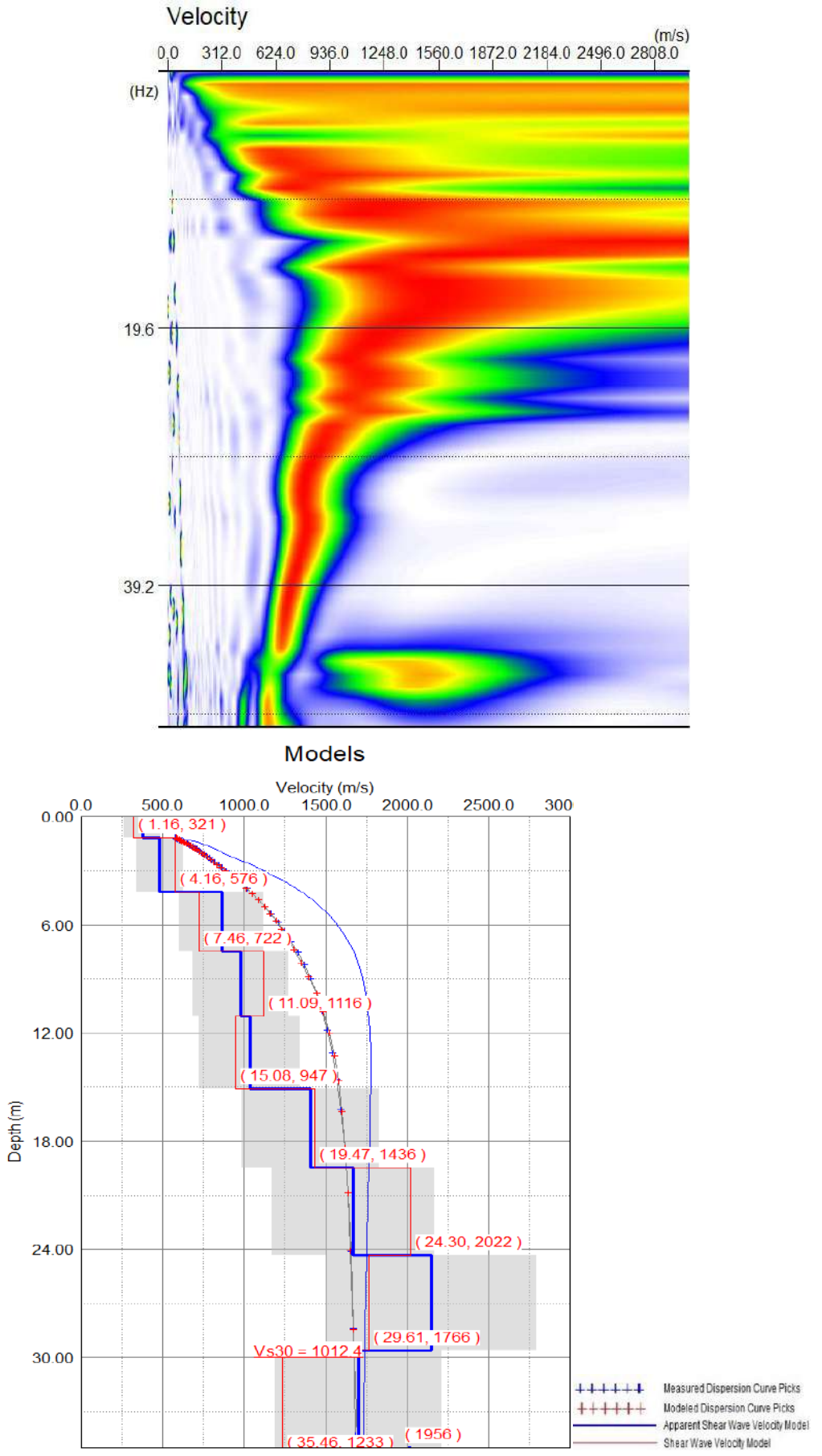
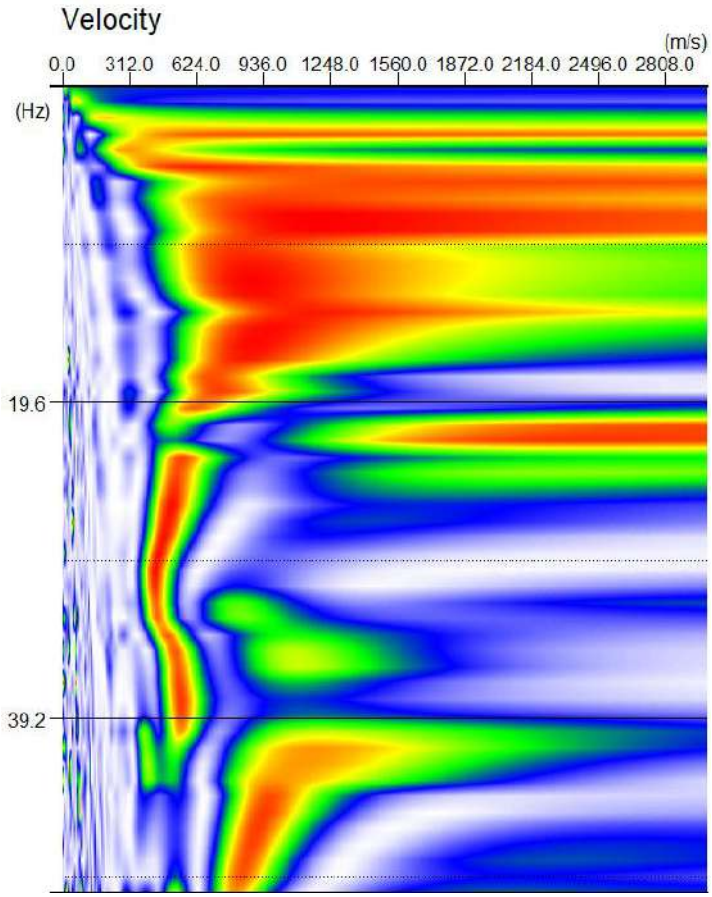


Figure 22: Dispersion Curve and inverted S-wave Velocity Model of MASW-20



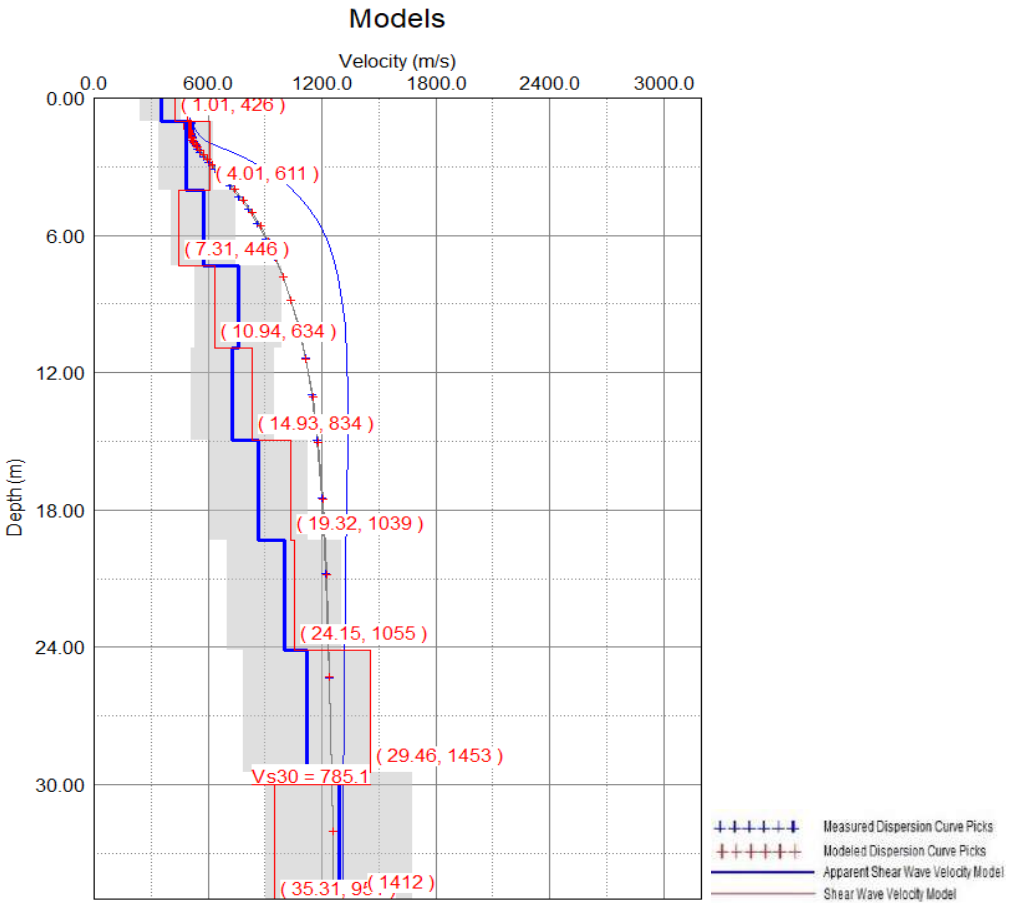


Figure 23: Dispersion Curve and inverted S-wave Velocity Model of MASW-21

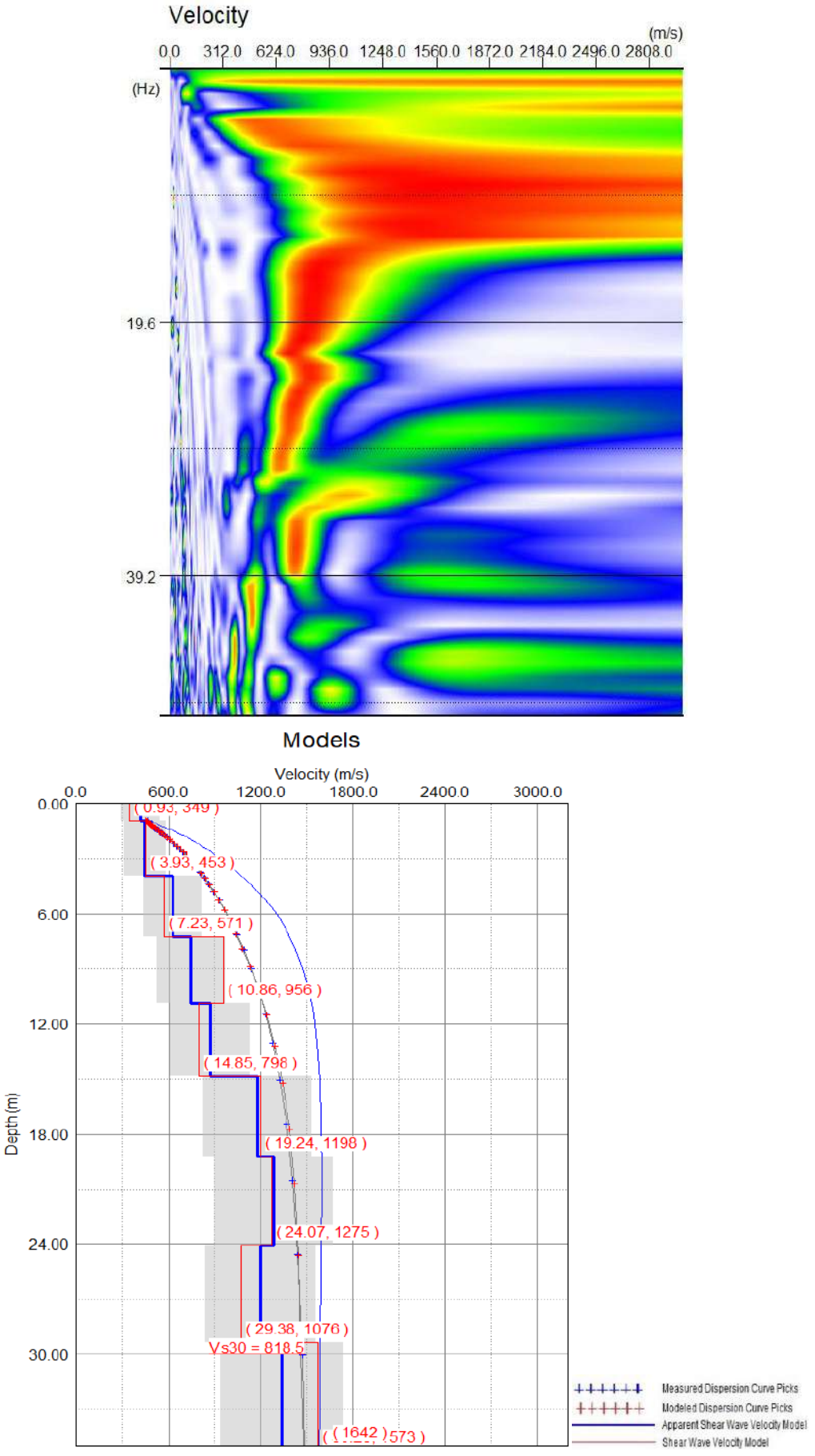


Figure 24: Dispersion Curve and inverted S-wave Velocity Model of MASW-22

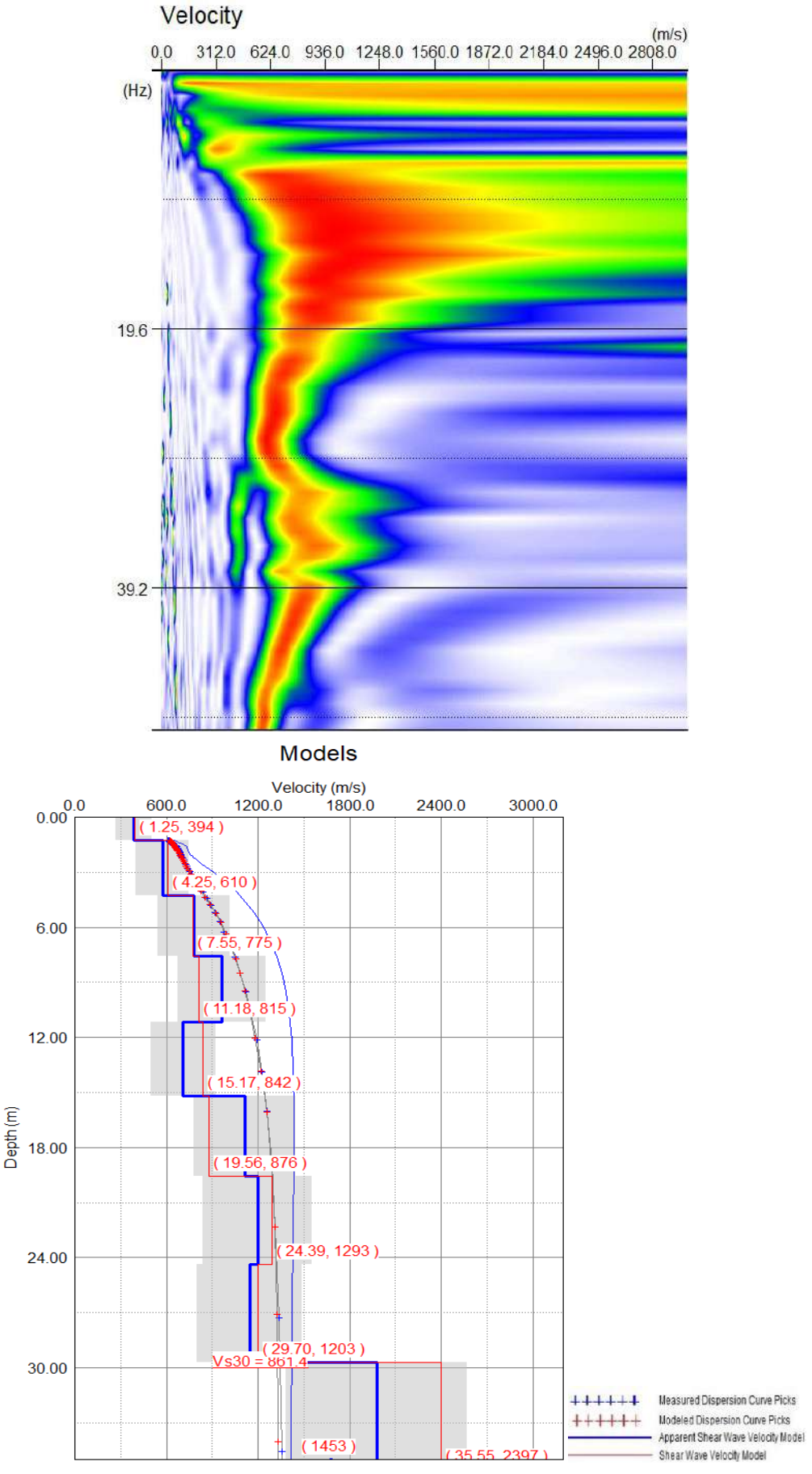


Figure 25: Dispersion Curve and inverted S-wave Velocity Model of MASW-23

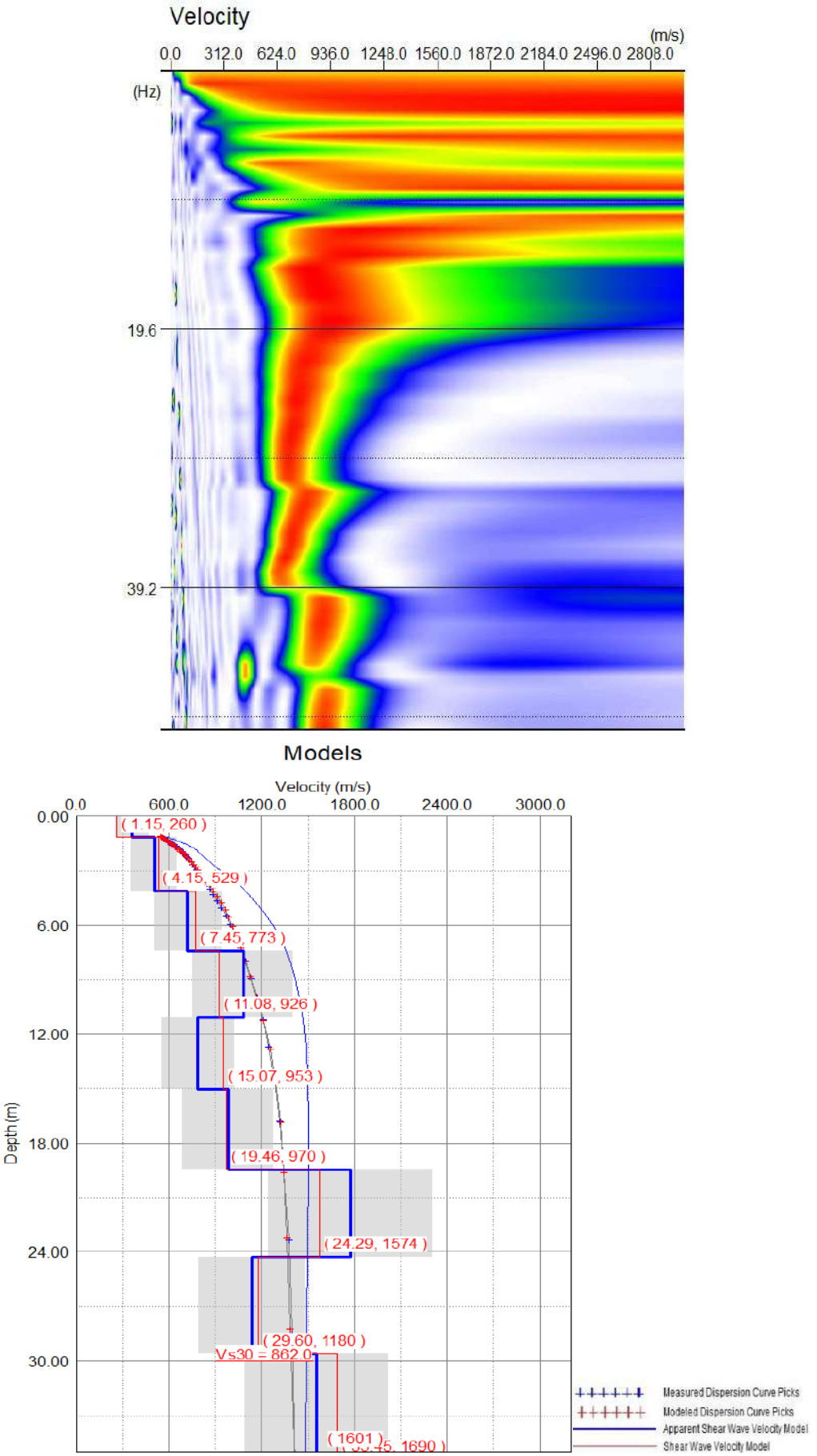


Figure 26: Dispersion Curve and inverted S-wave Velocity Model of MASW-24

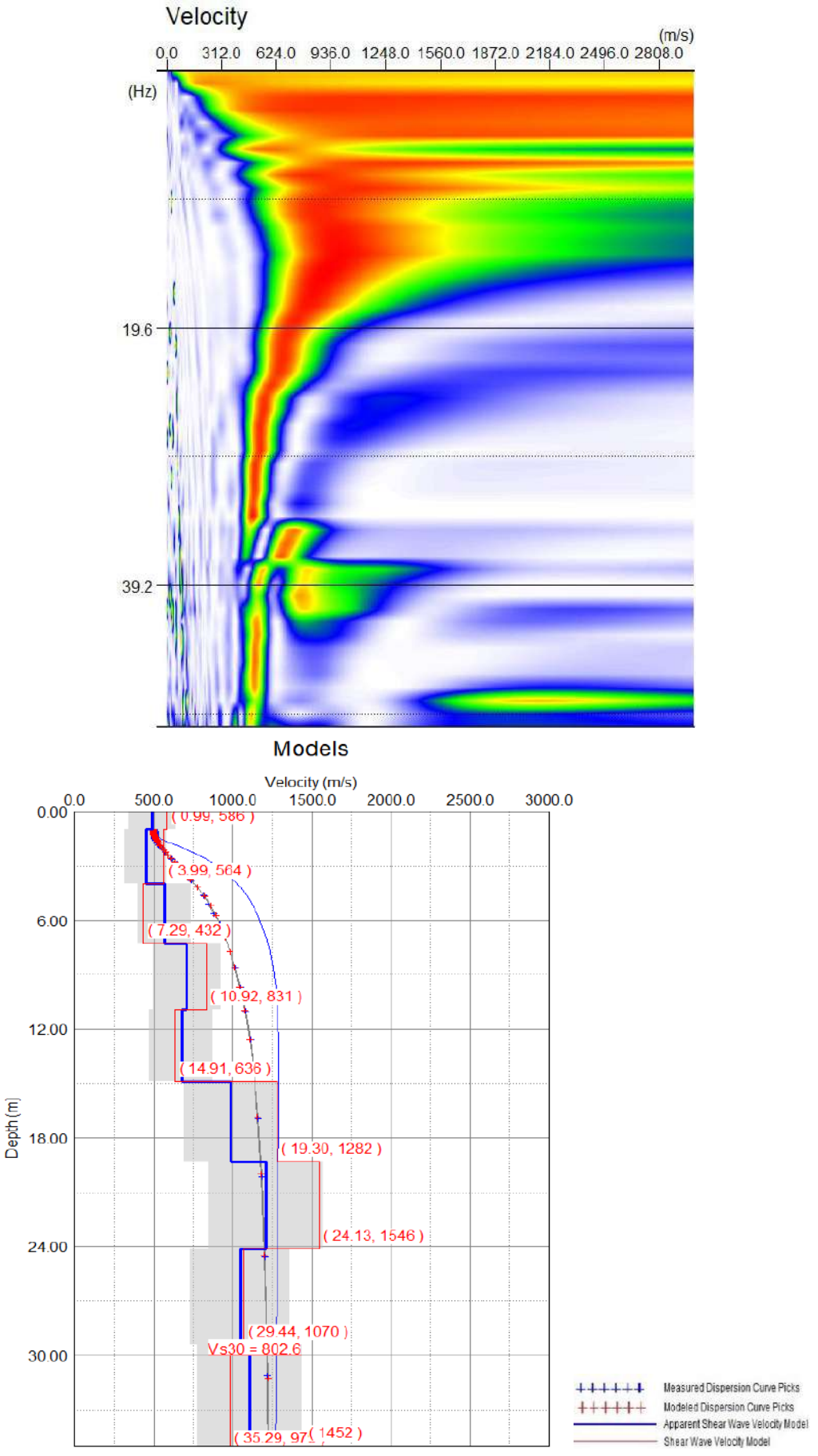


Figure 27: Dispersion Curve and inverted S-wave Velocity Model of MASW-25

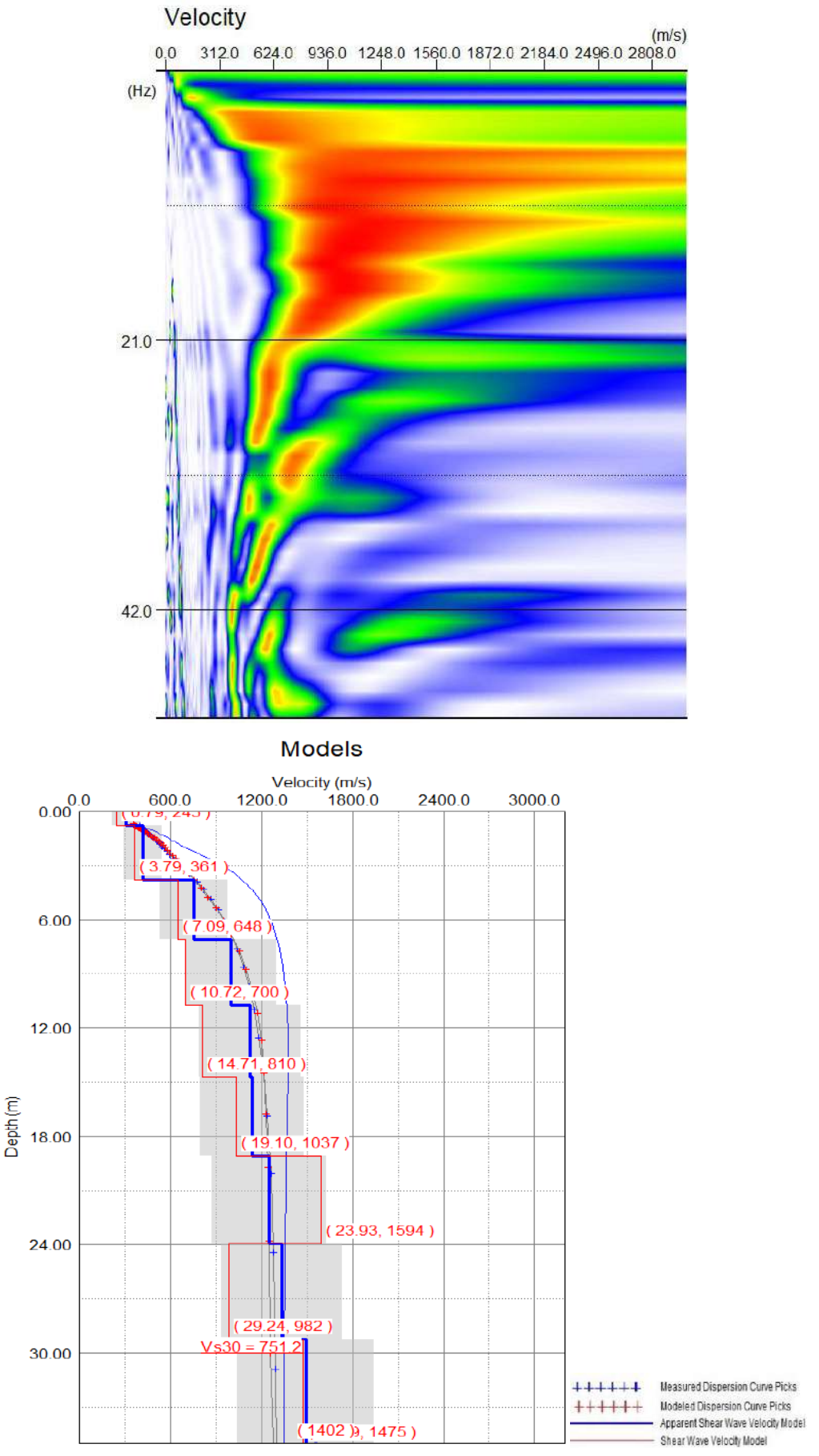


Figure 28: Dispersion Curve and inverted S-wave Velocity Model of MASW-26

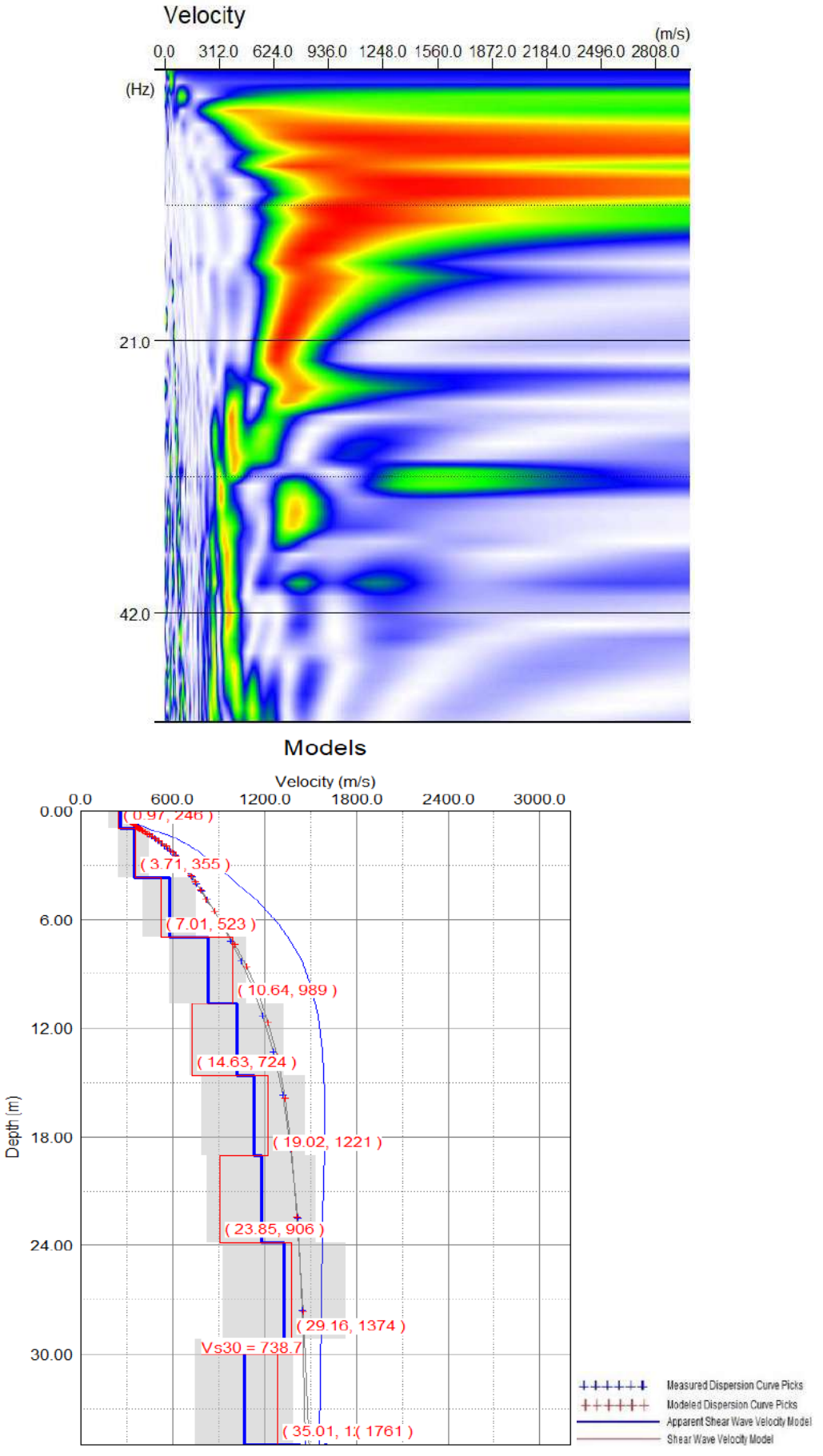


Figure 29: Dispersion Curve and inverted S-wave Velocity Model of MASW-27

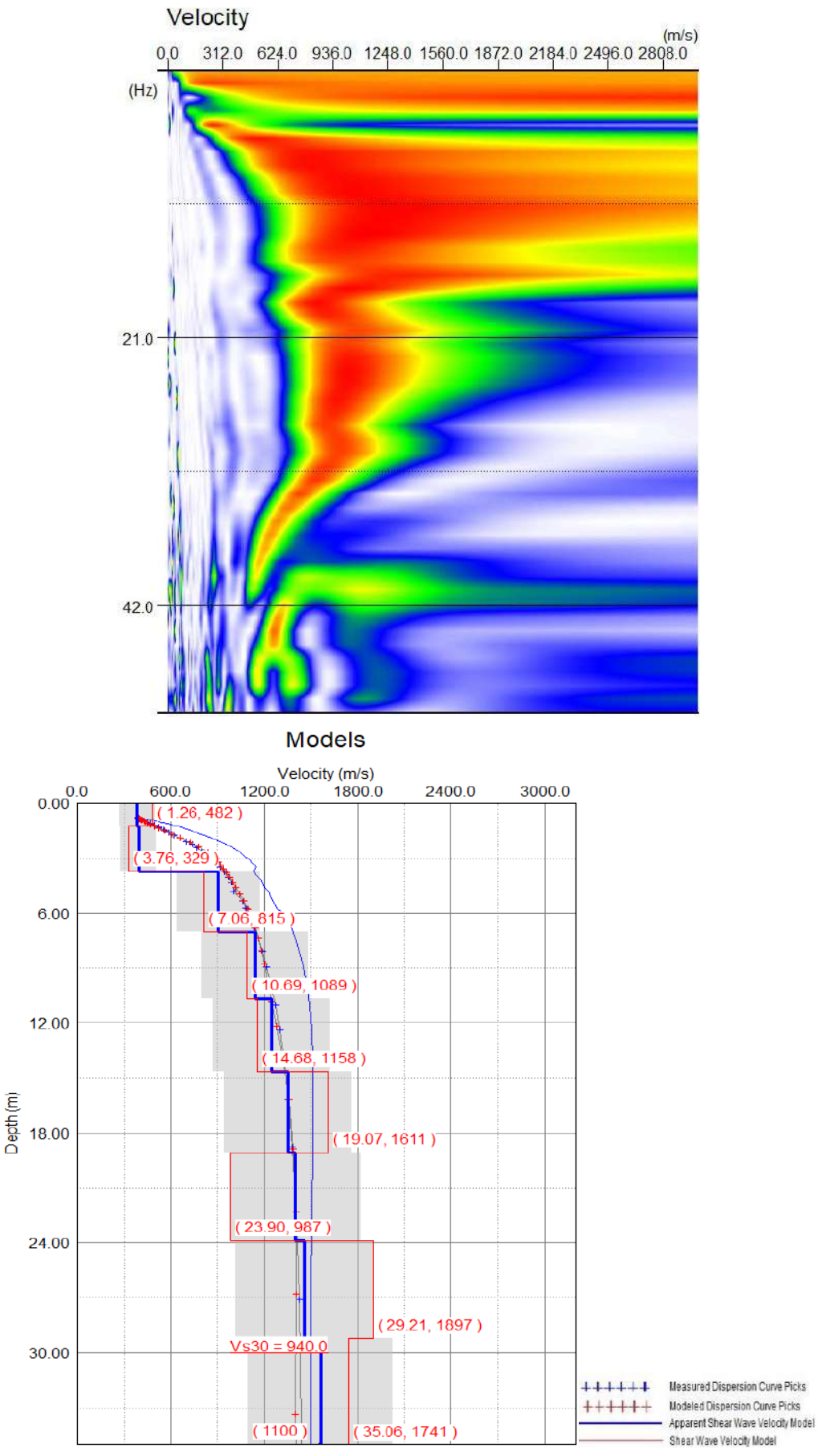


Figure 30: Dispersion Curve and inverted S-wave Velocity Model of MASW-28

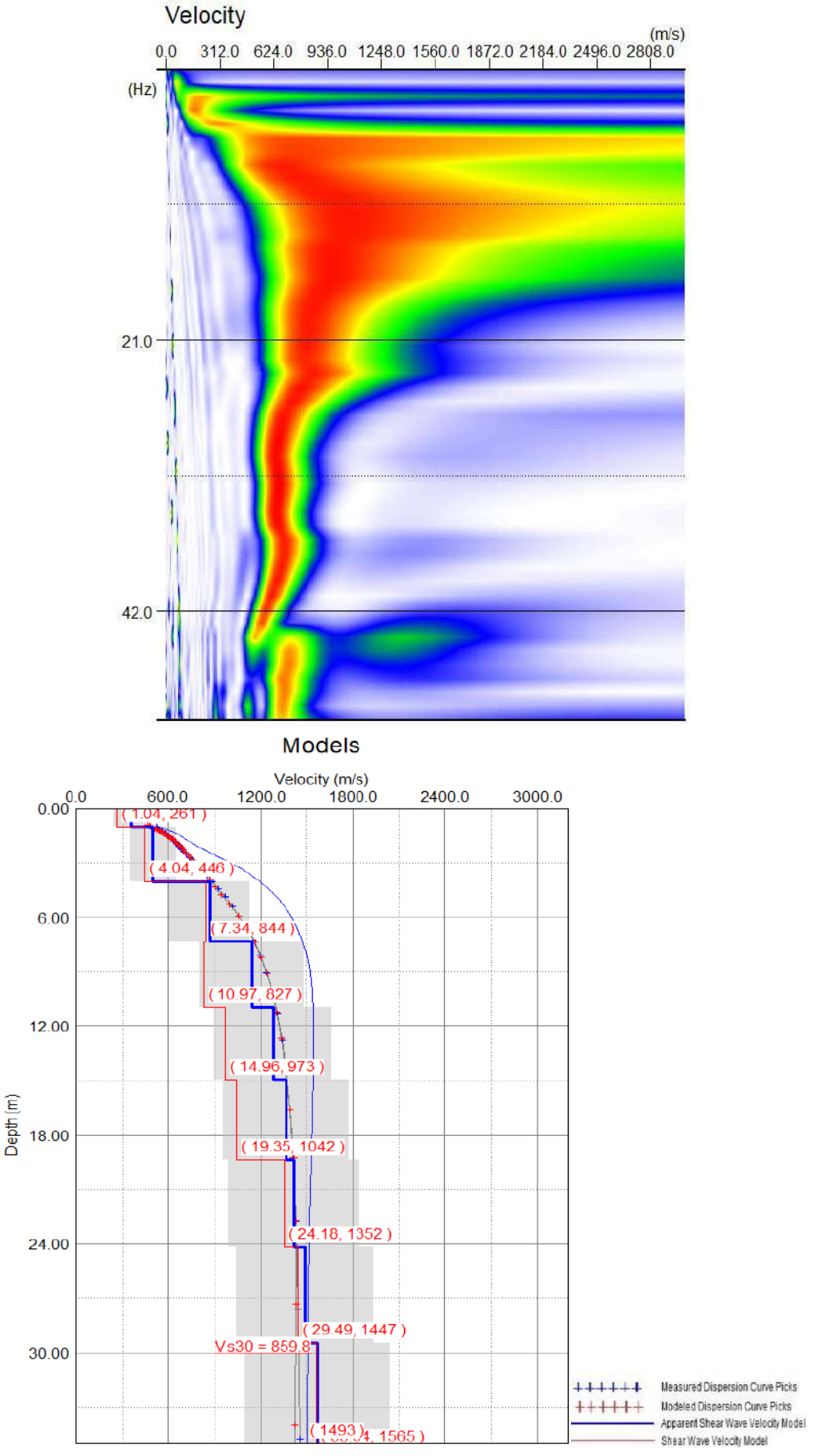


Figure 31: Dispersion Curve and inverted S-wave Velocity Model of MASW-29

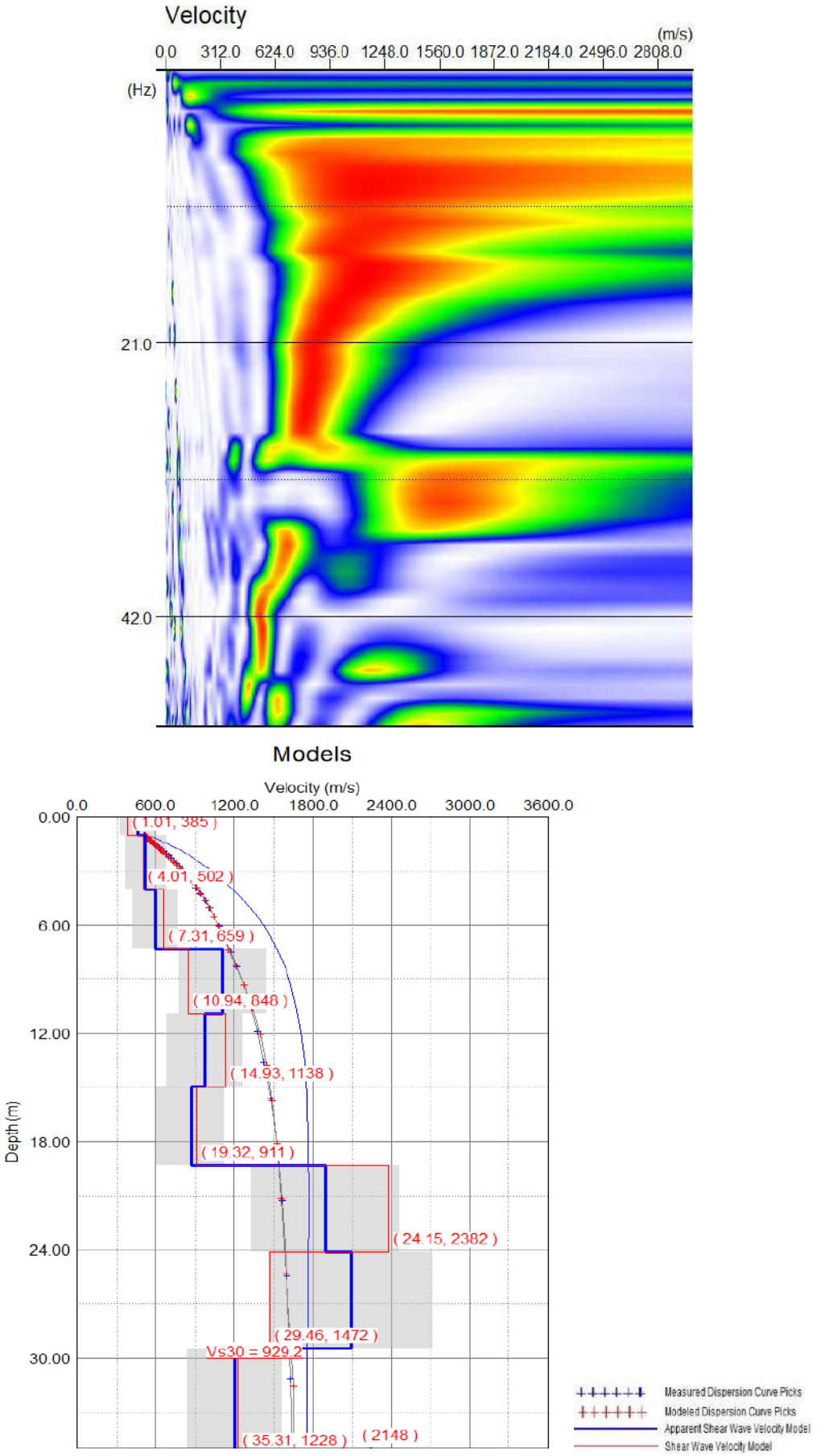


Figure 32: Dispersion Curve and inverted S-wave Velocity Model of MASW-30

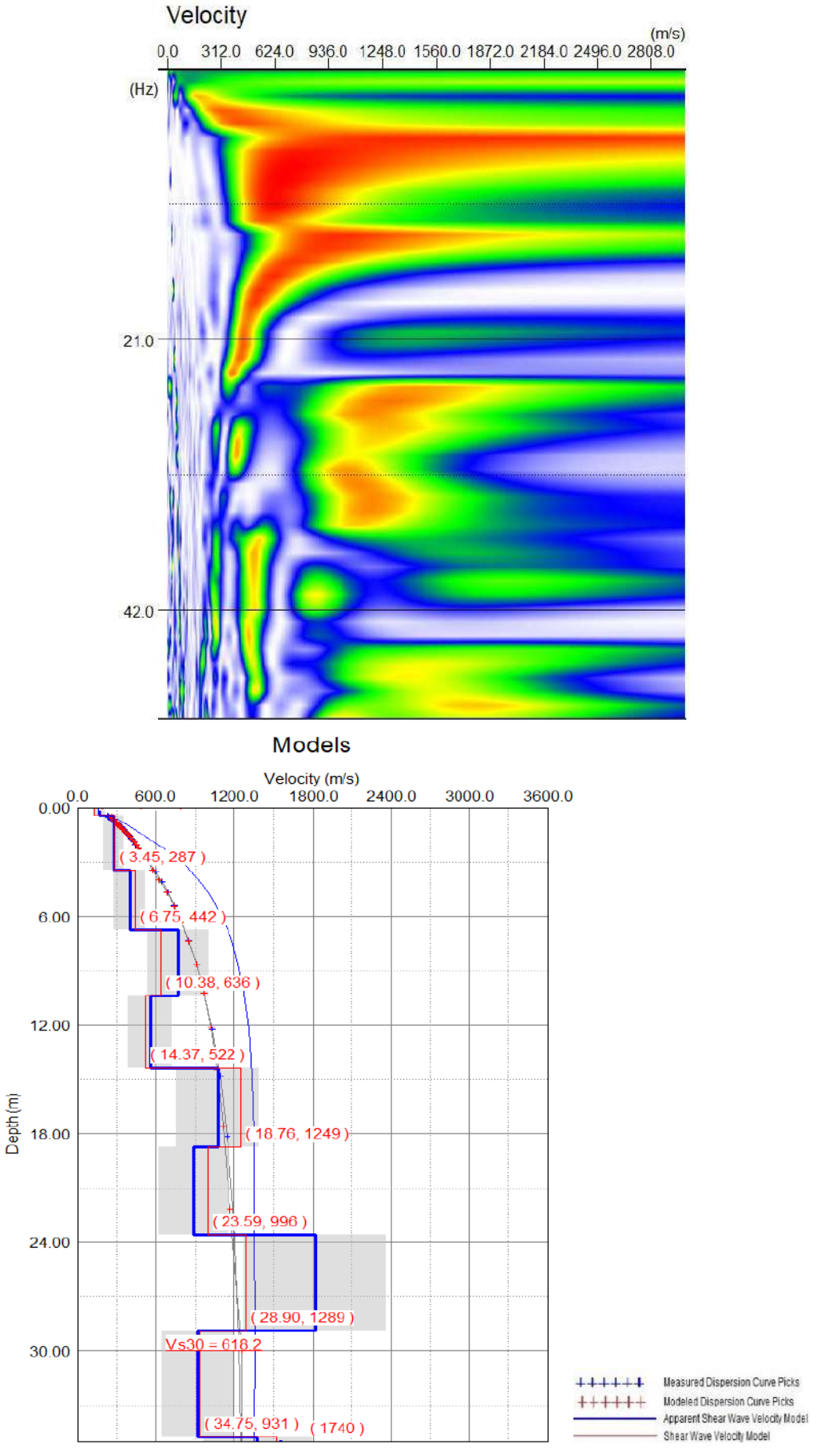


Figure 33: Dispersion Curve and inverted S-wave Velocity Model of MASW-31

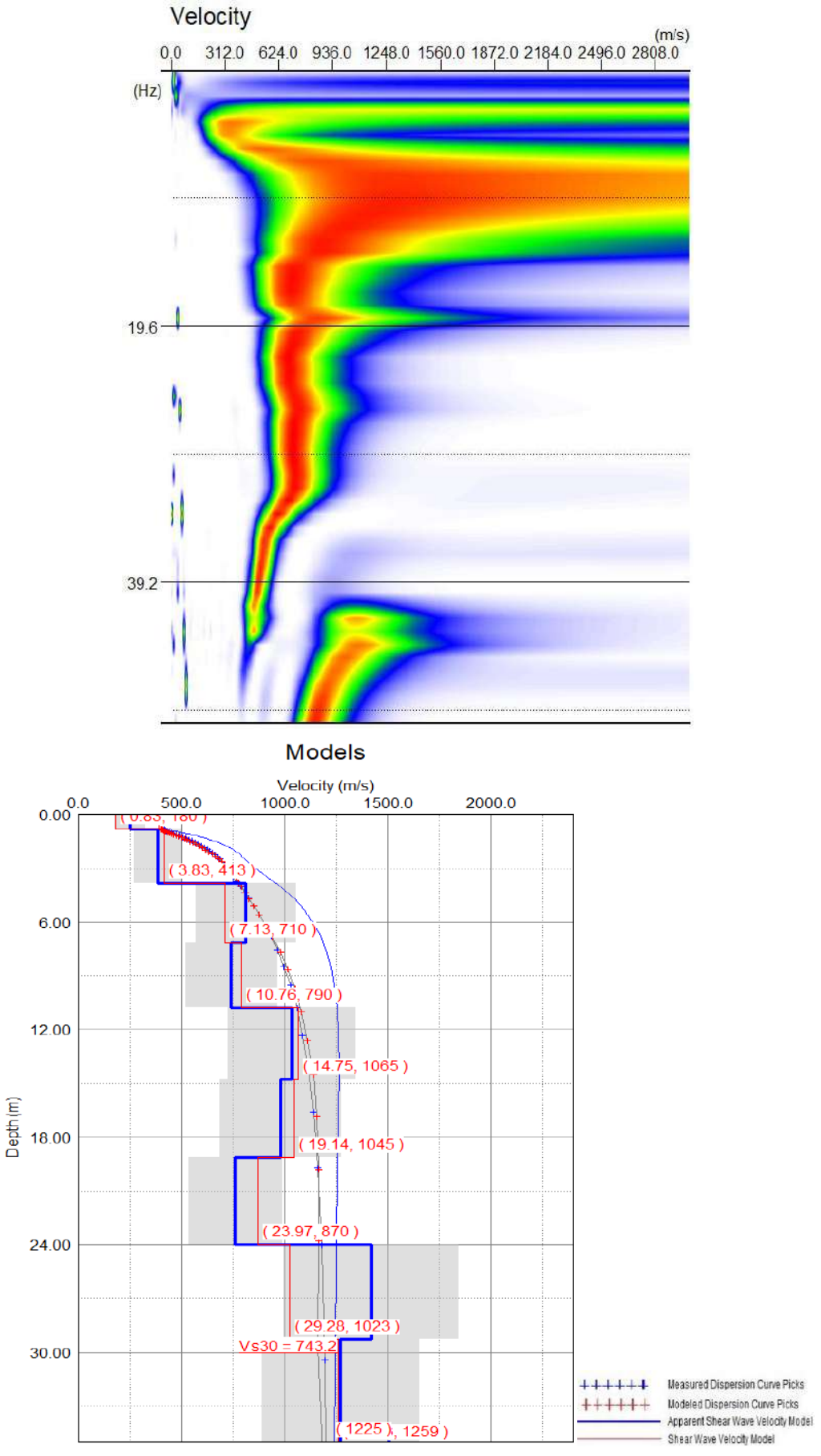


Figure 34: Dispersion Curve and inverted S-wave Velocity Model of MASW-32

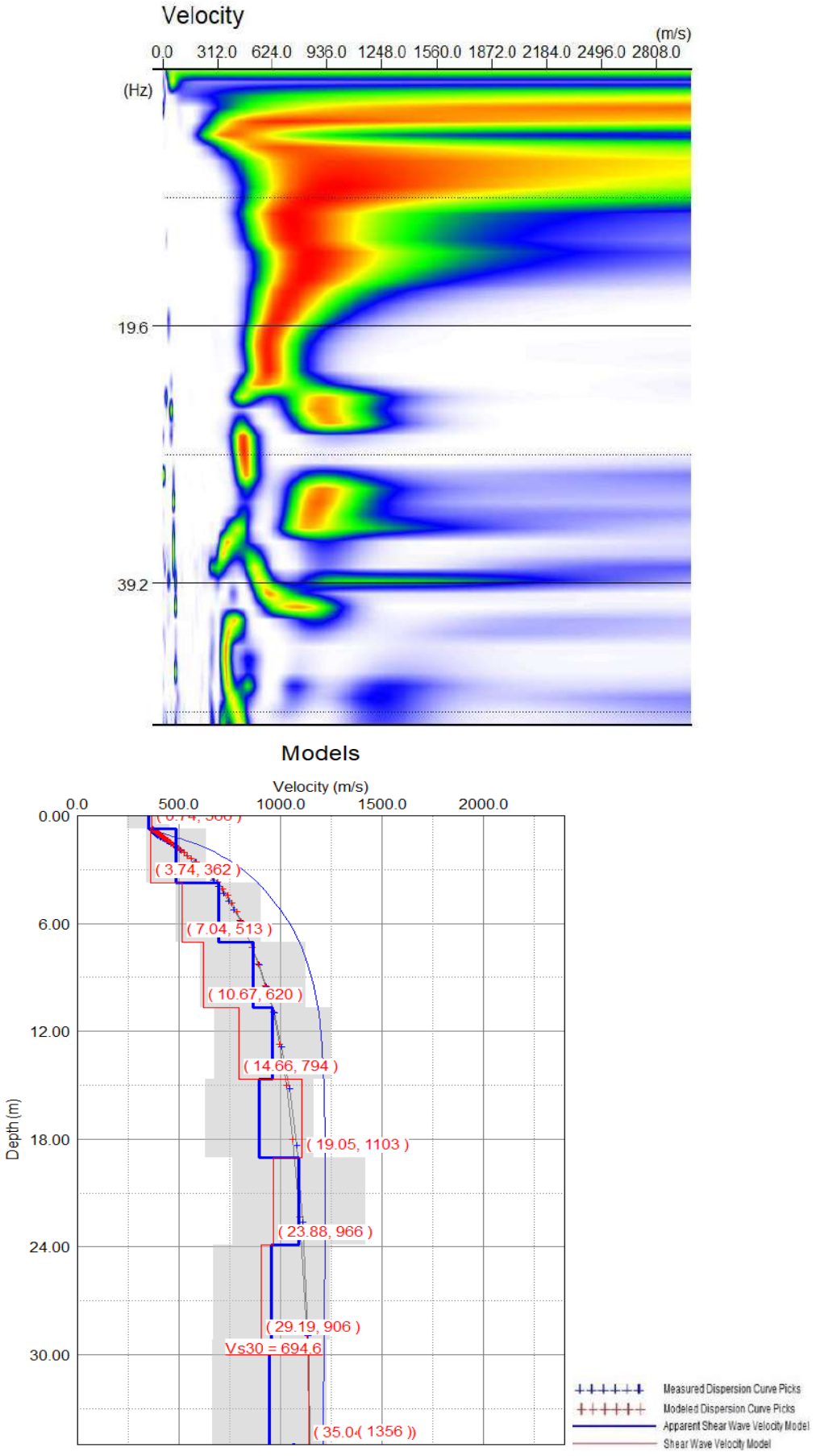


Figure 35: Dispersion Curve and inverted S-wave Velocity Model of MASW-33

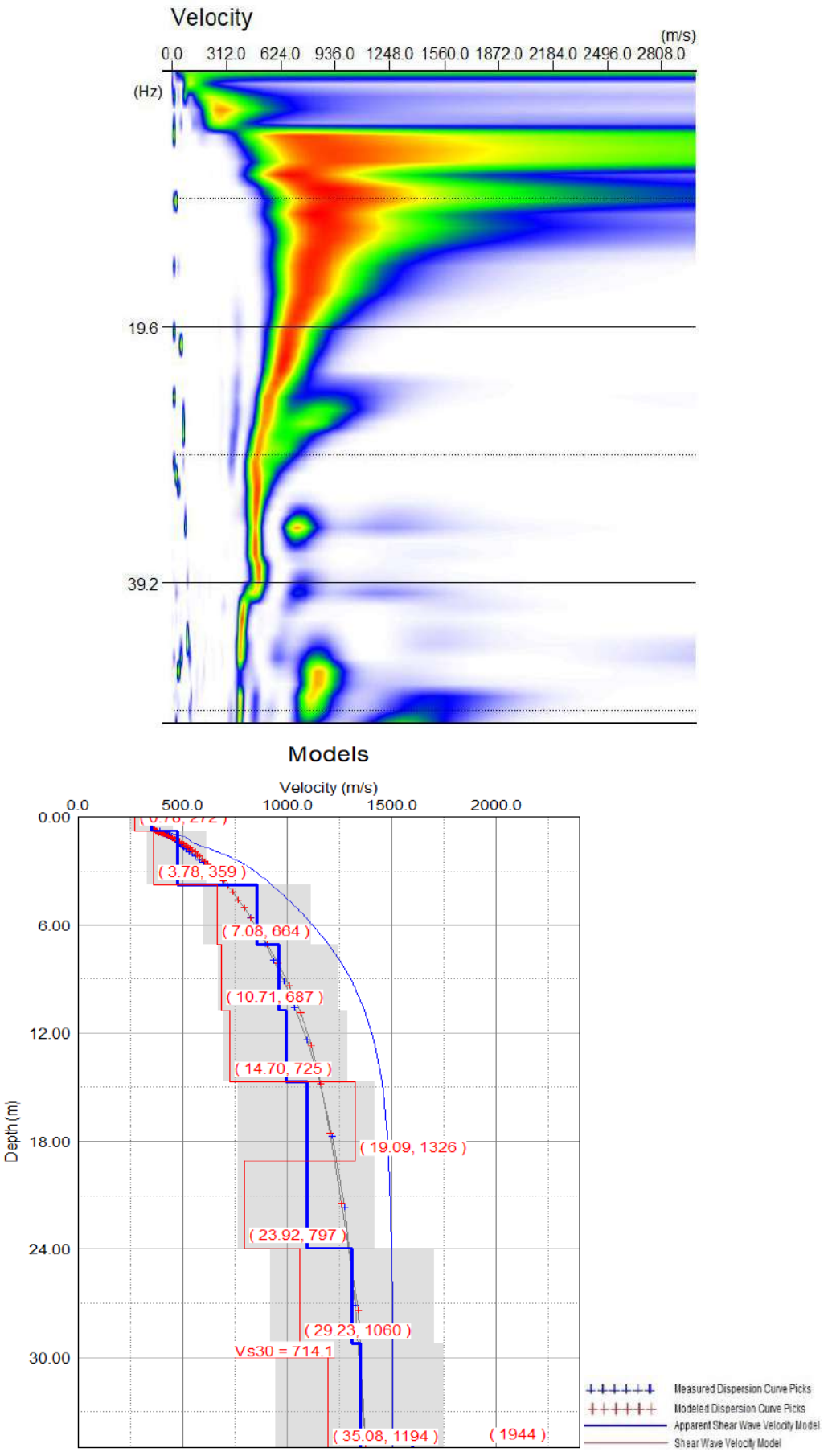


Figure 36: Dispersion Curve and inverted S-wave Velocity Model of MASW-34

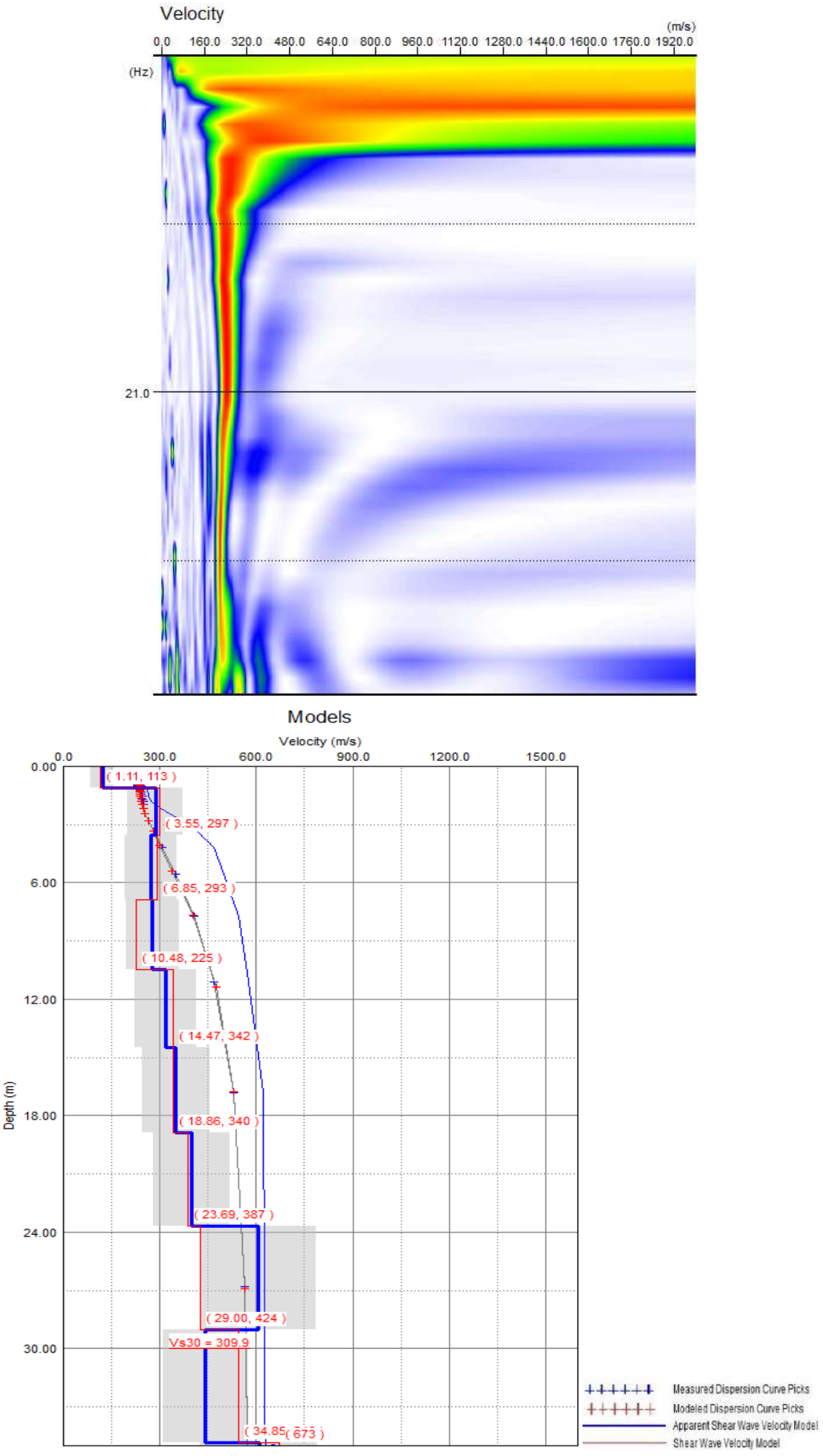


Figure 37: Dispersion Curve and inverted S-wave Velocity Model of MASW-35

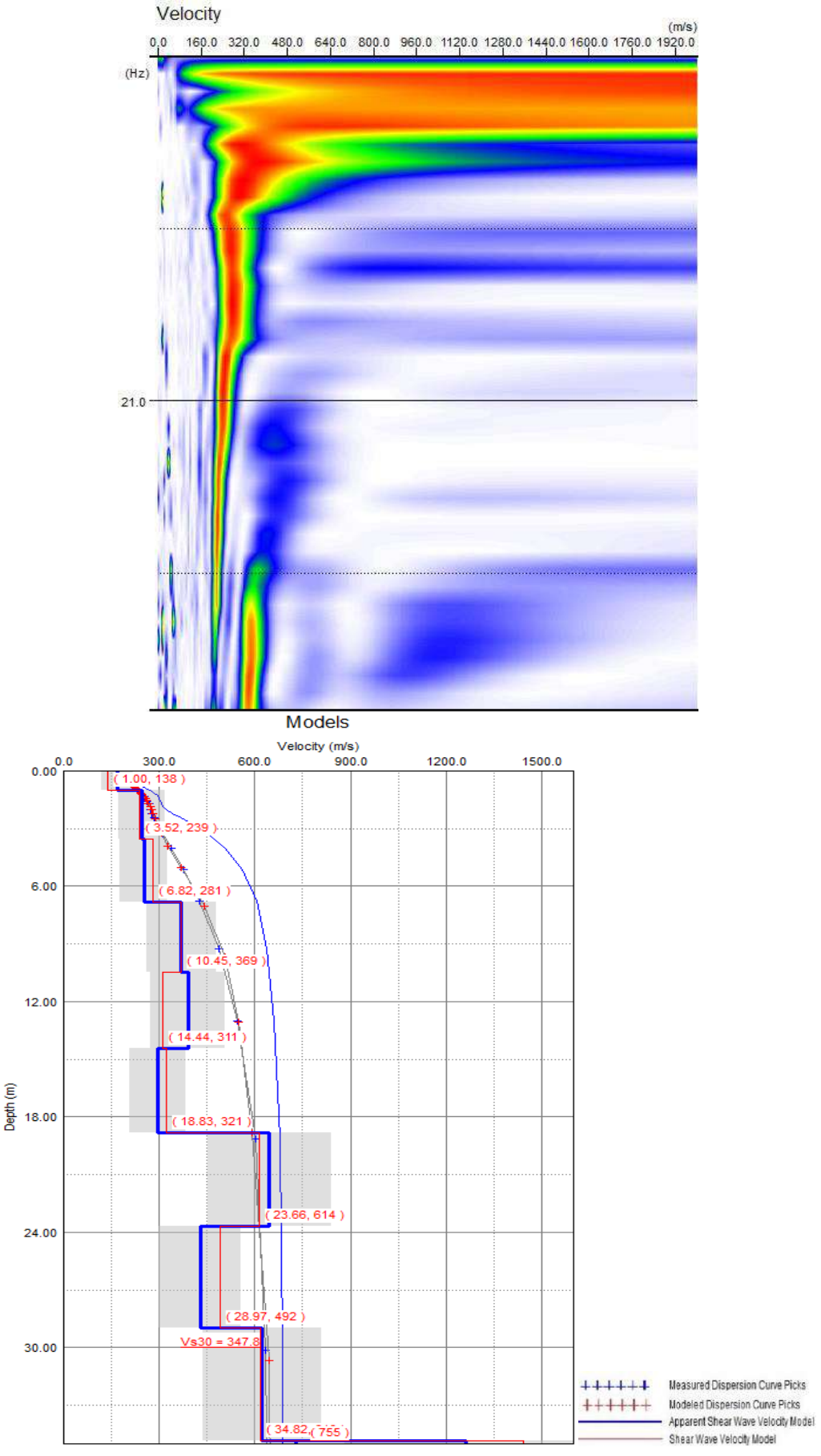


Figure 38: Dispersion Curve and inverted S-wave Velocity Model of MASW-36

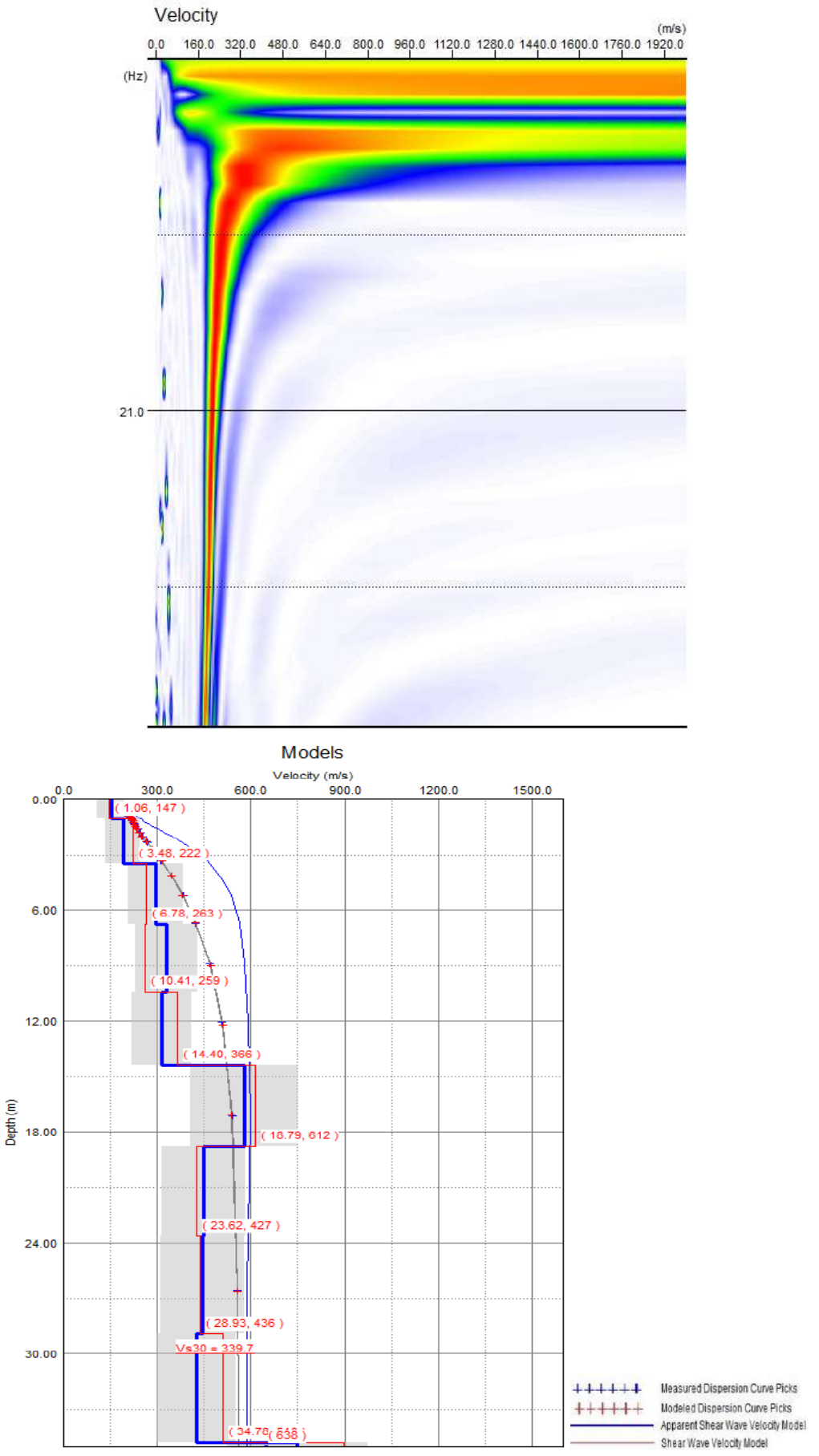


Figure 39: Dispersion Curve and inverted S-wave Velocity Model of MASW-37

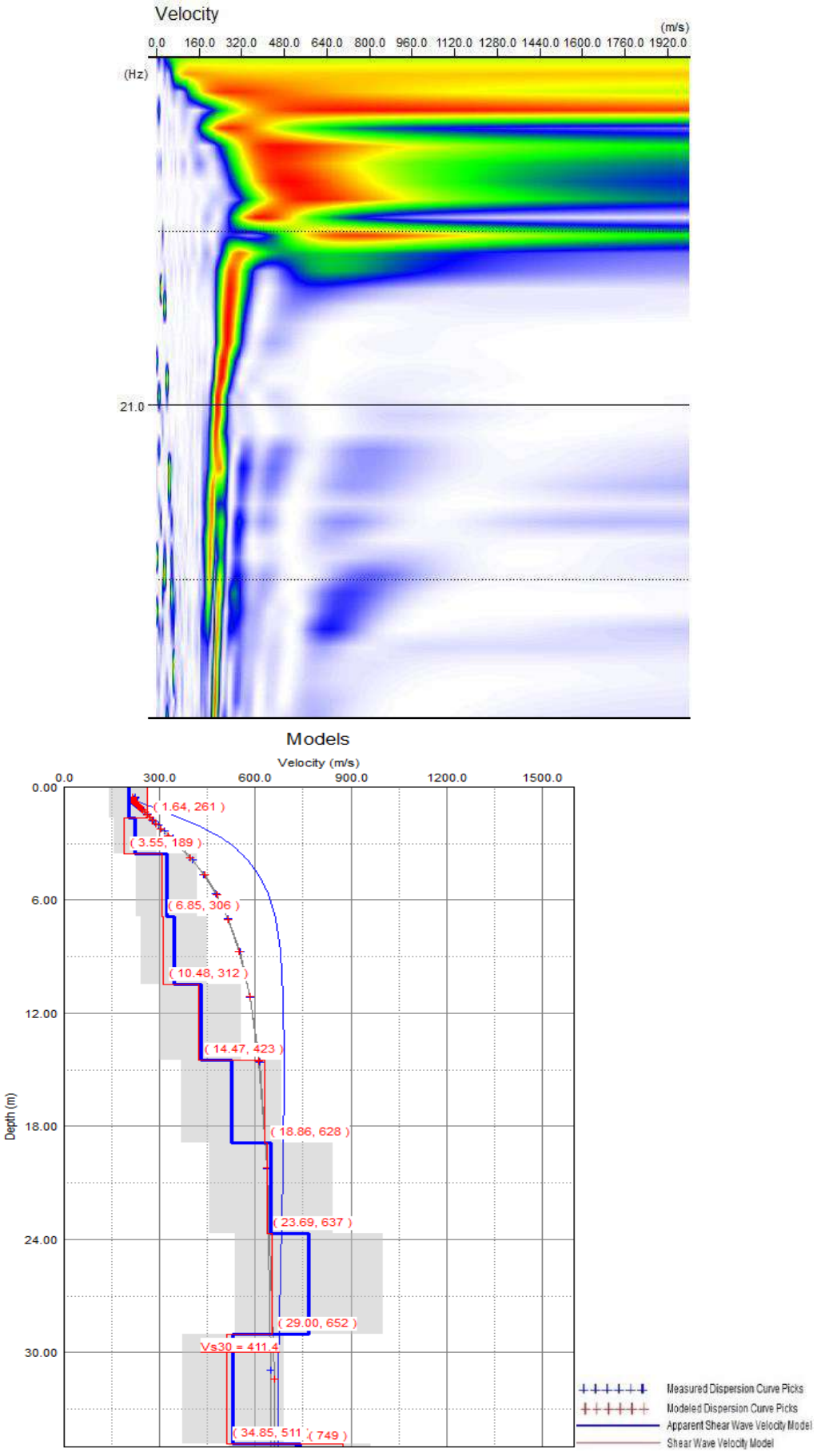


Figure 40: Dispersion Curve and inverted S-wave Velocity Model of MASW-38

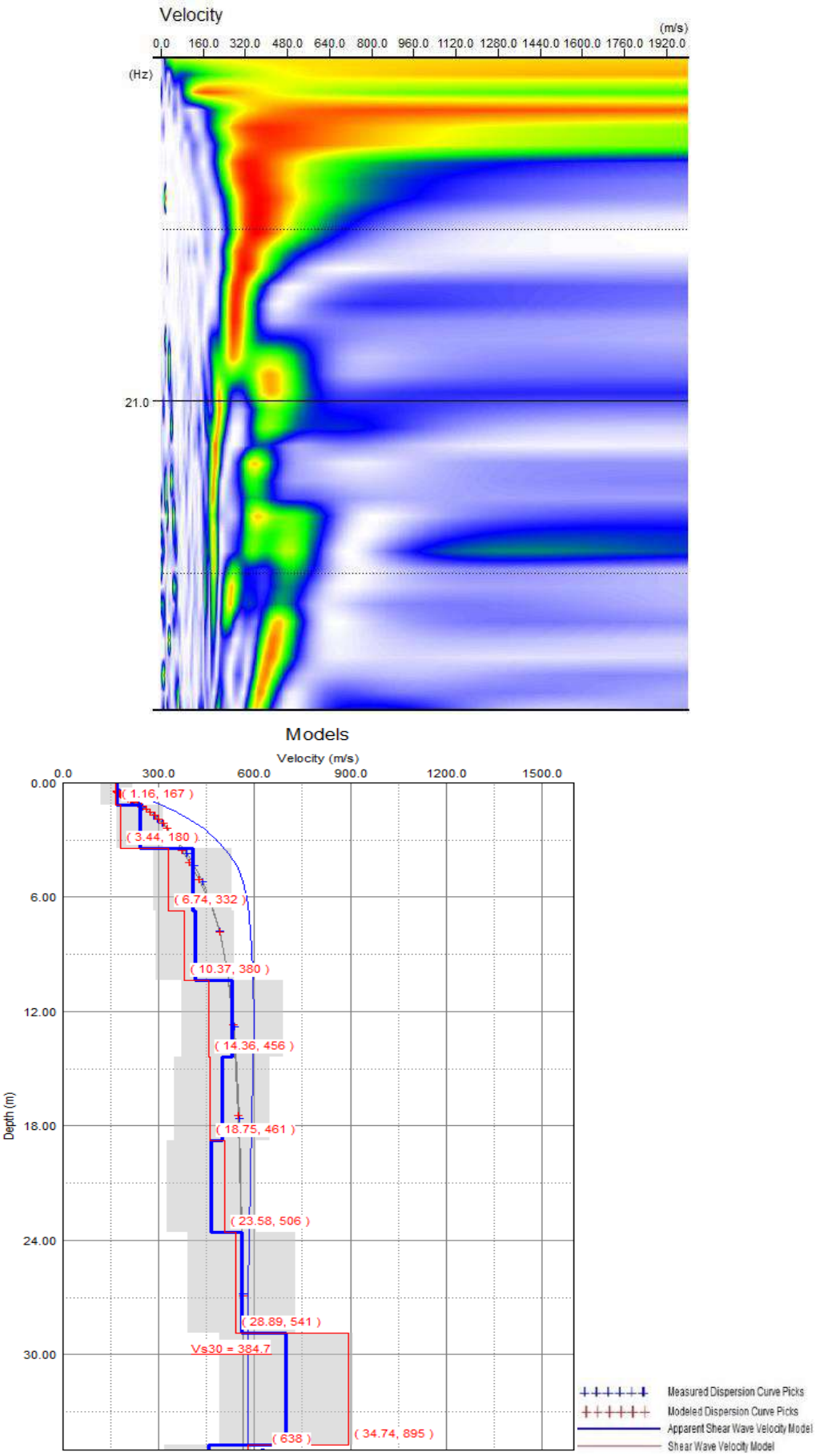


Figure 41: Dispersion Curve and inverted S-wave Velocity Model of MASW-39

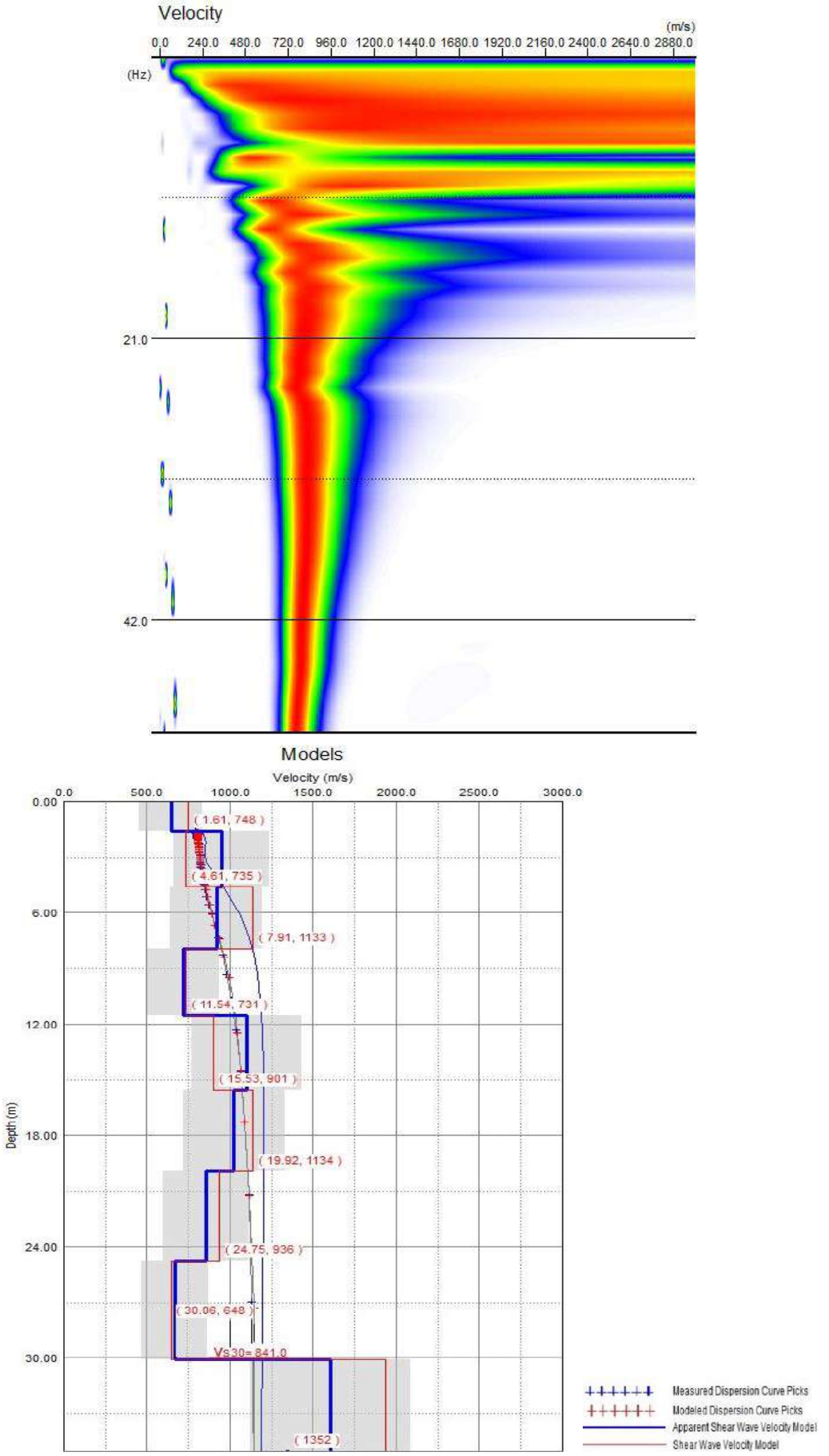


Figure 42: Dispersion Curve and inverted S-wave Velocity Model of MASW-40

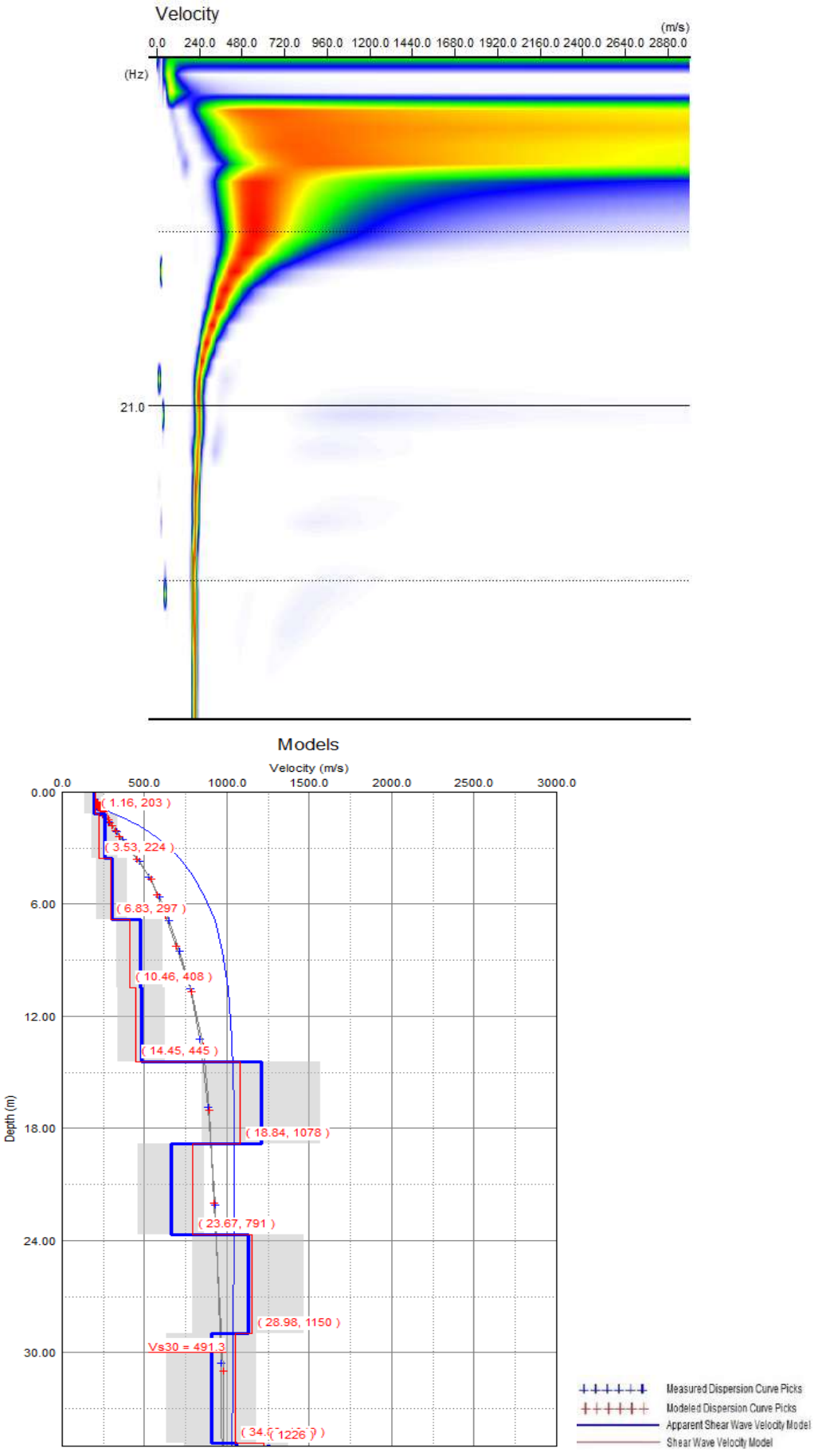


Figure 43: Dispersion Curve and inverted S-wave Velocity Model of MASW-41

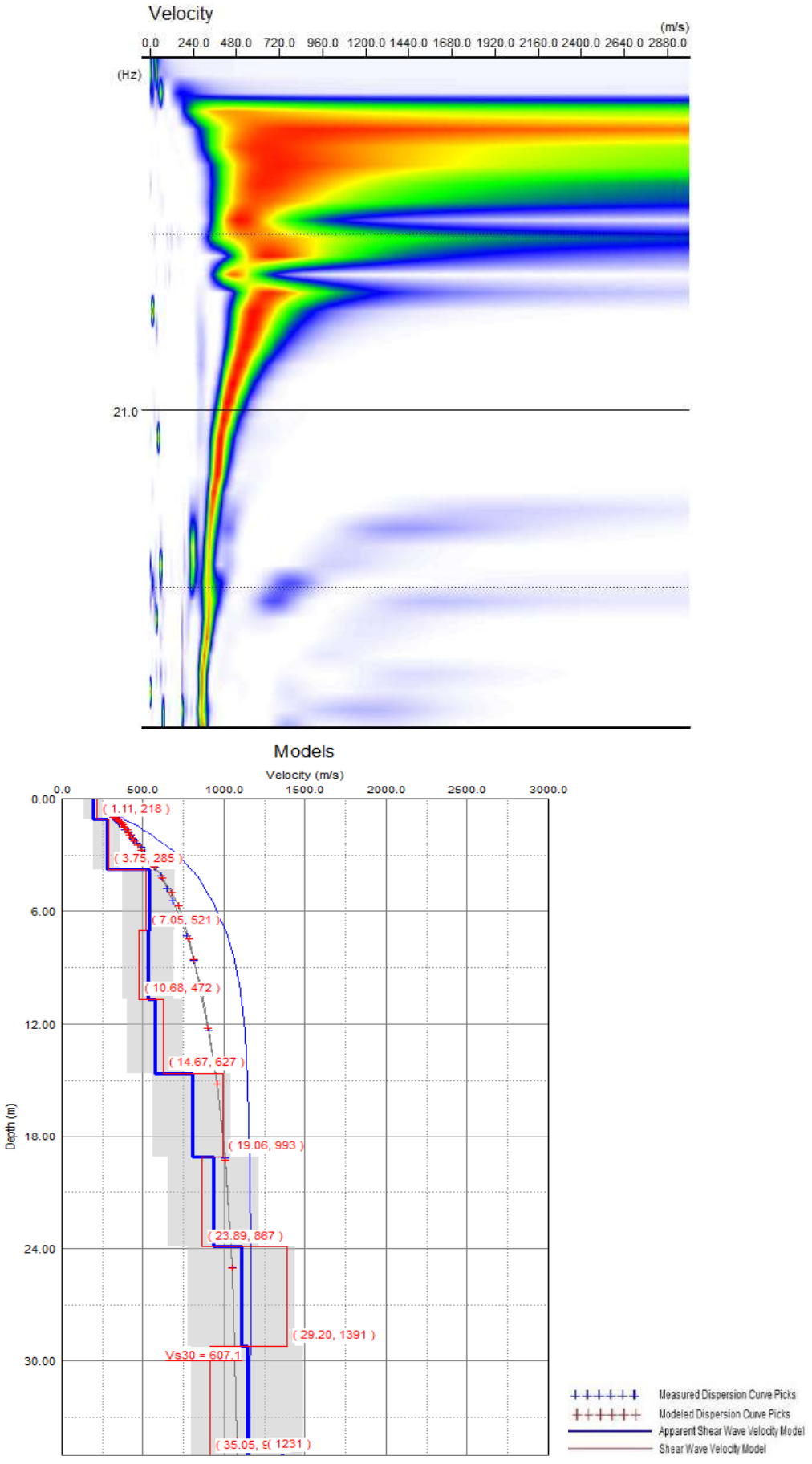


Figure 44: Dispersion Curve and inverted S-wave Velocity Model of MASW-42

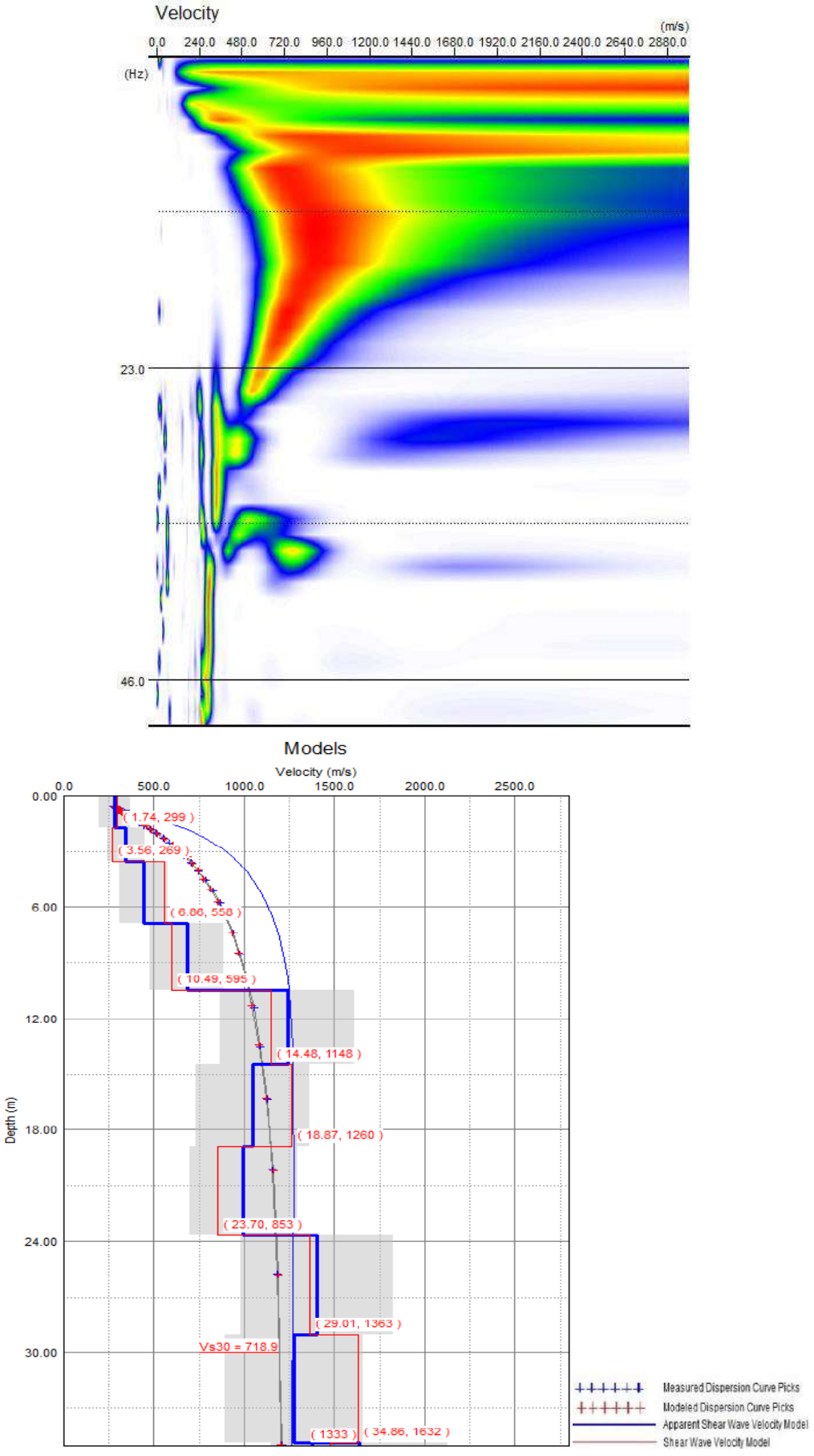


Figure 45: Dispersion Curve and inverted S-wave Velocity Model of MASW-43

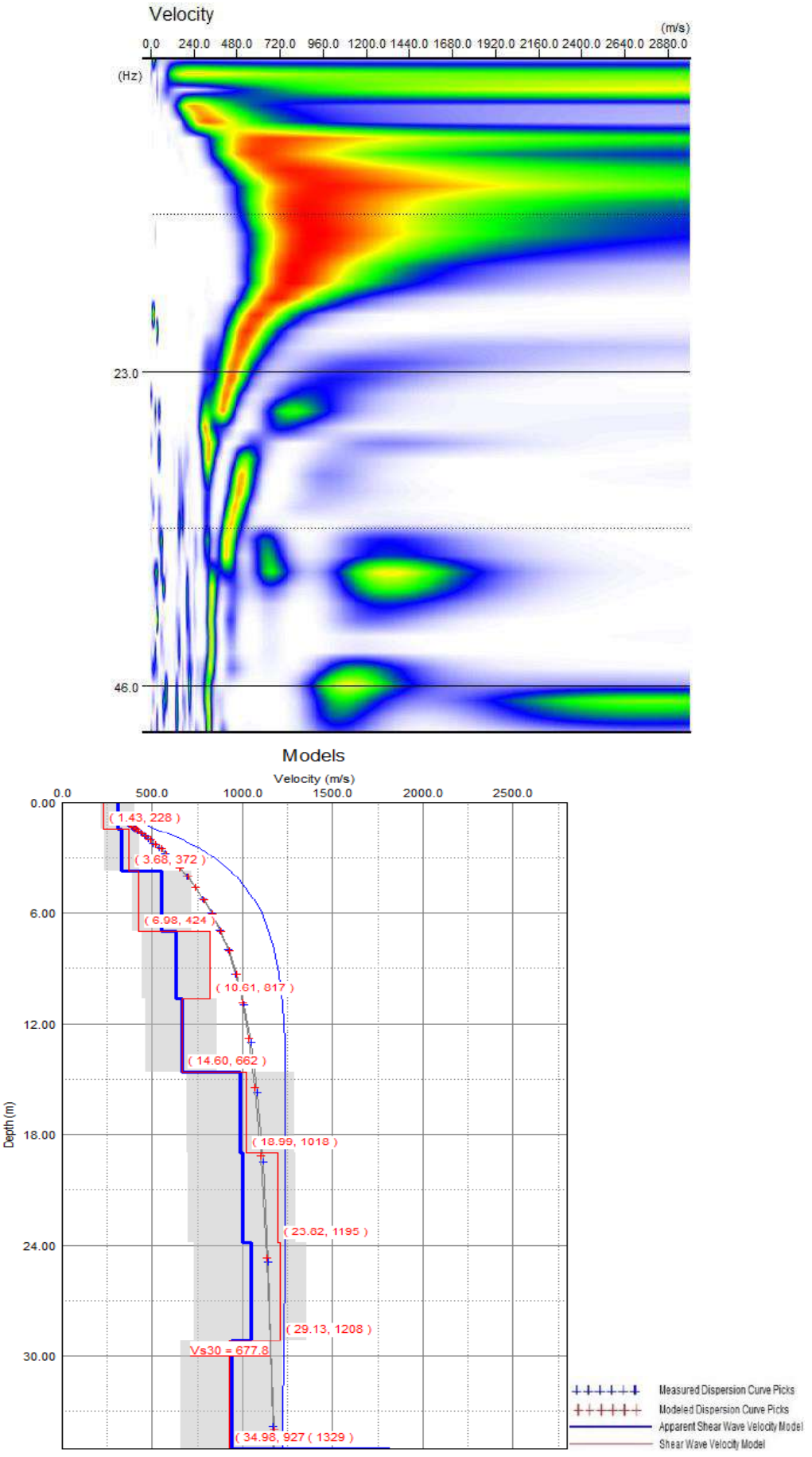


Figure 46: Dispersion Curve and inverted S-wave Velocity Model of MASW-44

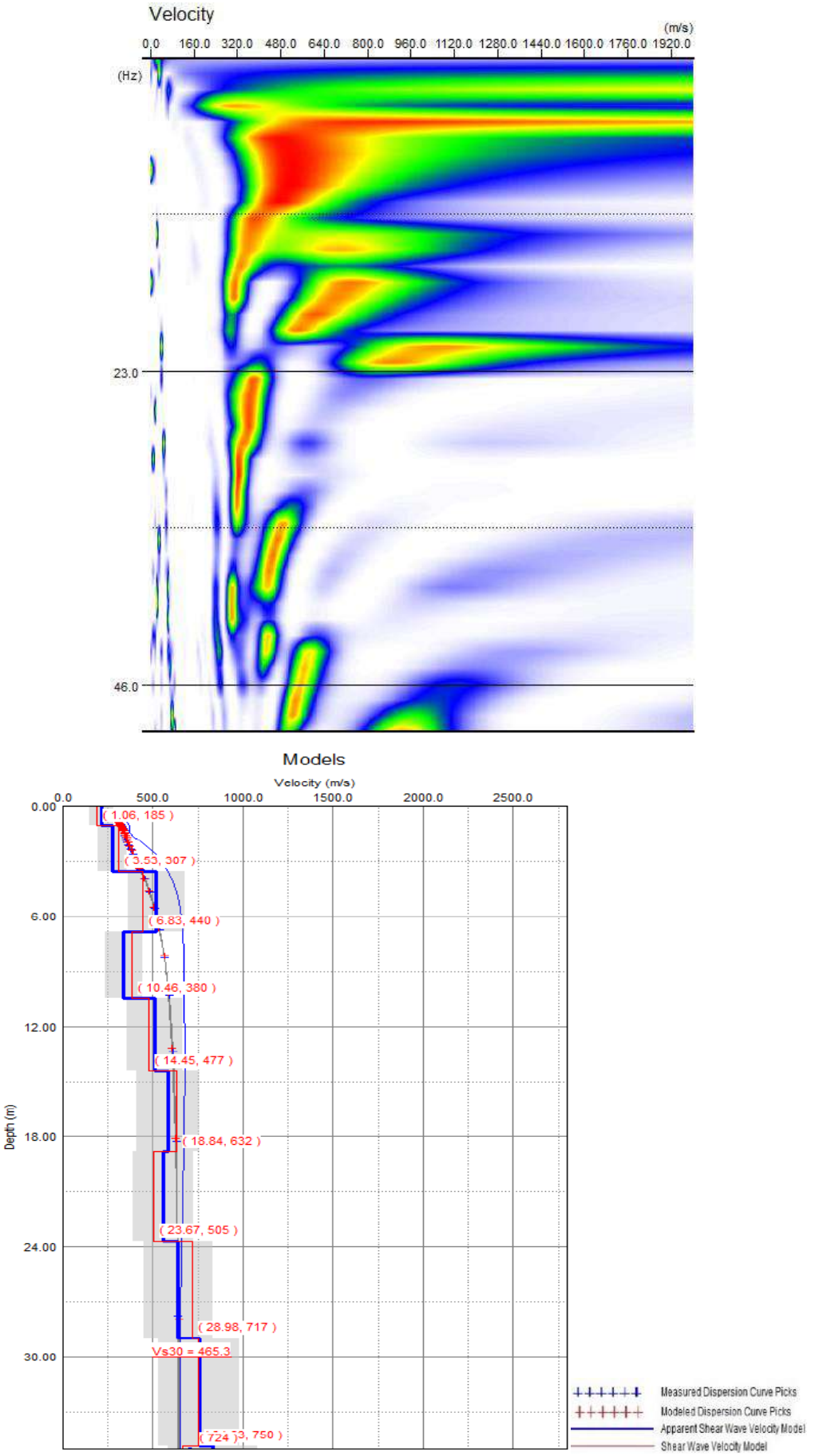


Figure 47: Dispersion Curve and inverted S-wave Velocity Model of MASW-45

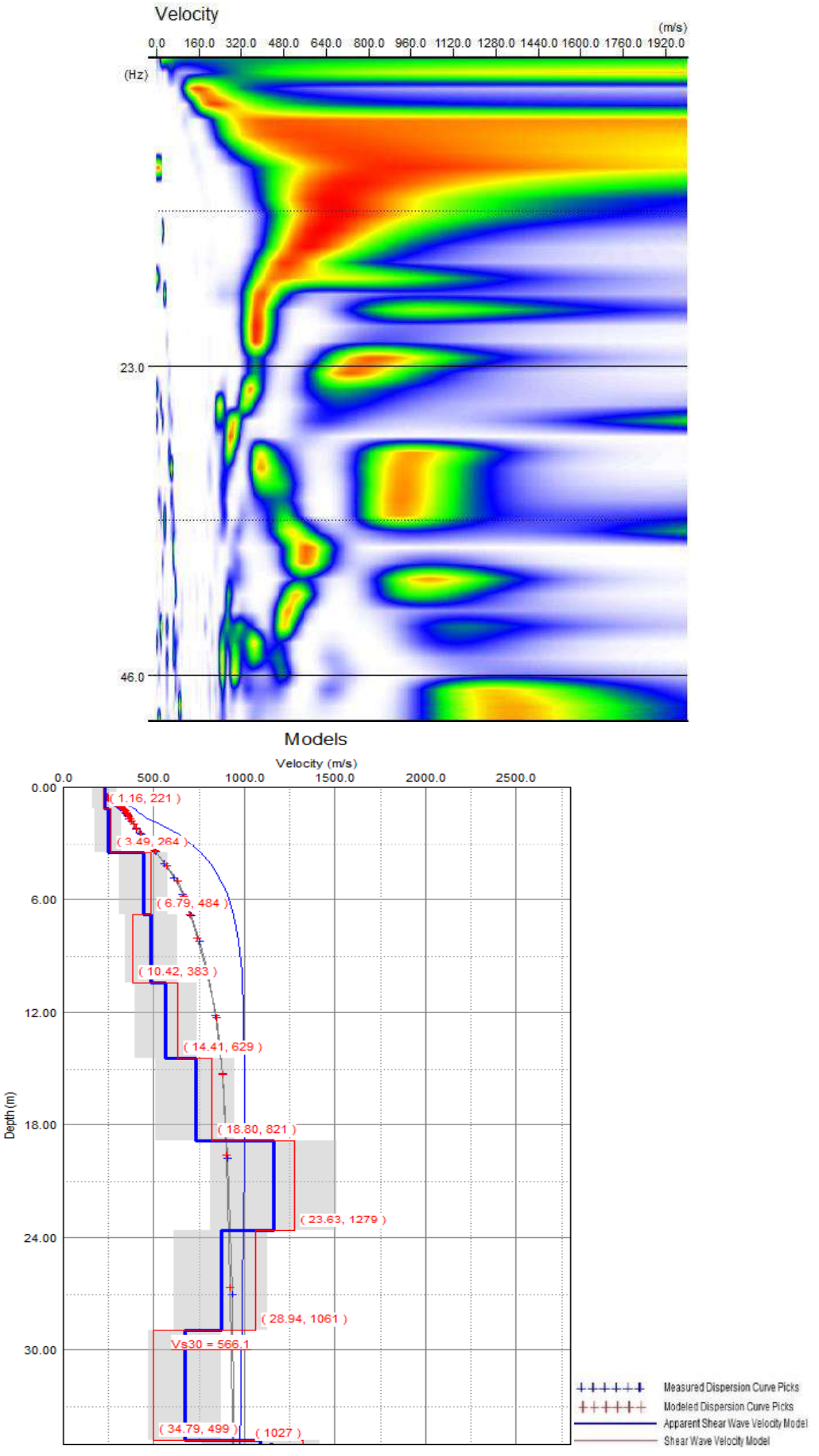


Figure 48: Dispersion Curve and inverted S-wave Velocity Model of MASW-46

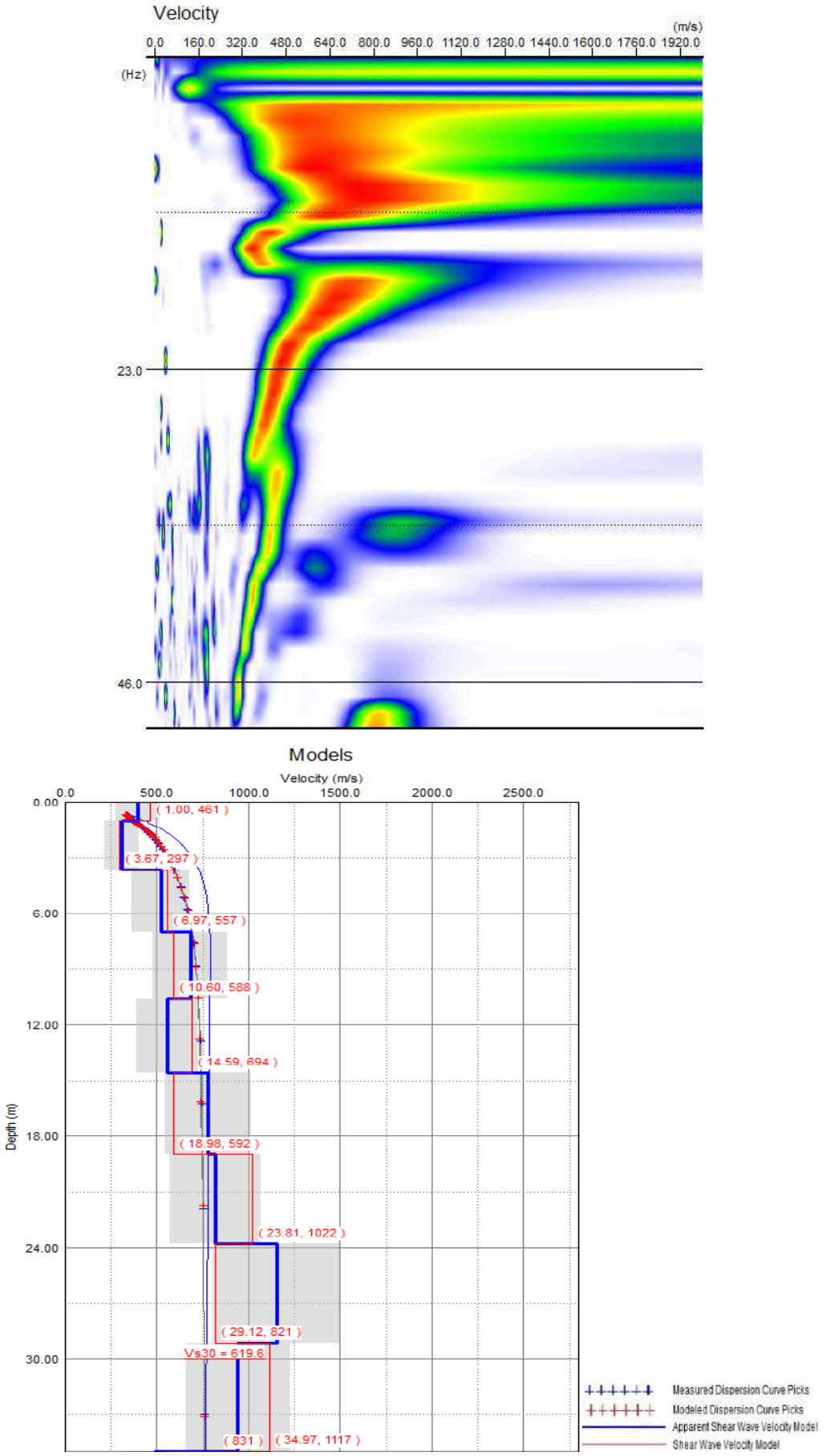


Figure 49: Dispersion Curve and inverted S-wave Velocity Model of MASW-47

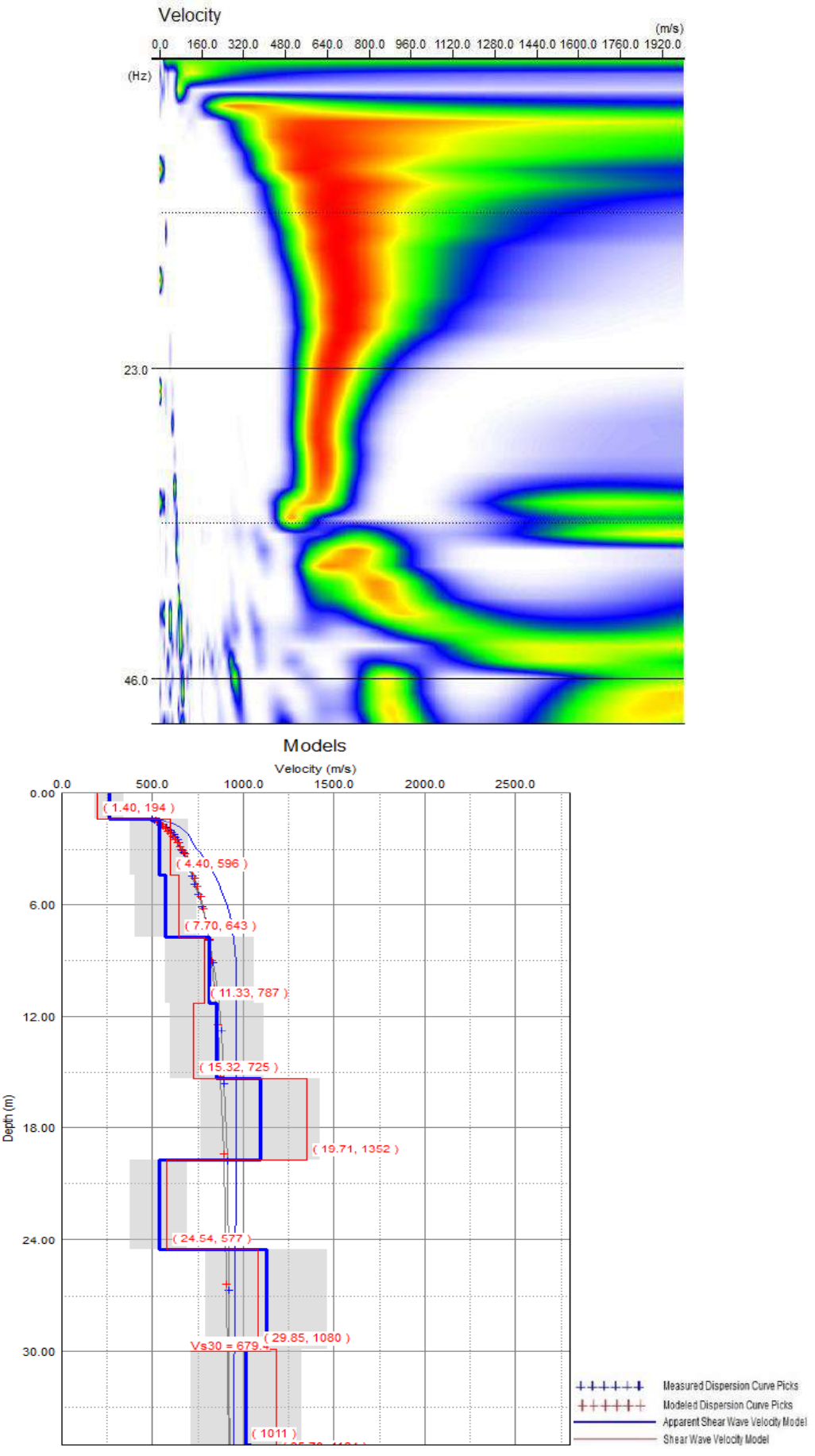


Figure 50: Dispersion Curve and inverted S-wave Velocity Model of MASW-48

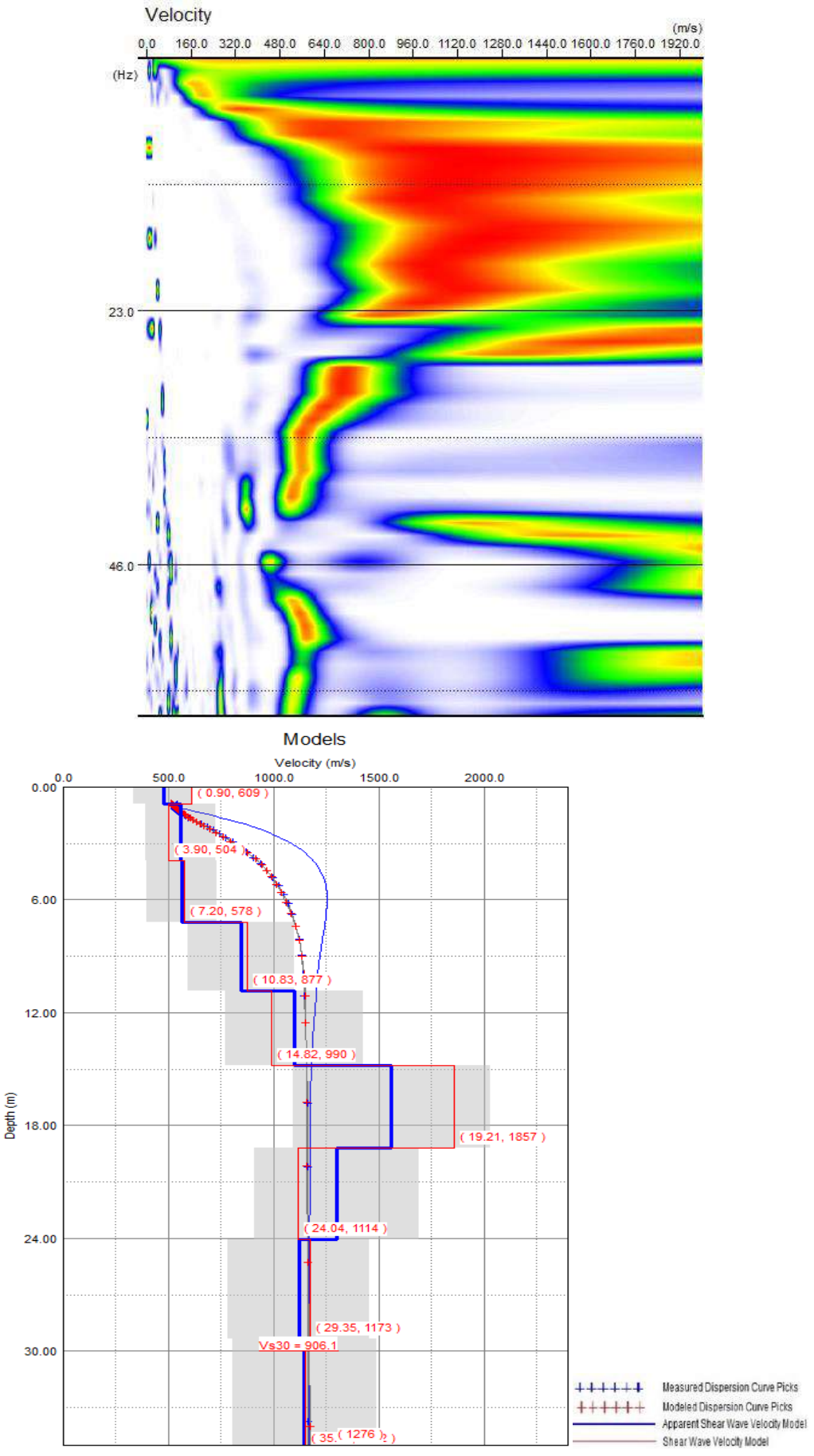


Figure 51: Dispersion Curve and inverted S-wave Velocity Model of MASW-49

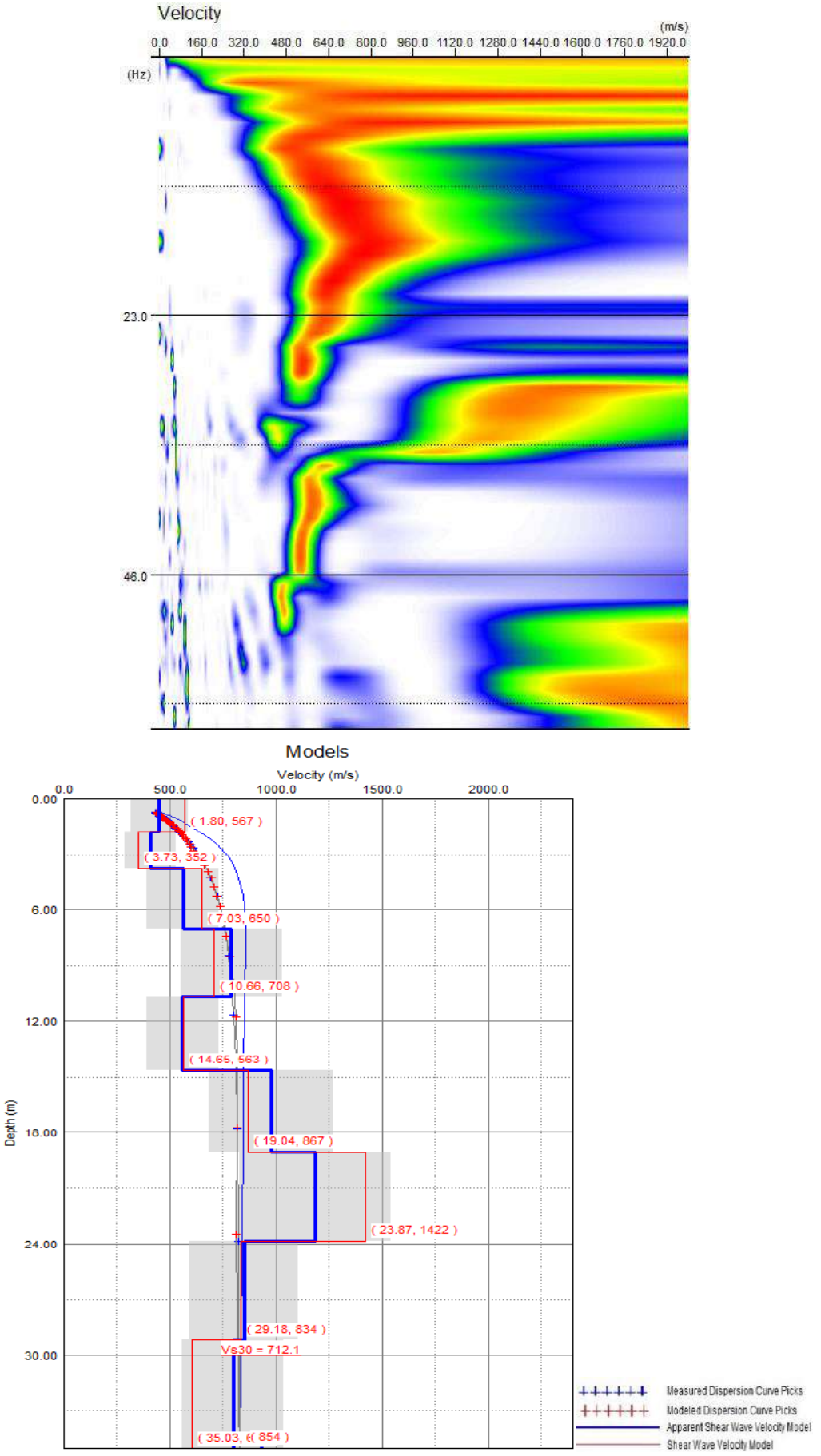


Figure 52: Dispersion Curve and inverted S-wave Velocity Model of MASW-50

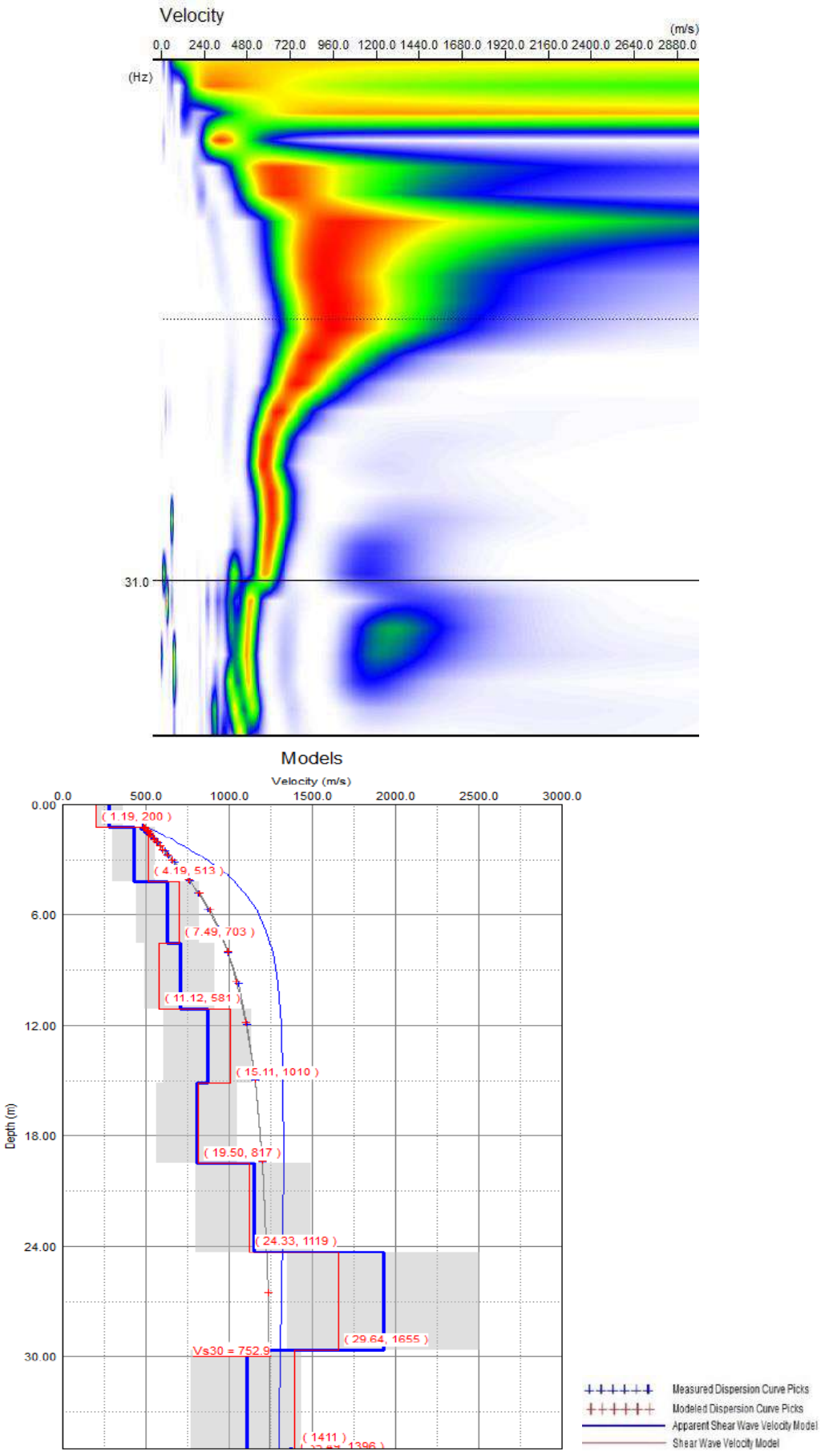


Figure 53: Dispersion Curve and inverted S-wave Velocity Model of MASW-51

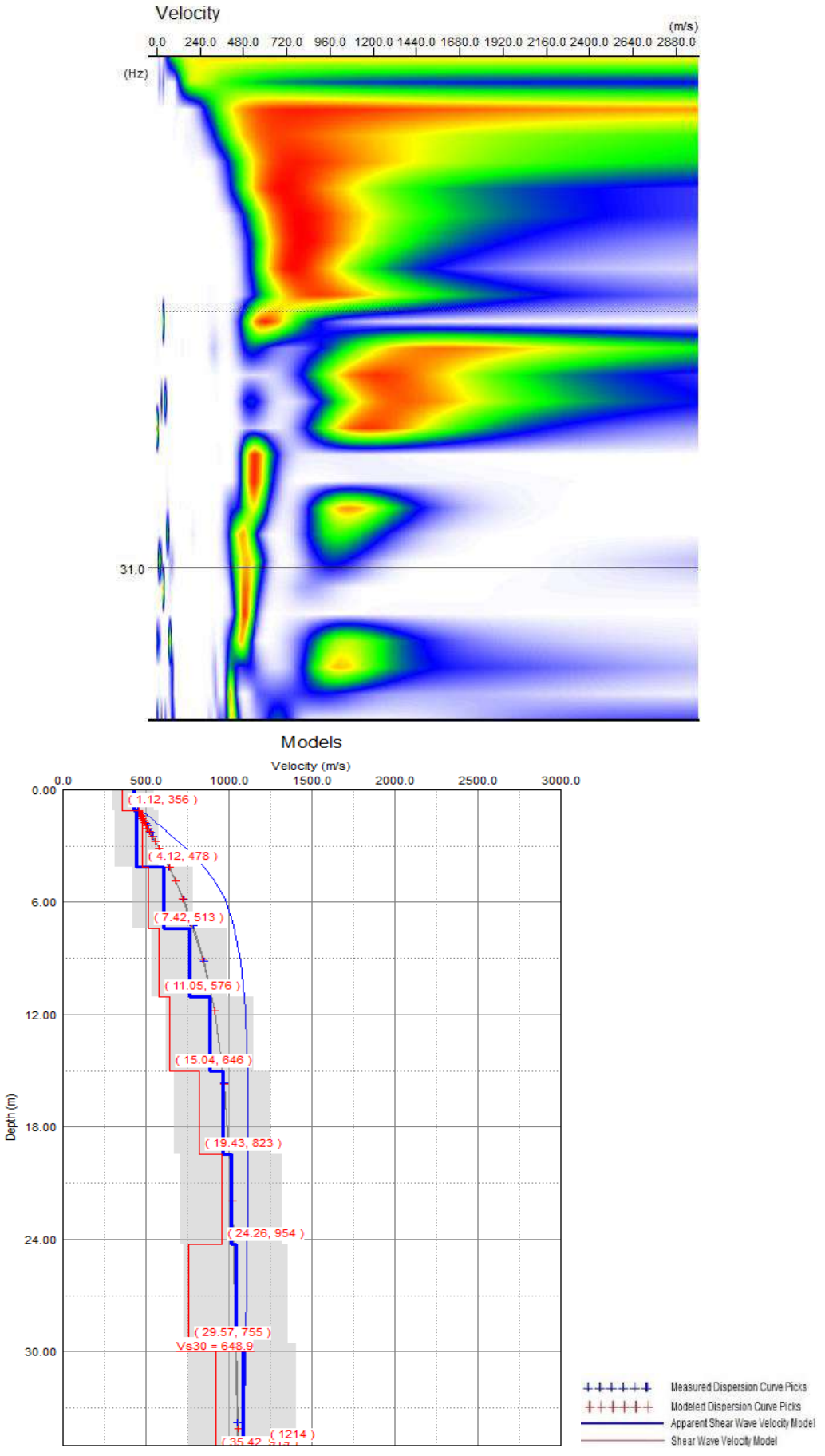
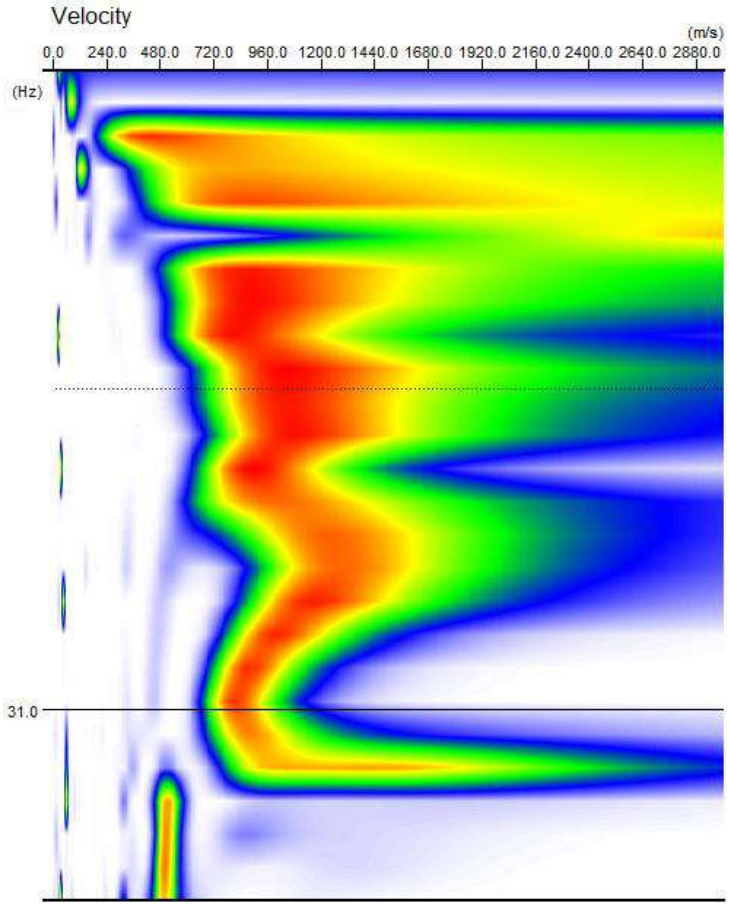


Figure 54: Dispersion Curve and inverted S-wave Velocity Model of MASW-52



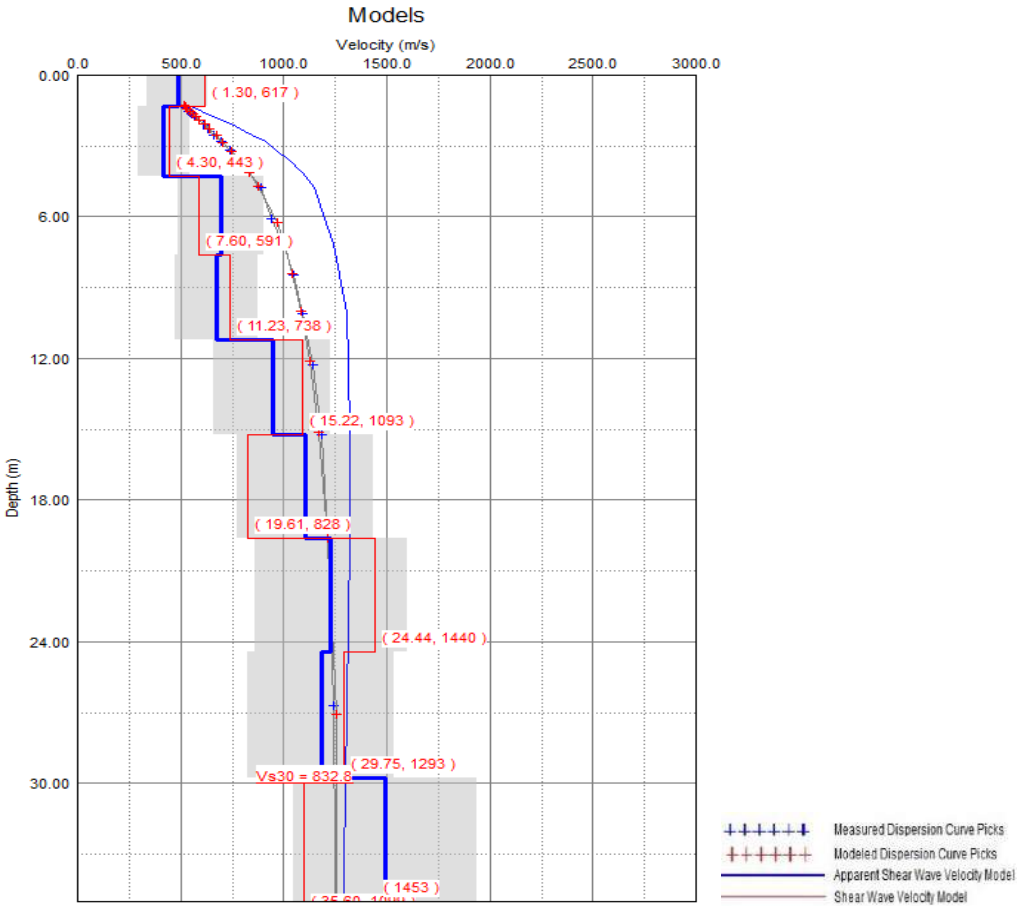
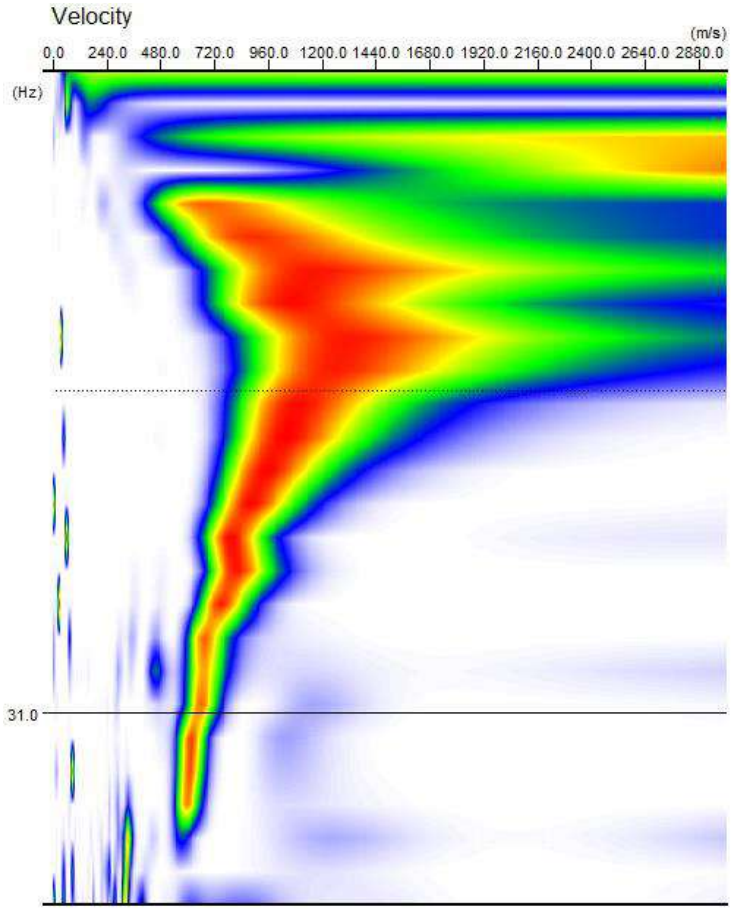


Figure 55: Dispersion Curve and inverted S-wave Velocity Model of MASW-53



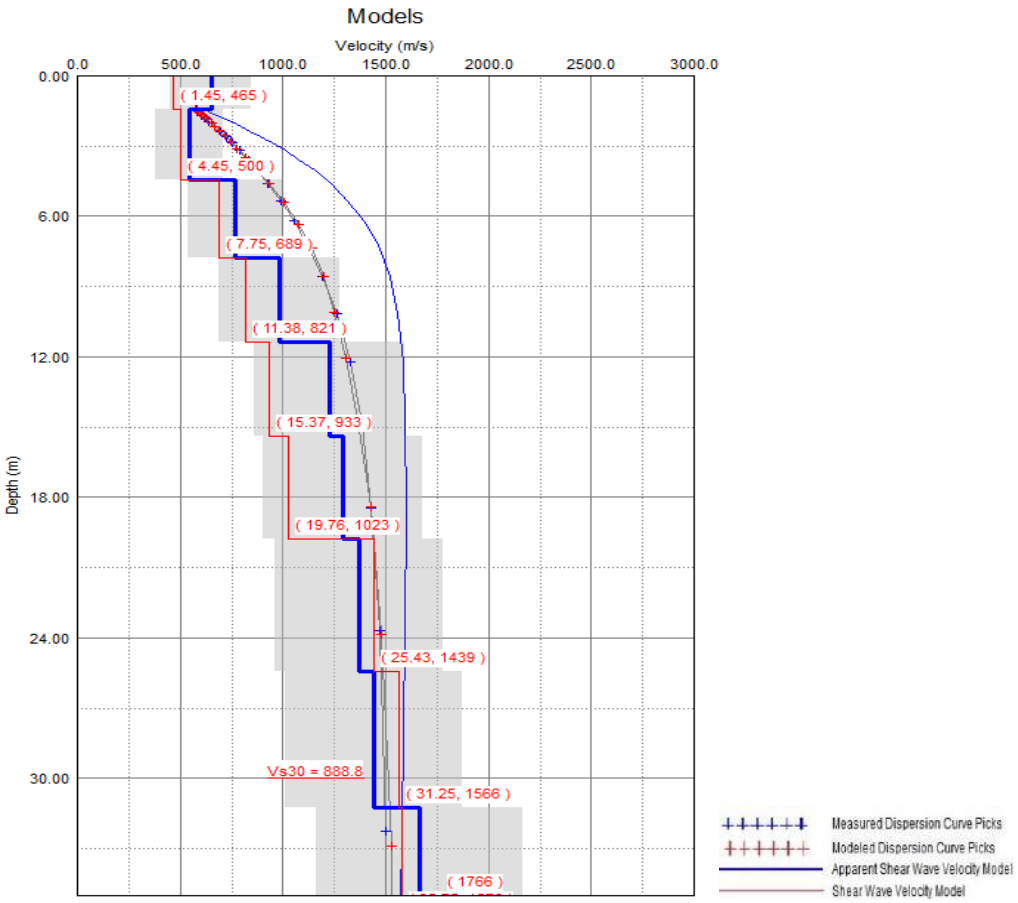


Figure 56: Dispersion Curve and inverted S-wave Velocity Model of MASW-54

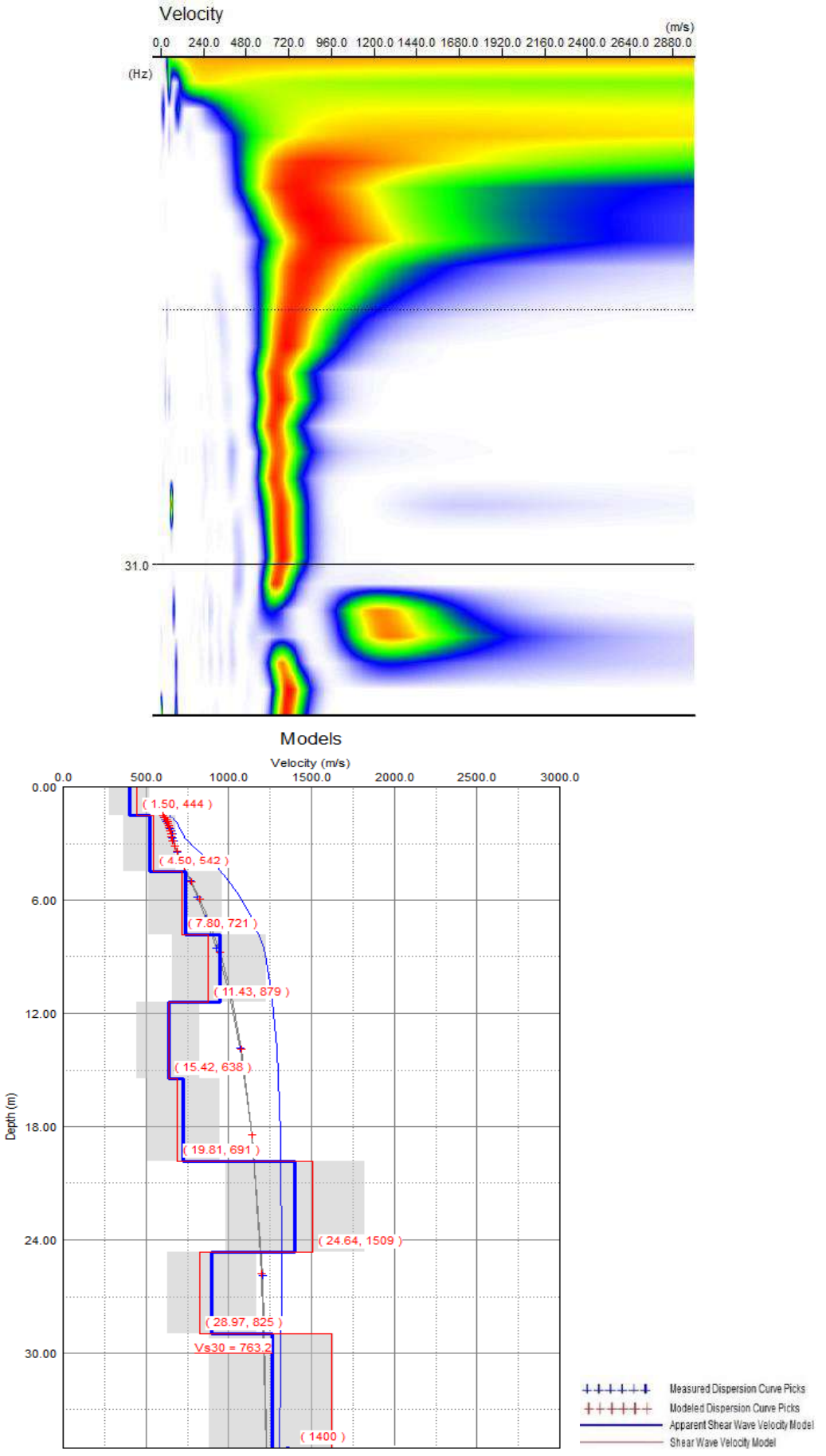


Figure 57: Dispersion Curve and inverted S-wave Velocity Model of MASW-55

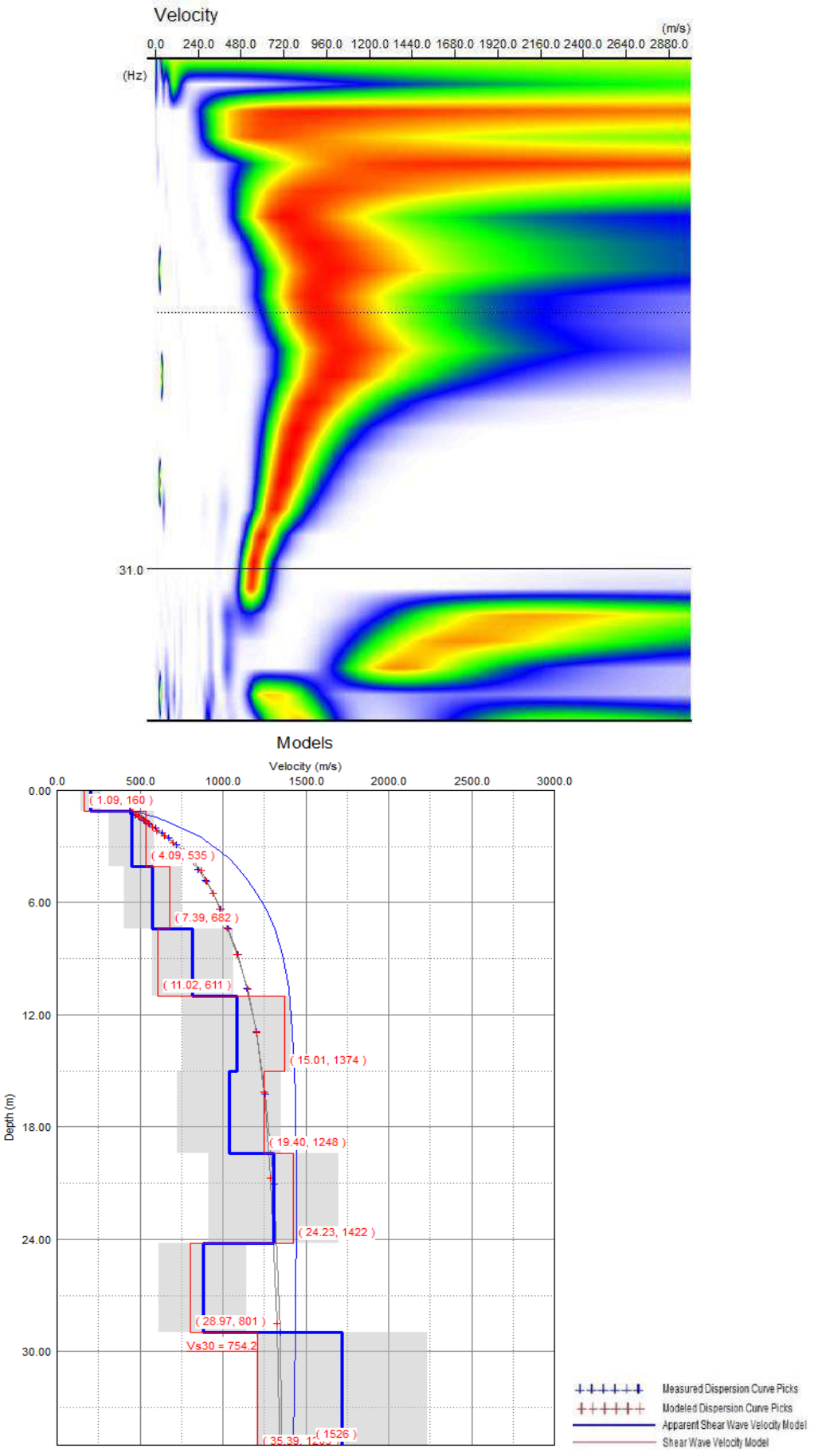


Figure 58: Dispersion Curve and inverted S-wave Velocity Model of MASW-56

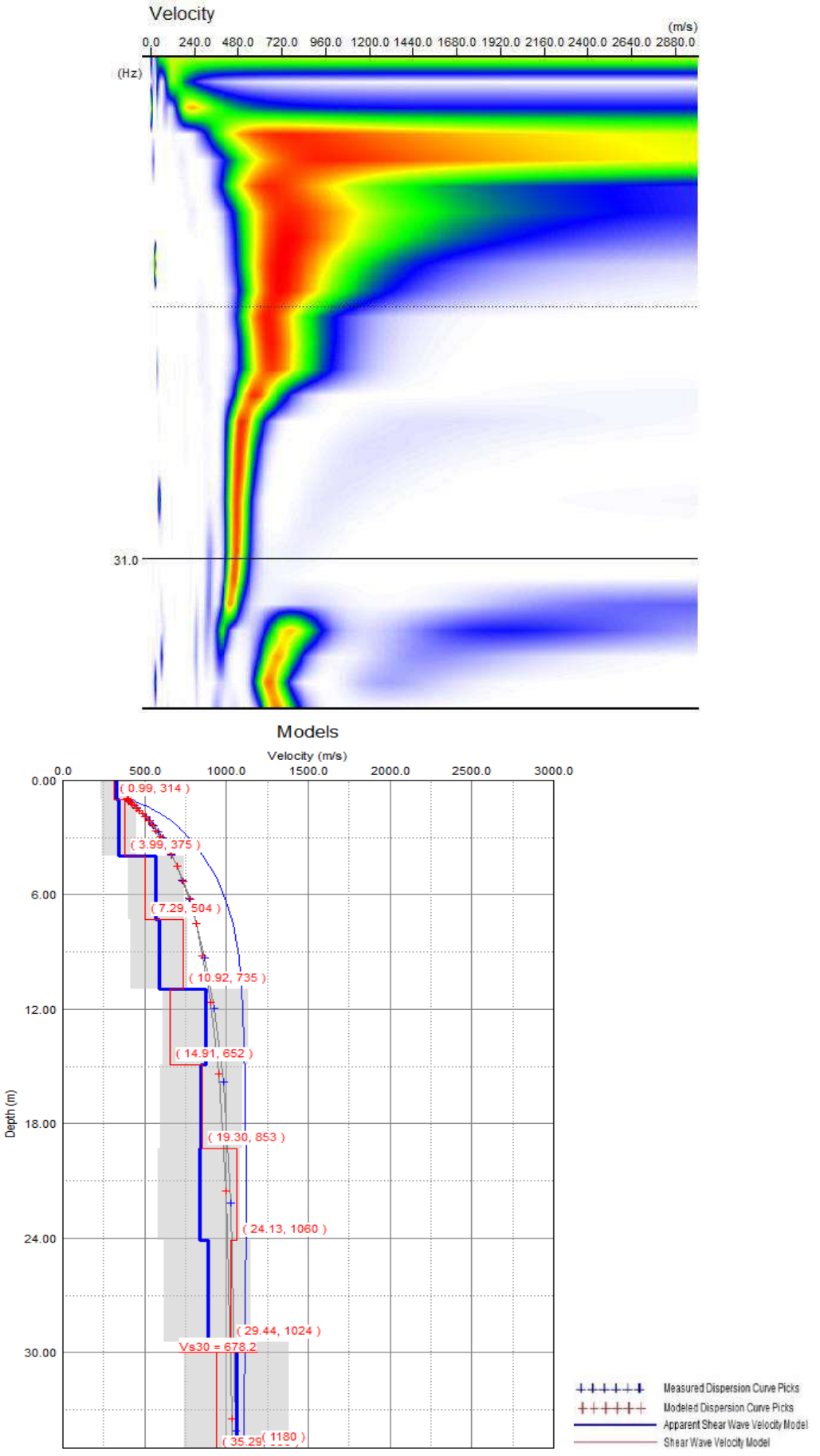


Figure 59: Dispersion Curve and inverted S-wave Velocity Model of MASW-57

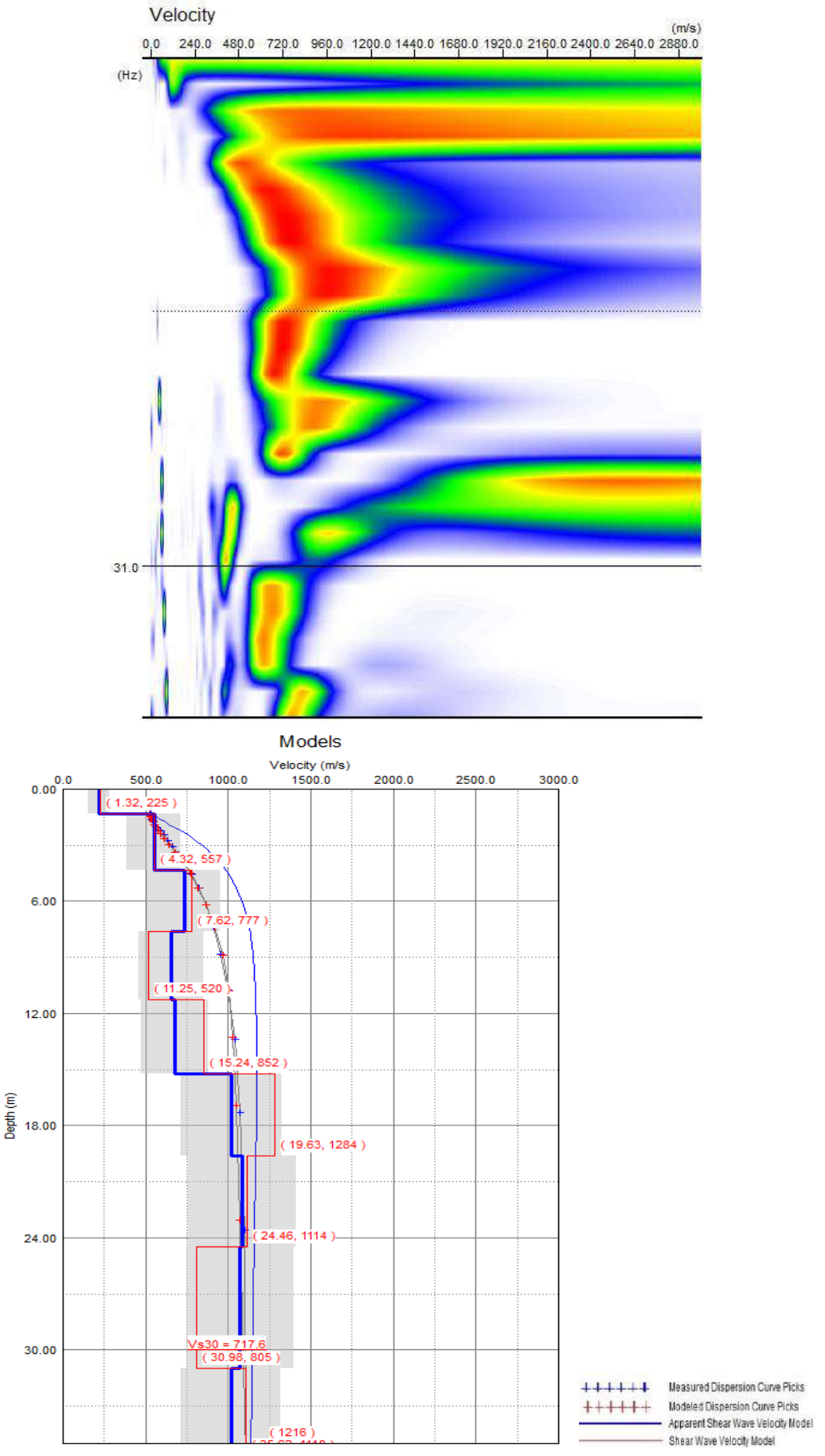


Figure 59: Dispersion Curve and inverted S-wave Velocity Model of MASW-58

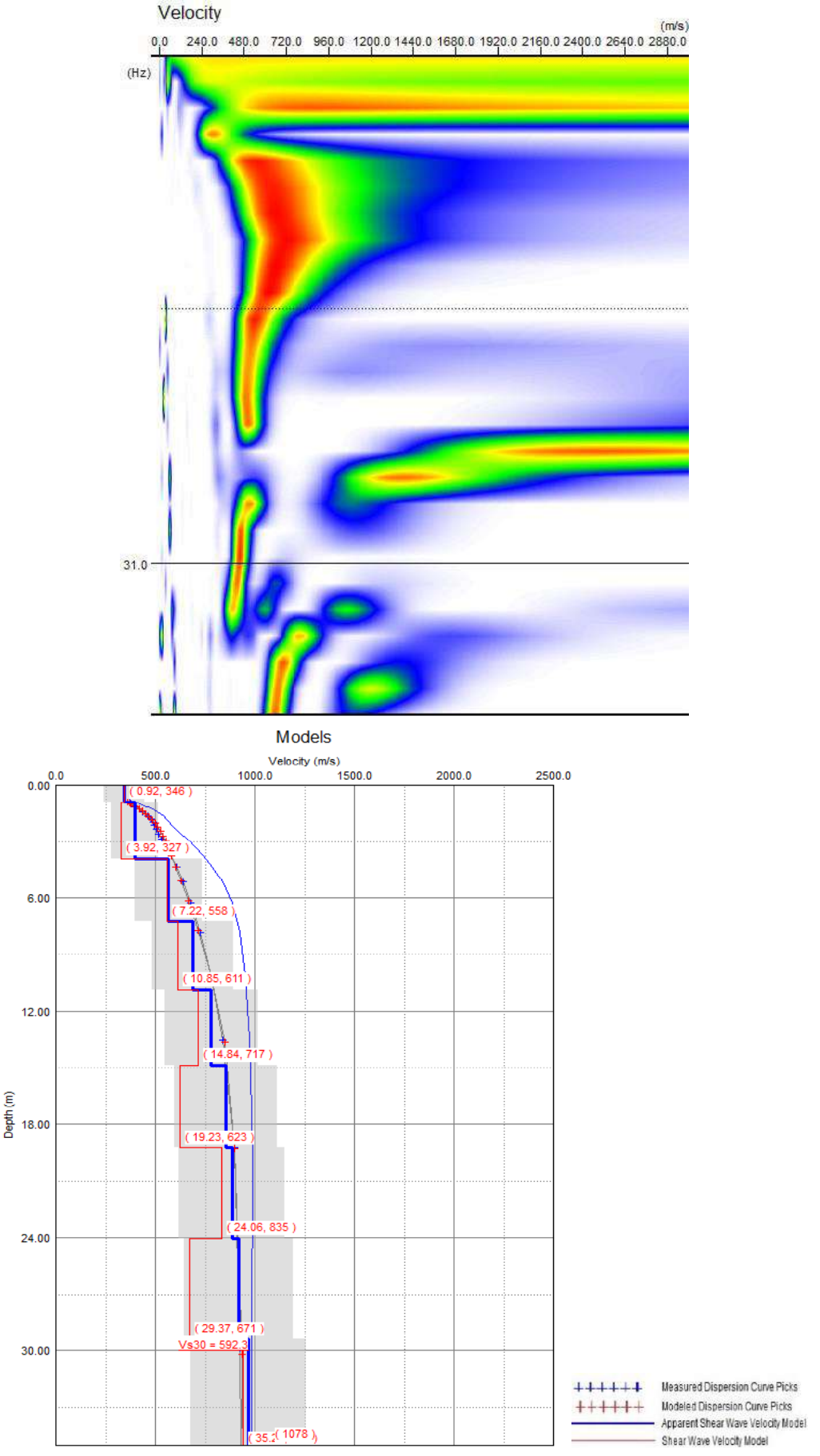


Figure 60: Dispersion Curve and inverted S-wave Velocity Model of MASW-59

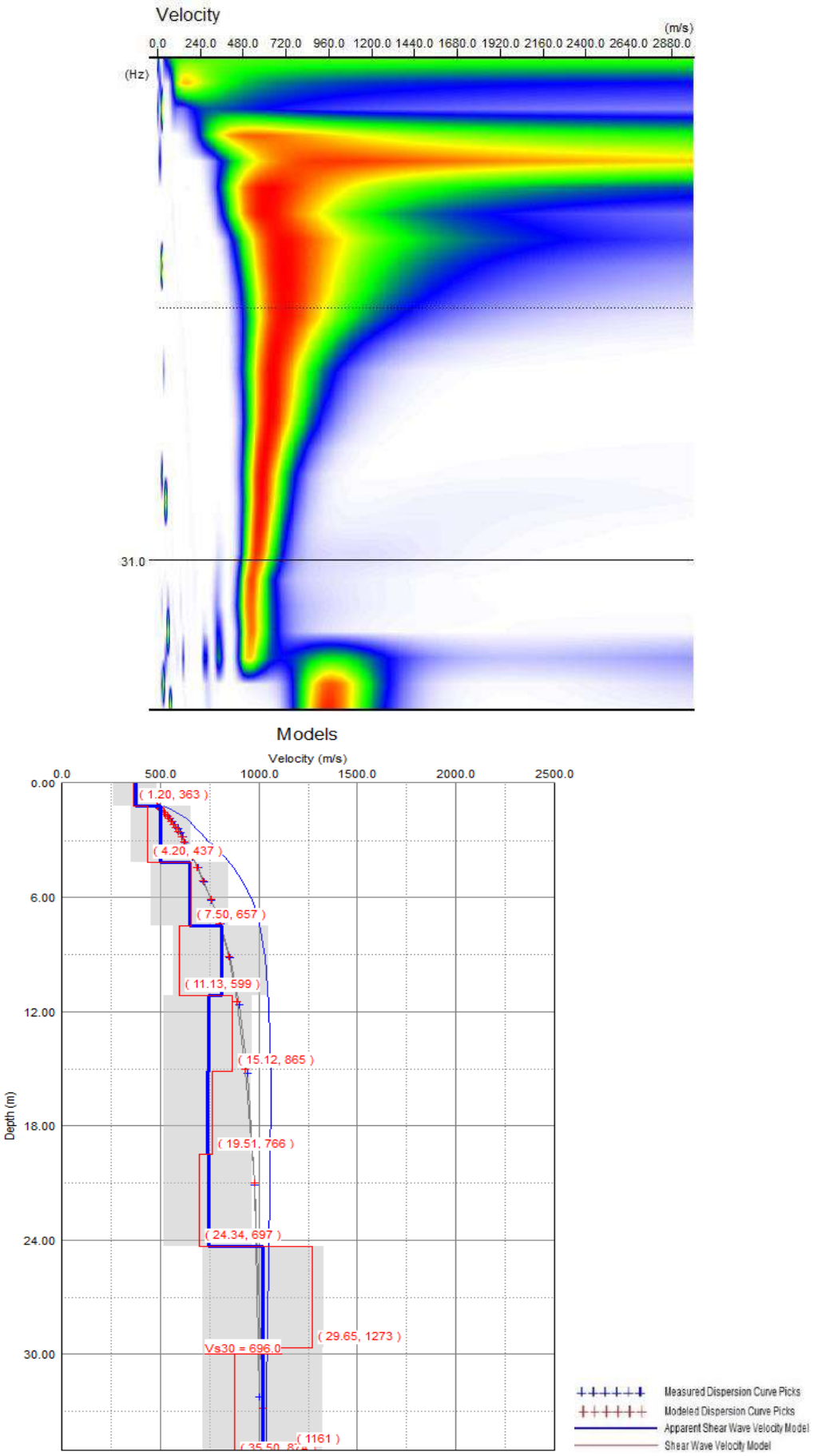


Figure 61: Dispersion Curve and inverted S-wave Velocity Model of MASW-60

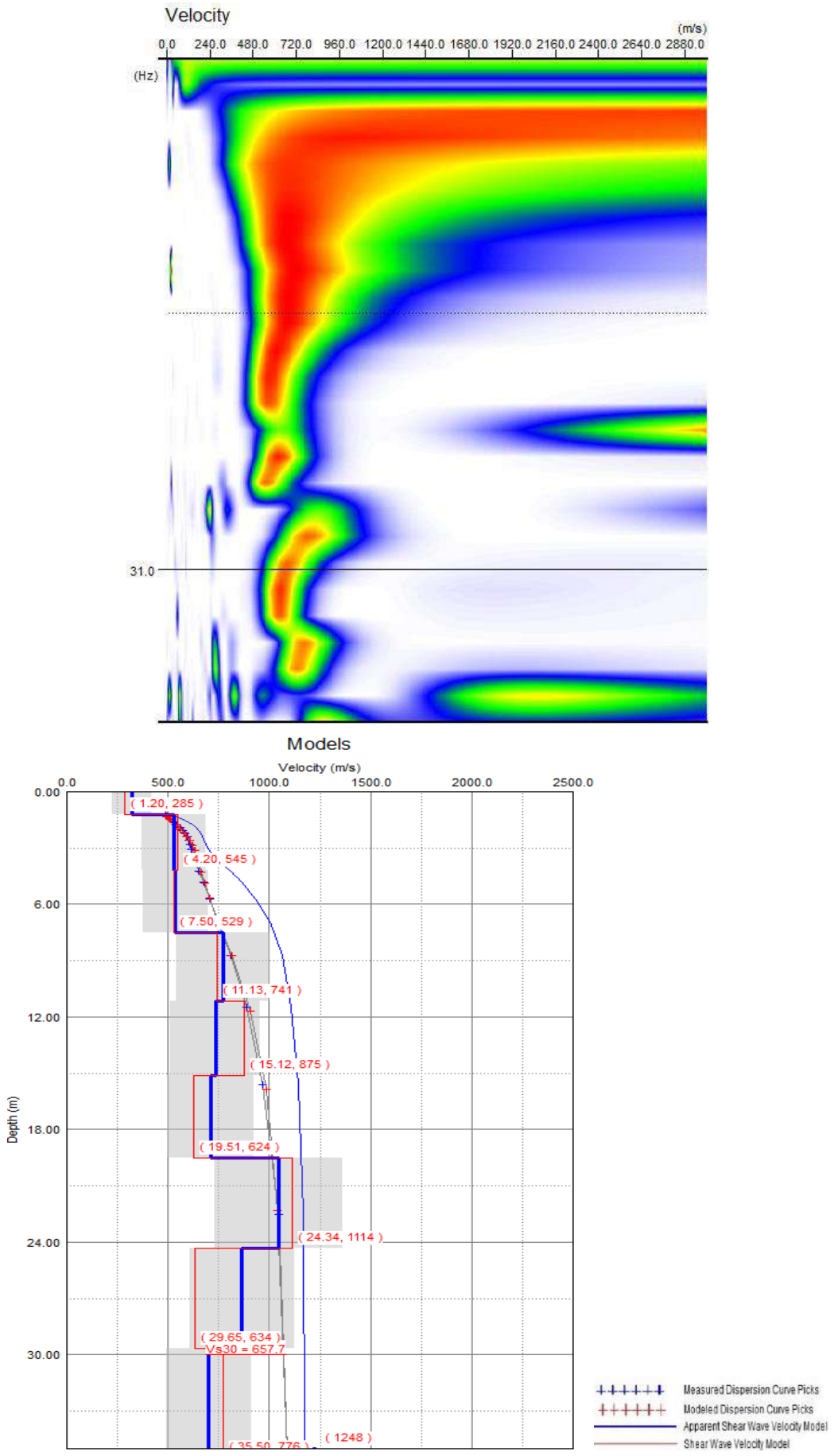


Figure 62: Dispersion Curve and inverted S-wave Velocity Model of MASW-61

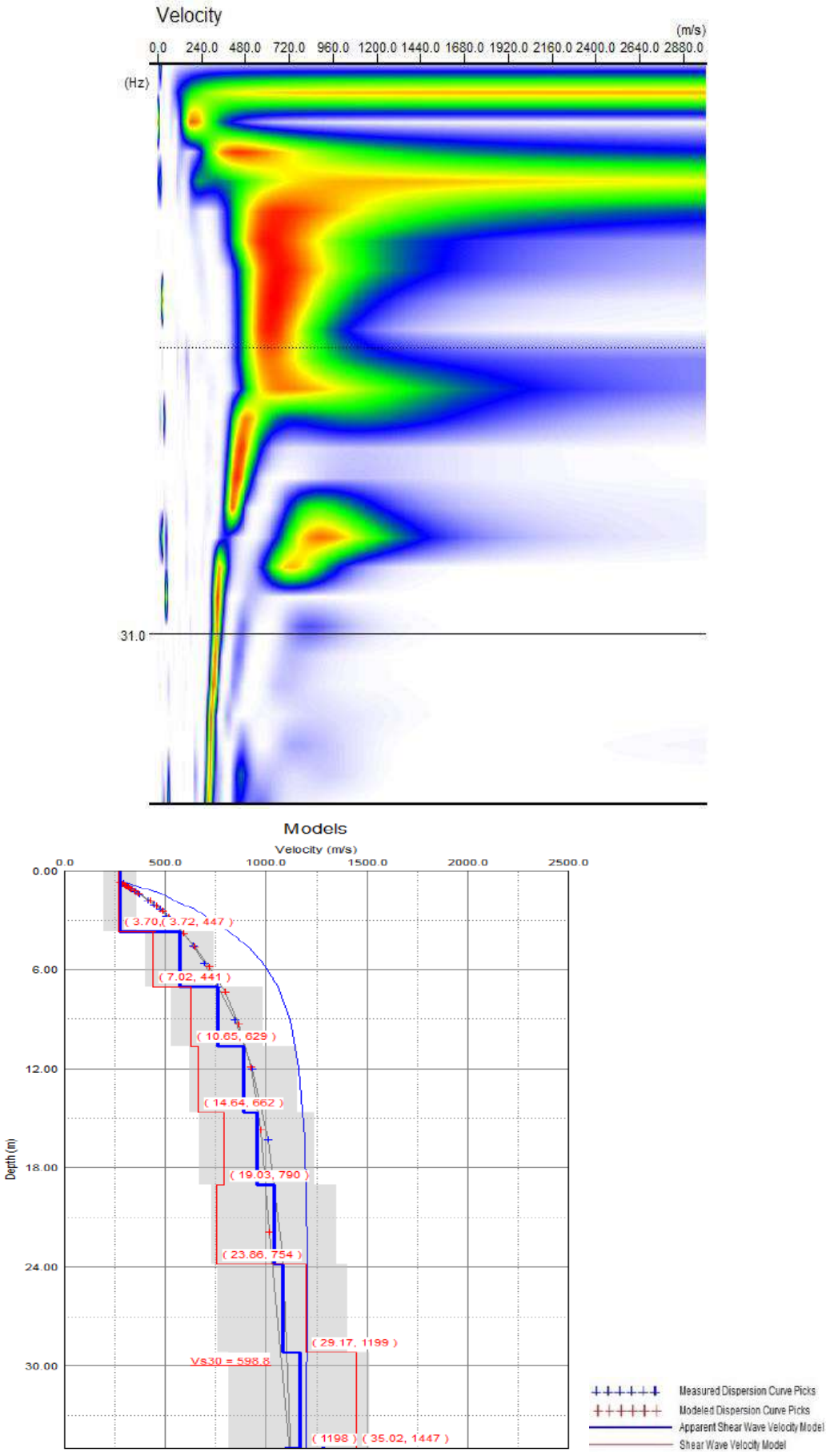


Figure 63: Dispersion Curve and inverted S-wave Velocity Model of MASW-62

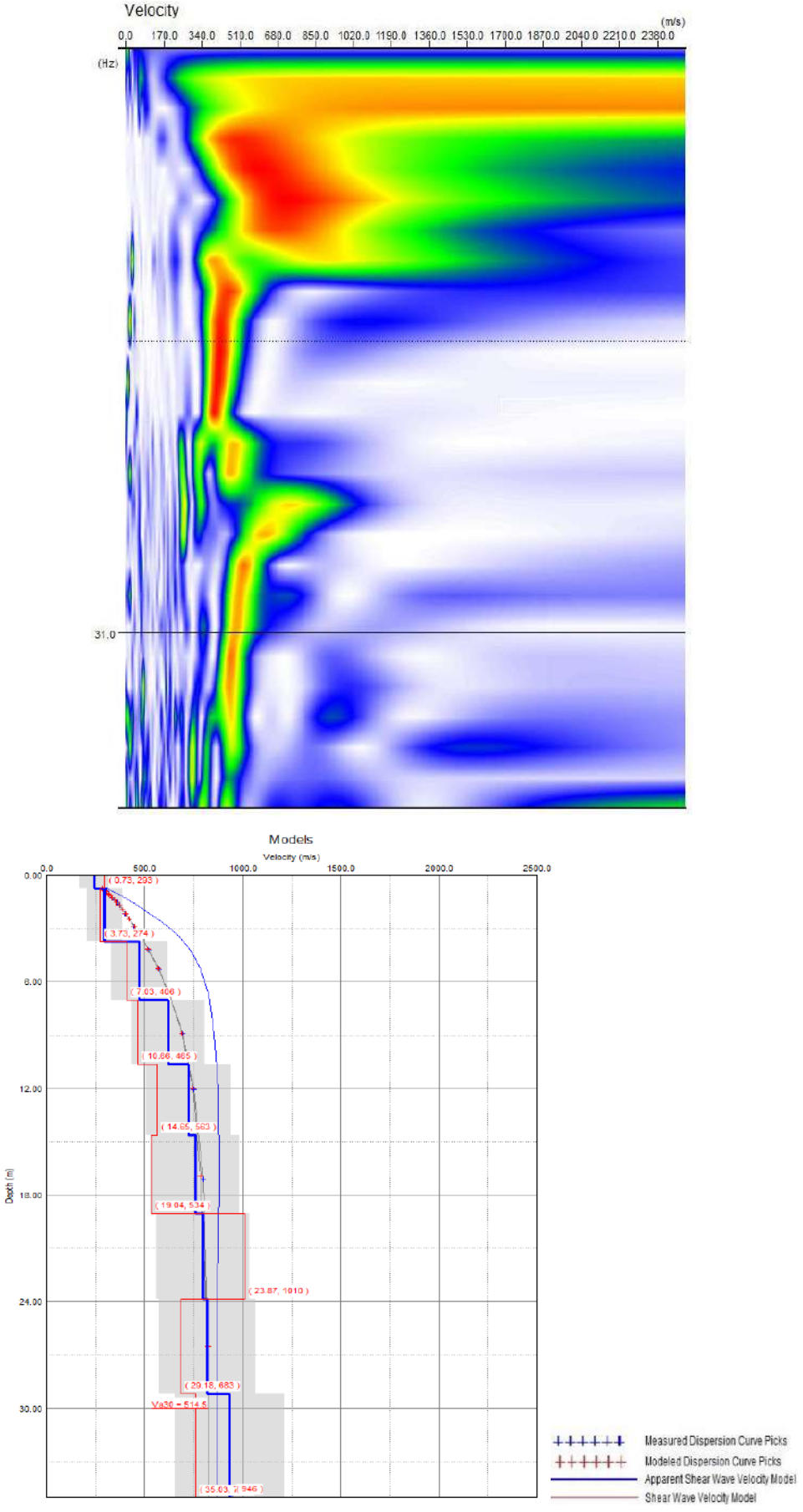


Figure 64: Dispersion Curve and inverted S-wave Velocity Model of MASW-63

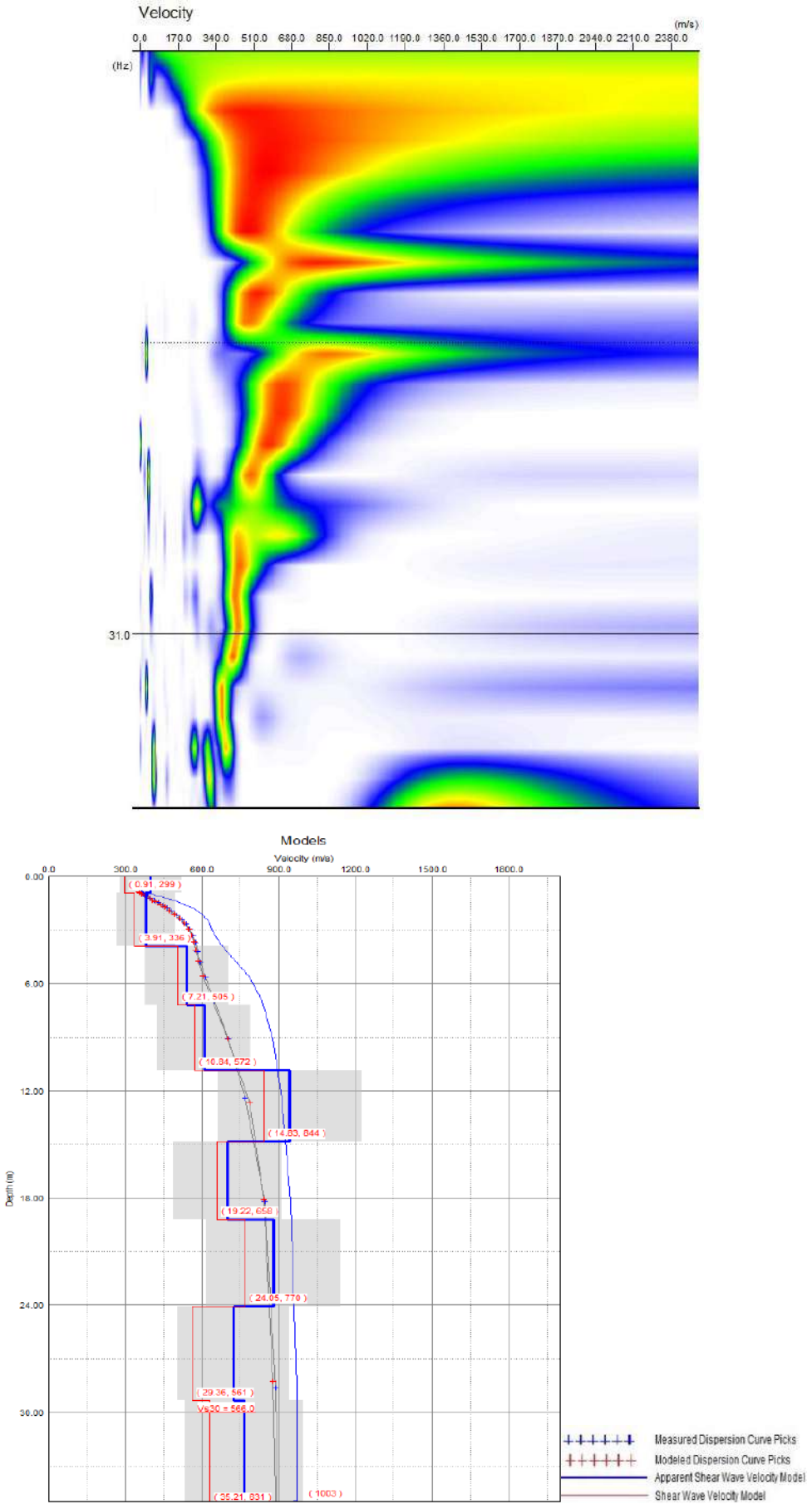


Figure 65: Dispersion Curve and inverted S-wave Velocity Model of MASW-64

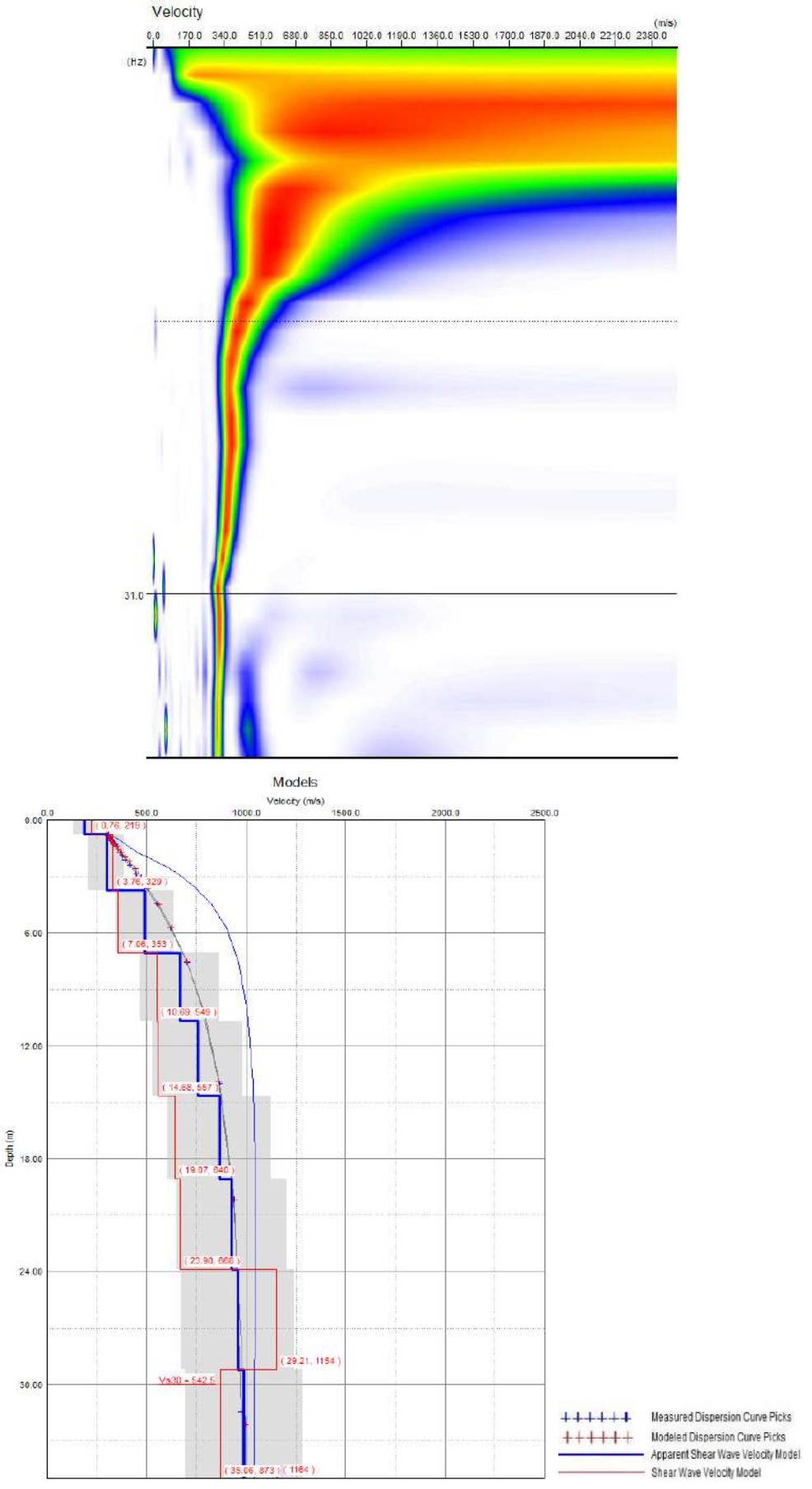


Figure 66: Dispersion Curve and inverted S-wave Velocity Model of MASW-65

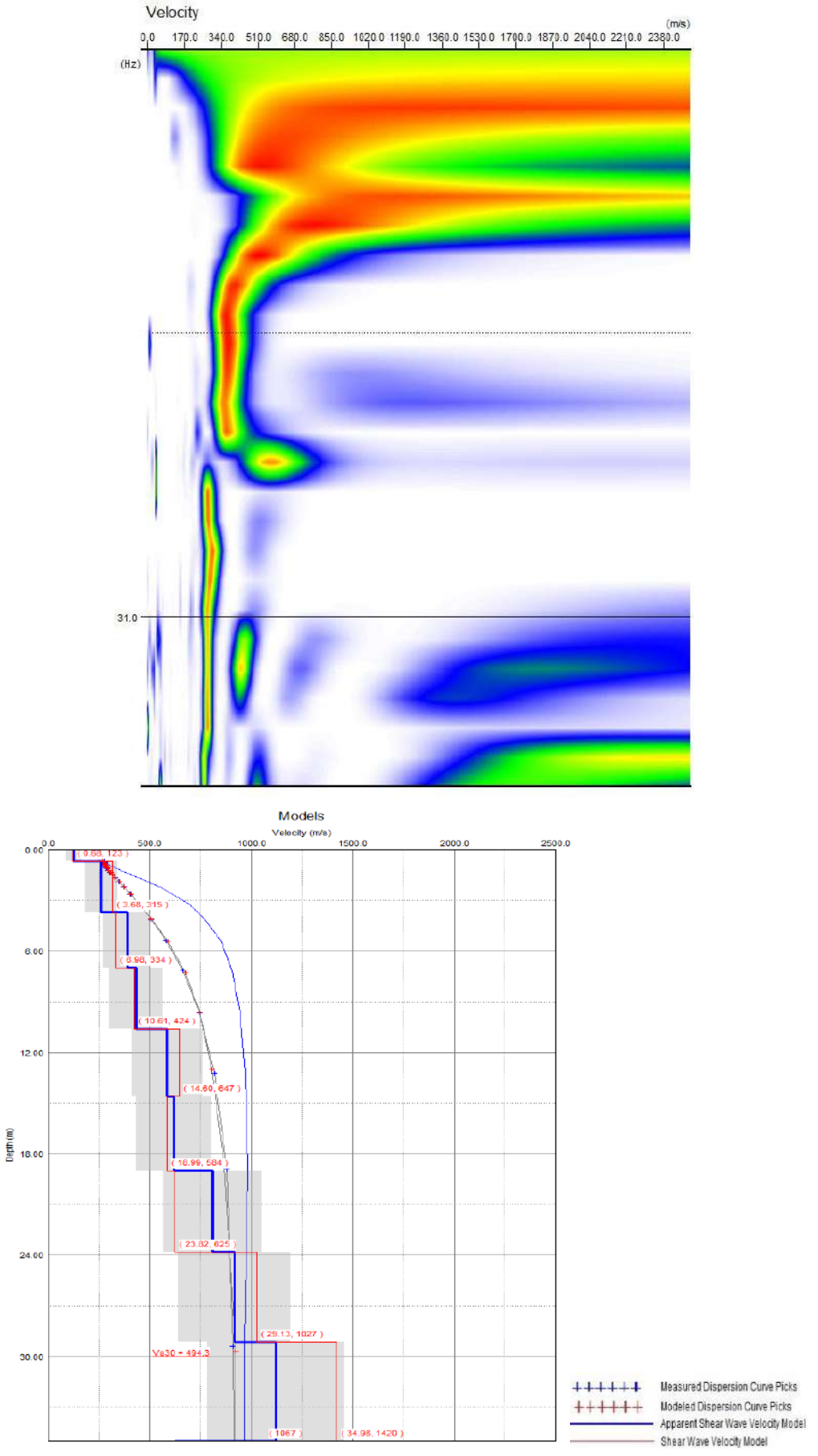
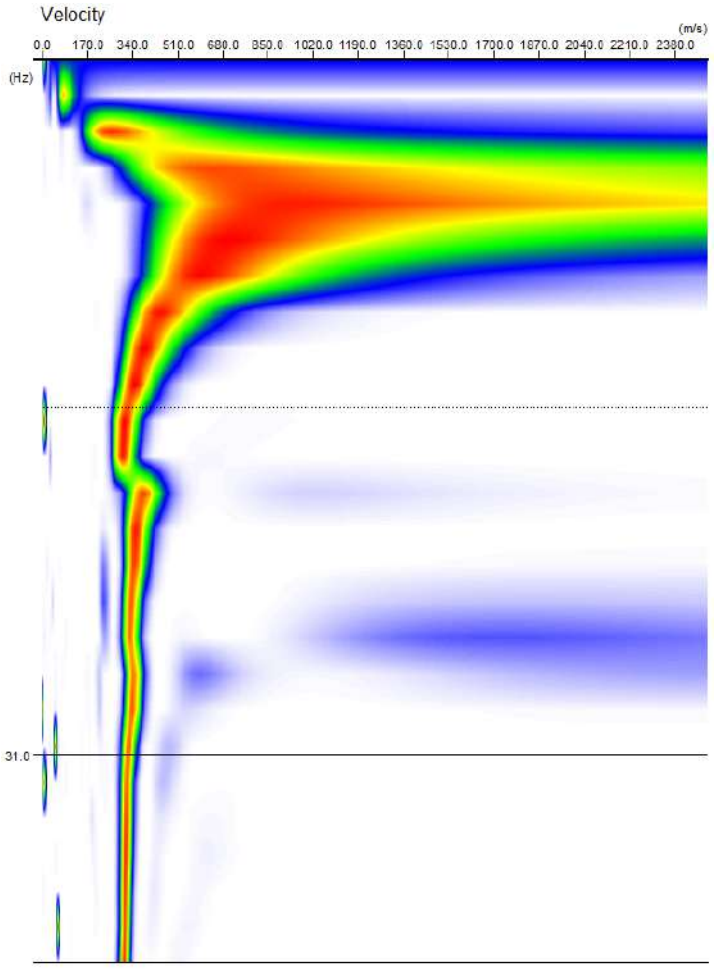


Figure 67: Dispersion Curve and inverted S-wave Velocity Model of MASW-66



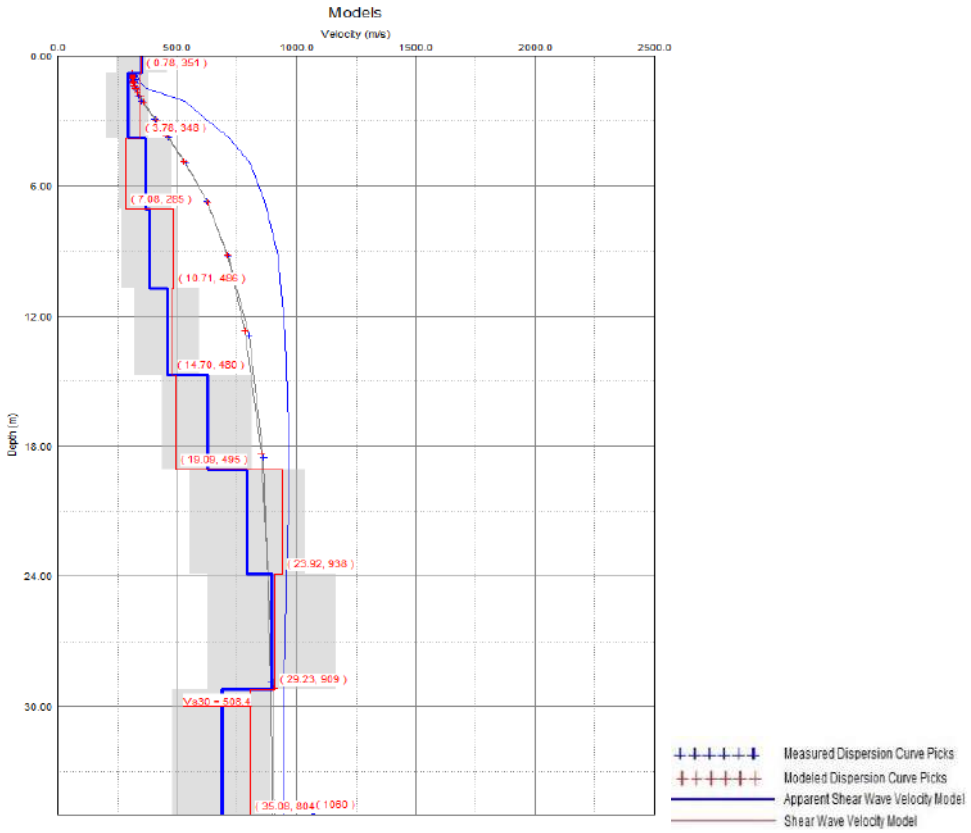


Figure 68: Dispersion Curve and inverted S-wave Velocity Model of MASW-67

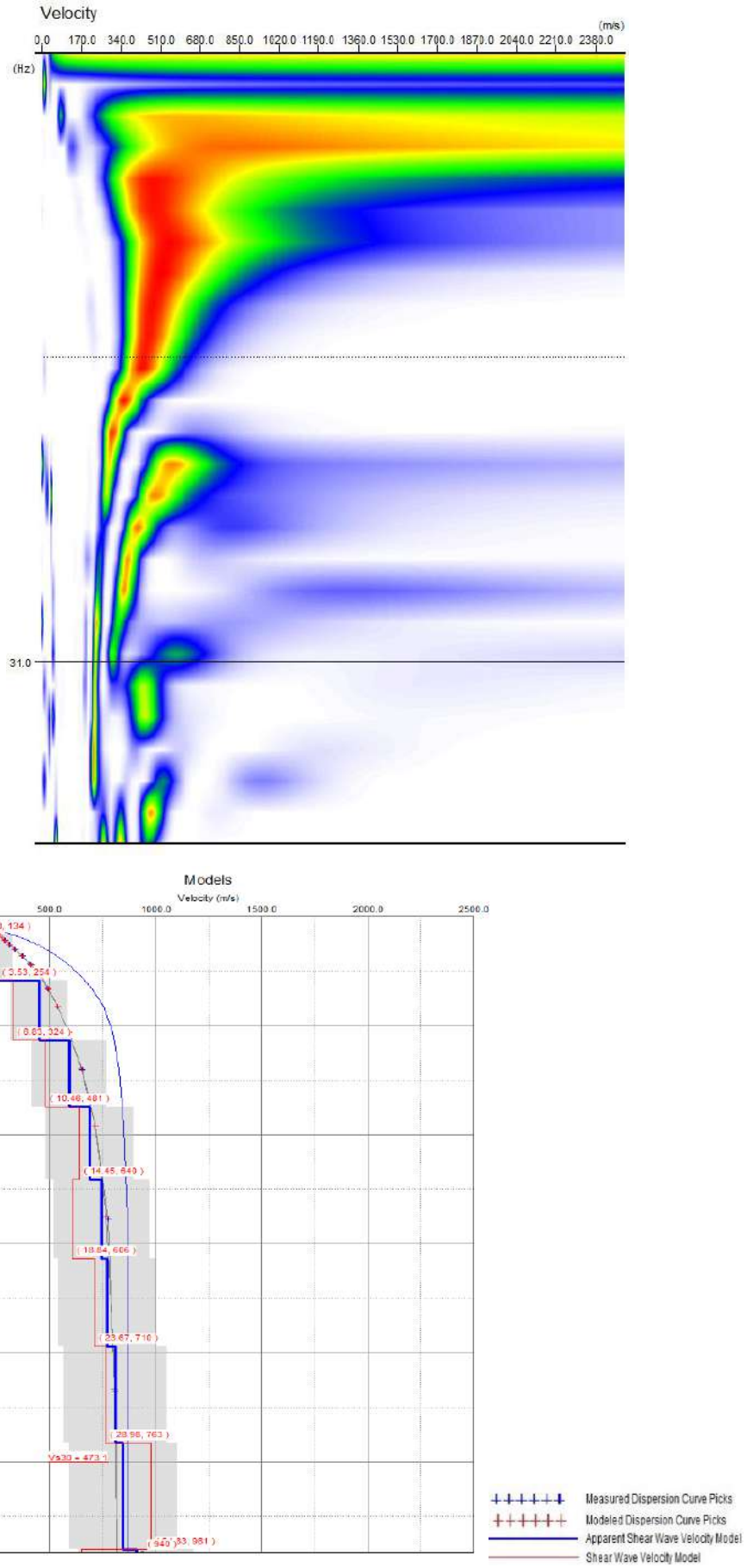


Figure 69: Dispersion Curve and inverted S-wave Velocity Model of MASW-68

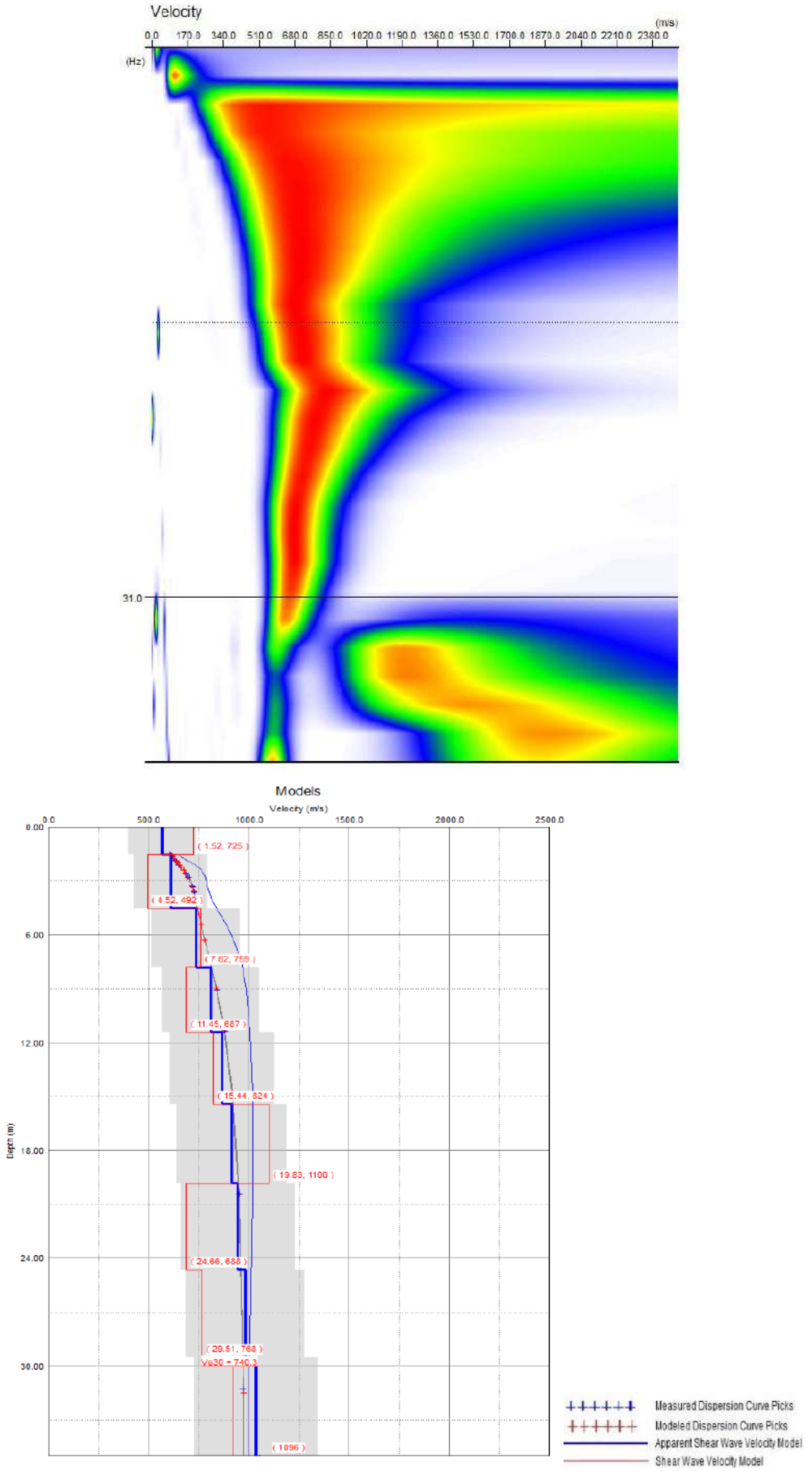


Figure 70: Dispersion Curve and inverted S-wave Velocity Model of MASW-69

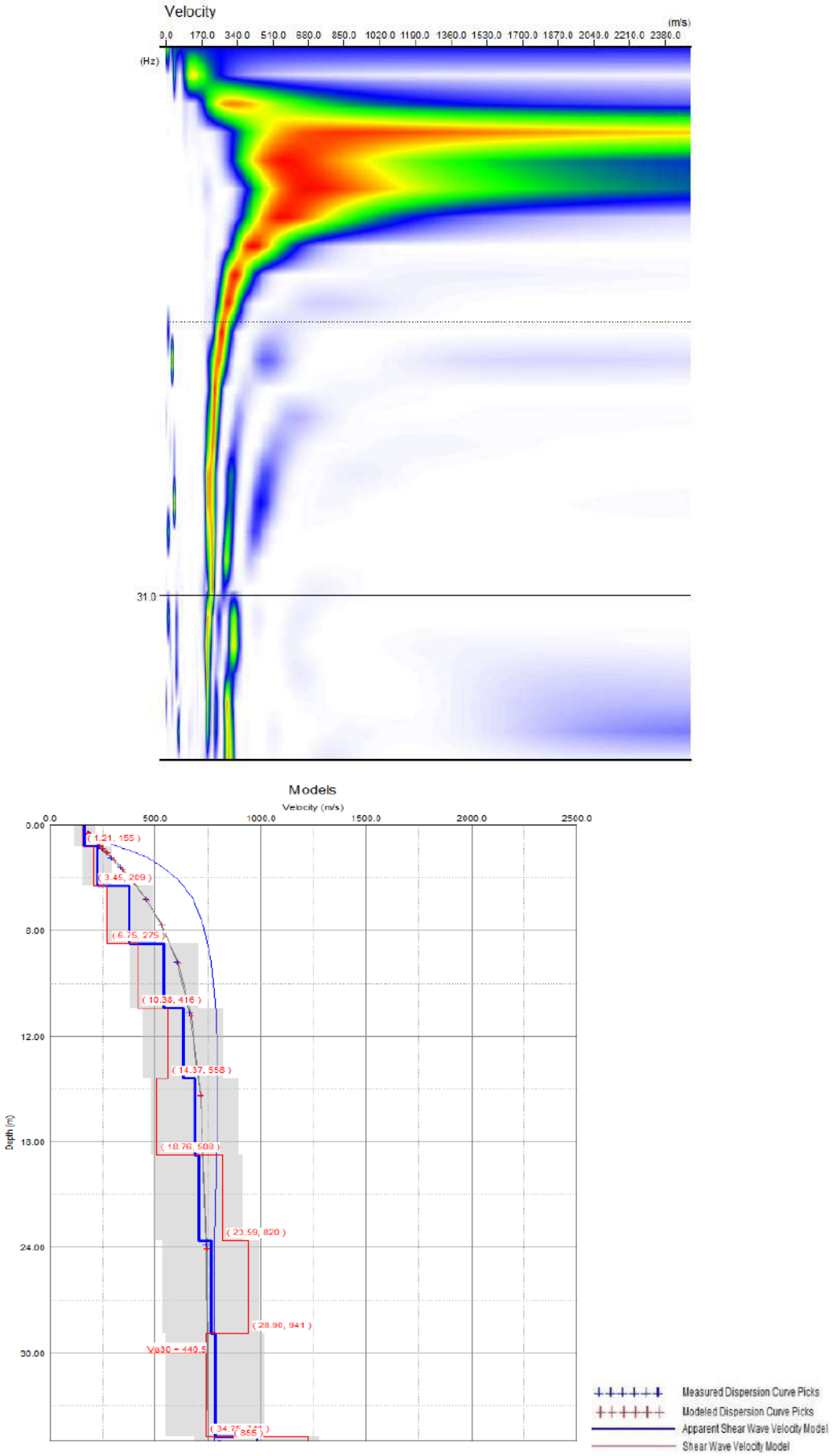


Figure 71: Dispersion Curve and inverted S-wave Velocity Model of MASW-70

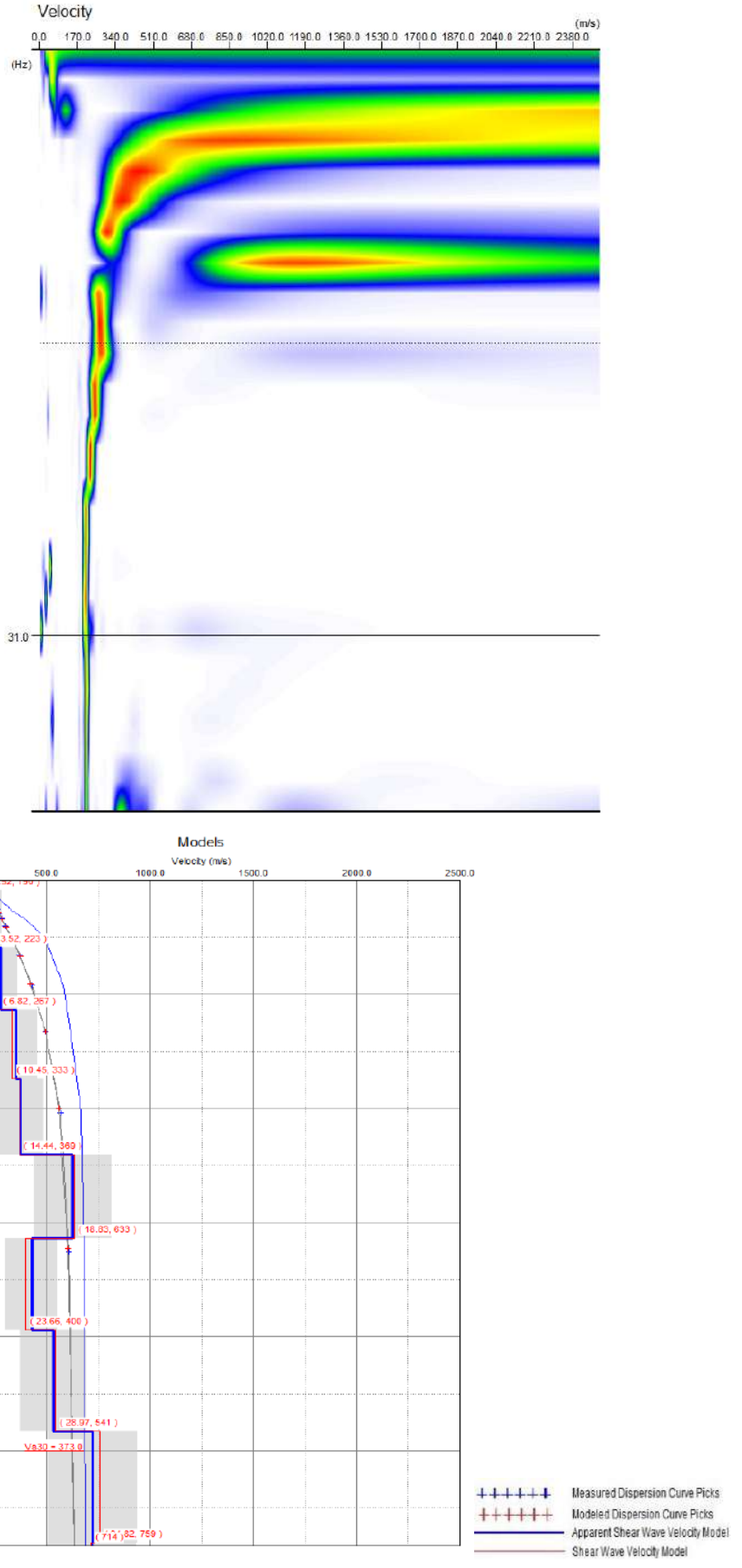


Figure 72: Dispersion Curve and inverted S-wave Velocity Model of MASW-71

PHOTOLOG
MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW) SURVEY



Plate-1: MASW Survey Data Acquisition at Profile-02



Plate-2: MASW Survey Data Acquisition at Profile-08



Plate-3: MASW Survey Data Acquisition at Profile-55



Plate-4: MASW Survey Data Acquisition at Profile-71

PUNJAB MASS TRANSIT AUTHORITY



TOPOGRAPHIC SURVEY REPORT

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT) LIMITED

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MURREE GLASS TRAIN

TOPOGRAPHIC SURVEY

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Executive Summary

A high-resolution topographic survey was conducted using LiDAR technology to map the complex terrain between Rawalpindi and Murree. The survey produced accurate Digital Elevation Models (DEMs) and 3D terrain data, enabling precise analysis of slopes, elevation, and potential hazard zones. By combining LiDAR with drone-based photogrammetry, the study ensured efficient, non-intrusive mapping across dense forest cover and steep landscapes—providing critical data for future infrastructure and environmental planning.

Project Overview

The Tourist Glass Train Project is a high-profile infrastructure and tourism initiative, conceived to establish a world-class panoramic rail corridor between Rawalpindi and Murree. Featuring advanced, glass-enclosed coaches tailored for scenic viewing, this premium venture merges state-of-the-art engineering with environmental sustainability. As a flagship development in Pakistan's northern highlands, the project is designed not only to improve regional accessibility but also to position the country as a premier destination for high-altitude experiential travel. With significant capital investment, it reflects national ambitions for sustainable growth, modern mobility, and international tourism appeal.

1. Introduction

The Tourist Glass Train Project is an innovative infrastructure and tourism initiative aimed at establishing a scenic rail corridor between Rawalpindi Tehsil and Murree Tehsil. Designed with panoramic glass coaches, the railway promises travellers an immersive experience through the picturesque Himalayan foothills—offering views of towering pine forests, lush valleys, and dramatic mountain terrain. This project is more than just a transport solution—it positions itself as a flagship attraction for eco-tourism and regional development. By significantly improving access to Murree, one of Pakistan's most visited hill stations, the train is expected to reduce road congestion, enhance commuter safety, and create new economic opportunities in surrounding communities.

In light of the region's complex topography, the project integrates advanced aerial surveying techniques, including drone-based photogrammetry and LiDAR (Light Detection and Ranging). These technologies are instrumental in capturing detailed Digital Elevation Models (DEMs), ensuring precise route alignment while minimizing environmental disruption.

Combining modern engineering with natural beauty, the project reflects Pakistan's ambition to transition toward smart, sustainable transport infrastructure. Through this initiative, the government aspires to strengthen regional connectivity, generate employment, and showcase the scenic splendour of the northern highlands on a global stage.

1.1 Background & Objectives

To transform access to Murree by developing a scenic, comfortable rail alternative, enhancing mobility, reducing seasonal road congestion, and fostering tourism in Punjab's highland belt.

1.2 Scope of the Project

The study assesses feasibility, demand, technical solutions (like funicular/rack rail systems), station design, environmental and social impacts, and potential PPP investment models.

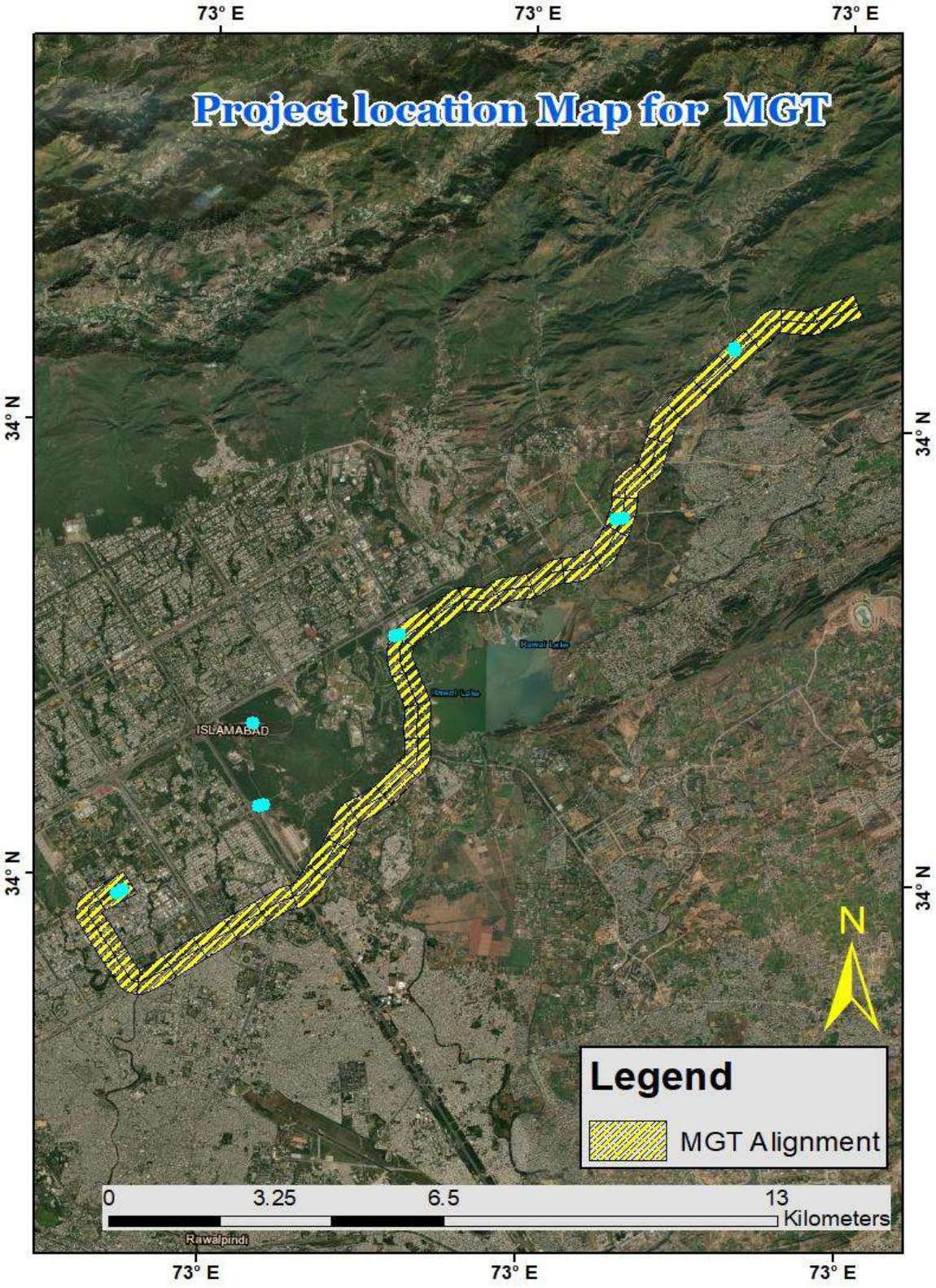


Fig 1.1: Project location map for Muree Glass Train

2. Technical Feasibility

2.1 Terrain & Topographical Analysis

Topographical challenges include rugged slopes, potential landslide zones, and forest density—all navigated through precision mapping and route optimization.

This report outlines the use of LiDAR (Light Detection and Ranging) technology for conducting a high-resolution topographic survey between Rawalpindi and Murree. Given the corridor's mountainous terrain, dense forests, and susceptibility to landslides, conventional surveying methods were insufficient for accurate terrain modeling. LiDAR, in combination with drone-based photogrammetry, was deployed to overcome these challenges and generate precise spatial data for route planning and engineering design.

3. LiDAR Survey Methodology

Aircraft-mounted LiDAR sensors were flown along the proposed route. These sensors emitted rapid laser pulses (hundreds of thousands per second), which penetrated vegetation and reflected off the ground surface. The time delay between pulse emission and return was used to calculate elevation values with centimeter-level accuracy.

3.1 Survey Methods (LiDAR & Drone Mapping)

Initial ground efforts were hindered by foliage and terrain. High-resolution drone imagery and LiDAR sensors enabled deep-forest scanning and 3D model creation. To overcome the challenges of dense forest cover and rugged topography between Rawalpindi and Murree, the project utilizes a combination of drone-based aerial mapping and LiDAR (Light Detection and Ranging) technology. Drones equipped with high-resolution cameras conduct photogrammetric surveys to capture detailed surface imagery and geographic features. However, in areas where dense tree canopies obscure the ground, LiDAR is deployed to penetrate vegetation and generate precise Digital Elevation Models (DEMs). LiDAR sensors emit thousands of laser pulses per second, recording the time it takes for each pulse to return—accurately capturing surface contours beneath foliage. Together, these technologies

provide an integrated 3D landscape model, enabling informed route alignment, hazard detection, and engineering planning.

3.2 LiDAR Surveying for Route Alignment and Terrain Assessment

To navigate the Himalayan foothills' complex and densely forested topography between Rawalpindi and Murree, the Tourist Glass Train Project harnesses LiDAR (Light Detection and Ranging)—a state-of-the-art remote sensing technology that enables unparalleled accuracy in terrain modeling.

Highlights of LiDAR Integration:

Vegetation Penetration: Unlike optical imaging techniques, LiDAR can pierce through thick tree canopies, making it especially effective in densely forested areas. This was crucial for mapping elevation in the pine-covered slopes of Murree.

Precision Mapping: LiDAR sensors emit rapid pulses of laser light (up to hundreds of thousands per second), measuring the time it takes for each to reflect back. This results in high-resolution 3D point clouds representing both canopy and ground levels.

Digital Elevation Models (DEMs): The collected data was used to generate accurate DEMs, aiding in route optimization, slope analysis, and identifying potential hazard zones such as landslides or unstable ground.

Integrated Planning: LiDAR outputs were synchronized with drone-based photogrammetry and GIS platforms to support multi-layered route engineering, environmental impact assessments, and structural design.

Topographic Survey Summary (LiDAR-Based)

Section	Details
Data Acquisition	
Scan Density	~20 pulses/m²
Flight Altitude	~800–1000 meters AGL
Swath Overlap	30–40% for redundancy
GPS Control Points	Fixed base stations for geo-referencing
Data Processing	
Point Cloud Classification	Separated into ground, vegetation, and man-made features
DEM/DSM Generation	Created elevation models of terrain (DEM) and surface (DSM)
3D Terrain Models	Visualized slope, aspect, and elevation variations
Cross-Sectional Profiles	Generated for critical engineering points

4.Flight Plan and Control Points Network

A detailed flight plan was developed to ensure optimal coverage of the survey area using drone-mounted LiDAR sensors. Control points were strategically established and georeferenced to enhance the accuracy of the elevation data. The integration of these control points with the flight path enabled precise terrain modeling and ensured consistency across all survey outputs.



Figure 1.2: Flight plan for Alignment

List of Control Network			
Control Network	**Latitude**	**Longitude**	**Elevation**
SOP Point	33.69473	73.07633	588
MGT-01	33.77332	73.22819	689
MGT-02	33.77297	73.22734	685
MGT-03	33.77829	73.25024	659
MGT-04	33.77953	73.25037	690
MGT-05	33.80624	73.29555	786
MGT-06	33.80682	73.29618	794
MGT-07	33.83124	73.32353	920
MGT-08	33.83113	73.3231	917
MGT-09	33.88245	73.33922	1544
MGT-10	33.88348	73.33995	1538
MGT-11	33.87877	73.36341	1817
MGT-12	33.87909	73.36392	1812
MGT-13	33.91192	73.38157	1906
MGT-14	33.91198	73.3809	1905
MGT-15	33.76464	73.17599	644
MGT-16	33.76497	73.17591	649
MGT-17	33.73363	73.15319	574
MGT-18	33.73324	73.15176	578
MGT-19	33.71152	73.10672	547
MGT-20	33.7113	73.10586	545
MGT-21	33.67962	73.07787	529
MGT-22	33.67991	73.07894	523
MGT-22	33.67991	73.07894	523
MGT-23	33.66379	73.04968	515
MGT-24	33.66323	73.0486	515

A geodetic control network was established along the Rawalpindi–Murree corridor to ensure accurate geo-referencing of LiDAR survey data. Each control point was precisely marked with GPS-derived latitude, longitude, and elevation values. These ground-based reference stations formed the foundation for aligning aerial data, maintaining positional accuracy across the rugged terrain, and validating elevation outputs from the LiDAR-derived Digital Elevation Models (DEMs).

6. Conclusion

The LiDAR-enabled topographic survey for the Rawalpindi–Murree alignment has provided highly detailed elevation and surface data critical for precision engineering in a region characterized by steep gradients, dense forest, and geological instability. The integration of classified point clouds, Digital Elevation Models (DEMs), and 3D terrain profiles enabled the identification of suitable corridor alignments, avoidance of landslide-prone slopes near Jhika Gali and Kashmir Point, and slope optimization across elevation transitions exceeding 1000 meters. Control points distributed across the surveyed zone ensured centimeter-level geo-referencing accuracy. This targeted dataset supports the engineering design, environmental evaluation, and phased construction planning of the Murree Glass Train Project while setting a technical precedent for future infrastructure development in Pakistan's upland terrain.

Hydraulic Modelling of Stream Crossings Along the

GLASS TRAIN PROJECT

Islamabad – Murree

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD
NESPAK HOUSE, 1-C, BLOCK-N MODEL TOWN EXTENSION, LAHORE, PAK.

JUNE 2025

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HYDRAULIC MODELLING OF STREAM CROSSINGS ALONG THE GLASS TRAIN PROJECT ISLAMABAD – MURREE

1 INTRODUCTION

1.1 PROJECT BACKGROUND

The Government of Punjab has introduced a transformative scheme to establish a scenic rail link between Rawalpindi/Islamabad and Murree, designed to enhance accessibility for both the public and tourists. The highlight of the project is the proposed Glass Train, a scenic rail concept featuring large windows and glass ceilings to provide passengers with uninterrupted panoramic views of the breathtaking mountainous terrain. Such trains are globally recognized for their popularity in scenic destinations, such as Switzerland, Norway, Japan, and Canada, offering a unique and immersive travel experience.

This initiative aims to provide an alternative and sustainable transportation mode for tourists, many of whom currently rely on private vehicles to reach Murree. By reducing vehicular traffic, the Glass Train project is envisioned as a step towards sustainable tourism and improved accessibility. Previous work by Pakistan Railways on a rail linkage between Rawalpindi/Islamabad and Murree forms a foundational basis for this project, which will address gaps in earlier studies and propose a viable connection to the Murree hilltop at an elevation of approximately 2,000 meters.

The Feasibility Study, led by the Punjab Mass Transit Authority (PMA) with support from the Transport Planning Unit under the Transport and Mass Transit Department, will comprehensively evaluate the project. The study will focus on:

- Assessing passenger and freight demand within the region.
- Identifying the most viable route alignment and rail technology, including rack tracks and funicular systems, to support the operations of the Glass Train.
- Integrating proposed rail infrastructure with Pakistan Railways' existing network while ensuring compliance with track standards.
- Exploring procurement models, including Public-Private Partnerships (PPP) and Engineering, Procurement, and Construction (EPC), to recommend the best execution and operational strategy.
- Developing preliminary engineering designs and specifications for stations and rolling stock to ensure safe, efficient, and affordable mobility.
- Proposing a comprehensive legal and institutional framework for the design, construction, operation, and maintenance of the project.

This Feasibility Study will also assist in paving the way for a modern, scenic, and efficient railway system to meet the region's growing demand for connectivity and sustainable tourism.

1.2 PROJECT OBJECTIVES

The Punjab Mass Transit Authority aims to achieve the following key objectives:

1. Integrated Regional Connectivity:

Establish a direct, efficient, and scenic rail link between Rawalpindi/Islamabad and Murree Hilltop through the implementation of the Glass Train concept, enhancing accessibility to a major tourist destination.

2. Route Optimization and Technology Selection:

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Identify the most viable route alignment and evaluate suitable rail and train technologies to ensure operational efficiency, safety, and an enjoyable travel experience for passengers.

3. Aesthetic and Recreational Enhancement:

Promote tourism and public engagement by offering a visually immersive and recreational mode of transportation that highlights the natural beauty of the Margalla and Murree hills.

4. Economic, Environmental, and Social Impact Assessment:

Evaluate the project's potential impacts on the economy, local communities, and natural environment, ensuring that the design and operation of the rail system align with principles of long-term sustainability.

5. Project Structuring and Implementation Readiness:

Explore feasible financing and procurement models, and prepare comprehensive documentation to facilitate smooth project execution, including technical, financial, and regulatory frameworks.

1.3 PROJECT LAYOUT PLAN

The overall plan of the project area is shown in **Figure 1.1**. The total length of the Glass Train Track is approximately 40,879 meters (40.9 km).

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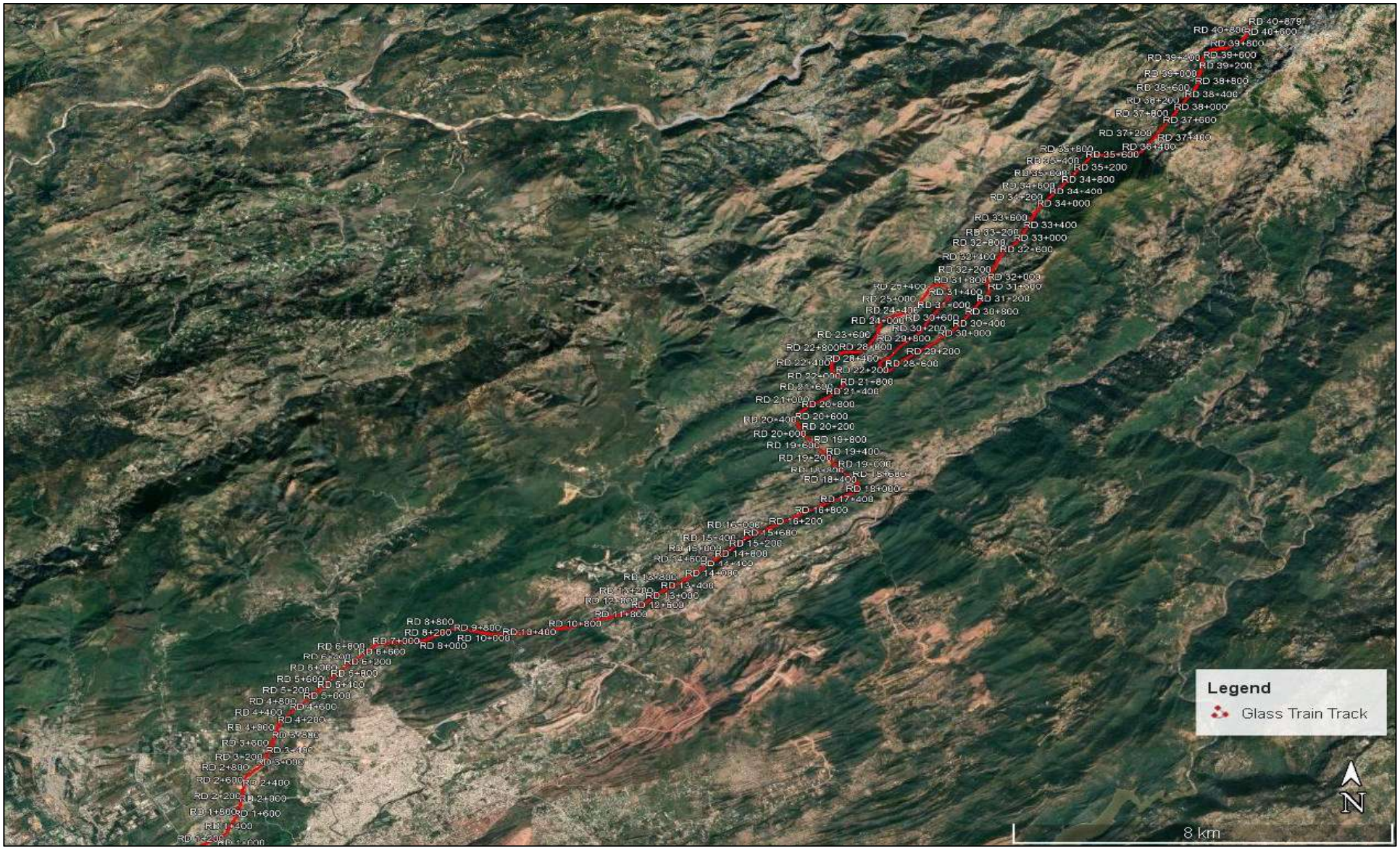


Figure 1.1: Layout Plan of the Glass Train Project

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1.4 SCOPE & OBJECTIVE OF THIS REPORT

The primary objective of this report is to perform a hydraulic analysis and water surface profile modeling for selected stream crossings along the alignment of the Glass Train Islamabad–Murree project. The analysis aims to evaluate the hydraulic behavior of natural streams intersecting the Glass Train corridor, under various design flood scenarios corresponding to 25-year, 50-year, and 100-year return periods.

The scope of the study encompasses the following:

1. Identification and delineation of contributing catchments intersecting the proposed Glass Train alignment, with a focus on Catchment 4 and Catchment 6.
2. Development of one-dimensional hydraulic model using HEC-RAS to simulate steady-state water surface profiles along stream channels at the crossing locations.
3. Determination of flood levels and water surface elevations at critical stream crossings located at RD 6+350, RD 7+450, and RD 12+240.
4. Evaluation of potential impacts of the predicted water levels on the proposed rail infrastructure, aiding in the design of appropriate waterway, pier placement, bridges (if required and protective measures.
5. Documentation and interpretation of modeling results to support engineering decisions and ensure structural safety and hydraulic adequacy of the crossing structures.

This study serves as a foundational input to the detailed design phase by identifying hydraulically sensitive locations along the train route and providing quantitative flood level data necessary for infrastructure sizing and clearance provision.

2 HYDRAULIC MODELING

2.1 MODEL SELECTION

HEC-RAS (Version 6.6) has been selected for modelling purpose. This model has been developed by the United States Army corps of Engineers and is a free ware in the public domain. It can perform steady/unsteady flow calculations, sediment transport computations and water temperature/quality modelling, etc.

The latest version of HEC-RAS can be downloaded from the following link:

https://www.hec.usace.army.mil/software/hec-ras/download.aspx

2.2 MODEL INPUTS

1-D model of River Ravi has been configured in HEC-RAS with the following main inputs;

- Delineated Catchment Areas
- Discharge values against 25, 50 and 100 years Return Periods
- Digital Elevation Model (DEM)
- Distance between the cross – sections
- Data of the existing infrastructure (if any) in the study reach
- High banks along the river, on both sides
- Upstream/ downstream boundary conditions
- Manning’s roughness coefficient

2.2.1 Catchments in Our Project Area

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The alignment of the Glass Train Islamabad–Murree project traverses a steep, hydrologically varying terrain intersected by multiple natural streams. As part of the hydraulic analysis, two significant catchments, Catchment 4 and Catchment 6 were delineated, based on topography and stream flow paths, as shown in **Figure 2.1** (catchment delineation and crossing locations).

Catchment 6 is the larger of the two, with a total contributing area of approximately 45.04 km². It exhibits a steep gradient, with an upper elevation of 904 meters and a lower elevation of 542 meters. The main stream within this catchment has a length of 14,517.81 meters, which reflects a long and well-developed flow path. This catchment has two stream crossings along the proposed Glass Train alignment at RD 6+350 and RD 7+450, which are hydraulically critical points evaluated in this study.

Catchment 4, in comparison, is relatively smaller with a total area of 2.34 km². It ranges in elevation from 652 meters at the upper end to 609 meters at the downstream point, with a main stream length of 2,831.89 meters. The rail-stream intersection within this catchment occurs at RD 12+240. Despite its smaller size, the catchment's hydrologic response during storm events remains significant due to the steep slopes and short concentration time.

These delineated catchments form the basis of the hydraulic and water surface profile modeling using HEC-RAS for various return periods (25, 50, and 100 years), enabling the identification of potential flood risks and the estimation of water levels at each stream crossing.

2.2.2 Hydrological Data

To facilitate accurate hydraulic modeling at stream crossing locations along the Glass Train Islamabad–Murree alignment, design flood discharges were estimated for return periods of 25, 50, and 100 years for each contributing catchment. These discharges represent peak flows derived through standard hydrological assessment procedures and reflect the anticipated magnitude of flood events within the respective catchment areas. **Table 2-1** below shows the estimated discharges in the specific catchments as mentioned.

Table 2-1: Estimated Revised Floods

T (years)	Flood (Cumecs)			
	Catchment - 2	Catchment - 3	Catchment - 4	Catchment - 6
25	616.45	594.45	67.87	611.57
50	743.26	703.03	81.06	702.55
100	868.72	810.52	94.15	792.68

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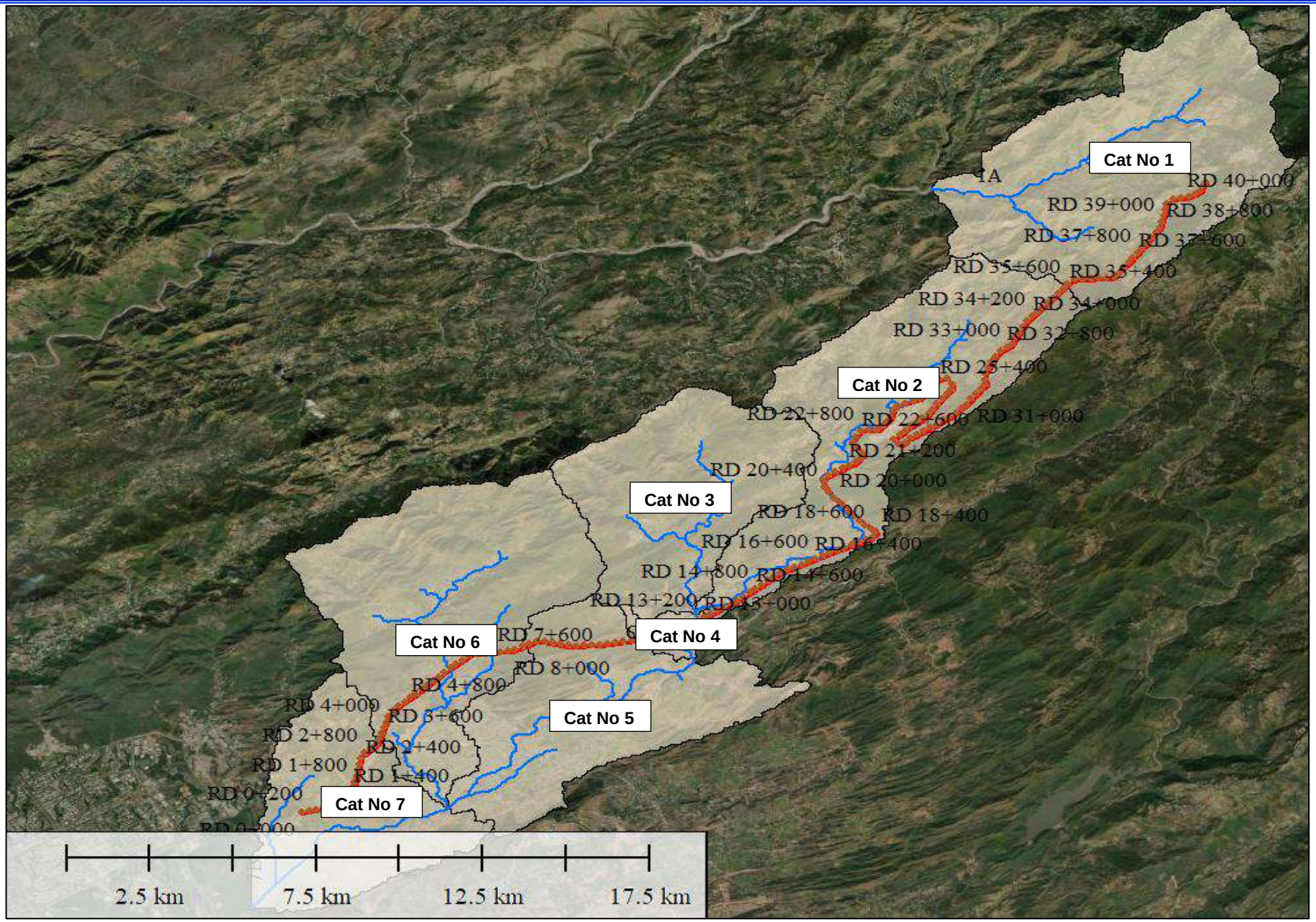


Figure 2.1: Catchments in our Project Area

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2.2.3 Digital Elevation Model (DEM)

In this analysis, the Digital Elevation Model (DEM) was used within HEC-RAS to define the terrain along each stream reach and extract accurate bed slopes for hydraulic modeling. The DEM provided a continuous elevation profile, enabling the generation of realistic channel geometries where currently detailed survey data was unavailable. This helped improve the accuracy of longitudinal profiles and water surface elevation results at the stream crossings along the Glass Train Islamabad–Murree alignment. The combined DEM of all the catchments is shown in the **Figure 2.2** below.

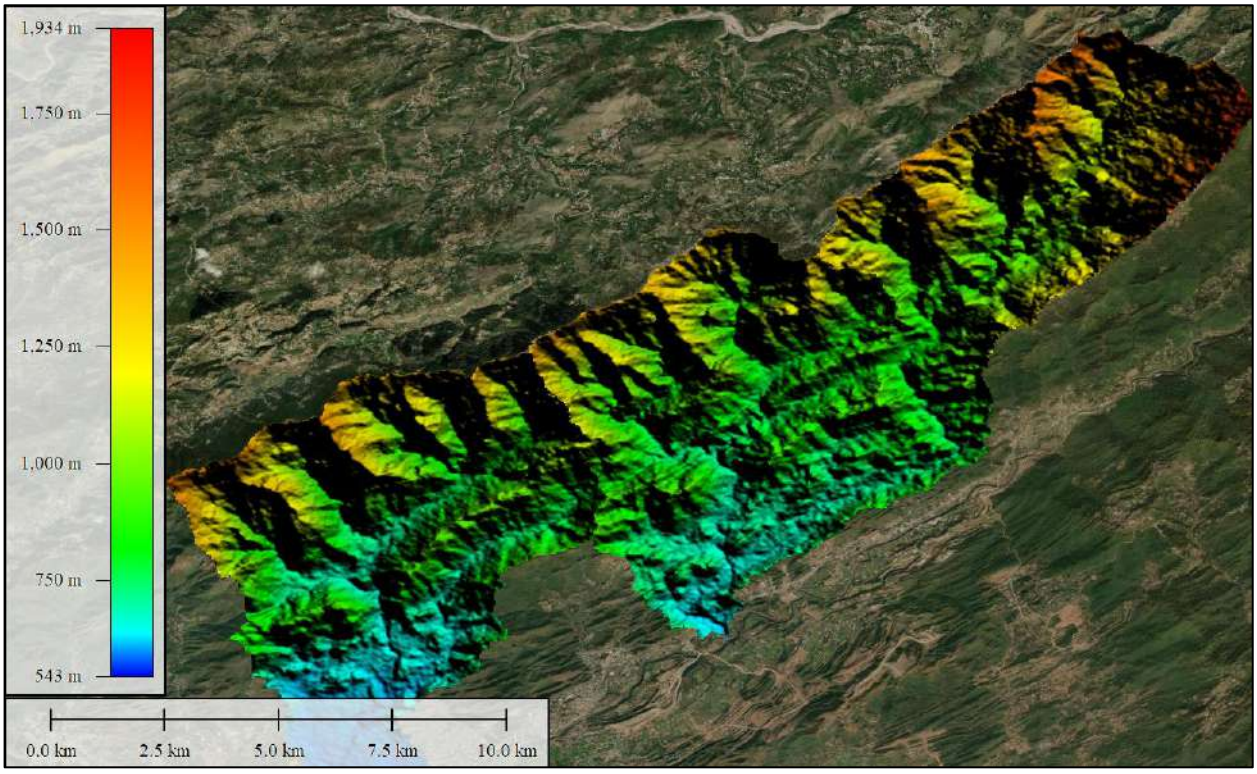


Figure 2.2: Digital Elevation Model (DEM)

2.3 STREAM BED PROFILES

For the purpose of hydraulic modeling in HEC-RAS, the longitudinal bed profiles of the intersecting streams at the specified locations along the Glass Train alignment have been developed. These profiles are essential for accurate simulation of flow behavior and water surface elevations during flood events. Each stream has been modeled with an adequate upstream and downstream reach to ensure proper conveyance and boundary condition stability within the computational domain. The stream names correspond to the RDs where they intersect the proposed rail track. The catchment wise streams distribution is as follows:

1. **Catchment – 6 contains two stream crossings:**
    - **RD 6+350 Stream:** This stream reach has been modeled over a length of 1,873.3 m, with bed elevations ranging from 660.68 m at the upstream end to 612.50 m at the downstream end. The profile indicates a steady decline in elevation, suggesting a relatively steep gradient allowing high-velocity flows during storm events.
    - **RD 7+450 Stream:** This stream has been represented with a total length of 2,119.9 m, where the elevation varies from 685.18 m upstream to 629.38 m downstream. The profile

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reflects a well-defined gradient and suggests substantial energy potential in flood scenarios.

2. **Catchment – 4 includes one stream crossing:**

- **RD 12+240 Stream:** Modeled over a length of 1,480.0 m, this stream shows elevation values decreasing from 650.37 m to 632.85 m. The profile illustrates a gentler slope compared to those in Catchment 6, potentially leading to slower flow velocities and longer retention times during high-flow conditions.

The bed profile graphs for each stream are shown in **Figure 2.3, Figure 2.4** and **Figure 2.5** respectively to provide a visual representation of the longitudinal slope and terrain characteristics of each channel. These profiles were used to construct the geometry within the HEC-RAS model and directly influence the resulting water surface profiles generated for the various flood return periods.

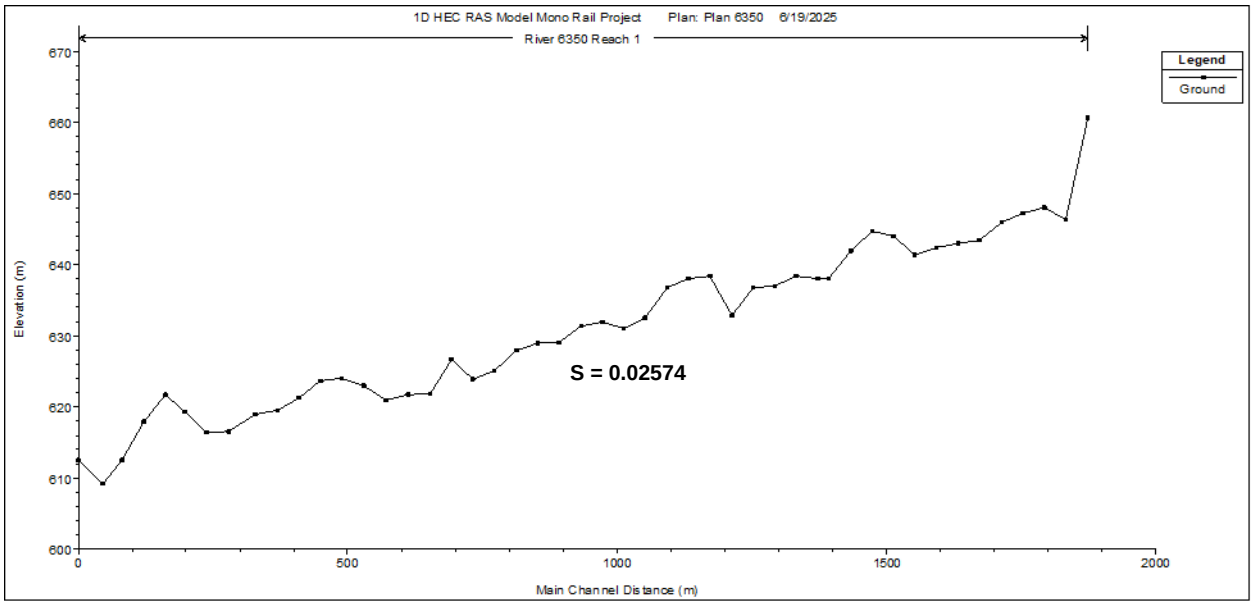


Figure 2.3: RD 6+350 Stream Bed Profile

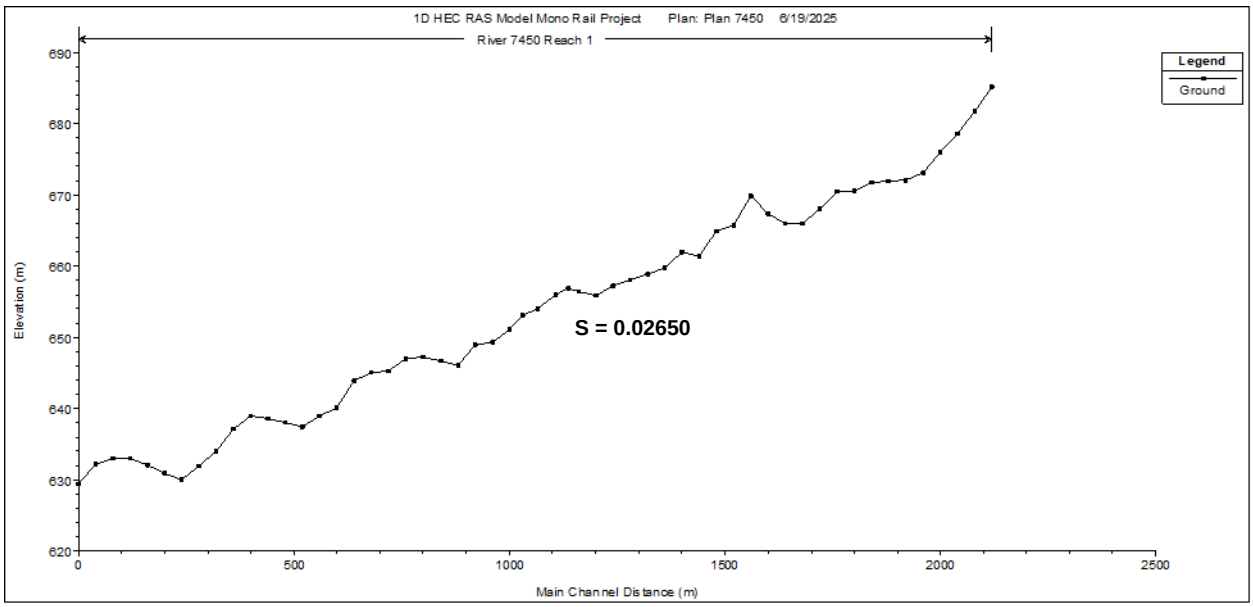


Figure 2.4: RD 7+450 Stream Bed Profile

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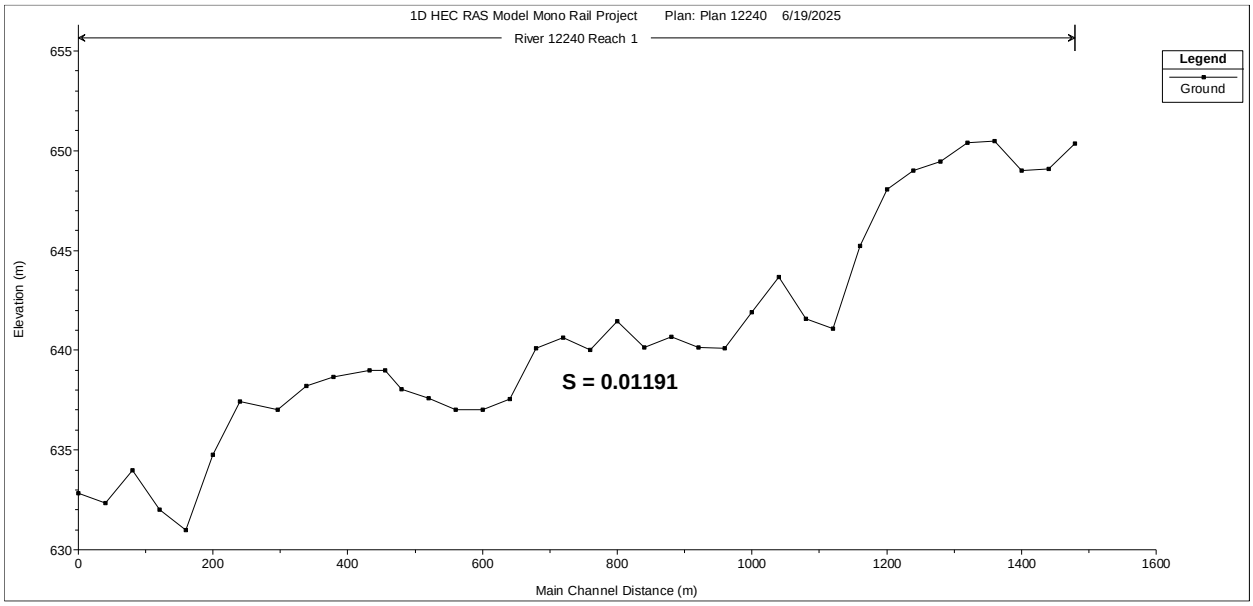


Figure 2.5: RD 12+240 Stream Bed Profile

2.4 RIVER WATER SURFACE PROFILE ANALYSIS

For the development of rating curves at critical stream crossing locations along the Glass Train Islamabad–Murree alignment, the latest version of HEC-RAS (v6.6), developed by the U.S. Army Corps of Engineers (USACE), has been utilized. The hydraulic model incorporates surveyed cross sections extracted from the Digital Elevation Model (DEM) of each catchment within the study area.

Figure 2.6, Figure 2.7, and **Figure 2.8** presents the plan view of the streams with the train alignment, overlaid on a satellite image, showing the locations of cross sections used in the modeling process.

The primary objective of this analysis is to evaluate the hydraulic parameters at stream crossings, specifically at RD 6+350, RD 7+450, and RD 12+240, to support the design of glass train structure by providing accurate water level estimations for varying discharge conditions. These curves help define relationships between discharge and corresponding water surface elevation, which are critical for:

- Determining the required hydraulic capacity of waterway openings,
- Setting safe clearance levels for train infrastructure,
- Ensuring resilience against extreme flood events with 25, 50, and 100-year return periods.

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Figure 2.6: HEC-RAS model showing modelled cross sections at Stream RD 6+350

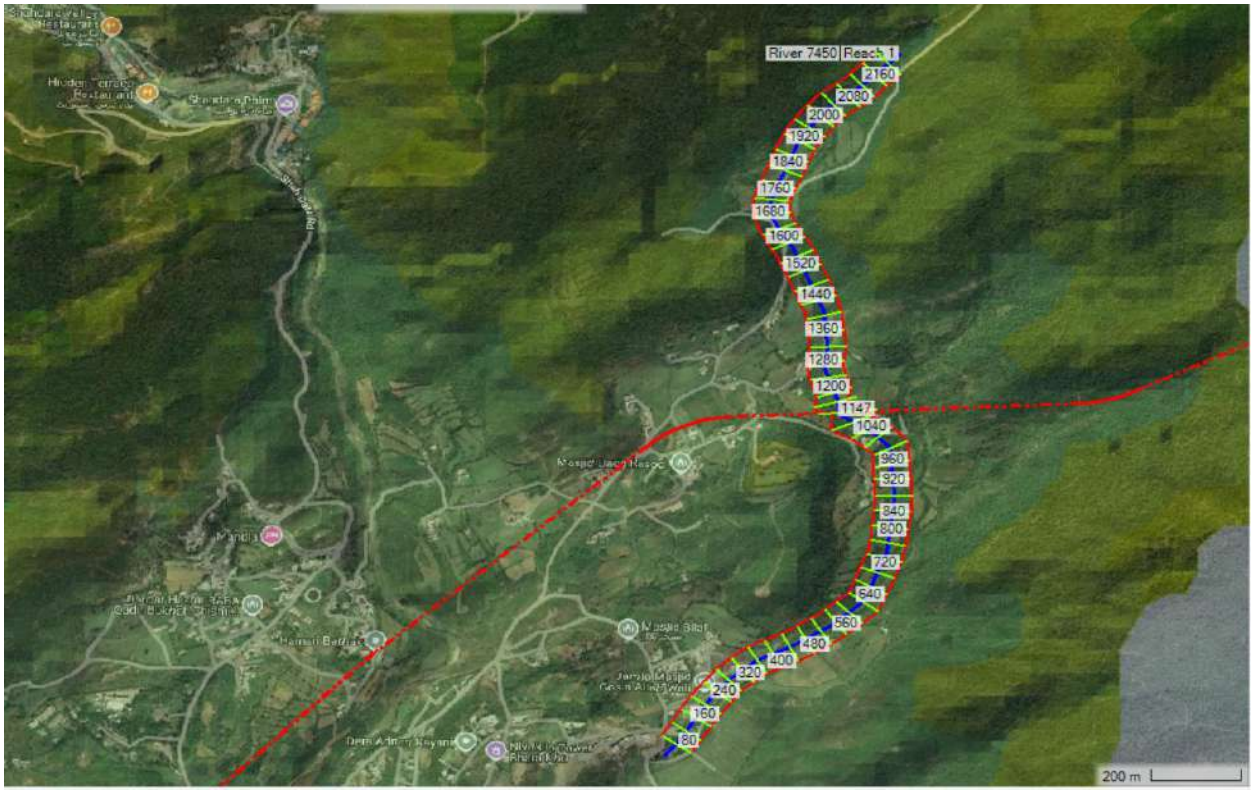


Figure 2.7: HEC-RAS model showing modelled cross sections at Stream RD 7+450

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Figure 2.8: HEC-RAS model showing modelled cross sections at Stream RD 12+240

2.4.1 Procedure and Assumption

Following assumptions made are:

- There is no change or accretion in the river/stream because of infrastructure development.
- A steady state flow has been assumed in the entire reach for each discharge.

2.5 HEC-RAS Analysis

For the hydraulic analysis of stream crossings along the Glass Train Islamabad–Murree alignment, a total of three stream reaches were modeled in HEC-RAS at RD 6+350, RD 7+450, and RD 12+240. The modeled reach lengths are approximately 1,873.3 meters, 2,119.9 meters, and 1,480.0 meters, respectively, covering adequate lengths upstream and downstream of each crossing to capture the full hydraulic response under flood conditions.

Surveyed cross sections were incorporated from the detailed topographic survey, providing accurate channel geometry for each stream. A Manning's roughness coefficient of 0.040 was used throughout, in line with recommendations from Open-Channel Hydraulics by Ven Te Chow, and appropriate for natural mountainous streams with irregular and gravel-lined beds.

For boundary condition definition, normal depth slopes were assigned at the downstream ends of each modeled reach and critical depths at the upstream ends. These were taken as 0.02574 for RD 6+350, 0.02650 for RD 7+450, and 0.01191 for RD 12+240, based on the average bed gradients derived from longitudinal profile data. These slopes allowed realistic estimation of tailwater conditions and contributed to stable and hydraulically consistent model behavior.

The streams intersecting the Glass Train alignment at RD 6+350, RD 7+450, and RD 12+240 have been modelled in HEC-RAS, with cross-sections labelled as 872, 1147, and 419, respectively. The **Figure 2.9, Figure 2.10,** and **Figure 2.11** attached below depict these representative cross-sectional profiles, showing the water depths resulting from the design discharges provided in Section 2.2.2. These outputs help visualize flow behavior at each crossing

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location and serve as a basis for evaluating hydraulic clearance, inundation risk, and the structural design requirements for the proposed train – stream crossings.

Table 2.2: Results of HEC-RAS analysis at RD

Sr. No.	Stream Name	Station	Discharge (cumecs) (100yrs RI)	Water Level (m)	Velocity (m/sec)
1	RD 6350	872	307.31	631.18	3.96
2	RD 7450	1147	485.37	657.22	6.14
3	RD 12240	419	94.15	640.10	2.22

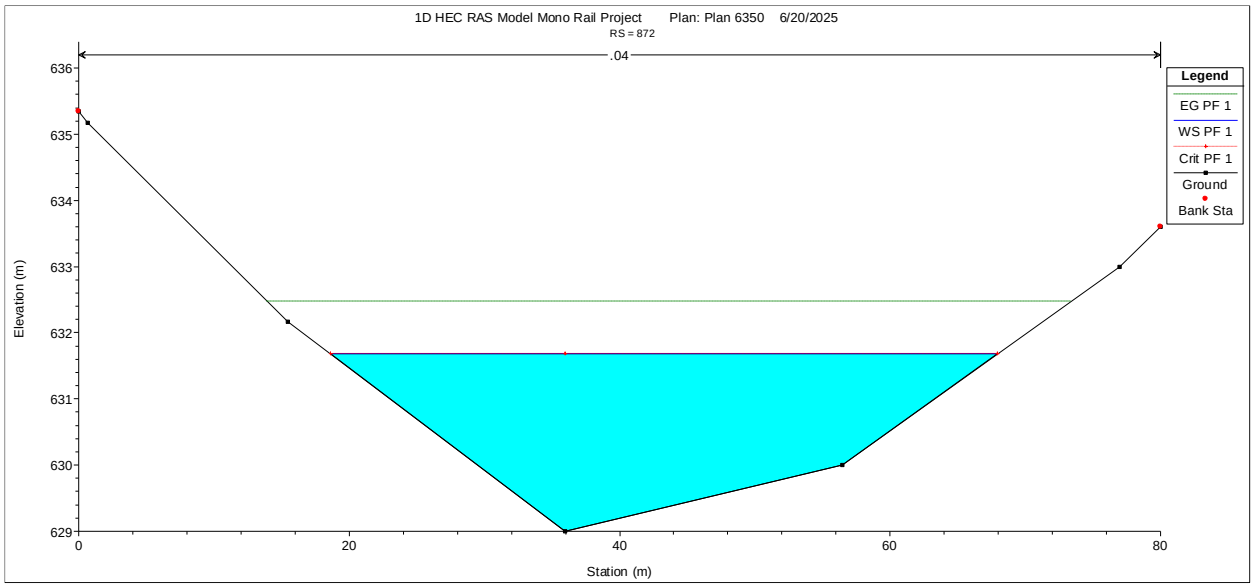


Figure 2.9: Cross section 872 at stream RD 6350

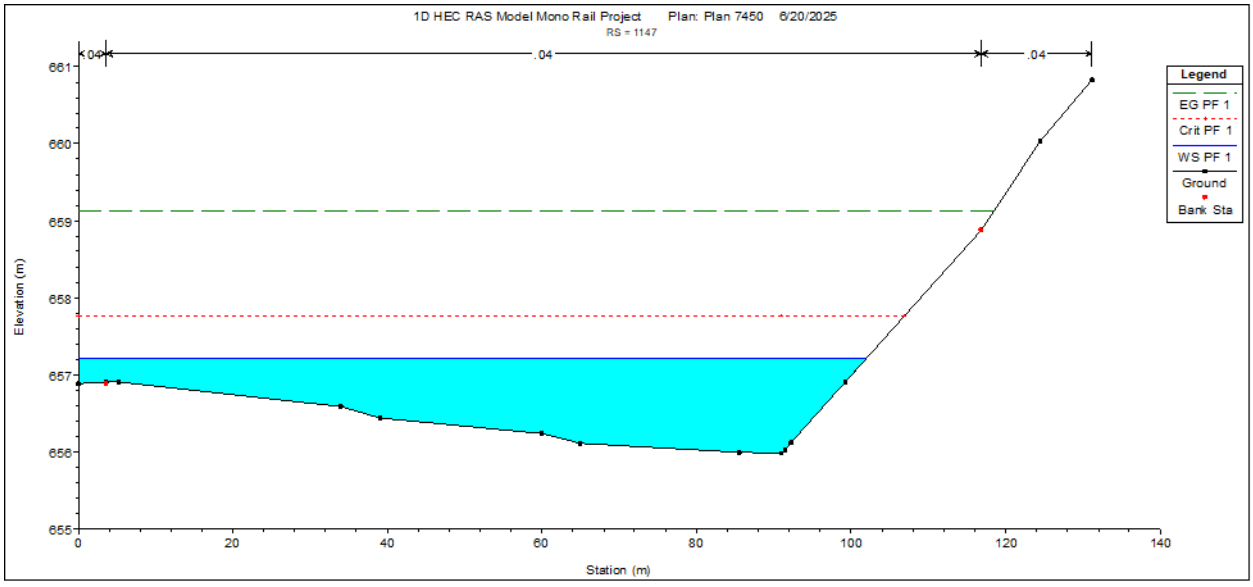


Figure 2.10: Cross section 419 at stream RD 7450

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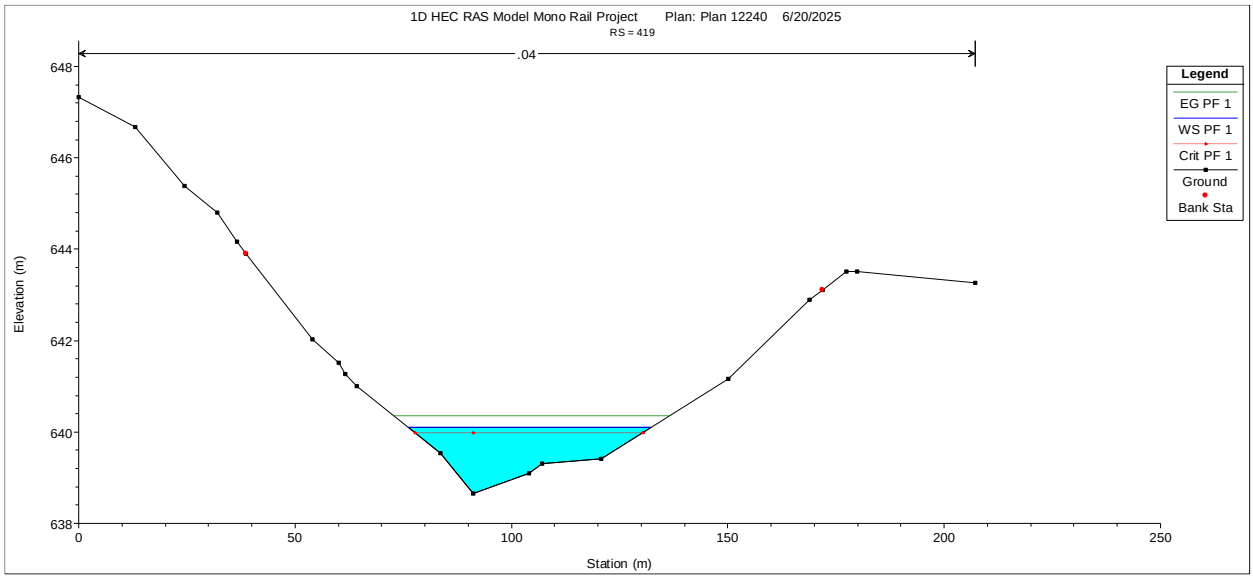


Figure 2.11: Cross section 1147 at stream RD 12240

3 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are primarily derived from the HEC-RAS analysis based on the modeled stream profiles, water surface elevations, and flow velocities at the three critical stream crossings intersecting the Glass Train Islamabad–Murree alignment. This detailed assessment will aid in determining whether raising the bottom level of the Glass Train structure is required, or if not, whether additional protective measures are needed and to what extent they should be implemented.

3.1 CONCLUSIONS

1. High Water Levels and Potential Inundation:

The peak water levels simulated at the critical stream crossings are 631.18 m at RD 6+350, 657.22 m at RD 7+450, and 640.10 m at RD 12+240. These levels represent the water surface elevations during the 100-year design flood and must be carefully compared with the proposed bottom elevation of the rail structure to evaluate freeboard and inundation risk.

2. Flow Velocities and Scour Potential:

Flow velocities reach up to 6.14 m/s at RD 7+450, which is significantly high and indicates a potential for local scour and erosion near any bridge piers, abutments, or foundation structures. RD 6+350 and RD 12+240 show velocities of 3.96 m/s and 2.22 m/s, respectively, which are moderate but still warrant protective measures, especially where soil or sediment transport is likely.

3. Catchment and Terrain Influence:

The modeled slopes and flow characteristics reflect steep mountainous terrain, especially in Catchment 6, suggesting rapid runoff and flashy flood response. This increases the hydraulic vulnerability of stream crossing structures during extreme events.

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3.2 RECOMMENDATIONS

1. Review and Adjustment of Track Bottom Elevation:

At each stream crossing, the bottom level of the Glass Train structure should be reviewed in light of the simulated water levels. Where the freeboard (typically 0.5 to 1.0 m depending on design standards) is insufficient, raising the bottom elevation should be considered to ensure safety and structural resilience.

2. Provision of Scour Protection:

Given the high velocity at RD 7+450 and moderate velocities at the other locations, it is recommended to implement scour countermeasures, such as riprap, gabions, or concrete aprons, at the foundation zones of all crossing structures.

3. Regular Inspection and Maintenance Protocol:

Due to the steep terrain and flash flood behavior, regular inspection and maintenance of drainage and protective works must be incorporated into the operation plan, particularly before and after the monsoon season.

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PUNJAB MASSTRANSIT AUTHORITY
GOVERNMENT OF PUNJAB

FEASIBILITY STUDY FOR THE TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE



GEOTECHNICAL INVESTIGATION REPORT FOR TRACKWAY, STATIONS AND STRUCTURES

MAY 2025

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GEOTECHNICAL INVESTIGATION REPORT FOR TRACKWAY, STATIONS AND STRUCTURES

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LIST OF ABBREVIATIONS

ASR	Alkali-Silica Reaction
ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BCP - SP	Building Code of Pakistan - Seismic Provisions
BH	Borehole
BS	British Standard
EGL	Existing Ground Level
FHWA	Federal Highway Administration
FOS	Factor of Safety
HKS	Hazara Kashmir Syntaxis
ISRM	International Society for Rock Mechanics
KP	Khyber Pakhtunkhwa
LL	Liquid Limit
MBT	Main Boundary Thrust
MDD	Maximum Dry Density
NAVFAC	Naval Facilities Engineering Command
NESPAK	National Engineering Services Pakistan (Pvt.) Ltd
NMC	Natural Moisture Content
OPC	Ordinary Portland Cement
PI	Plasticity Index
PL	Plastic Limit
PMA	Punjab Masstransit Authority
PPRA	Public Procurement Regulatory Authority
RMR	Rock Mass Rating
RQD	Rock Quality Designation
SPT	Standard Penetration Test
TDS	Total Dissolved Solids
USCS	Unified Soil Classification System

EXECUTIVE SUMMARY

Punjab Masstransit Authority (PMA), Government of Punjab (hereinafter referred to as “the Client”) is undertaking a Feasibility Study for the Tourist Glass Train from Rawalpindi to Murree (hereinafter referred to as “the project”). The objective of the project is to develop a scenic and sustainable transport system to promote tourism and improve accessibility to the Murree region, while minimizing environmental impact.

To support this initiative, the Client has engaged National Engineering Services Pakistan (Pvt.) Limited (NESPAK), hereinafter referred to as “the Consultant”, to carry out the feasibility study. As part of this assignment, a feasibility-level geotechnical investigation has been conducted to assess general subsurface conditions and provide geotechnical input for feasibility-level foundation design.

At the time of planning and execution of the geotechnical investigation, a conventional rail line was under consideration, running from Islamabad Sector H-9 to Murree Bus Stand. This alignment, shown in yellow on the geotechnical investigation plan (Appendix-A), covered 62.8 km and involved a number of bridges, tunnels and mixed sections at grade or in cut-and-fill through mountainous terrain. However, as the investigation neared completion and findings from parallel studies became available, the project management team adopted a monorail system with revised alignment for the tourist glass train. This revised route, shown in black on the geotechnical investigation plan (Appendix-A), extends from Lake View Park to Murree Bus Stand, with a reduced total length of approximately 39 km. The proposed monorail will be constructed as a fully elevated system. This elevated option is more suitable for steep, hazardous terrain. This report presents the field and laboratory investigation results conducted for the earlier proposed alignment (shown in yellow on the plan). However, preliminary geotechnical recommendations have been provided in consideration of the revised monorail alignment (indicated in black on the plan).

It is important to note that the feasibility study encompasses multiple aspects, including evaluation of geological and geohazard conditions along the proposed route. As the alignment passes through mountainous terrain with complex geological formations, regional active faults and both existing and potential landslide zones, these critical aspects are being assessed by specialized geological and geohazard experts, with findings presented in their respective technical reports. The finalization of the alignment should be carried out in accordance with the recommendations of these studies. Furthermore, the estimated costs for geohazard mitigation measures should be duly incorporated in the project cost estimates.

To expedite the geotechnical investigation, the work was divided into multiple packages, allowing parallel field activities. Separate contracts were awarded for material studies, tunneling, and the main alignment. The alignment investigation was segmented into three parts, (1) Islamabad Sector H-9 to Shahdara Valley, (2) Shahdara Valley to Nandkot, and (3) Nandkot to Murree Bus Stand, and executed by different Contractors through a competitive bidding process. This report presents a consolidated interpretation of the investigation findings across all segments.

The field geotechnical investigation was conducted under the supervision of the Consultant's Engineering Geologists from March 8 to May 29, 2025. Selected soil, rock and water samples collected during the field geotechnical investigations are being tested at the laboratories of DECON, CMTL, SOILCON and UET Lahore, in accordance with the laboratory testing programs developed by the Consultant. This report presents the findings of the geotechnical investigation carried out for the trackway, stations and structures, including field and laboratory test results, evaluation of subsurface conditions and geotechnical recommendations to support the feasibility-level design of the project.

Geotechnical investigation revealed that on-site overburden soils generally comprised Lean Clay/Lean Clay with Sand/Gravelly Lean Clay with Sand (CL), Silty Clay/Silty Clay with Sand/Gravelly Silty Clay with Sand (CL-ML), Clayey Gravel with Sand (GC), Silty Clayey Gravel with Sand (GC-GM) and Poorly Graded Gravel with Clay and Sand (GP-GC) as per Unified Soil Classification System (USCS). The bedrock predominantly comprises interbedded Shale, Siltstone and Sandstone, with Shale and Siltstone being the dominant lithologies. Groundwater was generally not encountered during the geotechnical investigation conducted from March 8 to May 29, 2025. However, seepage was observed in two boreholes: BH-04 at a depth of 5.7 m and BH-06 at 18.5 m. These observations indicate localized zones of seepage rather than a continuous groundwater table.

Field and laboratory data indicated that the overburden soils generally exhibit medium to high shear strength, low to medium compressibility and low swelling potential. The estimated Rock Mass Rating (RMR_{89}), following Bieniawski (1989), ranges from 35 to 40, placing the rock mass on the boundary between "Poor" and "Fair" quality.

Bored cast-in-situ RC piles are anticipated to be required for supporting monorail piers and station structures, considering the anticipated load demands and performance requirements. However, estimated pile capacities are based on preliminary geotechnical data and shall be validated through detailed investigations at the detailed design stage to finalize foundation design parameters and construction methods.

Given the mountainous terrain and associated geohazards along the project corridor, particularly from Ghora Gali to Murree Bus Stand where landslide susceptibility is high, foundation design must account for more than just structural load demands. The proposed bored cast-in-situ RC piles are intended to support the elevated monorail superstructure and are not proposed to resist loads arising from unstable ground or slope movement. Therefore, in landslide-prone sections, the alignment should be carefully reviewed and mitigation measures implemented based on the recommendations of geohazard specialists to ensure long-term structural safety.

1. INTRODUCTION

1.1 GENERAL

Punjab Masstransit Authority (PMA), Government of Punjab (hereinafter referred to as "the Client") is undertaking a Feasibility Study for the Tourist Glass Train from Rawalpindi to Murree (hereinafter referred to as "the project"). The objective of the project is to develop a scenic and sustainable transport system to promote tourism and improve accessibility to the Murree region, while minimizing environmental impact.

To support this initiative, the Client has engaged National Engineering Services Pakistan (Pvt.) Limited (NESPAK), hereinafter referred to as "the Consultant", to carry out the feasibility study. As part of this assignment, a feasibility-level geotechnical investigation has been conducted to assess general subsurface conditions and provide geotechnical input for feasibility-level foundation design.

At the time of planning and execution of the geotechnical investigation, a conventional rail line was under consideration, running from Islamabad Sector H-9 to Murree Bus Stand. This alignment, shown in yellow on the geotechnical investigation plan (Appendix-A), covered 62.8 km and involved a number of bridges, tunnels and mixed sections at grade or in cut-and-fill through mountainous terrain. However, as the investigation neared completion and findings from parallel studies became available, the project management team adopted a monorail system with revised alignment for the tourist glass train. This revised route, shown in black on the geotechnical investigation plan (Appendix-A), extends from Lake View Park to Murree Bus Stand, with a reduced total length of approximately 39 km. The proposed monorail will be constructed as a fully elevated system. This elevated option is more suitable for steep, hazardous terrain. This report presents the field and laboratory investigation results conducted for the earlier proposed alignment (shown in yellow on the plan). However, preliminary geotechnical recommendations have been provided in consideration of the revised monorail alignment (indicated in black on the plan).

It is important to note that the feasibility study encompasses multiple aspects, including evaluation of geological and geohazard conditions along the proposed route. As the alignment passes through mountainous terrain with complex geological formations, regional active faults and both existing and potential landslide zones, these critical aspects are being assessed by specialized geological and geohazard experts, with findings presented in their respective technical reports. The finalization of the alignment should be carried out in accordance with the recommendations of these studies. Furthermore, the estimated costs for geohazard mitigation measures should be duly incorporated in the project cost estimates.

To ensure timely completion of geotechnical investigation, the work was divided into multiple packages to enable parallel field activities. A separate package was dedicated to materials studies and another focused-on tunnels, for which relevant reports from other experts should be referred to. The remaining scope, covering the trackway, stations and structures, was divided into three investigation packages corresponding to the alignment segments: (1) Islamabad Sector H-9 to Shahdara Valley, (2) Shahdara Valley to Nandkot and (3) Nandkot

to Murree Bus Stand. This report specifically addresses the geotechnical investigation carried out for these three segments.

The geotechnical investigation for the Islamabad Sector H-9 to Shahdara Valley section was awarded to M/s SAFE Soil and Foundation Engineering Services, while the investigation for the remaining two sections, from Shahdara Valley to Nandkot and from Nandkot to Murree Bus Stand, were awarded to M/s The Driller, Lahore. All contracts were awarded through a competitive bidding process in accordance with PPRA rules, with work assigned to the most advantageous bidders. The segmentation of the alignment was intended purely to enable simultaneous fieldwork; however, this report presents a consolidated interpretation of the investigation results. Recommendations are developed based on geotechnical variations along the corridor, rather than the administrative or execution-based divisions used during investigation.

The field geotechnical investigation was conducted under the supervision of the Consultant's Engineering Geologists from March 8 to May 29, 2025. Selected soil, rock and water samples collected during the field geotechnical investigations are being tested at the geotechnical laboratories of DECON, CMTL, SOILCON and UET Lahore, in accordance with the laboratory testing programs developed by the Consultant. This report presents the findings of the geotechnical investigation carried out for the trackway, stations and structures, including field and laboratory test results, evaluation of subsurface conditions and geotechnical recommendations to support the feasibility-level design of the project.

The preliminary geotechnical recommendations presented in this report are based on a limited, feasibility-level geotechnical investigation carried out in accordance with standard geotechnical practices. These findings are intended to inform the overall planning and evaluation of development options. Detailed geotechnical investigations shall be undertaken at the subsequent design stage to support final design and construction of the tourist glass train.

1.2 OBJECTIVES OF GEOTECHNICAL INVESTIGATION

The geotechnical investigation was undertaken to meet the following objectives:

1) To identify the major subsurface soil and rock types along the proposed alignment
2) To evaluate the overall suitability of ground conditions along the route.
3) To estimate soil and rock parameters and develop geotechnical recommendations to guide feasibility-level foundation design and assess construction feasibility.
4) To assess potential aggressiveness of subsurface materials on underground reinforced concrete works.

1.3 SCOPE OF GEOTECHNICAL INVESTIGATION

The following scope of work for the feasibility-level geotechnical investigation was developed to meet the outlined objectives:

1) Execution of twenty (20) boreholes at selected locations along the proposed alignment, with depths ranging from 25 to 35 m below existing ground level (EGL), including continuous core drilling in bedrock up to 25 m below rock strike level.
2) Performance of Standard Penetration Tests (SPTs) in boreholes at 1 m intervals.
3) Collection and preservation of disturbed and undisturbed soil samples from boreholes.
4) Collection and preservation of rock core samples from boreholes.
5) Collection and preservation of groundwater samples from boreholes.
6) Laboratory testing of selected soil and rock samples to determine classification, strength, compressibility and chemical characteristics along with chemical analysis of groundwater.
7) Estimation of soil and rock parameters and formulation of preliminary geotechnical recommendations to support feasibility-level foundation design.
8) Preparation of a Geotechnical Investigation Report presenting key findings and baseline data for use in the feasibility study.

1.4 DESCRIPTION OF THE PROJECT SITE

The proposed monorail route extends from Lake View Park in Islamabad to the Murree Bus Terminal, spanning approximately 39 km. Key locations along the alignment include Quaid-e-Azam University, Barakahu, Shahdara Valley, Chattar Park, Bahria Golf City, Manga, Nandkot, Ghora Gali, Pindi Point and Murree Bus Stand.

The route begins in the semi-urban outskirts of Islamabad and moves into the Margalla and Murree Hills, characterized by steep, mountainous terrain with dense forest cover and undulating topography. Land use varies from urban and institutional areas near the origin to largely natural and protected zones in the upper reaches. The alignment lies in a geo-hazard-prone region, with risks of landslides and unstable slopes, particularly beyond Ghora Gali up to the Murree Bus Stand. The location plan of the proposed glass train project is appended as Fig. A-1 (Appendix-A).

2. GEOLOGICAL, GEOTECTONIC AND SEISMIC CHARACTERISTICS OF THE AREA

2.1 GEOLOGICAL, GEOHAZARD AND SEISMIC RISK CONTEXT

The project alignment traverses a geologically complex and tectonically active region, situated within the Hazara Kashmir Syntaxis (HKS) zone of the Lesser Himalayas. The stratigraphy along the project corridor is primarily composed of the Murree Formation of Miocene age, which consists of molasse-type deposits including shale, siltstone and sandstone. Overlying this bedrock unit in various locations are Quaternary deposits such as colluvium, alluvium and landslide debris, particularly concentrated in valleys and along unstable slopes. Tectonically, the area lies near major structural features, most notably the Main Boundary Thrust (MBT) and the Jhelum Fault, both of which contribute to the region's structural complexity and seismic vulnerability.

Landslides have historically posed a significant geohazard in the Murree Hills due to sheared and weathered rock masses, steep terrain, intense seasonal rainfall, and seismic activity. This hazard potential is particularly elevated in the final stretch of the alignment, from Ghora Gali to the Murree Bus Stand, where topographic and geological conditions are especially adverse.

In light of these factors, comprehensive understanding of terrain instability and seismic risk was essential for terrain characterization. For a detailed appraisal of geological hazards and seismic parameters, crucial for defining appropriate mitigation strategies and ensuring that structural design aligns with site-specific seismic demands, reference should be made to the Geological and Geohazard Assessment Report and the Seismological Studies Report being prepared as part of this feasibility.

3. FIELD GEOTECHNICAL STUDIES

3.1 PLANNING

As part of the feasibility-level investigation, boreholes were drilled along the proposed alignment at relatively wider intervals, consistent with the scope of this preliminary assessment. While this spacing is sufficient for feasibility-level foundation design, closer spacing and more detailed investigations will be required during the detailed design phase to support final foundation design and construction planning. The geotechnical investigation plan showing locations of the boreholes is appended to this report as Fig. A-2 (Appendix-A). The photographs of field activities are included in Appendix-F.

3.2 DRILLING OF BOREHOLES

A total of twenty (20) boreholes were drilled along the proposed alignment, to depths ranging from 25 to 35 me below EGL, including 15 to 25 m of continuous coring in bedrock. Borehole details are summarized in Table 3-1:

Table 3-1: Details of Boreholes

Sr. No.	Borehole No.	Total Drilled Depth (m)	Drilled Depth in Overburden (m)	Drilled Depth in Bedrock (m)	Groundwater Depth (m)
1	BH-01	25.0	25.0	-	Not Encountered
2	BH-02	25.0	25.0	-	Not Encountered
3	BH-03	25.0	25.0	-	Not Encountered
4	BH-04	25.0	25.0	-	Seepage at 5.7 m
5	BH-05	25.0	25.0	-	Not Encountered
6	BH-06	25.0	25.0	-	Seepage at 18.5 m
7	BH-07	26.0	1.0	25.0	Not Encountered
8	BH-08	27.0	2.0	25.0	Not Encountered
9	BH-09	27.0	2.0	25.0	Not Encountered
10	BH-10	25.0	3.3	21.7	Not Encountered
11	BH-11	27.0	1.5	25.5	Not Encountered
12	BH-12	26.0	1.0	25.0	Not Encountered
13	BH-12A	27.0	2.0	25.0	Not Encountered
14	BH-13	25.0	10.0	15.0	Not Encountered

Sr. No.	Borehole No.	Total Drilled Depth (m)	Drilled Depth in Overburden (m)	Drilled Depth in Bedrock (m)	Groundwater Depth (m)
15	BH-14	25.0	8.1	16.9	Not Encountered
16	BH-15	24.0	9.0	15.0	Not Encountered
17	BH-16	30.0	14.0	16.0	Not Encountered
18	BH-17	25.0	6.0	19.0	Not Encountered
19	BH-18	25.0	10.0	15.0	Not Encountered
20	BH-19	35.0	20.0	15.0	Not Encountered

Straight rotary drilling method was employed to drill the boreholes with bentonite slurry as the drilling fluid. Fish tail / Tricon roller bit with a diameter of 125 mm was used to drill the boreholes.

Different drilling techniques were employed based on the nature of subsurface materials encountered along the alignment. In clayey overburden soils, the straight rotary method was used with a 125 mm diameter fishtail bit and bentonite slurry as the drilling fluid. In gravelly overburden soils, the percussion boring method was adopted using a 200 mm diameter percussion bailer, plain water and temporary casing to prevent hole collapse. Upon encountering bedrock, drilling proceeded with the straight rotary method using a double tube core barrel of NX size and a tungsten carbide-tipped bit. Plain water served as the drilling fluid during core recovery operations in rock strata.

Field borehole logs were developed based on the material encountered at the site and were later verified through laboratory test results. The borehole logs are appended to this report as Appendix-B. The subsurface soil profile, developed based on these borehole logs, is included as Fig. A-3 (Appendix-A).

3.3 STANDARD PENETRATION TESTS

Standard Penetration Tests (SPT) were performed at 1 m intervals in all boreholes through overburden soils, in accordance with ASTM D1586, using a 63.5 kg donut-type hammer dropped from 0.76 m. In clayey soils, a split spoon sampler without a liner was used, with the hammer operated manually using a rope and cathead. In gravelly strata, due to coarse material, a solid 60-degree cone was used instead, with the hammer similarly dropped manually using a rope through a pulley system mounted on a tripod. The SPT-N values are recorded in the respective borehole logs (Appendix-B). Plots of the field and corrected SPT-N values with depth are presented in Fig. C1 and Fig. C2 (Appendix-C), respectively.

3.4 DISTURBED SOIL SAMPLING

Disturbed soil samples were collected from boreholes using methods suited to the soil type. In clayey soils, samples were obtained from the split spoon sampler, while in gravelly soils,

material was recovered using a percussion bailer. All samples were properly labeled, preserved and transported to the approved laboratories in accordance with ASTM D4220.

3.5 UNDISTURBED SOIL SAMPLING

Six (6) relatively undisturbed soil samples were recovered from boreholes using Shelby tubes and Denison samplers in accordance with ASTM D1587. After determining the in-situ density, the soil samples were properly waxed, labeled, preserved and transported to the approved laboratories in accordance with ASTM D4220.

3.6 UNDISTURBED ROCK SAMPLING

The rock cores recovered using double tube core barrel were placed in secured wooden boxes. The selected rock cores were properly waxed, labeled, preserved and transported to the approved laboratories in accordance with ASTM D5079. Photographs of the rock cores, preserved in wooden boxes, are provided in Appendix-B alongside the corresponding borehole logs.

3.7 GROUNDWATER

Groundwater was generally not encountered during the geotechnical investigation conducted from March 8 to May 29, 2025. However, seepage was observed in two boreholes: BH-04 at a depth of 5.7 m and BH-06 at 18.5 m. These observations indicate localized zones of seepage rather than a continuous groundwater table.

4. LABORATORY TESTING

4.1 GENERAL

Selected soil, rock and water samples collected from boreholes are being subjected to the following tests as per laboratory testing programs prepared by the Consultant, in accordance with ASTM, BS, ISRM or equivalent standards, at the geotechnical laboratories of DECON, CMTL, SOILCON and UET Lahore:

1) Grain Size Analysis (ASTM D421, 422)
2) Atterberg Limits (ASTM D4318)
3) Natural Moisture Content (ASTM D2216)
4) Density (ASTM D7263)
5) Direct Shear (ASTM D3080)
6) Unconfined Compression (ASTM D2166)
7) Consolidation with Swell Pressure Measurement (ASTM D2435)
8) Uniaxial Compression and Elastic Modulus (ASTM D7012)
9) Hoek Shear (ISRM, 1981)
10) Sulfate Content (BS 1377 Part 3)
11) Chloride Content (BS 1377 Part 3)
12) Organic Matter Content (BS 1377 Part 3)
13) Chemical Analysis of Water (BS 1377 Part 3)

A summary of laboratory test results completed to date is appended to this report as Table D-1 (Appendix-D) along with test result sheets.

4.2 TESTING ON SOIL SAMPLES

4.2.1 Classification Tests

Grain size analysis was proposed for fifty-four (54) soil samples collected from boreholes, with twenty-six (26) tests completed so far. The percentage of fines (i.e. passing sieve no. 200) for coarse grained soils ranged between 1 and 44 %, while the percentage of fines for fine grained soils varied from 50 to 100 %. Hydrometer analysis was proposed for ten (10) soil samples collected from boreholes, with four (4) tests completed so far. The tested samples contained 58 to 96 % silt-sized particles (0.002 to 0.075 mm) and 2 to 9 % clay-sized particles (<0.002 mm).

Atterberg limits tests were proposed for thirty-seven (37) soil samples, with twenty (20) tests completed so far. The test results indicated liquid limit (LL) as 24 to 34 and plasticity index (PI) as 5 to 12.

The results indicated that on-site soils generally comprised Lean Clay/Lean Clay with Sand/Gravelly Lean Clay with Sand (CL), Silty Clay/Silty Clay with Sand/Gravelly Silty Clay with Sand (CL-ML), Clayey Gravel with Sand (GC), Silty Clayey Gravel with Sand (GC-GM)

and Poorly Graded Gravel with Clay and Sand (GP-GC) as per Unified Soil Classification System (USCS).

4.2.2 Natural Moisture Content and Dry Density Tests

Natural moisture content (NMC) and dry density tests were proposed for seven (7) relatively undisturbed soil samples collected from boreholes, with four (4) tests completed so far. The test results indicated that the NMC ranged from 17.1 to 18.1 % and dry density ranged from 16.1 to 16.4 kN/m^3.

4.2.3 Specific Gravity Tests

Specific gravity tests were proposed for five (5) relatively undisturbed cohesive soil samples extracted from boreholes, with three (3) tests completed so far. The test results indicated specific gravity as 2.68

4.2.4 Direct Shear Tests

Direct shear tests were proposed on three (3) soil samples obtained from boreholes using the split spoon sampler. These samples are to be remolded at their natural moisture content and in-situ bulk density and tested under a slow rate of shearing to ensure drained conditions. Test results have not yet been received.

4.2.5 Unconfined Compression Tests

Unconfined compression tests were proposed on seven (7) relatively undisturbed cohesive soil samples extracted from boreholes, with four (4) tests completed so far. The test results indicated unconfined compressive strength ranging from 45 to 69 kPa and failure strain ranging from 3.6 to 14.3 %.

4.2.6 Consolidation Tests

Consolidation tests were proposed on five (5) relatively undisturbed cohesive soil samples extracted from boreholes, with three (3) tests completed so far. The test results indicated initial void ratio (e_o) ranging from 0.63 to 0.66, compression index (C_c) ranging from 0.09 to 0.14 and coefficient of volume compressibility (m_v) ranging from 0.13 x 10^{-3} to 0.24 x 10^{-3} m^2/kN at 160 kPa pressure. The swell pressure was recorded as 9 to 10 kPa.

4.2.7 Chemical Tests

Chemical tests were proposed for fourteen (14) soil samples collected from boreholes, with nine (9) tests completed so far. The test results indicated soluble sulphate content ranging from 0.01 to 0.05 %, chloride content ranging from 0.02 to 0.04 % and organic matter ranging from 0.08 to 0.14 %.

Chemical tests were also proposed for two (2) seepage water samples collected from boreholes. Test results have not yet been received.

4.3 TESTING ON ROCK SAMPLES

4.3.1 Natural Moisture Content and Dry Density Tests

Natural moisture content (NMC) and dry density tests were proposed for thirty-two (32) intact rock core samples collected from boreholes, with twenty-four (24) tests completed so far. The test results indicated that the NMC ranged from 0.8 to 10.0 % and dry density ranged from 18.4 to 30.0 kN/m^3.

4.3.2 Specific Gravity Tests

Specific gravity tests were proposed for sixteen (16) intact rock core samples collected from boreholes, with ten (10) tests completed so far. The test results indicated specific gravity ranging from 2.68 to 2.73

4.3.3 Uniaxial Compression Tests

Uniaxial compression tests were proposed for forty-eight (48) intact rock core samples collected from boreholes, with thirty-four (34) tests completed so far. The test results indicated uniaxial compressive strength ranging from 0.26 to 10.79 MPa for shale, 1.22 to 27.63 MPa for siltstone and 8.12 to 36.92 MPa for sandstone.

4.3.4 Elastic Modulus Tests

Elastic modulus tests were proposed for six (6) intact rock core samples collected from boreholes, all of which have been completed. The test results indicated elastic modulus as 104 and 1273 MPa for shale, 1607 and 2472 MPa for siltstone and 724 and 1634 MPa for sandstone.

4.3.5 Hoek Shear Tests

Hoek shear tests were proposed on seven (7) intact rock core samples collected from boreholes and prepared by saw-cutting the cores into matched halves for shearing. Test results have not yet been received.

5. SITE GEOTECHNICS

5.1 SUBSURFACE STRATIGRAPHY AND MATERIAL CHARACTERISTICS

The engineering characteristics of soils and rocks along the proposed monorail alignment, from Lake View Park to Murree Bus Stand, were assessed through a feasibility-level geotechnical investigation. Although a total of twenty (20) boreholes were drilled during the investigation, only sixteen (16) boreholes, BH-5 to BH-19, are relevant to the revised 39 km monorail alignment from Lake View Park to Murree Bus Stand. Since the monorail alignment begins from Lake View Park, the initial four boreholes (BH-1 to BH-4), which were located before this point, are not considered in the current assessment. Based on the subsurface conditions encountered, the boreholes were categorized into four (4) stratigraphic groups (Group-1 to Group-4) with similar lithological and geotechnical characteristics. Due to the exploratory nature and spacing of the boreholes, the lateral continuity and spatial extent of these groups along the alignment could not be reliably defined at this stage. Such delineation would require more detailed investigations with closely spaced boreholes during subsequent design phases. A summary of these groups and their corresponding stratigraphic units is provided in Table 5-1.

Table 5-1: Stratigraphy and Material Characteristics

Group No.	Layer Thickness below EGL (m)	Stratigraphy and Material Characteristics
Group-1 (BH-05)	0.0 - 18.0	Medium Stiff to Hard Lean Clay (CL) / Silty Clay (CL-ML)
	18.0 - 25.0	Very Dense Clayey Gravel with Sand (GC) / Silty Clayey Gravel with Sand (GC-GM)
Group-2 (BH-06)	0.0 - 4.0	Stiff to Very Stiff Gravelly Lean Clay (CL) / Gravelly Silty Clay (CL-ML)
	4.0 - 12.0	Dense to Very Dense Clayey Gravel with Sand (GC) / Silty Clayey Gravel with Sand (GC-GM)
	12.0 - 25.0	Hard Gravelly Lean Clay (CL) / Gravelly Silty Clay (CL-ML) with interbedded layers of Very Dense Silty Clayey Gravel with Sand (GC-GM)

Group No.	Layer Thickness below EGL (m)	Stratigraphy and Material Characteristics
Group-3 BH-07, BH-08, BH-09, BH-10, BH-11, BH-12 and BH-12A)	0.0 - 3.0	Stiff to Hard Lean Clay with Sand (CL) / Silty Clay with Sand (CL)
	3.0 - 25.0	Interbedded Shale, Siltstone and Sandstone, with Shale and Siltstone predominant, except in BH-09 and BH-12 where Sandstone dominates. In general, Siltstone and Sandstone are weak to medium strong; Shale is extremely weak to very weak.
Group-4 BH-13, BH-14, BH-15, BH-16, BH-17, BH-18 and BH-19)	0.0 - 5.0	Stiff to Hard Lean Clay (CL) / Silty Clay (CL) with interbedded layers of Very Dense Clayey Gravel (GC) / Silty Clayey Gravel (GC-GM)
	5.0 - 10	Very Dense Clayey Gravel with Sand (GC) / Silty Clayey Gravel with Sand (GC-GM). This stratum extends to a depth of 14 m in BH-16 and 20 m in BH-19.
	10.0 - 35.0	Interbedded Shale, Siltstone and Sandstone, with Shale and Siltstone predominant, except in BH-16 where Sandstone dominates. In general, Siltstone and Sandstone are weak to medium strong; Shale is extremely weak to very weak.

5.2 OVERBURDEN CHARACTERISTICS

5.2.1 Shear Strength, Compressibility and Swell Potential

Field and laboratory data indicated that the overburden soils generally exhibit medium to high shear strength, low to medium compressibility and low swelling potential.

5.2.2 Chemical Characteristics

Chemical testing of soil samples indicated low concentrations of sulphates and chlorides, as per the limits specified by ACI 318 (Building Code Requirements for Structural Concrete). Results of chemical testing on seepage water samples are still awaited.

5.3 BEDROCK CHARACTERISTICS

The bedrock predominantly comprises interbedded Shale, Siltstone and Sandstone, with Shale and Siltstone being the dominant lithologies. It is generally slightly to moderately weathered and exhibits moderate to high fracturing. Core recovery typically ranges from 70 to 90 %, while Rock Quality Designation (RQD) varies between 0 and 50 %, as shown in Fig. C3 and Fig. C4 (Appendix-C), respectively. According to BS 5930:2015, the uniaxial compressive strength of Siltstone and Sandstone falls within the weak to medium strong range, whereas Shale is classified as extremely weak to very weak. Based on these characteristics, the estimated Rock Mass Rating (RMR_{89}), following Bieniawski (1989), ranges from 35 to 40, placing the rock mass on the boundary between “Poor” and “Fair” quality.

6. PRELIMINARY GEOTECHNICAL RECOMMENDATIONS FOR FEASIBILITY-LEVEL FOUNDATION DESIGN

6.1 GENERAL

This chapter presents preliminary geotechnical recommendations for feasibility-level foundation design for the proposed fully elevated monorail system. The recommendations are based on the feasibility-level geotechnical investigation carried out through boreholes drilled along the proposed alignment at relatively wider intervals. While this spacing is sufficient for feasibility-level foundation design, closer spacing and more detailed investigations will be required during the detailed design phase to support final foundation design and construction planning.

6.2 SUITABILE FOUNDATION TYPE AND DESIGN CRITERIA

At this feasibility stage, general guidance on the most suitable foundation type and design criteria is provided based on anticipated project needs:

Bored cast-in-situ RC piles are anticipated to be required for supporting monorail piers and station structures, considering the anticipated load demands and performance requirements. A FOS of 2.5 is required for pile foundations, with settlement performance verified against structural tolerance criteria.

The estimated pile capacities are based on preliminary geotechnical data and shall be validated through detailed investigations at the detailed design stage to finalize foundation design parameters and construction methods.

6.3 SUBSURFACE SOIL AND ROCK PARAMETERS

The preliminary foundation recommendations are based on representative subsurface soil and rock parameters derived from the feasibility-level investigation. These parameters are selected using field and laboratory test results, supported by engineering judgment, relevant literature and experience with similar ground conditions. The derived values are presented in Table 6-1:

Table 6-1: Subsurface Soil and Rock Parameters

Group No.	Material Type	Depth below EGL	N'_{70}	γ_b	c_u	ϕ'	σ_{ci}	RMR
		(m)	-	(kN/m^3)	(kN/m^2)	(deg.)	(MPa)	-
Group-1	Lean Clay	0.0 - 3.0	4	17	30	0	-	-
	Lean Clay	3.0 - 18.0	14	20	100	0	-	-
	Clayey Gravel with Sand	18.0 - 25.0	50	22	0	40	-	-
Group-2	Gravelly Lean Clay	0.0 - 4.0	10	19	70	0	-	-
	Clayey Gravel with Sand	4.0 - 12.0	50	22	0	40	-	-
	Gravelly Lean Clay	12.0 - 25.0	50	21	150	0	-	-
Group-3	Lean Clay with Sand	0.0 - 3.0	10	19	*	*	-	-
	Bedrock	3.0 - 25.0	-	25	-	-	4	35
Group-4	Lean Clay	0.0 - 5.0	10	19	*	*	-	-
	Clayey Gravel with Sand	5.0 - 10	50	22	*	*	-	-
	Bedrock	10.0 - 35.0	-	25	-	-	4	35

** Overburden layer parameters are not considered in pile capacity calculations due to its limited thickness and potential for erosion or instability in steep or mountainous terrain.*

Where, N'_{70} = Corrected SPT-N Value (with applicable corrections), γ_b = Bulk Density, c_u = Undrained Cohesion, ϕ' = Effective Angle of Internal Friction, σ_{ci} = Weighted Average Uniaxial Compressive Strength of Intact Rock, RMR = Rock Mass Rating

While the parameters in Table 6-1 represent the predominant subsurface conditions observed

along the proposed alignment, boreholes BH-16 and BH-19 indicated comparatively thicker overburden deposits than those encountered at other locations. Given the wide spacing of boreholes at this feasibility stage, it is not practical to define the lateral extent of such variability. Therefore, representative values reflecting the more consistent conditions have been adopted to guide feasibility-level foundation design. However, the localized deviations highlight the need for detailed geotechnical investigation during the detailed design stage to validate and, if needed, refine these parameters.

6.4 PRELIMINARY PILE CAPACITY RECOMMENDATIONS

The preliminary pile capacity recommendations for feasibility-level foundation design are evaluated considering the guidelines provided in U.S. Army Corps of Engineers Design Manuals, U.S. Department of Transportation, Federal Highway Administration Design Manuals and NESPAK Design Manuals.

Bored cast-in-situ RC piles are anticipated to be required for supporting monorail piers and station structures, considering the anticipated load demands and performance requirements.

Type of Foundation	Bored RC Piles
Pile Cut-off Level	2.0 m below EGL
Pile Diameter	1200 mm
Preliminary Allowable Pile Capacity in Compression and Tension	Refer to Fig. E1 for Group-1, E2 for Group-2 and E3 for Group-3 and Group-4

Pile capacities must be confirmed by full-scale compressive pile load tests before construction of working piles. The full-scale compressive pile load test shall be carried out up to at least 3.0 times of design load, i.e. $P_{Test\ Load} \nless P_{Design}$ Load x 3.0/η to finalize pile capacities.

Given the mountainous terrain and associated geohazards along the project corridor, particularly from Ghora Gali to Murree Bus Stand where landslide susceptibility is high, foundation design must account for more than just structural load demands. The proposed bored cast-in-situ RC piles are intended to support the elevated monorail superstructure and are not proposed to resist loads arising from unstable ground or slope movement. Therefore, in landslide-prone sections, the alignment should be carefully reviewed and mitigation measures implemented based on the recommendations of geohazard specialists to ensure long-term structural safety.

Furthermore, once topographic survey data and site-specific geological and geomorphological mapping become available, geological and geohazard experts should carry out detailed slope stability analyses.

6.5 SOIL PROFILE TYPE

The subsoil generally corresponds to soil profile type $\boldsymbol{S_D}$ for Group-1 and Group-2 and $\boldsymbol{S_C}$ for Group-3 and Group-4, as per criteria of Building Code of Pakistan Seismic Provisions (2007), for preliminary structural design of the proposed monorail system.

6.6 DURABILITY CONSIDERATIONS FOR BORED CAST-IN-SITU RC PILES

Chemical testing of soil samples indicated low concentrations of sulphates and chlorides, within the permissible limits defined by ACI 318. Based on these results, the use of Ordinary Portland Cement (OPC) may be considered acceptable. However, chemical test results of seepage water samples are still awaited and will be critical in confirming the final cement type selection. In addition, appropriate concrete cover to reinforcement, typically 75 mm for pile foundations, is recommended. However final cement type selection and mix specifications should be confirmed during the detailed design phase through a more refined geochemical evaluation.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

1) The on-site overburden soils generally comprised Lean Clay/Lean Clay with Sand/Gravelly Lean Clay with Sand (CL), Silty Clay/Silty Clay with Sand/Gravelly Silty Clay with Sand (CL-ML), Clayey Gravel with Sand (GC), Silty Clayey Gravel with Sand (GC-GM) and Poorly Graded Gravel with Clay and Sand (GP-GC) as per Unified Soil Classification System (USCS). The bedrock predominantly comprises interbedded Shale, Siltstone and Sandstone, with Shale and Siltstone being the dominant lithologies. *For details, refer to Section 5.1.*
2) Groundwater was generally not encountered during the geotechnical investigation conducted from March 8 to May 29, 2025. However, seepage was observed in two boreholes: BH-04 at a depth of 5.7 m and BH-06 at 18.5 m. These observations indicate localized zones of seepage rather than a continuous groundwater table.
3) Field and laboratory data indicated that the overburden soils generally exhibit medium to high shear strength, low to medium compressibility and low swelling potential. The estimated Rock Mass Rating (RMR_{89}), following Bieniawski (1989), ranges from 35 to 40, placing the rock mass on the boundary between “Poor” and “Fair” quality.
4) The subsoil generally corresponds to soil profile type $\boldsymbol{S_D}$ for Group-1 and Group-2 and $\boldsymbol{S_C}$ for Group-3 and Group-4, as per criteria of Building Code of Pakistan Seismic Provisions (2007).
5) Chemical testing of soil samples indicated low concentrations of sulphates and chlorides, within the permissible limits defined by ACI 318.

7.2 RECOMMENDATIONS

1) Bored cast-in-situ RC piles are anticipated to be required for supporting monorail piers and station structures, considering the anticipated load demands and performance requirements. However, estimated pile capacities are based on preliminary geotechnical data and shall be validated through detailed investigations at the detailed design stage to finalize foundation design parameters and construction methods.
2) Given the mountainous terrain and associated geohazards along the project corridor, particularly from Ghora Gali to Murree Bus Stand where landslide susceptibility is high, foundation design must account for more than just structural load demands. The proposed bored cast-in-situ RC piles are intended to support the elevated monorail superstructure and are not proposed to resist loads arising from unstable ground or slope movement. Therefore, in landslide-prone sections, the alignment should be carefully reviewed and mitigation measures implemented based on the recommendations of geohazard specialists to ensure long-term structural safety. *For details, refer to Section 6.4.*
3) Based on the chemical test results of soil samples, the use of Ordinary Portland Cement (OPC) may be considered acceptable. However, chemical test results of seepage water samples are still awaited and will be critical in confirming the final cement type selection.

8. DISCLAIMER

This report has been prepared by the Consultant for the project titled as “Feasibility Study for the Tourist Glass Train from Rawalpindi to Murree”. The information provided in this report reflects engineering characteristics of soils and preliminary recommendations based on field and laboratory test results at the time of preparation of this report.

This report is intended solely for the use of the authorized recipient. Any third-party use of this report or reliance on its findings is at the third party’s own risk and the Consultant assumes no responsibility for any damages or consequences resulting from such use.

The findings in this report are based on a preliminary investigation conducted in accordance with standard industry practices at this feasibility stage. They represent a reasonable interpretation of the subsurface conditions along the project alignment, but these conditions may vary across different segments. These findings shall be validated through detailed, investigations at the detailed design stage to finalize foundation design parameters and construction methods.

APPENDICES

- **APPENDIX-A:**

  LOCATION PLAN
  GEOTECHNICAL INVESTIGATION PLAN
  SUBSURFACE SOIL/ROCK PROFILE

- **APPENDIX-B:**

  BOREHOLE LOGS

- **APPENDIX-C:**

  VARIATION OF SPT BLOWS WITH DEPTH
  VARIATION OF CORE RECOVERY WITH DEPTH
  VARIATION OF RQD WITH DEPTH

- **APPENDIX-D:**

  SUMMARY OF LABORATORY TEST RESULTS
  DETAILED TEST RESULT SHEETS

- **APPENDIX-E:**

  FOUNDATION DESIGN RECOMMENDATIONS

- **APPENDIX-F:**

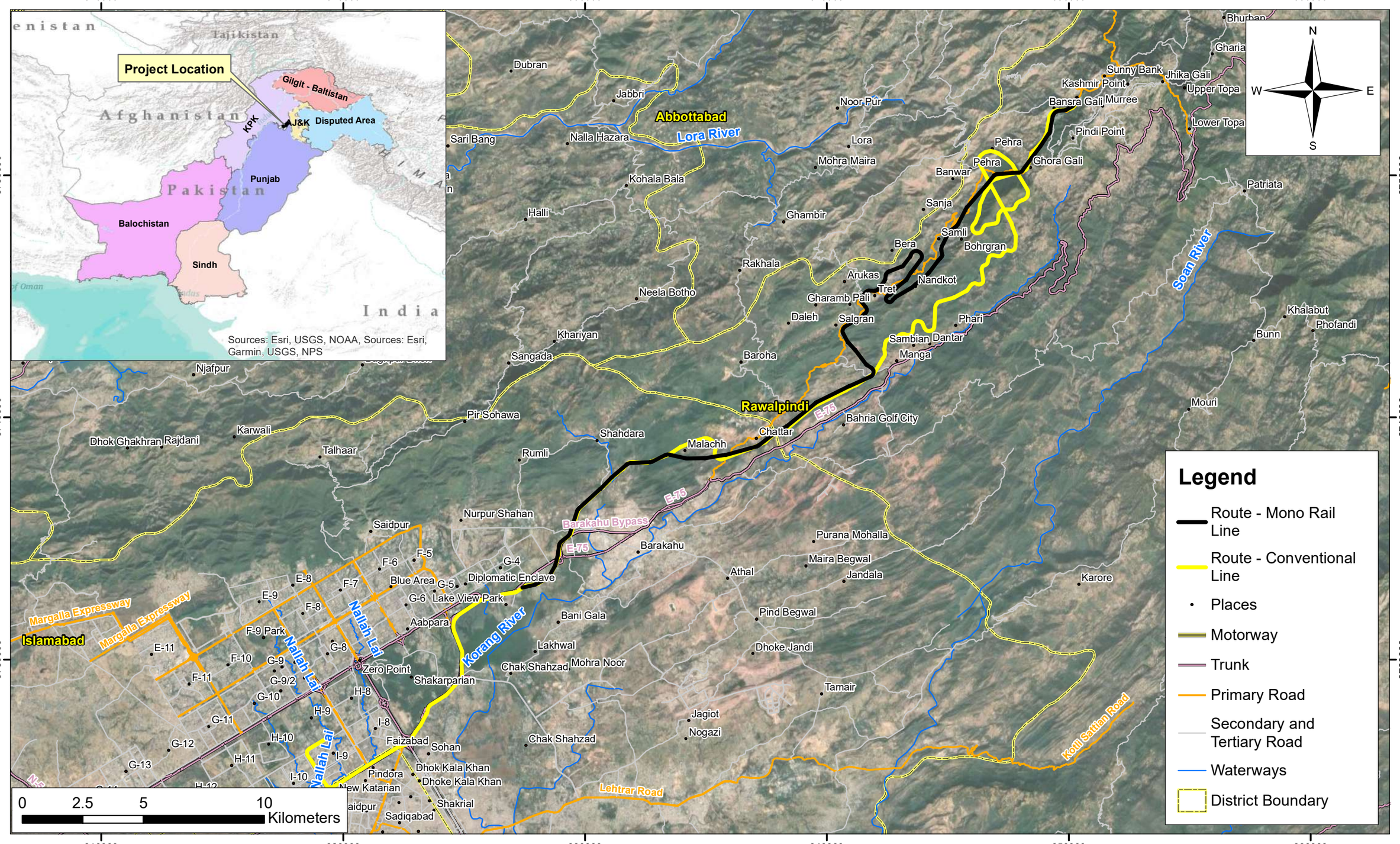
  SITE PHOTOGRAPHS

APPENDIX-A

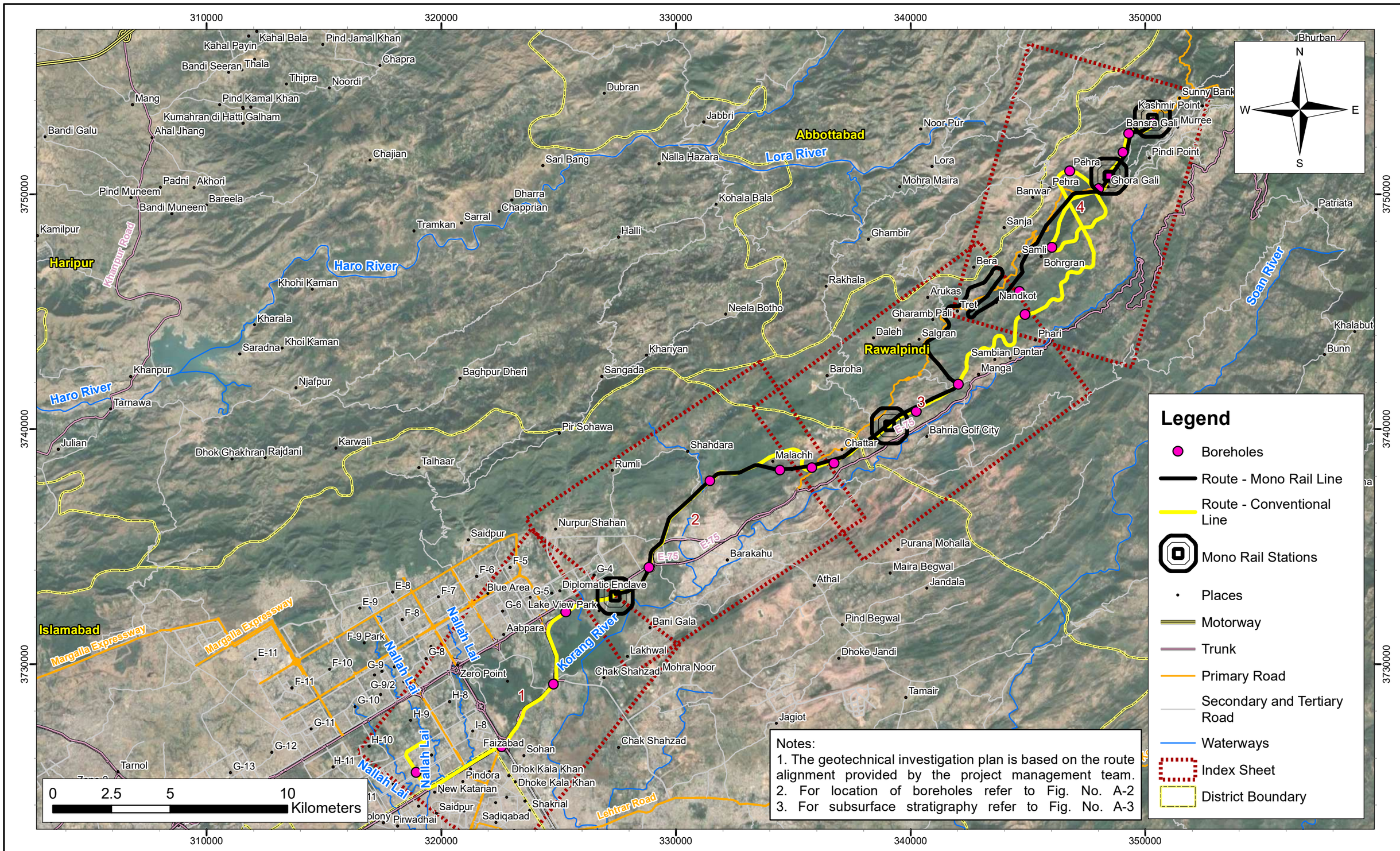
FIG. A-1: LOCATION PLAN

FIG. A-2: GEOTECHNICAL INVESTIGATION PLAN

FIG. A-3: SUBSURFACE SOIL/ROCK PROFILE



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		03				SUBMITTED	IRFAN			
		02				RECOM.				
		01				CHD./VER.	OBAID		DATE: MAY, 2025 / FIG.: A-1	REV.: 0
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM			



Legend

- Boreholes
- Route - Mono Rail Line
- Route - Conventional Line
- Mono Rail Stations
- Places
- Motorway
- Trunk
- Primary Road
- Secondary and Tertiary Road
- Waterways
- Index Sheet
- District Boundary

Notes:
1. The geotechnical investigation plan is based on the route alignment provided by the project management team.
2. For location of boreholes refer to Fig. No. A-2
3. For subsurface stratigraphy refer to Fig. No. A-3

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PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

GEOTECHNICAL INVESTIGATION PLAN (INDEX SHEET)

MAP SCALE: 1 : 150,000

DATE: MAY, 2025 | FIG.: A-2 | REV.: 0

Borehole Depth, Elevation and Coordinates				
BH No.	BH Depth (m)	Elevation (m)	Easting (m)	Northing (m)
BH-01	25	513.40	318939.40	3725388.16
BH-02	25	528.76	322576.58	3726480.08
BH-03	25	544.36	324792.38	3729148.02
BH-04	25	537.18	325313.08	3732200.43

320000

330000

3730000

N

W

E

S

BH-05 (25 m)

BH-04 (25 m)

BH-03 (25 m)

BH-02 (25 m)

BH-01 (25 m)

Saidpur, F-5, F-6, G-4, Blue Area, G-5, Diplomatic Enclave, Diplomatic Enclave, G-6, Lake View Park, F-8, Bani Gala, G-7, Aabpara, F-9 Park, G-8/3, G-8, Zero Point, Lakhwal, E-11, F-10, G-9, G-9/2, Islamabad, Mohra Noor, Chak Shahzad, G-9/4, Shakarparian, F-11, G-9/1, G-10, H-8, H-9, I-8, G-11, Zone 1, H-10, G-12, Faizabad, Chak Shahzad, I-9, H-11, Dhoke Babu Irfan, Gulshan Dadan Khan, Shamsabad, I-10, Pindora, Dhoke Kala Khan, H-12, New Katarian, Satellite Town F Block, Dhoke Kashmirian, Qayyumabad, I-11, Khayaban-e-Sir Syed South, Dhoke Paracha, H-13, Saidpur, Sattelite Town, Shakrial, Rawalpindi, Fouji Colony, Pirwadhai, Sadiqabad, Affandi Colony, Muslim Town, Dhoke Hassu South, Ferozepura Mohallah, Chah Sultan, Khurram Colony, Dhoke Mangtal, Amirpura

Constitution Avenue, 7th Avenue, 7th Avenue Underpass, Jinnah Avenue, Main Margalla Road, Ahmed Faraz Road, Nallah Lai, Murree Road, Korang River, Nazim-ud-din Road, Srinagar Highway, Agha Shahi (9th) Avenue, Islamabad Expressway, Khanna Road, Lehtrar R, E-75

0 1 2 4 Kilometers

Notes:
1. The geotechnical investigation plan is based on the route alignment provided by the project management team.
2. For location of boreholes refer to Fig. No. A-2
3. For subsurface stratigraphy refer to Fig. No. A-3

Legend

- Boreholes
- Route - Mono Rail Line
- Route - Conventional Line
- Mono Rail Stations
- Places
- Motorway
- Trunk
- Primary Road
- Secondary and Tertiary Road
- Waterways
- Index Sheet
- District Boundary

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GEOTECHNICAL INVESTIGATION PLAN (SHEET 1 OF 4)		MAP SCALE
		1 : 60,000
DATE: MAY, 2025	FIG.: A-2	REV.: 0

Borehole Depth, Elevation and Coordinates				
BH No.	BH Depth (m)	Elevation (m)	Easting (m)	Northing (m)
BH-05	25	581.50	328847.42	3734113.78
BH-06	25	650.56	331461.72	3737788.18
BH-07	26	650.87	334440.19	3738245.07
BH-08	27	677.23	335799.40	3738352.78

320000 330000 340000

3740000 3730000

N W E S

BH-10 (25 m)
BH-09 (27 m)
BH-08 (27 m)
BH-07 (26 m)
BH-06 (25 m)
BH-05 (25 m)
BH-04 (25 m)

Baroha
Rawalpindi
Kashmir Road
E-75
Bahria Golf City
Chattar
Malachh
Shahdara
Pir Sohawa
Rumli
Nurpur Shahan
Saidpur
Islamabad
Main Margalla Road
Constitution Avenue
F-5
F-6
F-7
G-4
G-5
G-6
G-7
G-8/3
Blue Area
Diplomatic Enclave
Diplomatic Enclave
Jinnah Avenue
7th Avenue
Nallah Lai
Aabpara
Srinagar Highway
Murree Road
Lake View Park
Barakahu Bypass
Korang River
Bani Gala
Lakhwal
Mohra Noor
Chak Shahzad
Athal
Pind Begwal

1 2 3

0 1 2 4 Kilometers

Notes:
1. The geotechnical investigation plan is based on the route alignment provided by the project management team.
2. For location of boreholes refer to Fig. No. A-2
3. For subsurface stratigraphy refer to Fig. No. A-3

Legend

- Boreholes
- Route - Mono Rail Line
- Route - Conventional Line
- Mono Rail Stations
- Places
- Motorway
- Trunk
- Primary Road
- Secondary and Tertiary Road
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- District Boundary

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01				CHD./VER.	OBAID

PROJECT
FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

GEOTECHNICAL INVESTIGATION PLAN (SHEET 2 OF 4)

MAP SCALE 1 : 60,000

DATE MAY, 2025

FIG. A-2

REV. 0

330000 340000 350000

Borehole Depth, Elevation and Coordinates				
BH No.	BH Depth (m)	Elevation (m)	Easting (m)	Northing (m)
BH-08	27	677.23	335799.40	3738352.78
BH-09	27	661.55	336741.14	3738546.21
BH-10	25	790.27	340248.37	3740742.70
BH-11	27	788.73	342038.91	3741907.01
BH-12A	27	941.70	344879.77	3744876.22

3740000

Abbottabad
Samli
Bohrgran
BH-14 (25 m)
Bera
Korang River
Arukas
4
Nandkot
BH-12 (26 m)
Tret
Gharamb
Pali
BH-12A (27 m)
Daleh
Salgran
Phari
Sambian
Dantar
E-75
Baroha
Manga
BH-11 (27 m)
Rawalpindi
3
Kashmir Road
BH-10 (25 m)
E-75
Bahria Golf City
Chattar
Shahdara
E-75
Malachh
BH-09 (27 m)
BH-07 (26 m)
BH-08 (27 m)
2
Islamabad
BH-06 (25 m)
E-75
Barakahu Bypass
Purana Mohalla

N
W E
S

0 1 2 4 Kilometers

Notes:
1. The geotechnical investigation plan is based on the route alignment provided by the project management team.
2. For location of boreholes refer to Fig. No. A-2
3. For subsurface stratigraphy refer to Fig. No. A-3

Legend

- Boreholes
- Route - Mono Rail Line
- Route - Conventional Line
- Mono Rail Stations
- Places
- Motorway
- Trunk
- Primary Road
- Secondary and Tertiary Road
- Waterways
- Index Sheet
- District Boundary

330000 340000 350000

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02			
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DRAWN	MUNEEB
SUBMITTED	IRFAN
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APPROVED	ASIM

PROJECT
FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

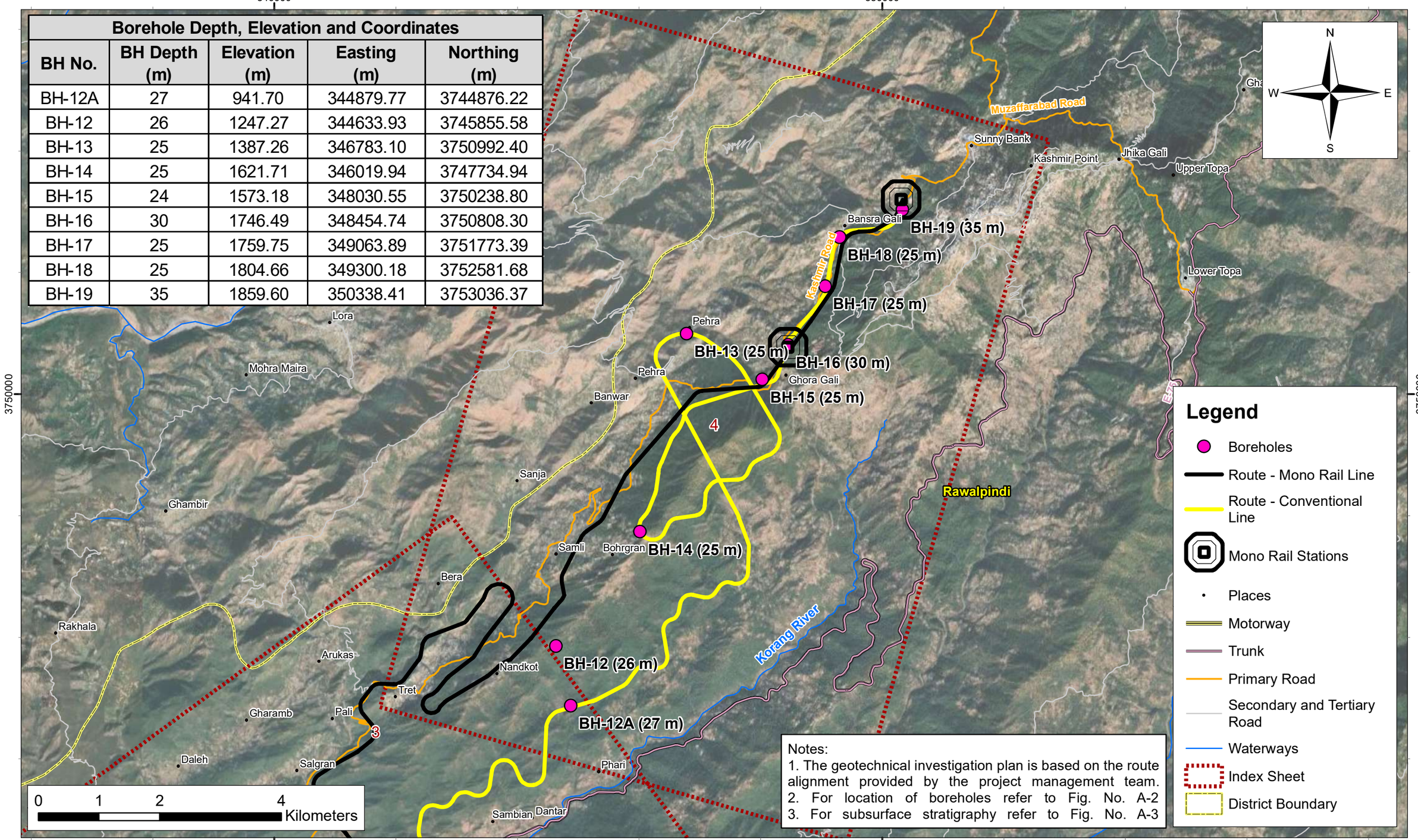
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

GEOTECHNICAL INVESTIGATION PLAN (SHEET 3 OF 4)

MAP SCALE: 1 : 60,000

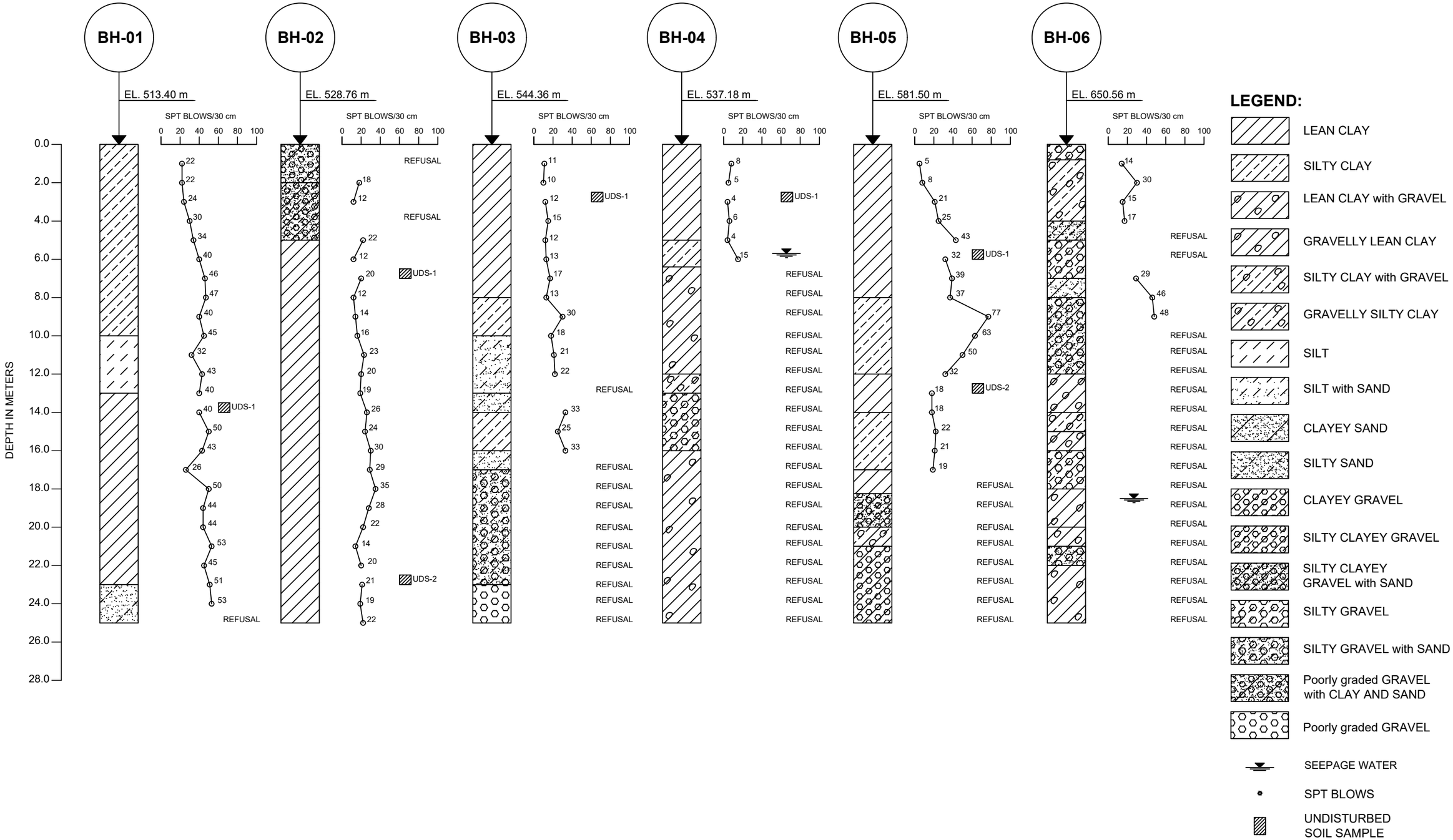
DATE: MAY, 2025
FIG.: A-2
REV.: 0

Borehole Depth, Elevation and Coordinates				
BH No.	BH Depth (m)	Elevation (m)	Easting (m)	Northing (m)
BH-12A	27	941.70	344879.77	3744876.22
BH-12	26	1247.27	344633.93	3745855.58
BH-13	25	1387.26	346783.10	3750992.40
BH-14	25	1621.71	346019.94	3747734.94
BH-15	24	1573.18	348030.55	3750238.80
BH-16	30	1746.49	348454.74	3750808.30
BH-17	25	1759.75	349063.89	3751773.39
BH-18	25	1804.66	349300.18	3752581.68
BH-19	35	1859.60	350338.41	3753036.37



Notes:
1. The geotechnical investigation plan is based on the route alignment provided by the project management team.
2. For location of boreholes refer to Fig. No. A-2
3. For subsurface stratigraphy refer to Fig. No. A-3

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		03				SUBMITTED	IRFAN			
		02				RECOM.				
		01				CHD./VER.	OBAID		DATE: MAY, 2025 / FIG.: A-2	REV.: 0
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM			



NOTES:

1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2

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CONSULTANT

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HEAD OFFICE:- NESPAK HOUSE, I-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN.

REV.	DATE	DESCRIPTION	APPROVED
04			
03			
02			
01			

DRAWN	FAIZAN
SUBMITTED	M. SHAHID
RECOMMENDED	M. SHAHID
CHD./VER.	OBAID
APPROVED	ASIM MASUD

PROJECT

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION
FOR TRACKWAY, STATIONS AND STRUCTURES

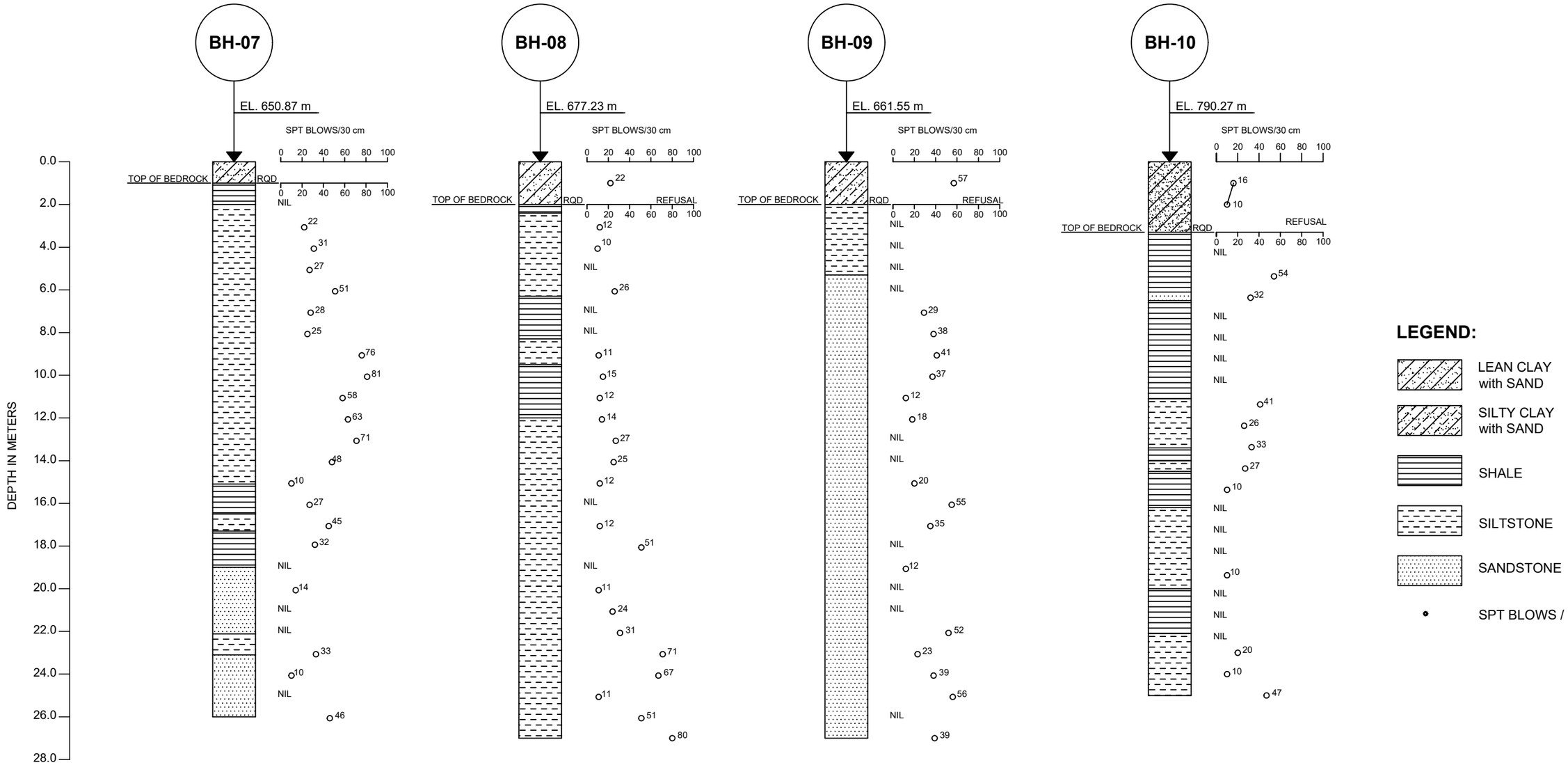
SUBSURFACE SOIL/ROCK PROFILE

DATE: MAY, 2025

FIG. NO. A-3 (SHEET 1 OF 5)

SCALE: HOR. NTS, VER. 1:200

REV. 0



NOTES:

1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2

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		03			SUBMITTED: M. SHAHID
		02			RECOMMENDED: M. SHAHID
		01			CHD./VER.: OBAID
		REV.	DATE	DESCRIPTION / APPROVED	APPROVED: ASIM MASUD

PROJECT

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

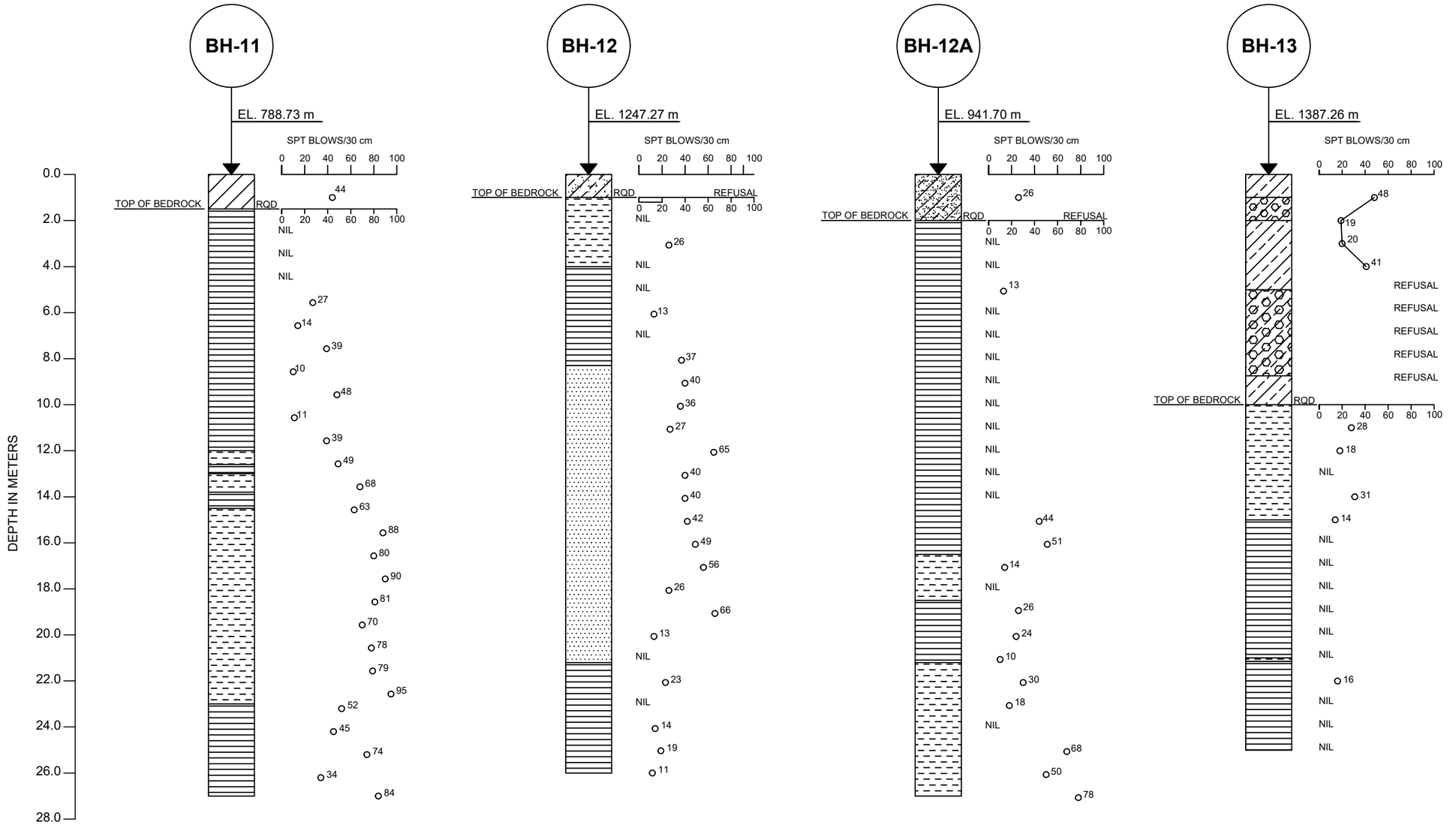
SUBSURFACE SOIL/ROCK PROFILE

DATE: MAY, 2025

FIG. NO. A-3 (SHEET 2 OF 5)

SCALE: HOR. NTS VER. 1:200

REV. 0



NOTES:

1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2

CLIENT	PUNJAB MASS TRANSIT AUTHORITY (PMA)	CONSULTANT	NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. HEAD OFFICE:- NESPAK HOUSE, I-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN.

REV.	DATE	DESCRIPTION	APPROVED		
04				DRAWN	FAIZAN
03				SUBMITTED	M. SHAHID
02				RECOMMENDED	M. SHAHID
01				CHD./VER.	OBAID
				APPROVED	ASIM MASUD

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

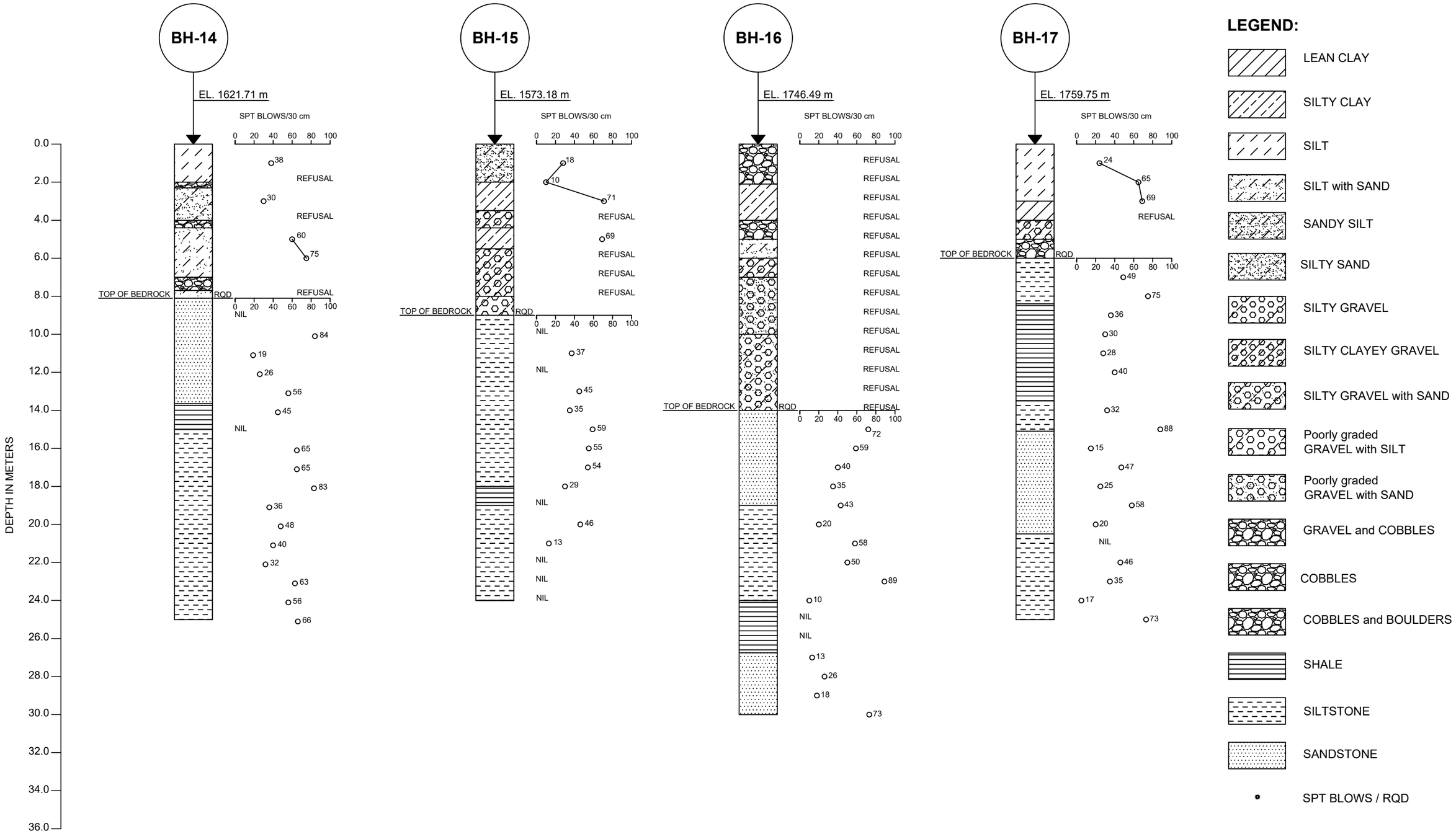
SUBSURFACE SOIL/ROCK PROFILE

SCALE: HOR. NTS VER. 1:200

DATE: MAY, 2025

FIG. NO. A-3 (SHEET 3 OF 5)

REV. 0



NOTES:

1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2

CLIENT: PUNJAB MASS TRANSIT AUTHORITY (PMA)

CONSULTANT: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD.
HEAD OFFICE:- NESPAK HOUSE, I-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN.

REV.	DATE	DESCRIPTION	APPROVED
04			
03			
02			
01			

DRAWN	FAIZAN
SUBMITTED	M. SHAHID
RECOMMENDED	M. SHAHID
CHD./VER.	OBAID
APPROVED	ASIM MASUD

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

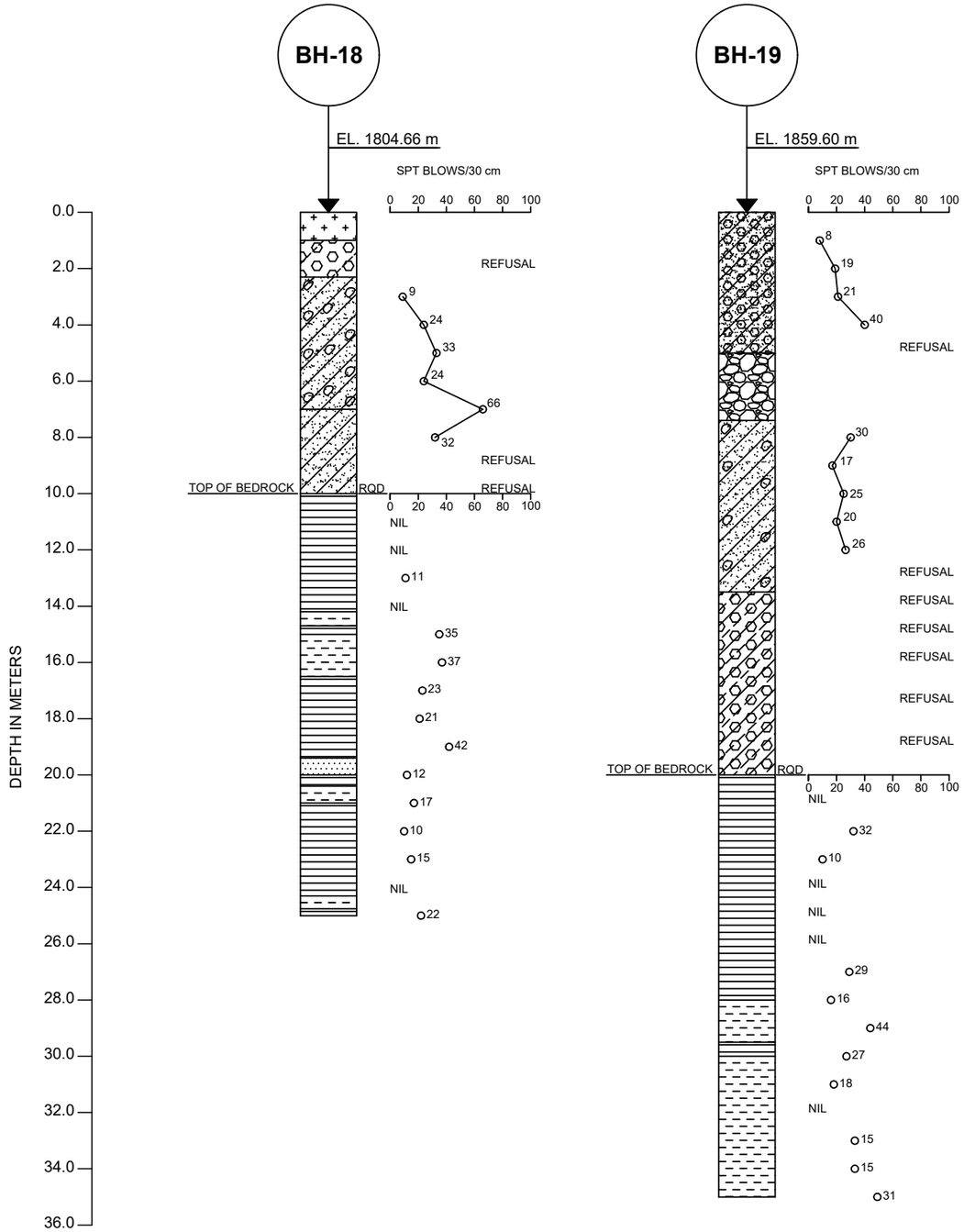
SUBSURFACE SOIL/ROCK PROFILE

DATE: MAY, 2025

FIG. NO. A-3 (SHEET 4 OF 5)

SCALE: HOR. NTS VER. 1:200

REV. 0



LEGEND:

- Fill Material
- LEAN CLAY with SAND
- GRAVELLY LEAN CLAY with SAND
- CLAYEY GRAVEL with SAND
- SILTY CLAYEY GRAVEL
- SILTY GRAVEL with SAND
- Poorly graded GRAVEL with SILT
- COBBLES and BOULDERS
- SHALE
- SILTSTONE
- SANDSTONE
- SPT BLOWS / RQD

NOTES:

1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2

CLIENT

PUNJAB MASS TRANSIT AUTHORITY (PMA)

CONSULTANT

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD.

HEAD OFFICE:- NESPAK HOUSE, I-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN.

REV.	DATE	DESCRIPTION	APPROVED
04			
03			
02			
01			

DRAWN	FAIZAN
SUBMITTED	M. SHAHID
RECOMMENDED	M. SHAHID
CHD./VER.	OBAID
APPROVED	ASIM MASUD

PROJECT

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

DATE: MAY, 2025

FIG. NO. A-3 (SHEET 5 OF 5)

SCALE: HOR. NTS, VER. 1:200

REV. 0

APPENDIX-B

BOREHOLE LOGS

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR SNGPL OFFICE-I9

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3725388.16 m E: 318939.40 m Ground Elevation 513.40 m Drafted By FAIZAN Date 22-04-2025 To 24-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0				Brown, very stiff to hard, SILTY CLAY, low plastic, medium dry strength, moist.	125 mm		
1.0	SPT-1		CL-ML			22	
2.0	SPT-2					22	
3.0	SPT-3					24	
4.0	SPT-4					30	
5.0	SPT-5					34	
6.0	SPT-6					40	
7.0	SPT-7					46	
8.0	SPT-8					47	
9.0	SPT-9					40	
10.0	SPT-10					45	

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01

SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR SNGPL OFFICE-I9

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3725388.16 m E: 318939.40 m Ground Elevation 513.40 m Drafted By FAIZAN Date 22-04-2025 To 24-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0	SPT-10		ML	Brown, hard, SILT, low plastic, low dry strength, trace concretion, moist.	125 mm	45	
11.0	SPT-11					32	
12.0	SPT-12					43	
13.0	SPT-13					40	
	UDS-1		CL	Dark brown, very stiff to hard, LEAN CLAY, low plastic, medium dry strength, moist.			(Denison) UDS-1 13.50-14.0 m depth.
14.0	SPT-14					40	
15.0	SPT-15					50	
16.0	SPT-16					43	
17.0	SPT-17					26	
18.0	SPT-18					50	
19.0	SPT-19					44	
20.0	SPT-20					44	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01

SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR SNGPL OFFICE-I9

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3725388.16 m E: 318939.40 m Ground Elevation 513.40 m Drafted By FAIZAN Date 22-04-2025 To 24-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
20.0	SPT-20		CL	Dark brown, hard, LEAN CLAY, low plastic, low to medium strong, moist.	125 mm	44	
21.0	SPT-21					53	
22.0	SPT-22					45	
23.0	SPT-23		SM	Brownish grey, very dense, SILTY SAND, trace mica, moist.		51	
24.0	SPT-24					53	
25.0	SPT-25					REFUSAL	

BOTTOM OF BOREHOLE

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR FAIZABAD INTERCHANGE

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3726480.08 m E: 322576.58 m Ground Elevation 528.76 m Drafted By FAIZAN Date 18-04-2025 To 21-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0							
1.0	SPT-1(c) DS-1		GP-GC	Reddish brown, very dense, Poorly graded GRAVEL with CLAY AND SAND, of size 4.75 to 44 mm, rounded to sub rounded, moist.	125 mm		REFUSAL
2.0	SPT-2					18	
3.0	SPT-3		GC-GM	Reddish brown, medium dense to very dense, SILTY CLAYEY GRAVEL with SAND, of size 4.75 to 21mm, sub rounded, moist.		12	
4.0	SPT-4						REFUSAL
5.0	SPT-5					22	
6.0	SPT-6		CL	Reddish brown, stiff to very stiff, LEAN CLAY, low plastic, medium dry strength, moist.		12	
	UDS-1						(Shelby) UDS-1 6.5-7.00 m depth.
7.0	SPT-7					20	
8.0	SPT-8					12	
9.0	SPT-9					14	
10.0	SPT-10					16	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02

SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR FAIZABAD INTERCHANGE

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3726480.08 m E: 322576.58 m Ground Elevation 528.76 m Drafted By FAIZAN Date 18-04-2025 To 21-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
10.0	SPT-10		CL	Brown, very stiff to hard, LEAN CLAY, low plastic, medium dry strength, moist.	125 mm	16	
11.0	SPT-11					23	
12.0	SPT-12					20	
13.0	SPT-13					19	
14.0	SPT-14					26	
15.0	SPT-15					24	
16.0	SPT-16					30	
17.0	SPT-17					29	
18.0	SPT-18					35	
19.0	SPT-19					28	
20.0	SPT-20					22	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02

SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR FAIZABAD INTERCHANGE

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3726480.08 m E: 322576.58 m Ground Elevation 528.76 m Drafted By FAIZAN Date 18-04-2025 To 21-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20			Greyish brown, stiff to very stiff, LEAN CLAY, low plastic, low dry strength, moist.	125 mm	22	
21.0	SPT-21					14	
22.0	SPT-22					20	
	UDS-3		CL				(Denison) UDS-3 22.5-22.90 m depth.
23.0	SPT-23					21	
24.0	SPT-24					19	
25.0	SPT-25					22	
				BOTTOM OF BOREHOLE			

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-03

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR MARGALLA TOWN

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3729148.02 m E: 324792.38 m Ground Elevation 544.36 m Drafted By FAIZAN Date 25-04-2025 To 28-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0				Brown, stiff to very stiff, LEAN CLAY, low plastic, medium dry strength, dry.	125 mm		
1.0	SPT-1					11	
2.0	SPT-2					10	
	UDS-1						(Shelby) UDS-1 2.5-3.00 m depth.
3.0	SPT-3					12	
4.0	SPT-4		CL			15	
5.0	SPT-5					12	
6.0	SPT-6					13	
7.0	SPT-7					17	
8.0	SPT-8			Reddish brownish, stiff to very stiff, SILTY CLAY, low plastic, medium dry strength, moist.		13	
9.0	SPT-9		CL-ML			30	
10.0	SPT-10					18	

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-03

SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR MARGALLA TOWN

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3729148.02 m E: 324792.38 m Ground Elevation 544.36 m Drafted By FAIZAN Date 25-04-2025 To 28-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm	Remarks
10.0	SPT-10		ML	Brown, medium dense, SILT with SAND, trace concretion, moist.	125 mm	18	
11.0	SPT-11					21	
12.0	SPT-12					22	
13.0	SPT-13						REFUSAL
			SM	Brownish grey, very dense, fine to medium grained, SILTY SAND, trace mica, moist.			
14.0	SPT-14		CL-ML	Brown, very stiff to hard, SILTY CLAY, low plastic, medium dry strength, moist.		33	
15.0	SPT-15					25	
16.0	SPT-16					33	
			SM	Brownish grey, dense, fine grained, SILTY SAND, trace mica, moist.			
17.0	SPT-17(c) DS-1		GM	Grey, very dense, SILTY GRAVEL with SAND, of size 5 to 40 mm, sub-rounded to sub angular, moist.			REFUSAL
18.0	SPT-18(c) DS-2						REFUSAL
19.0	SPT-19(c) DS-3						REFUSAL
20.0	SPT-20(c) DS-4						REFUSAL

P.L. ▽ N.M.C. x L.L. ○

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-03

SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR MARGALLA TOWN

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3729148.02 m E: 324792.38 m Ground Elevation 544.36 m Drafted By FAIZAN Date 25-04-2025 To 28-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm (10 20 30 40 | 10 20 30 40 50 60 70 80 90 100)	Remarks
20.0	SPT-20 DS-4(c)		GM	Grey, very dense, SILTY GRAVEL with SAND, size 18 to 54mm, sub rounded to sub-angular, moist.	125 mm	REFUSAL	
21.0	SPT-21 DS-5(c)					REFUSAL	
22.0	SPT-22 DS-6(c)					REFUSAL	
23.0	SPT-23 DS-7(c)		GP	Grey, very dense, Poorly graded GRAVEL, size 15 to 50mm, sub rounded to sub-angular, moist.		REFUSAL	
24.0	SPT-24 DS-8(c)					REFUSAL	
25.0	SPT-25					REFUSAL	
				BOTTOM OF BOREHOLE			

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-04

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR JINNAH SQUARE INTER CHANGE

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY/ PERCUSSION Drilling Fluid BENTONITE SLURRY/PLAIN WATER Ground Water Depth 5.7 m (SEEPAGE WATER)

Coordinates N: 3732200.43 m E: 325313.08 m Ground Elevation 537.18 m Drafted By FAIZAN Date 06-05-2025 To 22-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0				Brown, soft to medium stiff, LEAN CLAY, low plastic, medium dry strength, moist.	125 mm		0-6 m DRILLED WITH STRAIGHT ROTARY AND 6-25 m WITH PERCUSSION
1.0	SPT-1					8	
2.0	SPT-2					5	
	UDS-1		CL				(Shelby) UDS-1 2.5-3.00 m depth.
3.0	SPT-3					4	
4.0	SPT-4					6	
5.0	SPT-5			Brown, soft to stiff, SILTY CLAY, low plastic, medium dry strength, moist.		4	
6.0	SPT-6		CL-ML			15	SEEPAGE WATER ENCOUNTERED AT 5.7 m
	DS-1						
7.0	SPT-7(c)			Reddish brown, hard, GRAVELLY LEAN CLAY, low pastic, medium dry strength, wet.	200 mm	REFUSAL	
	DS-2						
8.0	SPT-8(c)					REFUSAL	
	DS-3		CL				
9.0	SPT-9(c)					REFUSAL	
	DS-4						
10.0	SPT-10(c)					REFUSAL	
	DS-5						

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-04

SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR JINNAH SQUARE INTER CHANGE

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth 5.7 m (SEEPAGE WATER)

Coordinates N: 3732200.43 m E: 325313.08 m Ground Elevation 537.18 m Drafted By FAIZAN Date 06-05-2025 To 22-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0	SPT-10(c)						
			CL	Reddish brown, hard, GRAVELLY LEAN CLAY, low pastic, medium dry strength, wet.			REFUSAL
11.0	SPT-11(c) DS-6						REFUSAL
12.0	SPT-12(c)						REFUSAL
	DS-7		CL-ML	Reddish brown, hard, SILTY CLAY with GRAVEL, low plastic, medium dry strength, wet.			
13.0	SPT-13(c)						REFUSAL
	DS-8		GC-GM	Reddish brown, very dense, SILTY CLAYEY GRAVEL, gravel of size 4.75-70 mm, trace cobble, wet.	200 mm		
14.0	SPT-14(c) DS-9						REFUSAL
15.0	SPT-15(c) DS-10						REFUSAL
16.0	SPT-16(c)						REFUSAL
	DS-11		CL	Reddish brown, hard, GRAVELLY LEAN CLAY, low pastic, medium dry strength, wet.			
17.0	SPT-17(c) DS-12						REFUSAL
18.0	SPT-18(c) DS-13						REFUSAL
19.0	SPT-19(c) DS-14						REFUSAL
20.0	SPT-20(c)						REFUSAL
	DS-15						

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-04

SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR JINNAH SQUARE INTER CHANGE

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth 5.7 m (SEEPAGE WATER)

Coordinates N: 3732200.43 m E: 325313.08 m Ground Elevation 537.18 m Drafted By FAIZAN Date 06-05-2025 To 22-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20(c) DS-15		CL	Reddish brown, hard, GRAVELLY LEAN CLAY, low pastic, medium dry strength, wet.	200 mm	REFUSAL	
21.0	SPT-21(c) DS-16					REFUSAL	
22.0	SPT-22(c) DS-17					REFUSAL	
23.0	SPT-23(c) DS-18					REFUSAL	
24.0	SPT-24(c) DS-19					REFUSAL	
25.0	SPT-25(c)					REFUSAL	
				BOTTOM OF BOREHOLE			

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-05

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location STARTING POINT BHARA KAHU BYPASS

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY/ PERCUSSION Drilling Fluid BENTONITE SLURRY/PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3734113.78 m E: 328847.42 m Ground Elevation 581.50 m Drafted By FAIZAN Date 03-05-2025 To 10-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0				Brown, medium stiff to hard, LEAN CLAY, low plastic, low dry strength, trace concretion, moist.	200 mm		0-5 m DRILLED WITH PERCUSSION AND 5-20 m WITH STRAIGHT ROTARY THEN FURTHER DRILLING CARRIED OUT WITH PERCUSSION UPTO 25 m
1.0	SPT-1					5	
2.0	SPT-2					8	
3.0	SPT-3					21	
4.0	SPT-4		CL			25	
5.0	SPT-5					43	
	DUS-1				125 mm		(Denison) UDS-1 5.5-6.00 m depth.
6.0	SPT-6					32	
7.0	SPT-7					39	
8.0	SPT-8					37	
				Brown, hard, SILTY CLAY, low plastic, medium dry strength, trace few fine gravel, moist.			
9.0	SPT-9		CL-ML			77	
10.0	SPT-10					63	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-05

SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location STARTING POINT BHARA KAHU BYPASS

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY/ PERCUSSION Drilling Fluid BENTONITE SLURRY/PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3734113.78 m E: 328847.42 m Ground Elevation 581.50 m Drafted By FAIZAN Date 03-05-2025 To 10-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	Remarks
10.0	SPT-10			Brown, hard, SILTY CLAY, low plastic, medium dry strength, trace fine gravel, moist.	125 mm	
11.0	SPT-11		CL-ML			
12.0	SPT-12			Brown, very stiff to hard, LEAN CLAY, low to medium plastic, medium dry strength, moist.		
	UDS-2					(Denison) UDS-2 12.50-13.0 m depth.
13.0	SPT-13		CL			
14.0	SPT-14			Brown, very stiff, SILTY CLAY, low plastic, medium dry strength, moist.		
15.0	SPT-15					
16.0	SPT-16		CL-ML			
17.0	SPT-17			Brown, very stiff to hard, LEAN CLAY, medium plastic, medium dry strength, moist.		
18.0	SPT-18		CL			REFUSAL
	DS-1			Brown, very dense, fine to coarse, SILTY CLAYEY GRAVEL, sub angular to sub rounded, gravel sedimentary origin of size 4-75mm, moist.		
19.0	SPT-19(c)					REFUSAL
	DS-2		GC-GM			
20.0	SPT-20(c)					REFUSAL
	DS-3					

P.L. ▽ N.M.C. x L.L. ○

SPT Blows/30cm

10 20 30 40 10 20 30 40 50 60 70 80 90 100

63 50 32 18 18 22 21 19

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-05

SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location STARTING POINT BHARA KAHU BYPASS

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3734113.78 m E: 328847.42 m Ground Elevation 581.50 m Drafted By FAIZAN Date 03-05-2025 To 10-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm (10 20 30 40 | 10 20 30 40 50 60 70 80 90 100)	Remarks
20.0	SPT-20(c)						
	DS-3		CL-ML	Brown, hard, SILTY CLAY with GRAVEL, low plastic, moist.	200 mm	REFUSAL	
	SPT-21(c)					REFUSAL	
21.0	DS-4		GC	Brown, very dense, fine to coarse, CLAYEY GRAVEL, sub angular to sub rounded, gravel sedimentary origin of size 4-75.5mm, moist.			
22.0	SPT-22(c)					REFUSAL	
	DS-5						
23.0	SPT-23(c)					REFUSAL	
	DS-6						
24.0	SPT-24(c)					REFUSAL	
	DS-7						
25.0	SPT-25(c)					REFUSAL	
				BOTTOM OF BOREHOLE			

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-06

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location SUBBAN SYEDIAN VILLEGE

Site Incharge M.ARIF/M. R SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY/ PERCUSSION Drilling Fluid BENTONITE SLURRY/PLAIN WATER Ground Water Depth 18.5 m (SEEPAGE WATER)

Coordinates N: 3737788.18 m E: 331461.72 m Ground Elevation 650.56 m Drafted By FAIZAN Date 09-05-2025 To 17-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0			GC-GM	Brown to grey, fine to coarse, SILTY CLAYEY GRAVEL, sub angular sub rounded, gravel of sedimentary origin of size 4.75-5 mm, moist.	125 mm		0-4 m DRILLED WITH STRAIGHT ROTARY AND 4-25 m WITH PERCUSSION
1.0	SPT-1		CL-ML	Brown, stiff, SILTY CLAY with GRAVEL, low plastic, size 4.75-10 mm, moist.		14	
2.0	SPT-2					30	
3.0	SPT-3					15	
4.0	SPT-4					17	
5.0	SPT-5(c)		SC-SM	Brownish grey, medium dense, SILTY CLAYEY SAND, trace mica, moist.			REFUSAL
	DS-1		GC-GM	Brown to grey, very dense, SILTY CLAYEY GRAVEL, sub angular sub rounded, gravel of sedimentary origin size 4.75-71 mm, moist.	200 mm		
6.0	SPT-6(c)						REFUSAL
	DS-2						
7.0	SPT-7(c)					29	
	DS-3		SC-SM	Brown to grey, medium dense, fine to coarse grained, SILTY CLAYEY SAND with GRAVEL, gravel are fine to course of size 5-70 mm, moist.			
8.0	SPT-8(c)					46	
	DS-4		GC-GM	Brown to grey, dense to very dense, fine to coarse, SILTY CLAYEY GRAVEL with SAND, sub angular sub rounded, gravel of sedimentary origin of size 5-60 mm, moist.			
9.0	SPT-9(c)					48	
	DS-5						
10.0	SPT-10(c)						REFUSAL
	DS-6						

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-06

SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location SUBBAN SYEDIAN VILLEGE

Site Incharge M.ARIF/M. R SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth 18.5 m (SEEPAGE WATER)

Coordinates N: 3737788.18 m E: 331461.72 m Ground Elevation 650.56 m Drafted By FAIZAN Date 09-05-2025 To 17-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0	SPT-10(c)						
	DS-6		GC-GM	Brown to grey, very dense, SILTY CLAYEY GRAVEL, sub angular to sub rounded, sedimentary origin of size 4.75-6.5 mm, few cobble of size 150 mm, moist.	125 mm	REFUSAL	
11.0	SPT-11(c)					REFUSAL	
	DS-7						
12.0	SPT-12(c)					REFUSAL	
	DS-8		CL	Brown to grey, hard, LEAN CLAY with GRAVEL, low plastic, sub angular to sub rounded, gravel of size 4.75-70 mm, moist.			
13.0	SPT-13(c)					REFUSAL	
	DS-9						
14.0	SPT-14(c)					REFUSAL	
	DS-10		CL-ML	Reddish brown, hard, SILTY CLAY with GRAVEL, low plastic, sub angular to sub rounded, gravel of sedimentary origin of size 5 mm 3.5 mm, moist.			
15.0	SPT-15(c)					REFUSAL	
	DS-11		CL	Brown to grey, hard, LEAN CLAY with GRAVEL and cobble, sub angular to sub rounded gravel of sedimentary of size 15 mm -75 mm, cobble of size 100 mm, moist.			
16.0	SPT-16(c)					REFUSAL	
	DS-12		GC-GM	Reddish brown to grey, very dense, SILTY CLAYEY GRAVEL and COBBLES, sub angular to sub rounded, gravel of sedimentary origin of size 15-75 mm, cobble of size 110 mm, moist.			
17.0	SPT-17(c)					REFUSAL	
	DS-13						
18.0	SPT-18(c)					REFUSAL	
	DS-14		CL	Reddish brown, hard, GRAVELLY LEAN CLAY, low to medium plastic, sub angular to sub rounded, gravel of sedimentary origin of size 4.75-55 mm, wet.			
19.0	SPT-19(c)					REFUSAL	SEEPAGE WATER ENCOUNTERED AT THE DEPTH OF 18.5 m
	DS-15						
20.0	SPT-20(c)					REFUSAL	
	DS-16						

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-06

SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location SUBBAN SYEDIAN VILLEGE

Site Incharge M.ARIF/M. R SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth 18.5 m (SEEPAGE WATER)

Coordinates N: 3737788.18 m E: 331461.72 m Ground Elevation 650.56 m Drafted By FAIZAN Date 09-05-2025 To 17-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20(c)						
	DS-16		CL	Reddish brown, hard, LEAN CLAY with GRAVEL, few sand, sub angular to sub rounded, gravel of sedimentary origin of size 4.75-50 mm, wet.	200 mm	REFUSAL	
	SPT-21(c)					REFUSAL	
21.0	DS-17		GC-GM	Reddish brown, very dense, SILTY CLAYEY GRAVEL with SAND, sub angular to sub rounded, gravel of sedimentary origin of size 4.75-65 mm, wet.			
	SPT-22(c)					REFUSAL	
22.0	DS-18		CL	Reddish brown, hard, LEAN CLAY with GRAVEL, few sand, sub angular to sub rounded, gravel of sedimentary origin of size 4.75-50 mm, wet.			
	SPT-23(c)					REFUSAL	
23.0	DS-19						
	SPT-24(c)					REFUSAL	
24.0	DS-20						
	SPT-25(c)					REFUSAL	
25.0				BOTTOM OF BOREHOLE			

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-07

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR PTCL EARTH SETTALLITE

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3738245.07 m E: 334440.19 m Ground Elevation 650.87 m Date 5-03-2025 To 10-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0						10 20 30 40	
	SPT-1		CL-ML	Dark brown, SILTY CLAY with SAND, low plastic, low dry strength, trace gravels, trace grass roots, etc.	75 mm	10 20 30 40 50 60 70 80 90 100	
1.0				TOP OF BEDROCK ENCOUNTERED AT 1.0 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION
SITE: FOR TRACKWAY, STATIONS AND STRUCTURES NEAR PTCL EARTH SETTALLITE
COORDINATES: N: 3738245.07 m, E: 334440.19 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 650.87 m
ROCK ELEVATION: 649.87 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 5-03-2025 COMPLETE: 10-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No.

BH-07

SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency Total Joints	Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
0.0																										
											TOP OF BEDROCK															
1.0	1	72	NIL		5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak to weak.															
2.0	2	98	22							M.St	SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, very weak.	WS-1: 2.27-2.35 m														
3.0	3	97	31																							
4.0	4	90	27									WS-2: 3.58-3.74 m														
5.0	5	87	51																							
6.0	6	96	28									WS-3: 5.68-5.81 m														
7.0	7	90	25									WS-4: 6.61-6.89 m														
8.0	8	98	76									WS-5: 8.49-8.64 m														
9.0	9	99	81																							
10.0																										

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSI
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USI
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSI

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR PTCL EARTH SETTALLITE
COORDINATES: N: 3738245.07 m, E: 334440.19 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 650.87 m
ROCK ELEVATION: 649.87 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 5-03-2025 COMPLETE: 10-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-07

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency Total Joints	Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
10.0																										
	10	94	58		5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			M.St	SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, very weak.	WS-6: 10.44-10.65m													
11.0	11	97	63									WS-7: 11.34-11.51m													
12.0	12	88	71																						
13.0	13	94	48																						
14.0	14	64	10									WS-8: 13.61-13.71m													
15.0	15	90	27							SH	SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, extremely weak to weak.	WS-9: 15.81-15.91m													
16.0	16	93	45							M.st	SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, very weak.														
17.0	17	79	32									WS-10: 17.37-17.48m													
18.0	18	80	NIL							SH	SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, extremely weak.														
19.0	19	78	14							S.st	SANDSTONE: Reddish brown, fine grained, slightly weathered, slightly fractured, weak.	WS-11: 19.51-19.65m													
20.0																									

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSI
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USI
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSI

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
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R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR PTCL EARTH SETTALLITE
COORDINATES: N: 3738245.07 m, E: 334440.19 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 650.87 m
ROCK ELEVATION: 649.87 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 5-03-2025 COMPLETE: 10-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-07

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0	20	55	NIL		5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			S.st	SANDSTONE: Grey, fine grained, slightly weathered, moderately fractured, weak.														
21.0	21	73	NIL																						
22.0	22	85	33							M.St	SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, very weak.	WS-12: 22.0-22.12m													
23.0	23	52	10							S.st	SANDSTON: Grey, fine grained, slightly weathered, moderately fractured, weak.														
24.0	24	64	NIL																						
25.0	25	60	46									WS-13: 25.34-25.60m													
26.0											BOTTOM OF BOREHOLE														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSI
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USI
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSI

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE COREBOX PHOTOGRAPHS					Depth (m)
HOLE NO	7	BOX No	1-5	NESPAK	
LOCATION	Near PTCL Earth Settallite	DEPTH (m)	1.0-26.00m		



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-08

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location AT GT ROAD TOWARDS MURREE

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3738352.78 m E: 335799.40 m Ground Elevation 677.23 m Date 9-03-2025 To 15-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0				Dark brown, very stiff, LEAN CLAY with SAND, low plastic, low dry strength, trace gravels, trace grass roots, etc.	75 mm		
1.0	SPT-1		CL			22	
2.0	SPT-2			TOP OF BEDROCK ENCOUNTERED AT 2.0 M DEPTH		REFUSAL	

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FFEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION
SITE: FOR TRACKWAY, STATIONS AND STRUCTURES AT GT ROAD TOWARDS MURREE
COORDINATES: N: 3738352.78 m, E: 335799.40 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 677.23 m
ROCK ELEVATION: 675.23 m
GROUND WATER ELEVATION: - m
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 9-03-2025 COMPLETE: 15-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-08

SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
0.0																									
1.0																									
2.0											TOP OF BEDROCK														
3.0	1	71	12		5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.	WS-1: 2.52-2.64 m													
4.0	2	41	10							M.St	SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.														
5.0	3	41	NIL																						
6.0	4	78	26									WS-2: 5.40-5.55 m													
7.0	5	76	NIL							SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.														
8.0	6	73	NIL								SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, very weak.														
9.0	7	92	11							M.St		WS-3: 8.34-8.45 m													
10.0	8	79	15							SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness								
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FFEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION
SITE: FOR TRACKWAY, STATIONS AND STRUCTURES AT GT ROAD TOWARDS MURREE
COORDINATES: N: 3738352.78 m, E: 335799.40 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 677.23 m
ROCK ELEVATION: 675.23 m
GROUND WATER ELEVATION: - m
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 9-03-2025 COMPLETE: 15-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No.

BH-08

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUTY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
10.0																										
11.0	9	86	12		5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.	WS-4: 10.46-10.58m														
12.0	10	87	14									WS-5: 11.12-11.25m														
13.0	11	82	27							M.St	SILTSTONE: Reddish brown, fine grained, slightly weathered, moderately to highly fractured, weak.	WS-6: 12.55-12.82m														
14.0	12	81	25																							
15.0	13	82	12									WS-7: 14.32-14.43m														
16.0	14	69	NIL																							
17.0	15	75	12									WS-8: 16.13-16.25m														
18.0	16	89	51									WS-9: 17.32-17.50m														
19.0	17	79	NIL																							
20.0	18	81	11								(Sandstone from 19.30-19.60)	WS-9: 19.10-19.21m														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness		
STEPPED	STATE	CODE
	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	STATE	CODE
	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	STATE	CODE
	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FFEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES
SITE: AT GT ROAD TOWARDS MURREE
COORDINATES: N: 3738352.78 m, E: 335799.40 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 677.23 m
ROCK ELEVATION: 675.23 m
GROUND WATER ELEVATION: - m
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 9-03-2025 COMPLETE: 15-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No.

BH-08

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA										WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0																										
	19	78	24								SILTSTONE: Reddish brown, fine grained, slightly weathered, slightly to moderately fractured, weak, shear zones are present.	WS-11: 20.33-20.47m													
21.0	20	79	31																							
22.0	21	86	71									WS-12: 21.65-21.75m														
23.0	22	85	67		5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			M.St		WS-13: 22.50-22.71m														
24.0	23	82	11									WS-14: 23.57-23.71m														
25.0	24	80	51									WS-15: 25.27-25.43m														
26.0	25	86	80									WS-16: 26.48-26.69m														
27.0											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE COREBOX PHOTOGRAPHS

HOLE NO	**8**	BOX No	**1-5**	NESPAK
LOCATION	**At GT Road Murree**	DEPTH (m)	**2.0-27.00m**	



Depth (m)
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-09

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR CHATTAR PARK

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3738546.21 m E: 336741.14 m Ground Elevation 661.55 m Date 12-03-2025 To 19-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm (10 20 30 40 50 60 70 80 90 100)	Remarks
0.0							
				Dark brown, hard, SILTY CLAY with SAND, low to medium plastic, low dry strength, trace gravels, trace grass roots etc.	75 mm		
1.0	SPT-1		CL-ML			57	
2.0	SPT-2					REFUSAL	
				TOP OF BEDROCK ENCOUNTERED AT 2.0 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR CHATTAR PARK

SITE:

COORDINATES: N: 3738546.21 m, E: 336741.14 m

ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 661.55 m

ROCK ELEVATION: 659.55 m

GROUND WATER ELEVATION: - m

BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND

PEIZOMETER: -

DATE START: 12-03-2025 COMPLETE: 19-03-2025

DRILLING AGENCY: M/S THE DRILLER

DRILLING RIG: STRAIGHT ROTARY

LOGGED BY: ALI AQDAS

CHECKED BY: M. SHAHID

BOREHOLE No. BH-09

SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA										WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
0.0																										
1.0											TOP OF BEDROCK															
2.0	1	55	NIL		5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			M.St	SILTSTONE: Reddish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.															
3.0	2	47	NIL										J1		R	45°		PR	2	R2-R3	1	1				
4.0	3	73	NIL										J1		R	46°		PR	2	R2-R3	1	1				
5.0	4	50	NIL																							
6.0	5	75	29							S.St	SANDSTONE: Greenish grey, fine grained, slightly to moderately weathered, highly fractured, medium strong.	WS-1: 6.45-6.57 m														
7.0	6	95	38																							
8.0	7	71	41									WS-2: 7.82-7.95 m														
9.0	8	72	37																							
10.0												WS-3: 9.30-9.66 m														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness		
STEPPED	STATE	CODE
	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	STATE	CODE
	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	STATE	CODE
	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
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Weathering of Rock Mass

Grade	Term
I	Fresh
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III	Moderately Weathered
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VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
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NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR CHATTAR PARK

COORDINATES: N: 3738546.21 m, E: 336741.14 m

ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 661.55 m

ROCK ELEVATION: 659.55 m

GROUND WATER ELEVATION: - m

BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND

PEIZOMETER: -

DATE START: 12-03-2025 COMPLETE: 19-03-2025

DRILLING AGENCY: M/S THE DRILLER

DRILLING RIG: STRAIGHT ROTARY

LOGGED BY: ALI AQDAS

CHECKED BY: M. SHAHID

BOREHOLE No. BH-09

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
10.0																									
	9	67	12								SANDSTONE: Grey, fine grained, slightly weathered, moderately to highly fractured, weak, Shear zones are present.													
11.0	10	59	18									WS-4: 11.25-11.42m													
12.0	11	56	NIL																						
13.0	12	54	NIL																						
14.0	13	69	20		5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			S.St		WS-5: 14.32-14.52m													
15.0	14	79	55										J1		R	37°		UR	2	R3-R4	3	3			
16.0	15	76	35									WS-6: 16.0-16.22m	J1		J	55°		PR	2	R3-R4	4	4			
17.0	16	54	NIL																						
18.0	17	54	12																						
19.0	18	20	NIL																						
20.0																									

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness		
STEPPED	STATE	CODE
	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	STATE	CODE
	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	STATE	CODE
	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR CHATTAR PARK

COORDINATES: N: 3738546.21 m, E: 336741.14 m

ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 661.55 m

ROCK ELEVATION: 659.55 m

GROUND WATER ELEVATION: - m

BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND

PEIZOMETER: -

DATE START: 12-03-2025 COMPLETE: 19-03-2025

DRILLING AGENCY: M/S THE DRILLER

DRILLING RIG: STRAIGHT ROTARY

LOGGED BY: ALI AQDAS

CHECKED BY: M. SHAHID

BOREHOLE No. BH-09

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA										WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0																										WAX SAMPLES:
	19	39	NIL								SANDSTONE: Grey, fine grained, slightly weathered, moderately to highly fractured, weak to medium strong. shear zones are present.														
21.0																										
	20	87	52									WS-7: 21.33-21.62m														
22.0																										
	21	84	23																							
23.0					5-10 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			S.St		WS-8: 23.00-23.16m														
	22	62	39																							
24.0												WS-9: 24.0-24.18m	J1		R	17°		R	2	R2	1	1				
	23	65	56																							
25.0																										
	24	51	NIL																							
26.0																										
	25	70	39									WS-10: 26.26-26.44m														
27.0											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness		
STEPPED	STATE	CODE
	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	STATE	CODE
	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	STATE	CODE
	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**9**	BOX No	**1-5**	NESPAK
LOCATION	**Near Chattar Park**	DEPTH (m)	**2.0-27.00m**	



Depth (m)
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-10

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BAHRIA GOLF CITY

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3740742.70 m E: 340248.37 m Ground Elevation 790.27 m Date 25-03-2025 To 28-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0				Dark brown, stiff to hard, SANDY LEAN CLAY, low plastic, low dry strength, trace gravels, trace concretion trace grass roots etc.	75 mm	16	
1.0	SPT-1		CL			10	
2.0	SPT-2						
	SPT-3					REFUSAL	
				TOP OF BEDROCK ENCOUNTERED AT 3.3 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BAHRIA GOLF CITY
COORDINATES: N: 3740742.70 m, E: 340248.37 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 790.27 m
ROCK ELEVATION: 786.97 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER:

DATE START: 25-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-10

SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUITY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
0.0											TOP OF BEDROCK														
1.0																									
2.0																									
3.0																									
4.0	1	84	NIL		15-30 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, moderately weathered, moderately to highly fractured, extremely weak.														
	2	99	54									WS-1: 4.41-4.55 m													
5.0	3	95	32																						
6.0	4	65	NIL							S.St	SANDSTONE: Grey, fine grained, moderately weathered, moderately fractured, weak.	WS-2: 5.72-5.95 m													
7.0	5	66	NIL							SH	SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.														
8.0	6	61	NIL																						
9.0	7	52	NIL																						
10.0																									

Note: Some fractures are mechanical fracture

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness								
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
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R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
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R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BAHRIA GOLF CITY
COORDINATES: N: 3740742.70 m, E: 340248.37 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 790.27 m
ROCK ELEVATION: 786.97 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER:

DATE START: 25-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-10

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
10.0																									
11.0	8	72	41		15-30 %	DOUBLE TUBE /TUNGSTON CARBIDE NX	STABIE			SH	SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.														
12.0	9	74	26							M.St	SILTSTONE: Brown, fine grained, slightly to moderately weathered, moderately to highly fractured, weak.	WS-3: 11.43-11.55m													
13.0	10	67	33									WS-4: 12.0-12.17m													
14.0	11	99	27							SH	SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.	WS-5: 13.42-13.58m													
15.0	12	80	10							M.St															
16.0	13	80	NIL							SH	SILTSTONE: Brown, fine grained, slightly to moderately weathered, highly fractured, weak.														
17.0	14	40	NIL								SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.														
18.0	15	33	NIL							M.St	SILTSTONE: Brown, fine grained, slightly to moderately weathered, moderately to highly fractured, weak.	WS-6: 18.11-18.21m													
19.0	16	35	10																						
20.0	17	37	NIL																						

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
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5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
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R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
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NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BAHRIA GOLF CITY
COORDINATES: N: 3740742.70 m, E: 340248.37 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 790.27 m
ROCK ELEVATION: 786.97 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER:

DATE START: 25-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-10

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
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20.0																									
	18	42	NIL		15-30 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.														
21.0	19	53	NIL																						
22.0	20	65	20							M.St	SILTSTONE: Brown, fine grained, slightly weathered, slightly to moderately fractured, medium strong. thin alternate layers of shale are present.	WS-7: 22.45-22.55m													
23.0	21	75	10									WS-8: 23.65-23.75m													
24.0	22	91	47									WS-9: 24.16-24.31m													
25.0											BOTTOM OF BOREHOLE														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
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O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
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Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
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	Smooth	USm
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	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
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R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**10**	BOX No	**1-5**	NESPAK
LOCATION	**Near Bahria Golf City**	DEPTH (m)	**3.30-25.00m**	



Depth (m)
3.30
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-11

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR MANGA

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3741907.01 m E: 342038.91 m Ground Elevation 788.73 m Date 16-03-2025 To 21-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm (10 20 30 40 50 60 70 80 90 100)	Remarks
0.0							
	SPT-1		CL	Dark brown, hard, LEAN CLAY, low plastic, medium dry strength, trace grass roots, etc.	75 mm	44	
1.0				TOP OF BEDROCK ENCOUNTERED AT 1.5 M DEPTH			
2.0							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR MANGA
COORDINATES: N: 3741907.01 m, E: 342038.91 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 788.73 m
ROCK ELEVATION: 787.23 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 16-03-2025 COMPLETE: 21-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-11

SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
0.0																										
1.0											TOP OF BEDROCK															
2.0	1	76	NIL		10-20 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.															
3.0	2	75	NIL																							
4.0	3	72	NIL																							
5.0	4	76	27									WS-1: 4.40-4.53 m														
6.0	5	64	14									WS-2: 5.22-5.36 m														
7.0	6	75	39									WS-3: 6.0-6.22 m														
8.0	7	83	10																							
9.0	8	76	48									WS-4: 8.0-8.21 m														
10.0	9	69	11									WS-5: 9.51-5.62 m														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR MANGA
COORDINATES: N: 3741907.01 m, E: 342038.91 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 788.73 m
ROCK ELEVATION: 787.23 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 16-03-2025 COMPLETE: 21-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-11

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
10.0																										
11.0	10	82	39		15-30 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	**SHALE**: Reddish brown, fine grained, slightly weathered, slightly fractured, very weak.	WS-6: 10.55-10.75m														
12.0	11	78	49									WS-7: 11.52-11.73m														
13.0	12	84	68							M.St	**SILTSTONE**: Reddish brown, fine grained, slightly weathered, slightly fractured, weak.															
										SH		WS-8: 12.42-12.60m														
14.0	13	84	63							M.St	**SHALE**: Reddish brown, fine grained, slightly weathered, slightly fractured, very weak.	WS-9: 13.29-13.45m														
	14	94	88							SH	**SILTSTONE**: Reddish brown, fine grained, slightly weathered, slightly fractured, weak.	WS-10: 14.0-14.16m														
15.0	15	93	80								**SHALE**: Reddish brown, fine grained, slightly weathered, slightly fractured, very weak.	WS-11: 15.55-15.71m	J1	T	R	16°	PR	2	R2-R3	3	3					
16.0	16	90	90								**SILTSTONE**: Reddish brown, fine grained, slightly weathered, slightly fractured, weak.		J1 J2	T PO	R	35° 52°	PR	2	R2-R3	2	2					
17.0	17	88	81							M.St		WS-12: 17.46-17.61m														
18.0	18	91	70									WS-13: 18.27-18.44m	J1	T	R	33°	PR	2	R2-R3	4	4					
19.0	19	84	78																							
20.0																										

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B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

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Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
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Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
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R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR MANGA
COORDINATES: N: 3741907.01 m, E: 342038.91 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 788.73 m
ROCK ELEVATION: 787.23 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 16-03-2025 COMPLETE: 21-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No.

BH-11

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
20.0																										
	20	92	79							M.St	SILTSTONE: Brown, fine grained, slightly weathered, slightly to moderately fractured, weak.	WS-14: 20.11-20.36m													
21.0	21	95	95																						
22.0	22	95	52		15-30 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE					WS-15: 22.0-22.12m													
23.0	23	76	45							SH	SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, very weak.														
24.0	24	88	74									WS-16: 24.0-24.25m													
25.0	25	83	34																						
26.0	26	94	84									WS-17: 26.20-26.43m													
27.0											BOTTOM OF BOREHOLE														

Key for Description of Discontinuities

Type	
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M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

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Weathering of Rock Mass

Grade	Term
I	Fresh
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VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
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R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**11**	BOX No	**1-5**	NESPAK
LOCATION	**Near Manga**	DEPTH (m)	**1.50-27.00m**	



Depth (m)
1.50
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-12

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR NANDKOT

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3745855.58 m E: 344633.93 m Ground Elevation 1247.27 m Date 19-03-2025 To 25-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0							
	SPT-1		CL-ML	Dark brown, SILTY CLAY with SAND, low plastic, low dry strength, trace gravels, trace grass roots etc.	75 mm	REFUSAL	
1.0				TOP OF BEDROCK ENCOUNTERED AT 1.0 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NANDKOT
COORDINATES: N: 3745855.58 m, E: 344633.93 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1247.27 m
ROCK ELEVATION: 1246.27 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 19-03-2025 COMPLETE: 25-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12

SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUTY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
0.0											TOP OF BEDROCK															
1.0	1	63	NIL		100 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			M.St	SILTSTONE: Reddish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.															
2.0	2	61	26									WS-1: 2.04-2.17 m														
3.0	3	46	NIL																							
4.0	4	49	NIL							SH	SHALE: Reddish brown, moderately to highly weathered, highly fractured, extremely weak.															
5.0	5	55	13									WS-2: 5.30-5.43 m														
6.0	6	69	NIL																							
7.0	7	86	37																							
8.0	8	76	40							S.ST	SANDSTONE: Grey, fine grained, slightly to moderately weathered, moderately to highly fractured, medium strong. shear zone is present.															
9.0	9	82	36									WS-3: 9.16-9.52 m	J1	O	R	41°	PR	2	R3-R4	5	5					
10.0																										

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness								
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
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Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
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Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
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GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 19-03-2025 COMPLETE: 25-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
10.0																										
11.0	10	79	27		100 %		STABLE			S.ST	SANDSTONE: Grey, fine grained, slightly to moderately weathered, moderately to highly fractured, medium strong.	WS-4: 10.11-10.27m														
12.0	11	91	65									WS-5: 11.0-11.14m														
13.0	12	95	40									WS-6: 12.64-12.74m														
14.0	13	84	40									WS-7: 13.44-13.71m	J1	O	R	24°	PR	2	R3-R4	3	3					
15.0	14	84	42									WS-8: 14.36-14.53m														
16.0	15	76	49									WS-9: 15.27-15.49m	J1	O	R	18°	PR	2	R3-R4	4	4					
17.0	16	83	56									WS-10: 16.63-16.75m	J1 J2	T O	J R	12° 08°	PR PR	2 2	R3-R4	4	4					
18.0	17	85	26										J1	O	R	07°	PR	2	R3-R4	3	3					
19.0	18	85	66									WS-11: 18.0-18.31m														
20.0	19	67	13									WS-12: 19.40-19.52m														

Key for Description of Discontinuities

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M	Major Joint
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Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
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R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NANDKOT
COORDINATES: N: 3745855.58 m, E: 344633.93 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1247.27 m
ROCK ELEVATION: 1246.27 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 19-03-2025 COMPLETE: 25-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0																									
21.0	20	80	NIL		100 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			S.ST	SANDSTONE: Grey, fine grained, slightly to moderately weathered, moderately to highly fractured, medium strong. shear zone is present.														
22.0	21	70	23							SH	SHALE: Reddish brown, slightly weathered, highly fractured, very weak to weak. alternate layers of siltstone are present.														
23.0	22	41	NIL																						
24.0	23	55	14																						
25.0	24	50	19									WS-13: 24.16-24.35m													
26.0	25	59	11								BOTTOM OF BOREHOLE														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**12**	BOX No	**1-5**	NESPAK
LOCATION	**Near Nandkot**	DEPTH (m)	**1.0-26.00m**	



Depth (m)
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
26.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-12A

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR NUM VILLAGE

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3744876.22 m E: 344879.77 m Ground Elevation 941.70 m Date 23-03-2025 To 28-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm (10 20 30 40 50 60 70 80 90 100)	Remarks
0.0							
	SPT-1		CL-ML	Dark brown, very stiff to hard, SANDY SILTY CLAY, low plastic, low dry strength, trace concretion, trace grass roots, etc.	75 mm	26	
1.0							
	SPT-2					REFUSAL	
2.0				TOP OF BEDROCK ENCOUNTERED AT 2.0 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NUM VILLAGE
COORDINATES: N: 3744876.22 m, E: 344879.77 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 941.70 m
ROCK ELEVATION: 939.70 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 23-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12A

SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency per meter	Pressure psi	LU Value		
0.0																									
1.0											TOP OF BEDROCK														
2.0	1	48	NIL		15-30 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.														
3.0	2	55	NIL																						
4.0	3	79	13									WS-1: 4.42-4.55 m													
5.0	4	66	NIL																						
6.0	5	63	NIL																						
7.0	6	60	NIL																						
8.0	7	61	NIL																						
9.0	8	66	NIL																						
10.0																									

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NUM VILLAGE
COORDINATES: N: 3744876.22 m, E: 344879.77 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 941.70 m
ROCK ELEVATION: 939.70 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 23-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12A

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
10.0																										
11.0	9	62	NIL		15-30 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.															
12.0	10	71	NIL																							
13.0	11	70	NIL									WS-2: 12.16-12.24m														
14.0	12	55	NIL																							
15.0	13	92	44									WS-3: 14.45-14.65m														
16.0	14	93	51									WS-4: 15.61-15.76m														
17.0	15	86	14							M.St	SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, highly fractured, weak.															
18.0	16	70	NIL																							
19.0	17	82	26							SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, weak.	WS-5: 18.40-18.54m														
20.0	18	64	24									WS-6: 19.27-19.40m														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NUM VILLAGE
COORDINATES: N: 3744876.22 m, E: 344879.77 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 941.70 m
ROCK ELEVATION: 939.70 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 23-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12A

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0																									
	19	67	10							SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.														
21.0	20	76	30								SILTSTONE: Greyish brown, fine grained, slightly weathered, Slightly to moderately fractured, weak.														
22.0	21	70	18		15-30 %	DOUBLE TUBE /TUNGSTON CARBIDE BIT OF NX SIZE	STABIE					WS-7: 22.0-22.18m														
23.0	22	66	NIL																							
24.0	23	89	68							M.St		WS-8: 24.53-24.78m														
25.0	24	70	50									WS-9: 25.18-25.37m														
26.0	25	96	78									WS-10: 26.17-26.36m														
27.0											BOTTOM OF BOREHOLE														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**12A**	BOX No	**1-5**	NESPAK
LOCATION	**Near Num Village**	DEPTH (m)	**2.0-27.00m**	



Depth (m)
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-13

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR PERRAH VILLAGE

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3750992.40 m E: 346783.10 m Ground Elevation 1387.26 m Date 19-5-2025 To 27-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0							
			CL-ML	Blackish grey, SILTY CLAY, low plastic, medium dry strength, trace fine gravels, moist.			
1.0	SPT-1					48	
			GC-GM	Blackish grey, dense, SILTY CLAYEY GRAVEL, angular to subangular, size 5-10 mm, moist.			
2.0	SPT-2					19	
			CL-ML	Blackish brown, very stiff to hard, SILTY CLAY, low plastic, medium dry strength, trace fine gravels, moist.			
3.0	SPT-3					20	
4.0						41	
	SPT-4 DS-1						
5.0	SPT-5(c) DS-2						REFUSAL
			GC-GM	Brownish grey, very dense, SILTY CLAYEY GRAVEL, angular to sub-angular, size 5-30 mm, moist.			
6.0	SPT-6(c) DS-3						REFUSAL
7.0	SPT-7(c) DS-4						REFUSAL
8.0	SPT-8(c)						REFUSAL
9.0	SPT-9						REFUSAL
			CL-ML	Reddish brown, hard, SILTY CLAY, low plastic, medium dry strength, moist.			

TOP OF BEDROCK ENCOUNTERED AT 10.0 M DEPTH

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR PERRAH VILLAGE
COORDINATES: N: 3750992.40 m, E: 346783.10 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1387.26 m
ROCK ELEVATION: 1377.26 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 19-5-2025 COMPLETE: 27-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-13

SHEET 02 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
10.0											TOP OF BEDROCK															
11.0	1	77	28		100 %	DOUBLE TUBE TUNGSTON CARBIDE & DIAMOND NX	STABIE			M.St	SILTSTONE: Reddish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak to medium strong.	WS-1: 10.40-10.60m														
12.0	2	72	18									WS-2: 11.43-11.60 m														
13.0	3	75	NIL																							
14.0	4	73	31									WS-3: 13.24-13.40m														
15.0	5	70	14									WS-4: 14.0-14.14m														
16.0	6	68	NIL							SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fragmented, extremely weak.														
17.0	7	78	NIL																							
18.0	8	80	NIL																							
19.0	9	84	NIL																							
20.0	10	90	NIL																							

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR PERRAH VILLAGE
COORDINATES: N: 3750992.40 m, E: 346783.10 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1387.26 m
ROCK ELEVATION: 1377.26 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 19-5-2025 COMPLETE: 27-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-13

SHEET 03 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0																									
	11	87	NIL		100 %	DOUBLE TUBE TUNGSTON CARBIDE & DIAMOND NX	STABIE			SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fragmented, extremely weak.														
21.0	12	79	16							M.St	SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, slightly to moderately fractured, weak.	WS-5: 21.0-21.16m													
22.0	13	67	NIL							SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fragmented, extremely weak.														
23.0	14	81	NIL																						
24.0	15	83	NIL																						
25.0											BOTTOM OF BOREHOLE														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**13**	BOX No	**1-3**	NESPAK
LOCATION	**Near Perrah Village**	DEPTH (m)	**10.0-25.00m**	



Depth (m)
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-14

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BUDPIRAN VILLAGE

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3747734.94 m E: 346019.94 m Ground Elevation 1621.71 m Date 11-5-2025 To 17-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0				Reddish brown, SILT with concretion, low plastic, medium dry strength, moist.	75 mm		
1.0	SPT-1		ML			38	
2.0	SPT-2					REFUSAL	
				Reddish brown, very dense, SILTY SAND, trace mica, moist. (COBBLE FROM 2.0 -2.30 m)			
3.0	SPT-3		SM			30	
4.0	SPT-4					REFUSAL	
				Reddish brown, hard, SILT with SAND, low plastic, medium dry strength, trace concretion, moist. (COBBLE FROM 4.0-4.40 m and from 7.0-7.70 m)			
5.0	SPT-5					60	
6.0	SPT-6		ML			75	
7.0							
8.0	SPT-7					REFUSAL	
				TOP OF BEDROCK ENCOUNTERED AT 8.10 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BUDPIRAN VILLAGE
COORDINATES: N: 3747734.94 m, E: 346019.94 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1621.71 m
ROCK ELEVATION: 1613.61 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 11-5-2025 COMPLETE: 17-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-14

SHEET 02 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency per meter	Pressure psi	LU Value		
8.0											TOP OF BEDROCK															
9.0	1	67	NIL		100 %	DOUBLE TUBE TUNGSTON CARBIDE & DIAMOND NX	STABIE			S.St	SANDTONE: Grey, fine grained, slightly to moderately weathered, slightly to moderately moderately fractured, medium strong.														
10.0	2	96	84									WS-1: 9.0-9.33m													
11.0	3	80	19									WS-2: 10.08-10.26 m													
12.0	4	75	26									WS-3: 11.24-11.50m													
13.0	5	87	56																						
14.0	6	90	45									WS-4: 13.30-13.53m													
15.0	7	48	NIL							SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, Highly fragmented, Very weak.														
16.0	8	90	65								SILTSTONE: Grey, fine grained, slightly to moderately weathered, slightly to moderately fractured, weak.	WS-5: 15.0-15.28m													
17.0	9	96	65							M.St		WS-6: 16.26-16.46m													
18.0	10	88	83									WS-7: 17.41-17.60m													

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BUDPIRAN VILLAGE
COORDINATES: N: 3747734.94 m, E: 346019.94 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1621.71 m
ROCK ELEVATION: 1613.61 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 11-5-2025 COMPLETE: 17-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-14

SHEET 03 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA								Frequency		WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Total Joints	Frequency per meter	Pressure psi	LU Value		
18.0																										
19.0	11	79	36		100 %	DOUBLE TUBE TUNGSTON CARBIDE & DIAMOND NX	STABIE			M.St	SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, slightly to moderately fractured, weak.	WS-8: 18.09-18.29m												
	12	86	48									WS-9: 19.23-19.41m												
20.0	13	90	40									WS-10: 20.14-20.35m												
21.0	14	80	32									WS-11: 21.06-21.24m												
22.0	15	85	63									WS-12: 22.32-22.56m												
23.0	16	80	56									WS-13: 23.31-23.54m												
24.0	17	80	66									WS-14: 24.12-24.37m												
25.0											BOTTOM OF BOREHOLE														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**14**	BOX No	**1-4**	NESPAK
LOCATION	**Near Budpiran Village**	DEPTH (m)	**8.0-25.00m**	



Depth (m)
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-15

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR NUMB ROAD

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3750238.80 m E: 348030.55 m Ground Elevation 1573.18 m Date 24-5-2025 To 24-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	Remarks
0.0				Reddish brown, medium dense, SANDY SILT, trace to little clay, trace fine gravels, moist.		
1.0	SPT-1		ML			
2.0	SPT-2			Dark brown, stiff to hard, SILTY CLAY, low plastic, medium dry strength, trace fine gravels, moist.		
3.0	SPT-3		CL-ML			
	DS-1			Dark brown, very dense, SILTY CLAYEY GRAVEL, gravels are rounded to sub angular size 5-70mm, moist.		
4.0	SPT-4		GC-GM			
				Dark brown, hard, SILTY CLAY, low plastic, medium dry strength, trace fine gravels, moist		
5.0	SPT-5		CL-ML			
	DS-2			Brownish grey, very dense, SILTY CLAYEY GRAVEL, angular to sub-angular, size from 5-40 mm, moist.		
6.0	SPT-6(c)					
	DS-3					
7.0	SPT-7(c)		GC-GM			
	DS-4					
8.0	SPT-8(c)					
	DS-5			Grey, very dense, SILTY GRAVEL, angular to sub-angular, size from 5-80mm, moist		
9.0			GM			
				TOP OF BEDROCK ENCOUNTERED AT 9.0 M DEPTH		

P.L. ▽ N.M.C. x L.L. ○

SPT Blows/30cm

10 20 30 40 50 60 70 80 90 100

18

10

71

REFUSAL

69

REFUSAL

REFUSAL

REFUSAL

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NUMB ROAD
COORDINATES: N: 3750238.80 m, E: 348030.55 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1573.18 m
ROCK ELEVATION: 1564.18 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 24-5-2025 COMPLETE: 24-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-15

SHEET 02 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
9.0											TOP OF BEDROCK															
10.0	1	65	NIL		100 %	DOUBLE TUBE TUNGSTON CARBIDE & DIAMOND NX	STABIE			M.St	SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, weak, thin layers of shale are present.															
11.0	2	80	37									WS-1: 10.0-10.370m														
12.0	3	53	NIL																							
13.0	4	85	45									WS-2: 12.09-12.30 m														
14.0	5	90	35									WS-3: 13.17-13.39m														
15.0	6	92	59									WS-4: 14.0-14.30m														
16.0	7	72	55									WS-5: 15.0-15.33m														
17.0	8	89	54									WS-6: 16.21-16.53m														
18.0	9	63	29									WS-7: 17.16-17.32m														
19.0	10	84	NIL								SHALE: Reddis brown, fine grained, moderately weathered, extremely weak.															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
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NOTES:-
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Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
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R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NUMB ROAD
COORDINATES: N: 3750238.80 m, E: 348030.55 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1573.18 m
ROCK ELEVATION: 1564.18 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 24-5-2025 COMPLETE: 24-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-15

SHEET 03 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency Total Joints	Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
19.0																										
	11	80	46								SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, weak, thin layers of shale are present.	WS-8: 19.23-19.39m													
20.0	12	79	13									WS-9: 20.26-20.38m													
21.0	13	80	NIL		100 %	DOUBLE TUBE TUNGSTON CARBIDE & DIAMOND NX	STABIE			M.St	SILTSTONE from 21.0m to 24.0m, highly fractured,															
22.0	14	95	NIL																							
23.0	15	65	NIL																							
24.0											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness								
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**15**	BOX No	**1-4**	NESPAK
LOCATION	**Near Numb Road**	DEPTH (m)	**9.0-24.00m**	



Depth (m)
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-16

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BRURI

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3750808.30 m E: 348454.74 m Ground Elevation 1746.49 m Date 06-5-2025 To 20-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0							
				Reddish brown, very dense, Cobbles and Boulders of SILTSTONE, angular to sub-angular, trace fine gravels.	75 mm		
1.0	SPT-1(c)						REFUSAL
2.0	SPT-2(c)						REFUSAL
	DS-1			Reddish brown, hard, SILTY CLAY, low plastic, medium dry strength, trace to little fine gravels, trace clay, moist.			
3.0	SPT-3						REFUSAL
	DS-2		CL-ML				
4.0	SPT-4						REFUSAL
	DS-3			Reddish brown, very dense, Gravels and Cobbles, angular to sub angular.			
5.0	SPT-5(c)						REFUSAL
	DS-4			Reddish brown, hard, SILT with SAND, low plasticity, medium dry strength, trace to little fine gravels, moist.			
6.0	SPT-6		ML				REFUSAL
	DS-5			Reddish brown, very dense, SILTY CLAYEY GRAVELS, angular to sub-angular, trace concretion, moist.			
7.0	SPT-7(c)		GC-GM				REFUSAL
	DS-6			Grey, very dense, Poorly graded GRAVELS with SAND, angular to sub-angular.			
8.0	SPT-8(c)						REFUSAL
	DS-7		GP				
9.0	SPT-9(c)						REFUSAL
	DS-8						
10.0							REFUSAL

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-16

SHEET 2 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BRURI

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3750808.30 m E: 348454.74 m Ground Elevation 1746.49 m Date 06-5-2025 To 20-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
10.0				Grey, very dense, SILTY GRAVELS with SAND, SANDSTONE, angular to sub-angular, (AT PLACES COBBLES AND BOULDER)	75 mm	REFUSAL	
11.0	SPT-10(c) DS-09		GM			REFUSAL	
12.0	SPT-11(c) DS-10					REFUSAL	
13.0	DS-11					REFUSAL	
14.0	SPT-12(c)					REFUSAL	
				TOP OF BEDROCK ENCOUNTERED AT 14.0 M DEPTH			
15.0							
16.0							
17.0							
18.0							
19.0							
20.0							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BRURI
COORDINATES: N: 3750808.30 m, E: 348454.74 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1746.49 m
ROCK ELEVATION: 1432.49 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 06-5-2025 COMPLETE: 20-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-16

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUTY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency Total Joints	Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
14.0											TOP OF BEDROCK															
15.0	1	85	72		100 %	DOUBLE TUBE TUNGSTON CARBIDE & DIAMOND NX	STABIE			S.St	SANDSTONE: Grey, fine grained, slightly to moderately weathered, slightly to moderately fractured, medium strong.	WS-1: 14.0-14.28m														
16.0	2	87	59									WS-2: 15.35-15.60m	1	O	J	15°	-	PR	2	R3-R4	2					
17.0	3	71	40									WS-3: 16.17-16.36m														
18.0	4	79	35																							
19.0	5	92	43									WS-4: 18.10-18.44m														
20.0	6	89	20							M.St	SILTSTONE: Greyish brown, fine grained, slightly moderately weathered, slightly to moderately fractured, weak.															
21.0	7	69	58									WS-5: 20.12-20.33m														
22.0	8	70	50									WS-6: 21.0-21.25 m														
23.0	9	89	89																							
24.0	10	75	10									WS-7: 22.59-22.89m														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BRURI
COORDINATES: N: 3750808.30 m, E: 348454.74 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1746.49 m
ROCK ELEVATION: 1432.49 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 06-5-2025 COMPLETE: 20-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-16

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
24.0																									
25.0	11	80	NIL		100 %	DOUBLE TUBE TUNGSTON CARBIDE & DIAMOND NX	STABIE			SH	SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fragmented, very weak.														
26.0	12	83	NIL																						
27.0	13	96	13									WS-8: 26.18-26.31m													
28.0	14	76	26							S.St	SANDSTONE: Grey, fine grained, slightly to moderately weathered, slightly to moderately fractured, medium strong.	WS-9: 27.31-27.44m													
29.0	15	74	18									WS-10: 28.22-28.40m													
30.0	16	87	73									WS-11: 29.43-29.63m													
											BOTTOM OF BOREHOLE														

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**16**	BOX No	**1-4**	NESPAK
LOCATION	**Near Bruri**	DEPTH (m)	**14.0-30.00m**	



Depth (m)
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00
28.00
29.00
30.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-17

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BANSRA GALI CHAIR LIFT

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3751773.39 m E: 349063.89 m Ground Elevation 1759.75 m Date 03-5-2025 To 08-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0				Radish brown, very stiff to hard, SILT, medium dry strength, low plastic, strength, moist.	75 mm		
1.0	SPT-1		ML			24	
2.0	SPT-2					65	
3.0	SPT-3					69	
			CL	Dark brown, hard, LEAN CLAY, low to medium plastic, medium dry strength, trace to little concretion, moist.			
4.0	SPT-4(c)					REFUSAL	
			GC-GM	Grey, very dense, SILTY CLAYEY GRAVELS, angular to sub angular, moist.			
5.0				Grey, very dense, COBBLES and BOULDER of SANDSTONE origin, angular to sub angular.			
6.0				TOP OF BEDROCK ENCOUNTERED AT 6.0 M DEPTH			
7.0							
8.0							

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BANSRA GALI CHAIR LIFT
COORDINATES: N: 3751773.39 m, E: 349063.89 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1759.75 m
ROCK ELEVATION: 1753.75 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 03-5-2025 COMPLETE: 08-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-17

SHEET 02 OF 03

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUTY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
6.0											TOP OF BEDROCK															
7.0	1	83	49		25-50 %	DOUBLE TUBE TUNGSTON CARBIDE NX	STABIE			M.St	SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately fractured, weak.	WS-1: 6.10-6.30m														
8.0	2	94	75																							
9.0	3	84	36																							
10.0	4	72	30							SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, Highly fragmented, very weak.	WS-2: 8.54-8.77m WS-3: 9.28-9.43m														
11.0	5	70	28									WS-4: 10.51-10.68m														
12.0	6	73	40									WS-5: 11.21-11.42m														
13.0	7	62	NIL																							
14.0	8	74	32							M.St	SILTSTONE: Greyish brown, fine grained, moderately weathered, slightly to moderately fractured, weak.	WS-6: 13.24-13.37 m														
15.0	9	95	88									WS-7: 14.0-14.22m														
16.0	10	70	15							S.St	SANDTONE: Grey, fine grained, slightly to moderately weathered, moderately fractured, medium strong.															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BANSRA GALI CHAIR LIFT
COORDINATES: N: 3751773.39 m, E: 349063.89 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1759.75 m
ROCK ELEVATION: 1753.75 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 03-5-2025 COMPLETE: 08-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-17

SHEET 03 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUTY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
16.0																										
17.0	11	80	47		40-50 %	DOUBLE TUBE TUNGSTON CARBIDE NX	STABIE			S.St	SANDTONE: Grey, fine grained, slightly weathered, moderately fractured, medium strong.	WS-8: 16.08-16.24m														
18.0	12	88	25									WS-9: 17.0-17.14m														
19.0	13	77	58									WS-10: 18.0-18.24m														
20.0	14	66	20									WS-11: 19.13-19.33m														
21.0	15	83	NIL																							
22.0	16	90	46							M.St	SILTSTONE: Grey, fine grained, slightly weathered, moderately to high fractured, medium strong. At places alternate layer of shale are present.	WS-12: 21.10-21.39m														
23.0	17	80	35									WS-13: 22.17-22.36m														
24.0	18	62	17									WS-14: 23.45-23.61m														
25.0	19	90	73																							
											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**17**	BOX No	**1-4**	NESPAK
LOCATION	**Near Bansra Gali Chair lift**	DEPTH (m)	**6.0-25.00m**	



Depth (m)

6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-18

SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BANSRA GAL

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3752581.68 m E: 349300.18 m Ground Elevation 1804.66 m Date 20-04-2025 To 04-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0				Fill material of road	75 mm		
1.0	DS-1						
			GP-GM	Dark brown, very dense, Poorly graded GRAVEL with SILT, moist.			
2.0	SPT-1						REFUSAL
				Dark brown, stiff to hard, GRAVELLY LEAN CLAY with SAND, low plastic, medium dry strength, moist.			
3.0	SPT-2					9	
4.0	SPT-3					24	
5.0	SPT-4					33	
6.0	SPT-5		CL			24	
7.0	SPT-6					66	
				Dark brown, hard, LEAN CLAY with SAND, low plastic, medium dry strength, moist.			
8.0	SPT-7					32	
9.0	SPT-8						REFUSAL
10.0	SPT-9						REFUSAL

TOP OF BEDROCK ENCOUNTERED AT 10.0 M DEPTH

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BANSRA GAL
COORDINATES: N: 3752581.68 m, E: 349300.18 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1804.66 m
ROCK ELEVATION: 1794.66 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 20-04-2025 COMPLETE: 04-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-18

SHEET 02 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
10.0											TOP OF BEDROCK														
11.0	1	59	NIL		50-60 %	DOUBLE TUBE TUNGSTON CARBIDE NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.														
12.0	2	55	NIL																						
13.0	3	70	11									WS-1: 12.15-12.26m													
14.0	4	56	NIL								SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.														
15.0	5	85	35							M.St		WS-2: 14.20-14.31 m													
										SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.														
	6	97	37							M.St	SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.	WS-3: 15.12-15.28m													
16.0	7	90	23									WS-4: 16.65-16.75m													
17.0	8	82	21							SH	SANDTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak to medium strong.	WS-5: 17.20-17.41m													
18.0	9	85	42									WS-6: 18.0-18.18m													
19.0	9	70	12							S.St	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.	WS-7: 19.40-19.52m													
20.0										SH															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness

	STATE	CODE
STEPPED	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BANSRA GAL
COORDINATES: N: 3752581.68 m, E: 349300.18 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1804.66 m
ROCK ELEVATION: 1794.66 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 20-04-2025 COMPLETE: 04-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-18

SHEET 03 OF 03

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0										SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fractured, extremely weak to weak.														
21.0	11	70	17		30-50 %	DOUBLE TUBE TUNGSTON CARBIDE NX SIZE	STABIE			M.St		WS-8: 20.19-20.36m														
22.0	12	79	10							SH	SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately fractured, weak to medium strong.														
23.0	13	70	15								SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fractured, extremely weak to weak.														
24.0	14	92	NIL								SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately fractured, weak to medium strong.														
25.0	15	82	22							M.St SH		WS-9: 24.63-24.74m														
											SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fractured, extremely weak to weak.														
											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness								
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
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3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**18**	BOX No	**1-3**	NESPAK
LOCATION	**Near Bansra Gali**	DEPTH (m)	**10.0-25.00m**	



Depth (m)
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-19

SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR CHITTA MOR

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3753036.37 m E: 350338.41 m Ground Elevation 1859.60 m Date 17-04-2025 To 30-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0	DS-1			Dark brown, loose to dense, CLAYEY GRAVEL with SAND, moist.			
1.0	SPT-1					8	
2.0	SPT-2					19	
			GC				
3.0	SPT-3					21	
	DS-2						
4.0	SPT-4					40	
5.0	SPT-5(c)						REFUSAL
				Grey, very dense, COBBLES AND BOULDER of sand stone origin.			
6.0							
7.0							
	DS-3						
				Dark brown, very stiff to hard, GEAVELLY LEAN CLAY with SAND, low plastic, medium dry strength, moist.			
8.0	SPT-6(c)					30	
			CL				
9.0	SPT-7					17	
10.0	SPT-8					25	

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-19

SHEET 2 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR CHITTA MOR

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3753036.37 m E: 350338.41 m Ground Elevation 1859.60 m Date 17-04-2025 To 30-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
10.0	SPT-8						
				Dark brown, very stiff to hard, GEAVELLY LEAN CLAY with SAND, low plastic, medium dry strength, moist.		25	
11.0	SPT-9					20	
12.0	SPT-10		CL			26	
13.0	SPT-11						REFUSAL
	DS-4						
				Brownish grey, very dense, SILTY CLAYEY GRAVELS, angular to sub-angular, ranging in size 25mm to 76mm, moist.			
14.0	SPT-12(c)						REFUSAL
	DS-5						
15.0	SPT-13(c)						REFUSAL
	DS-6						
16.0	SPT-14(c)						REFUSAL
	DS-7						
17.0	SPT-15(c)		GC-GM				
	DS-8						REFUSAL
18.0							
19.0	SPT-16(c)						REFUSAL
20.0							

TOP OF BEDROCK ENCOUNTERED AT 20.0 M DEPTH

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR CHITTA MOR

COORDINATES: N: 3753036.37 m, E: 350338.41 m

ANGLE (with vertical): 0 BEARING: –

GROUND ELEVATION: 1859.60 m

ROCK ELEVATION: 1839.60 m

GROUND WATER ELEVATION: N.E.

BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND

PEIZOMETER: -

DATE START: 17-04-2025 COMPLETE: 30-04-2025

DRILLING AGENCY: M/S THE DRILLER

DRILLING RIG: STRAIGHT ROTARY

LOGGED BY: ALI AQDAS

CHECKED BY: M. SHAHID

BOREHOLE No. BH-19

SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUTY DATA									WPT		Point Load (Failure Pressure on Dial)	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0											TOP OF BEDROCK														
	1	86	NIL		20-30 %	DOUBLE TUBE TUNGSTON CARBIDE NX SIZE	STABIE			SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.														
21.0																									
	2	82	32									WS-1: 21.56-21.77m													
22.0																									
	3	69	10									WS-2: 22.50-22.60 m													
23.0																									
	4	86	NIL																						
24.0																									
	5	64	NIL																						
25.0																									
	6	60	NIL		15-30 %																				
26.0																									
	7	77	29									WS-3: 26.24-26.52m													
27.0											SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, moderately fractured, weak.														
	8	65	16									WS-4: 27.24-27.35m													
28.0																									
	9	75	44							M.St	SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, very weak.														
29.0																									
	10	64	27							SH		WS-5: 29.21-29.37m													
30.0																									

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness								
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
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2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR CHITTA MOR
COORDINATES: N: 3753036.37 m, E: 350338.41 m
ANGLE (with vertical): 0 BEARING: –

GROUND ELEVATION: 1859.60 m
ROCK ELEVATION: 1839.60 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINT/SAND
PEIZOMETER: -

DATE START: 17-04-2025 COMPLETE: 30-04-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-19

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUITY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Failure Pressure on Dial)	REMARKS
30.0																										
31.0	11	63	18		20-40 %	DOUBLE TUBE TUNGSTON CARBIDE NX SIZE	STABIE			M.St	SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, moderately fractured, weak.	WS-6: 30.14-30.32m														
32.0	12	41	NIL																							
33.0	13	59	15																							
34.0	14	71	15									WS-7: 33.0-33.15m														
35.0	15	95	31									WS-8: 34.64-34.80m														
											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shistocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness		
STEPPED	STATE	CODE
	Rough	SR
	Smooth	SSm
	Slickensided	SSl
UNDULATING	STATE	CODE
	Rough	UR
	Smooth	USm
	Slickensided	USl
PLANAR	STATE	CODE
	Rough	PR
	Smooth	PSm
	Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highy Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, Indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	**19**	BOX No	**1-3**	NESPAK
LOCATION	**Near Chitta Mor**	DEPTH (m)	**20.0-35.00m**	



Depth (m)
20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00
28.00
29.00
30.00
31.00
32.00
33.00
34.00
35.00

APPENDIX-C

FIG. C1: VARIATION OF FIELD SPT BLOWS WITH DEPTH

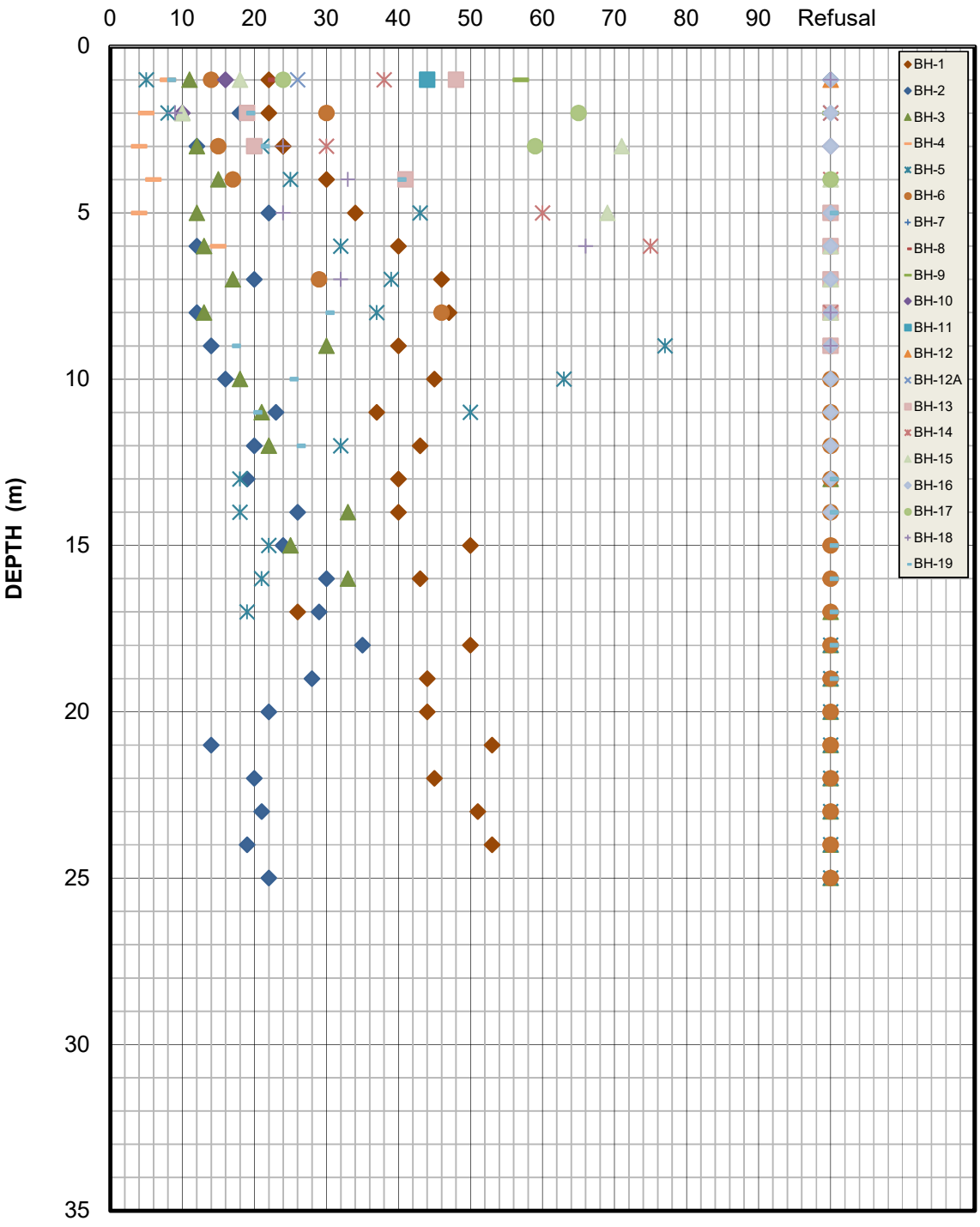
FIG. C2: VARIATION OF CORRECTED SPT BLOWS WITH DEPTH

FIG. C3: VARIATION OF CORE RECOVERY WITH DEPTH

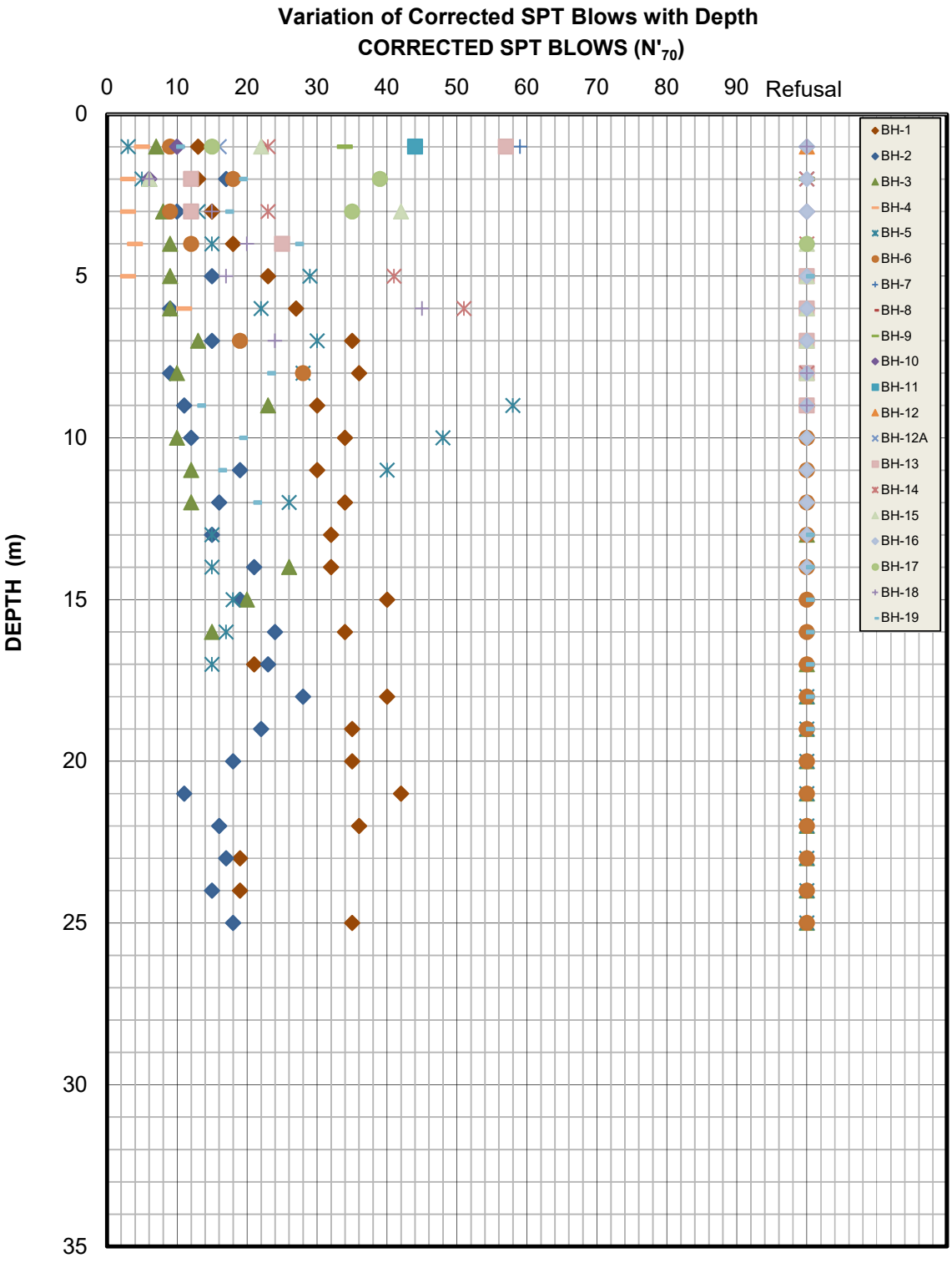
FIG. C4: VARIATION OF RQD WITH DEPTH

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

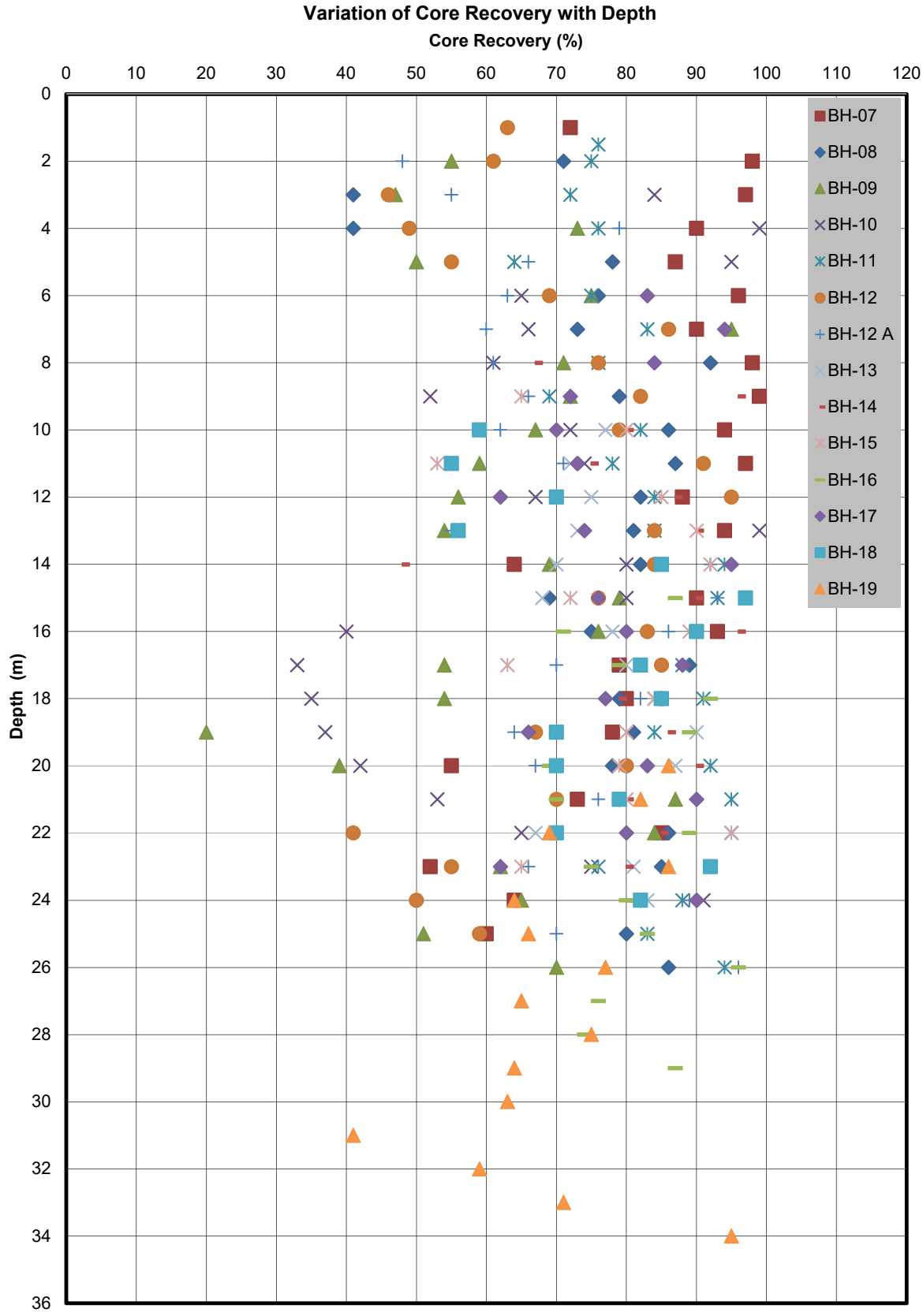
Variation of Field SPT Blows with Depth



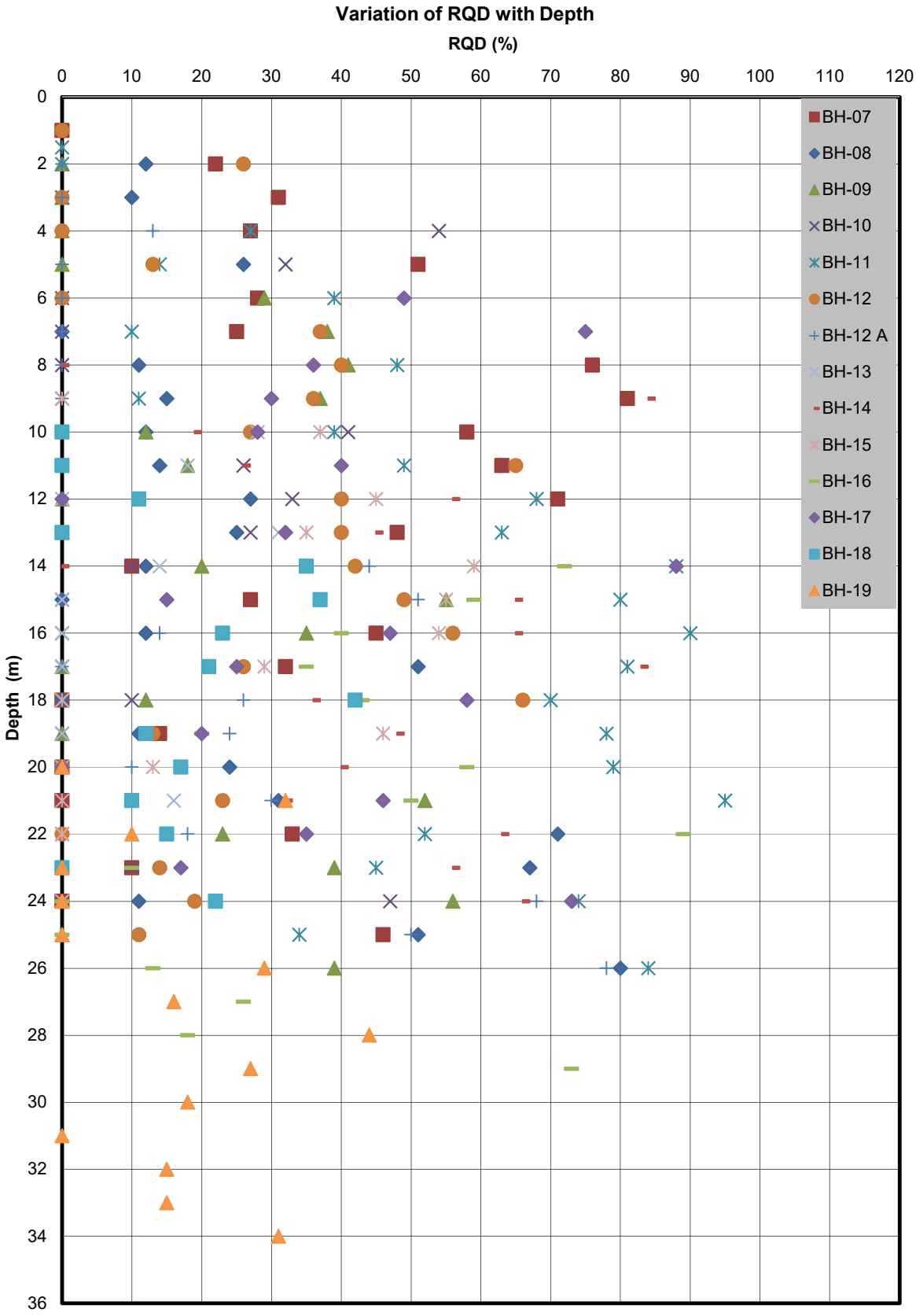
FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES



FEASIBILITY STUDY FOR THE TOURUST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES



FEASIBILITY STUDY FOR THE TOURUST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES



APPENDIX-D

TABLE D-1: SUMMARY OF LABORATORY TEST RESULTS

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

SUMMARY OF LABORATORY TEST RESULTS

BH No.	Sample No.	Depth	Natural Moisture Content (NMC)	In-situ Bulk Density	In-situ Dry Density	Specific Gravity	Grain Size Analysis (% Passing)									Atterberg Limits			Material Classification as per USCS		Type of Rock	Direct Shear Test		Unconfined Compression Test		Consolidation Test with Swell Pressure Measurement				Uniaxial Compression Test		Elastic Modulus	Hoek Shear Test		Chemical Analysis of Soil			Chemical Analysis of Water			
																			Symbol	Material Description		c	Ø	q_u	Failure Strain	e_o	C_c	m_v *	Swell Pressure	σ_{ci}	Failure Strain	E_{si}	c	Ø	Sulphate Content	Chloride Content	Organic Matter	Sulphate Content	Chloride Content	Total Dissolved Solids (TDS)	pH
		(m)	(%)	(kN/m^3)	(kN/m^3)		3"	3/4"	#4	#10	#40	#100	# 200	0.02	0.002	-	-	-				(kPa)	(deg.)	(kPa)	(%)	-	-	(m^2/kN)	(kPa)	(MPa)	(%)	(MPa)	(kPa)	(deg.)	(%)	(%)	(%)	(ppm)	(ppm)	(ppm)	-
BH-01	SPT-01	1.00-1.45					100	100	100	100	100	99	98	62	2	28	21	7	CL-ML	Silty Clay																					
	SPT-08	8.00-8.45					100	100	98	95	94	3	91			24	19	5	CL-ML	Silty Clay															0.01	0.02	0.11				
	UDS-01	13.50-14.00	17.1	19.2	16.4	2.68	100	100	100	100	100	100	100			33	22	11	CL	Lean Clay				69	14.3	0.63	0.13	0.22x10^{-3}	10											
	SPT-24	24.00-24.45					100	100	100	99	87	49	31						SM	Silty Sand																				
BH-02	SPT-01	1.00-1.45					100	45	26	18	12	11	8			27	19	8	GP-GC	Poorly Graded Gravel with Clay and Sand															0.03	0.04	0.13				
	SPT-04	4.00-4.45					100	79	36	28	24	22	20			24	18	6	GC-GM	Silty Clayey Gravel with Sand																				
	UDS-01	6.50-7.00	18.1	19.0	16.1	2.68	100	100	100	100	99	97	95			27	19	8	CL	Lean Clay				49	7.1	0.66	0.09	0.13x10^{-3}	9											
	UDS-03	22.50-22.90	17.2	19.2	16.4		100	100	98	96	95	95	94			31	21	10	CL	Lean Clay				54	5.4															
BH-03	UDS-01	2.50-3.00	17.1	19.0	16.2	2.68	100	100	100	100	100	99	99	62	3	29	19	10	CL	Lean Clay				45	3.6	0.64	0.14	0.24x10^{-3}	9						0.03	0.02	0.13				
	SPT-08	8.00-8.45					100	99	90	88	87	87	86			28	21	7	CL-ML	Silty Clay																				
	SPT-10	10.00-10.45					100	100	100	100	98	95	80						ML	Silt with Sand																				
	DS-02	18.00-19.00					100	58	47	47	45	25	16						GM	Silty Gravel with Sand																				
	DS-07	23.00-24.00					100	14	12	12	4	1	1						GP	Poorly Graded Gravel																				
BH-04	UDS-01	2.50-3.00																																					
	DS-03	8.00-9.00																																					
	DS-06	11.00-12.00																																					
	DS-10	15.00-16.00																																					
	DS-13	18.00-19.00																																					
	DS-18	23.00-24.00																																					
	WAS																																						
BH-05	SPT-01	1.00-1.45																																					
	UDS-01	5.00-6.00																																					
	UDS-02	12.50-13.00																																					
	DS-02	19.00-20.00																																					
	DS-06	23.00-24.00																																					
BH-06	SPT-01	1.00-1.45																																					
	SPT-04	4.00-4.45																																					
	DS-04	8.00-9.00																																					
	DS-11	15.00-16.00																																					
	DS-15	19.00-20.00																																					
	DS-19	23.00-24.00																																					
	WAS																																						
BH-07	WS-02	3.58-3.74				2.68															Siltstone									2.31	0.010	2472								
	WS-04	6.61-6.89	3.2	25.8	25.0																Siltstone																			
	WS-09	15.81-15.91	1.3	21.8	21.5																Shale									0.97										
	WS-11	19.51-19.65	0.8	24.5	24.3																Sandstone									24.38										
BH-08	SPT-1	1.00-1.45					100	100	99	96	91	83	73			28	20	8	CL	Lean Clay with Sand															0.03	0.04	0.08				
	WS-01	2.52-2.64	1.2	30.4	30.0																Siltstone									10.56										
	WS-03	8.34-8.45																			Siltstone									1.22										
	WS-06	12.55-12.82	3.7	25.4	24.5																Siltstone																			
	WS-13	22.50-22.71																			Siltstone									10.69										

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

SUMMARY OF LABORATORY TEST RESULTS

BH No.	Sample No.	Depth	Natural Moisture Content (NMC)	In-situ Bulk Density	In-situ Dry Density	Specific Gravity	Grain Size Analysis (% Passing)									Atterberg Limits			Material Classification as per USCS		Type of Rock	Direct Shear Test		Unconfined Compression Test		Consolidation Test with Swell Pressure Measurement				Uniaxial Compression Test		Elastic Modulus	Hoek Shear Test		Chemical Analysis of Soil			Chemical Analysis of Water			
																			Symbol	Material Description		c	Ø	q_u	Failure Strain	e_o	C_c	m_v *	Swell Pressure	σ_{ci}	Failure Strain	E_{si}	c	Ø	Sulphate Content	Chloride Content	Organic Matter	Sulphate Content	Chloride Content	Total Dissolved Solids (TDS)	pH
		(m)	(%)	(kN/m^3)	(kN/m^3)		3"	3/4"	#4	#10	#40	#100	# 200	0.02	0.002	LL	PL	PI				(kPa)	(deg.)	(kPa)	(%)	-	-	(m^2/kN)	(kPa)	(MPa)	(%)	(MPa)	(kPa)	(deg.)	(%)	(%)	(%)	(ppm)	(ppm)	(ppm)	-
BH-09	SPT-1	1.00-1.45					100	100	92	86	81	78	72			26	19	7	CL-ML	Silty Clay with Sand																				
	WS-01	6.45-6.57	1.0	25.2	25.0																Sandstone									36.92										
	WS-03	9.30-9.66																			Sandstone																			
	WS-06	16.00-16.22	0.9	26.7	26.4	2.72															Sandstone									8.12										
	WS-07	21.33-21.62	1.1	26.7	26.4																Sandstone									15.05	0.009	1634								
	WS-09	24.00-24.18																			Sandstone									27.47										
BH-10	SPT-2	2.00-2.45					100	95	92	81	77	61	50			28	20	8	CL	Sandy Lean Clay																0.03	0.04	0.08				
	WS-01	4.41-4.55	5.9	24.7	23.3	2.69															Shale									0.42										
	WS-02	5.72--5.95																			Shale																			
	WS-04	12.00-12.17	1.4	24.2	23.8																Siltstone									16.60										
	WS-06	18.11-18.21																			Siltstone									18.38										
	WS-09	24.16-24.31	1.0	23.9	23.7																Siltstone									27.63										
BH-11	SPT-01	1.00-1.45					100	100	100	100	99	98	96			30	21	9	CL	Lean Clay																0.03	0.04	0.09				
	WS-02	5.22-5.36	6.4	23.8	22.4																Shale									2.76										
	WS-04	8.00-8.21																			Shale																			
	WS-11	15.55-15.71	0.8	25.4	25.2																Siltstone									20.58										
	WS-16	24.00-24.25	3.4	24.6	23.8	2.71															Shale									10.79	0.010	1273								
BH-12	WS-01	2.04-2.17	2.0	24.8	24.3																Siltstone									11.88										
	WS-02	5.30-5.43																			Shale									0.91										
	WS-07	13.44-13.71	0.8	26.5	26.3																Sandstone																			
	WS-11	18.00-18.31																			Sandstone									31.20										
BH-12A	SPT-02	2.00-2.45					100	100	99	85	69	66	65			26	19	7	CL-ML	Sandy Silty Clay																				
	WS-01	4.42-4.55	1.5	22.8	22.5																Shale									2.48										
	WS-03	14.45-14.65																			Shale									0.28										
	WS-05	18.40-18.54	0.9	23.0	22.8	2.72															Siltstone									18.40										
	WS-08	24.53-24.76																			Siltstone									12.72										
BH-13	SPT-01	1.00-1.45																																						
	SPT-03	3.00-3.4																																						
	DS-04	7.00-8.00																																						
	WS-02	11.43-11.60																			Siltstone																			
	WS-04	14.00-14.14																			Siltstone																			
	WS-05	21.00-21.16																			Siltstone																			
BH-14	SPT-03	3.00-3.45																																						
	SPT-05	5.00-5.45																																						
	WS-01	9.00-9.33																			Sandstone																			
	WS-03	11.24-11.50																			Sandstone																			
	WS-10	20.14-20.35																			Siltstone																			
	WS-14	24.12-24.37																			Siltstone																			
BH-15	SPT-1	1.00-1.45																																						
	SPT-3	3.00-3.45																																						
	DS-05	8.00-9.00																																						
	WS-01	10.00-10.37																																						
	WS-04	14.00-14.30																			Siltstone																			
	WS-07	17.15-17.30																			Siltstone																			

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

SUMMARY OF LABORATORY TEST RESULTS

BH No.	Sample No.	Depth	Natural Moisture Content (NMC)	In-situ Bulk Density	In-situ Dry Density	Specific Gravity	Grain Size Analysis (% Passing)									Atterberg Limits			Material Classification as per USCS		Type of Rock	Direct Shear Test		Unconfined Compression Test		Consolidation Test with Swell Pressure Measurement				Uniaxial Compression Test		Elastic Modulus	Hoek Shear Test		Chemical Analysis of Soil			Chemical Analysis of Water			
							3"	3/4"	#4	#10	#40	#100	# 200	0.02	0.002	LL	PL	PI	Symbol	Material Description		c	Ø	q_u	Failure Strain	e_o	C_c	m_v *	Swell Pressure	σ_{ci}	Failure Strain	E_{si}	c	Ø	Sulphate Content	Chloride Content	Organic Matter	Sulphate Content	Chloride Content	Total Dissolved Solids (TDS)	pH
		(m)	(%)	(kN/m^3)	(kN/m^3)																	(kPa)	(deg.)	(kPa)	(%)	-	-	(m^2/kN)	(kPa)	(MPa)	(%)	(MPa)	(kPa)	(deg.)	(%)	(%)	(%)	(ppm)	(ppm)	(ppm)	-
BH-16	DS-01	2.00-3.00																			Siltstone																		
	DS-06	7.00-8.00																																						
	DS-09	11.00-12.00																																						
	WAS-01	14.00-14.28																			Sandstone																		
	WS-07	22.59-22.89																			Siltstone																		
	WS-10	28.22-28.40																			Sandstone																		
	WS-11	29.43-29.63																			Siltstone																		
BH-17	SPT-03	3.00-3.45					100	100	100	99	99	98	98	66	9	34	22	12	CL	Lean Clay																	0.05	0.02	0.14				
	WS-01	6.10-6.30				2.72															Siltstone									9.76												
	WS-03	9.28-9.43	2.3	23.0	22.5																Shale									4.16												
	WS-08	16.08-16.24				2.73															Sandstone									17.10	0.023	723.9										
BH-18	DS-01	1.00-2.00					100	19	12	11	9	9	8						GP-GM	Poorly Graded Gravel with Silt																								
	SPT-04	5.00-5.45					100	100	76	69	64	62	60	35	2	29	20	9	CL	Gravelly Lean Clay with Sand																	0.03	0.04	0.13				
	SPT-06	7.00-7.45					100	100	98	93	88	85	82			31	21	10	CL	Lean Clay with Sand																								
	WS-01	12.15-12.26	10.0	21.5	19.6	2.69															Shale									0.26												
	WS-03	15.12-15.28	1.8	26.0	25.5																Siltstone									23.81	0.02	1607										
	WS-05	17.20-17.41																			Shale																						
	WS-06	20.19-20.36	7.2	19.7	18.4																Shale									0.31												
	WS-07	24.63-24.74				2.72															Siltstone									1.64												
BH-19	SPT-01	1.00-1.45					100	85	71	62	52	49	44			27	19	8	GC	Clayey Gravel with Sand																	0.03	0.02	0.11				
	DS-03	7.40-8.00					100	89	71	68	62	61	56			32	21	11	CL	Gravelly Lean Clay with Sand																								
	SPT-09	11.00-11.45					100	100	76	70	65	63	57			28	19	9	CL	Gravelly Lean Clay with Sand																								
	DS-06	15.00-16.00					100	34	22	21	20	19	16						GC-GM	Silty Clayey Gravel																								
	WS-01	21.56-21.77				2.72															Shale									2.51	0.023	104.28										
	WS-05	29.21-29.37	1.6	26.1	25.7																Siltstone									13.30												
	WS-06	30.14-30.32	5.2	22.6	21.5																Shale									1.19												

NOTE:

LEGENDS:

BH: BOREHOLE UDS: UNDISTURBED SAMPLE SPT: STANDARD PENETRATION TEST WAS: WATER SAMPLE WS: WAXED SAMPLE DS: DISTURB SAMPLE RESULT AWAITED

APPENDIX-D

DETAILED TEST RESULT SHEETS

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		decon Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
Lab No	1003	Test Started	May 11, 2025
Sampled Date	-	Test Completed	May 12, 2025

Property Index

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Bulk density (gm/cm³)	Dry density (gm/cm³)	N.M.C (%)	Unit Weight (gm/cm³)	Specific Gravity	Water Absorption (%)
			From	To						
1	BH-01	UDS-01	13.50	14.00	1.915	1.636	-	-	2.681	-
2	BH-02	UDS-01	6.50	7.00	1.901	1.610	-	-	2.678	-
3		UDS-03	22.50	22.90	1.919	1.637	-	-	-	-

Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
Lab No	1003	Test Started	May 11, 2025
Sampled Date	-	Test Completed	May 12, 2025

Property Index

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Bulk density (gm/cm³)	Dry density (gm/cm³)	N.M.C (%)	Unit Weight (gm/cm³)	Specific Gravity	Water Absorption (%)
			From	To						
1	BH-03	UDS-01	2.50	3.00	1.902	1.624	-	-	2.679	-
										-
										-

Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CENTRAL MATERIAL TESTING LABORATORY WAPDA, LAHORE

(Property Index)
Standard ISRM

Project: GEOTECHNICAL INVESTIGATIONS, FOR FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE (PKG-4)
Client: DECON INTERNATIONAL (PVT) LTD.
Ref. No. NIL **Dated:** 25.03.2025 **Lab.No.** 24115

Sr. No.	Borehole No.	Sample No.	Depth (m)	Bulk Weight (g)	Saturated Weight (g)	Submerged Weight (wt. g)	Bulk Vol. (ml)	Dry Weight (g)	Pore+void (Vol. ml)	Bulk Density g/cm^3	Dry Density g/cm^3
1	BH-07	WS-04	6.61-6.89	98.57	99.36	61.10	38.26	95.69	3.67	2.58	2.50
2	BH-08	WS-06	12.55-12.62	104.69	105.16	63.99	41.17	100.79	4.37	2.54	2.45

Tested by:

Checked by:

C/S:

Executive Engineer
Central Material Testing
Laboratory WAPDA Lahore

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller, Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
Lab No	989	Test Started	March 23, 2025
Sampled Date	-	Test Completed	March 24, 2025

Property Index

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Bulk density (gm/cm^3)	Dry density (gm/cm^3)	N.M.C (%)	Unit Weight (gm/cm^3)	Specific Gravity	Water Absorption (%)
			From	To						
1	BH-07	WS-02	3.58	3.74					2.680	
2	BH-07	WS-09	15.81	15.91	2.219	2.191	1.27			
3	BH-07	WS-11	19.51	19.65	2.501	2.481	0.79			
4	BH-08	WS-01	2.52	2.64	3.099	3.063	1.18			
5	BH-09	WS-06	16.00	16.22	2.718	2.694	0.88		2.720	

Tested By	Checked By	Approved By
Imran Ali	Ikramullah	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller, Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
Lab No	989	Test Started	April 18, 2025
Sampled Date	-	Test Completed	April 19, 2025

Property Index

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Bulk density (gm/cm^3)	Dry density (gm/cm^3)	N.M.C (%)	Unit Weight (gm/cm^3)	Specific Gravity	Water Absorption (%)
			From	To						
1	BH-09	WS-01	6.45	6.57	2.571	2.546				

Tested By	Checked By	Approved By
Imran Ali	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller, Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
Lab No	989	Test Started	April 9, 2025
Sampled Date	-	Test Completed	April 10, 2025

Property Index

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Bulk density (gm/cm³)	Dry density (gm/cm³)	N.M.C (%)	Unit Weight (gm/cm³)	Specific Gravity	Water Absorption (%)
			From	To						
1	BH-10	WS-01	4.41	4.55	2.521	2.380			2.690	
2	BH-10	WS-04	12.00	12.17	2.462	2.429				
3	BH-10	WS-09	24.16	24.31	2.435	2.411				
4	BH-12A	WS-01	4.42	4.55	2.326	2.292				
5	BH-12A	WS-05	18.40	18.54	2.347	2.325				
6	BH-09	WS-07	21.33	21.62	2.719	2.689			2.723	

Tested By	Checked By	Approved By
Imran Ali	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller, Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
Lab No	989	Test Started	April 9, 2025
Sampled Date	-	Test Completed	April 10, 2025

Property Index

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Bulk density [gm/cm³]	Dry density [gm/cm³]	N.M.C (%)	Unit Weight [gm/cm³]	Specific Gravity	Water Absorption (%)
			From	To						
1	BH-11	WS-02	5.22	5.36	2.431	2.284				
2	BH-11	WS-11	15.55	15.71	2.590	2.569				
3	BH-11	WS-16	24.00	24.25	2.511	2.428			2.710	
4	BH-12	WS-01	2.04	2.17	2.531	2.482				

Tested By	Checked By	Approved By
Imran Ali	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CENTRAL MATERIAL TESTING LABORATORY WAPDA, LAHORE

(Property Index)
Standard ISRM

Project: GEOTECHNICAL INVESTIGATIONS, FOR FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE (PKG-4)
Client: DECON INTERNATIONAL (PVT) LTD.
Ref. No. NIL **Dated:** 07.04.2025

Lab.No. 24126

Sr. No.	Borehole No.	Sample No.	Depth (m)	Bulk Weight (g)	Saturated Weight (g)	Submerged Weight (wt. g)	Bulk Vol. (ml)	Dry Weight (g)	Pore+void (Vol. ml)	Bulk Density g/cm³	Dry Density g/cm³
1	BH-12	WS-07	13.44-13.71	143.59	143.92	89.67	54.25	142.57	1.35	2.65	2.63

Tested by:

Checked by:

C/S:

Executive Engineer
Central Material Testing
Laboratory WAPDA Lahore

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		**decon** Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
Lab No	1006	Test Started	May 22, 2025
Sampled Date	-	Test Completed	May 23, 2025

Property Index

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Bulk density (gm/cm³)	Dry density (gm/cm³)	N.M.C (%)	Unit Weight (gm/cm³)	Specific Gravity	Water Absorption (%)
			From	To						
1	BH-17	WS-01	6.10	6.30	-	-	-	-	2.724	-
2		WS-03	9.28	9.43	2.345	2.292	-	-	-	-
3		WS-08	16.08	16.24	-	-	-	-	2.726	-

Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
Lab No	1006	Test Started	May 12, 2025
Sampled Date	-	Test Completed	May 13, 2025

Property Index

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Bulk density (gm/cm³)	Dry density (gm/cm³)	N.M.C (%)	Unit Weight (gm/cm³)	Specific Gravity	Water Absorption (%)
			From	To						
1	BH-18	WS-01	12.15	12.26	2.154	1.958	-	-	2.694	-
2		WS-03	15.12	15.28	2.596	2.551	-	-	-	-
3		WS-06	20.19	20.36	1.970	1.837	-	-	-	-
4		WS-07	24.53	24.74			-	-	2.703	-
5	BH-19	WS-01	21.58	21.77					2.715	
6		WS-05	29.21	29.37	2.613	2.572				
7		WS-06	30.14	30.32	2.258	2.146				

Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

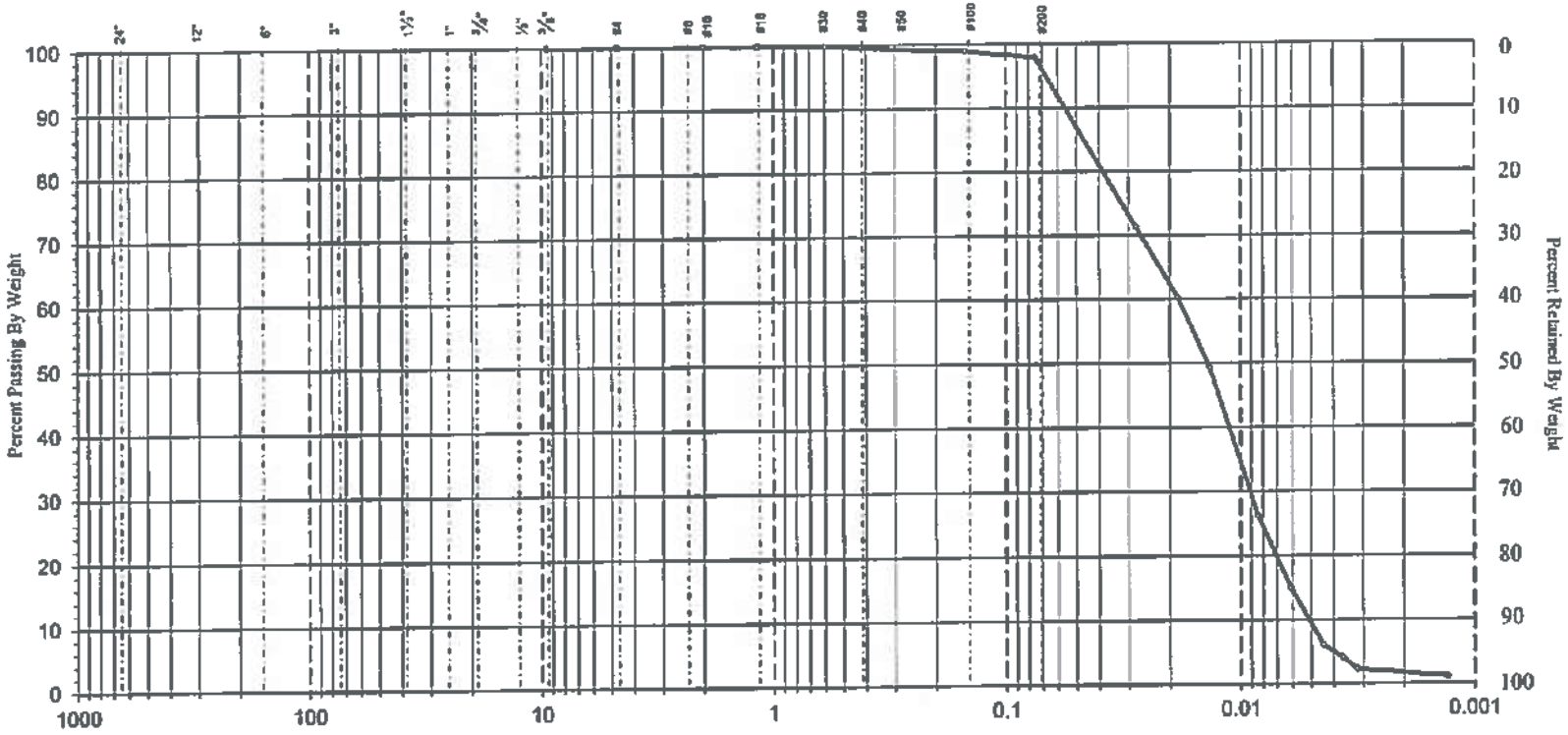
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST CLASS TRAIN FROM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-01	Sampled Date	-
Sample.	SPT-01	Test Started	May 9, 2025
Sample Depth (m)	1.00-1.45	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.00 %		Sand = 2.07 %			Silt = 88.48 %	Clay 9.45 %
		Coarse	Fine	Coarse	Medium	Fine		

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	100.00	99.96	99.92	99.84	99.62	98.98	97.93	87.05	34.55	9.45	1.70

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

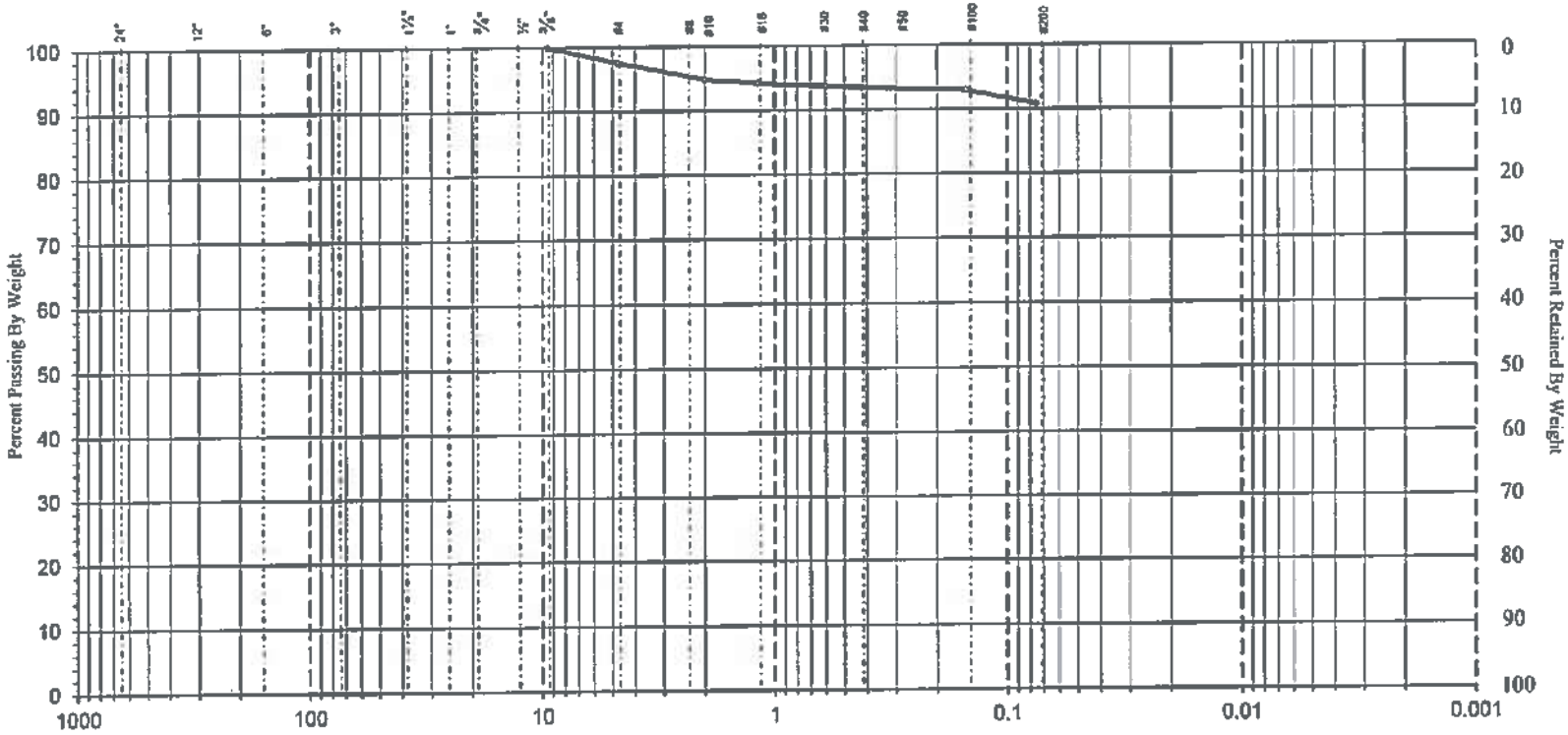
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE II: GEOTECHNICAL INVESTIGATION FOR RAILWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-01	Sampled Date	-
Sample.	SPT-08	Test Started	May 9, 2025
Sample Depth (m)	8.00-8.45	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 2.40 %		Sand = 6.79 %			Silt + Clay = 90.81 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	97.60	94.92	94.27	93.71	93.53	93.05	90.81	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

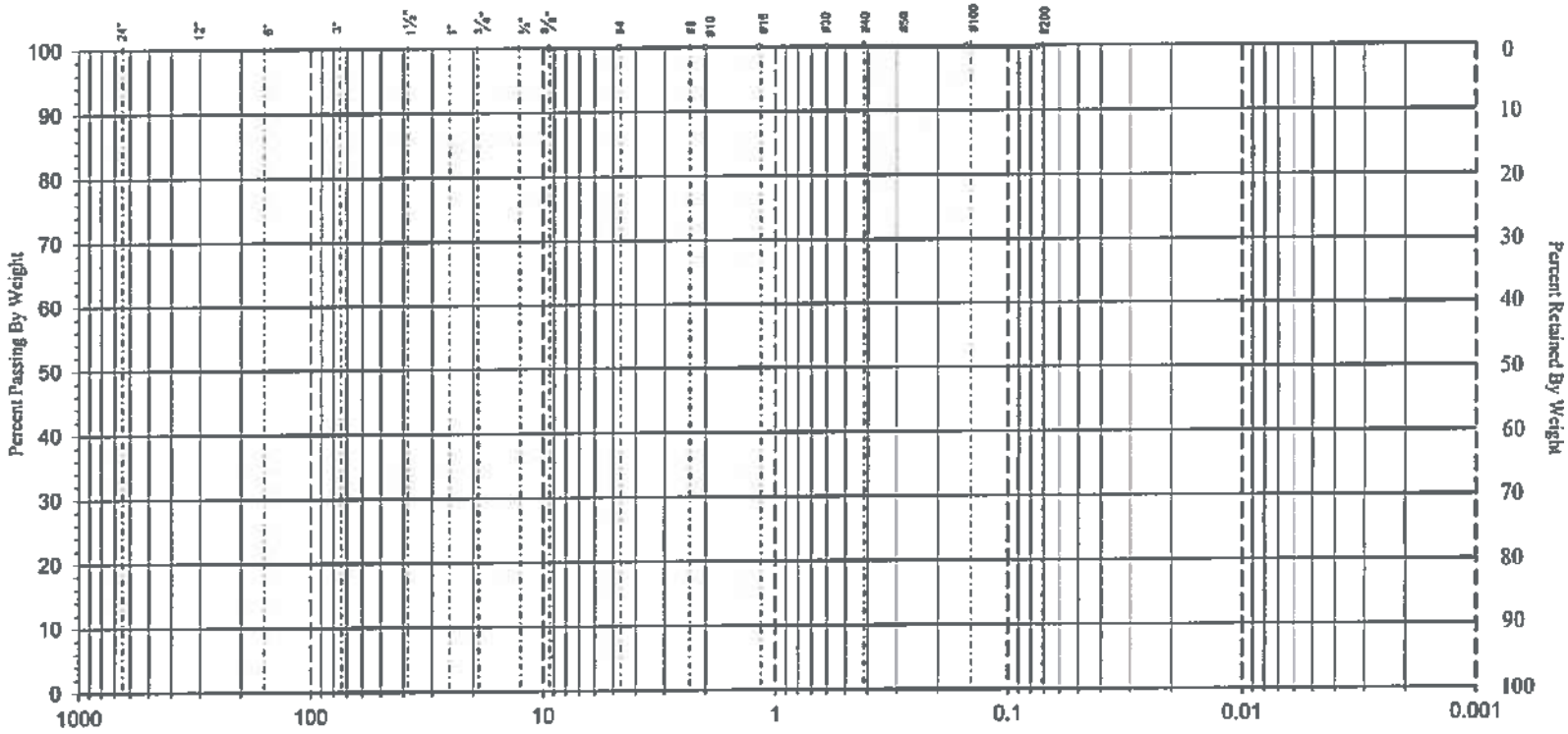
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO AJUNIE	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-03	Sampled Date	-
Sample.	U05-01	Test Started	May 9, 2025
Sample Depth (m)	13.50-14.00	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.00 %		Sand = 0.22 %			Silt + Clay = 99.78 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	100.00	100.00	100.00	100.00	100.00	99.91	99.78	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

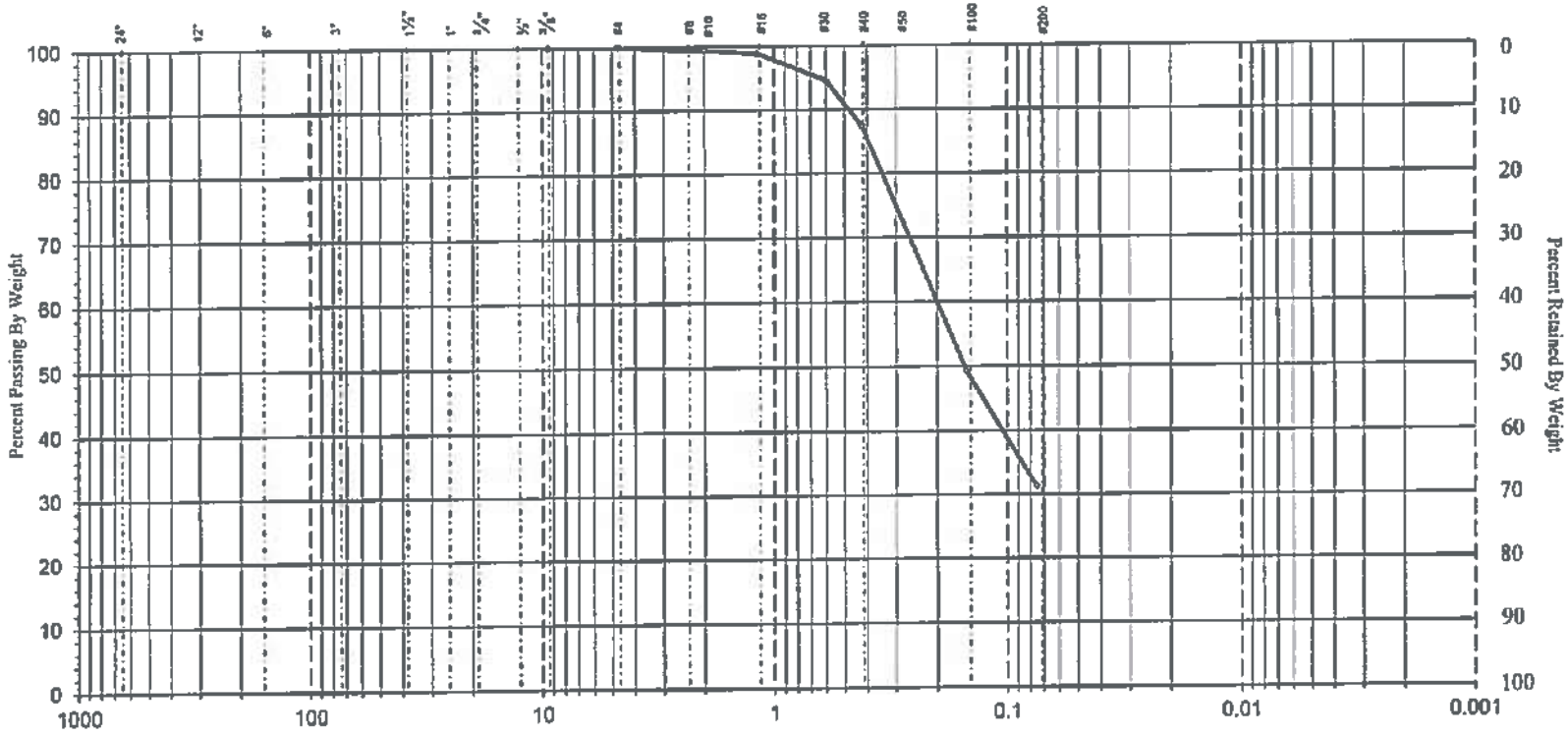
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-01	Sampled Date	-
Sample.	SPT-24	Test Started	May 9, 2025
Sample Depth (m)	24.00-24.45	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.00 %		Sand = 68.73 %			Silt + Clay = 31.27 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	100.00	99.40	98.92	94.65	87.43	49.31	31.27	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

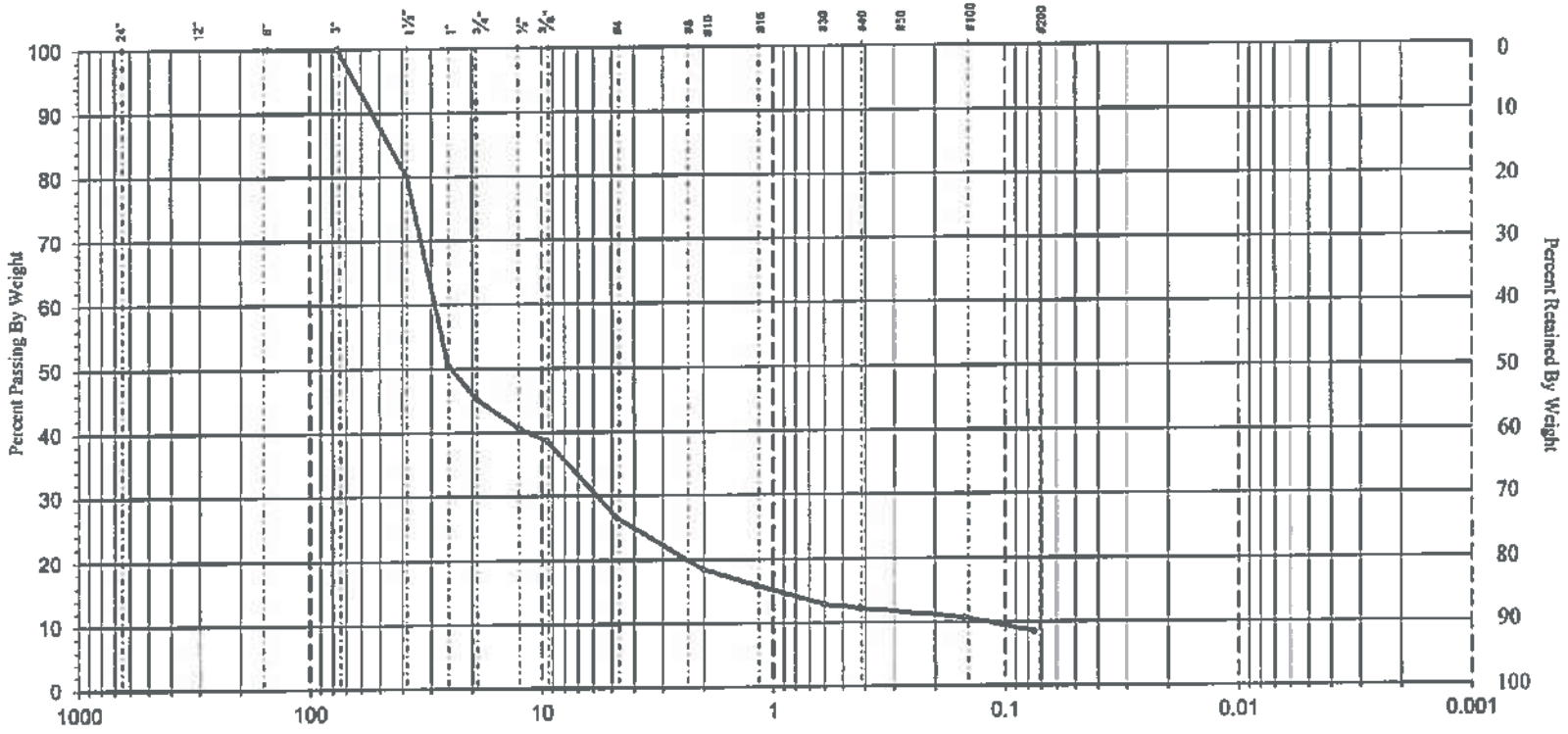
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-02	Sampled Date	-
Sample.	SPT-01	Test Started	May 9, 2025
Sample Depth (m)	1.00-1.45	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 73.45 %		Sand = 18.09 %			Silt + Clay = 8.46 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	80.03	50.52	45.23	40.59	38.66	26.55	18.41	15.84	12.92	12.31	10.74	8.46	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

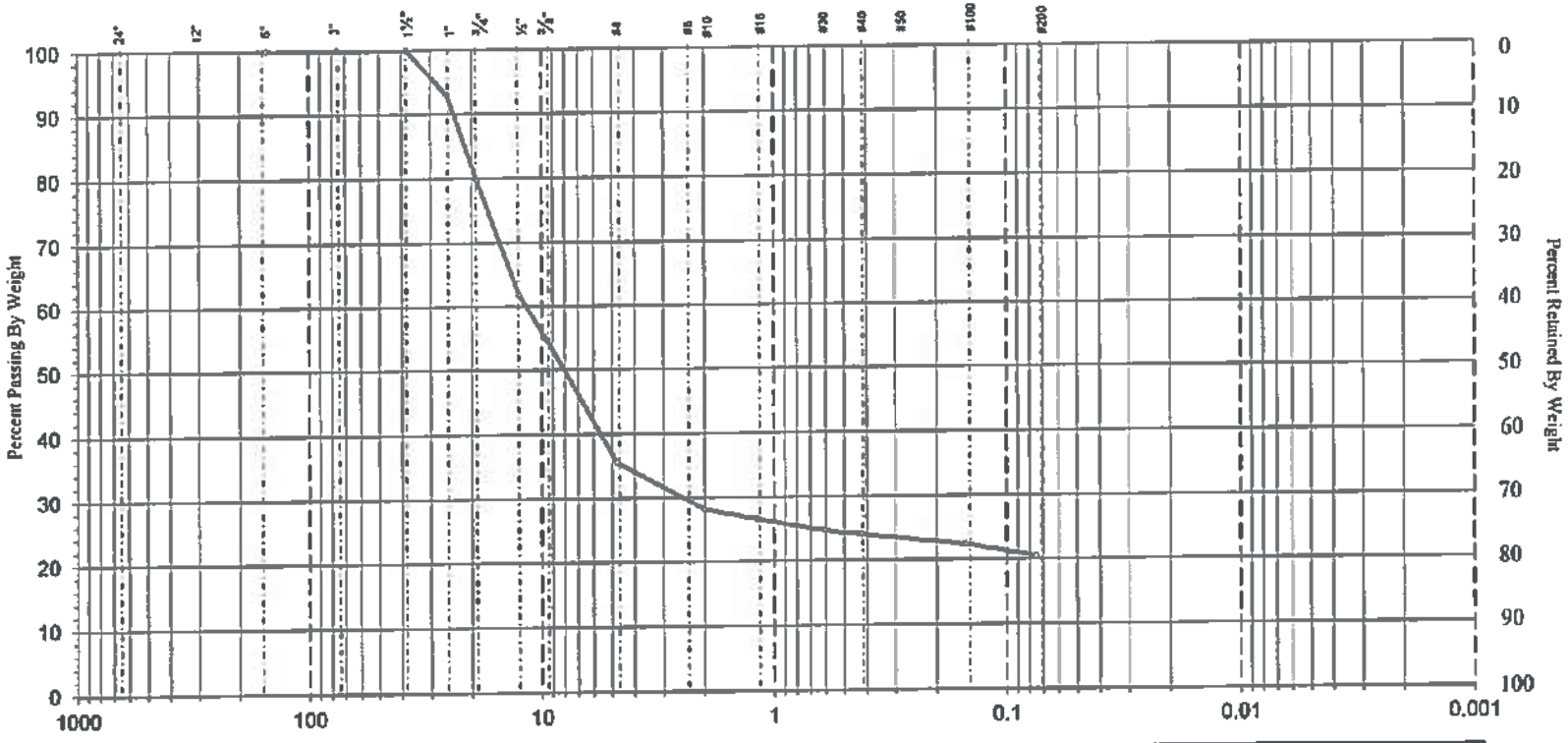
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS BEAM FROM RAWALPINDI TO AJMIRET	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-02	Sampled Date	-
Sample.	SPT-04	Test Started	May 9, 2025
Sample Depth (m)	4.00-4.45	Test Completed	May 31, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 64.48 %		Sand = 15.06 %			Silt + Clay = 20.46 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	100.00	92.90	79.78	61.75	54.64	35.52	28.16	26.54	24.70	24.05	22.36	20.46	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

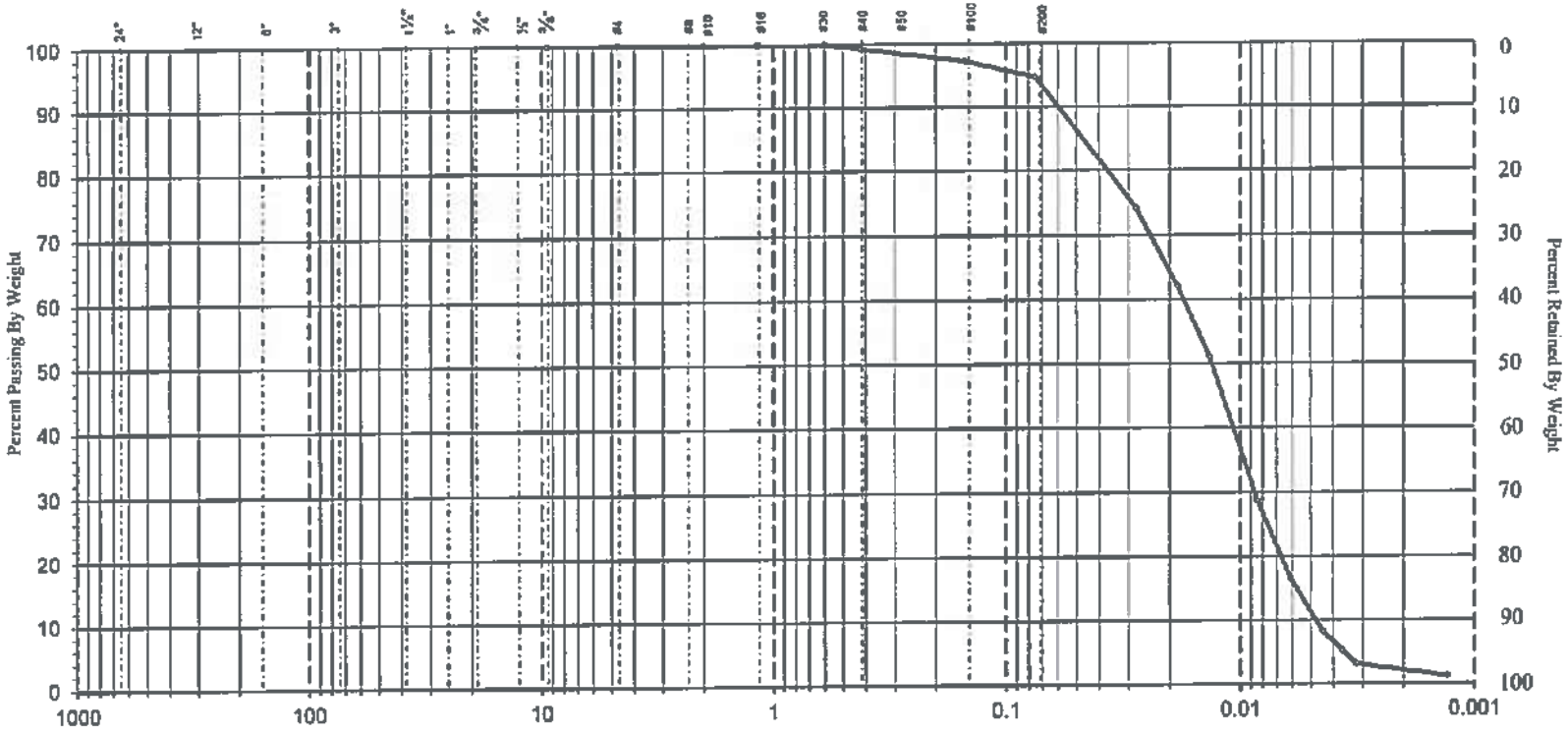
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE 1: GEOTECHNICAL INVESTIGATION FOR ROADWAS, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-02	Sampled Date	-
Sample.	UDS-01	Test Started	May 9, 2025
Sample Depth (m)	6.50-7.00	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.00 %		Sand = 5.21 %			Silt = 83.44 %	Clay 11.35 %
		Coarse	Fine	Coarse	Medium	Fine		

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	100.00	100.00	100.00	100.00	99.32	97.33	94.79	86.38	36.78	11.35	2.11

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

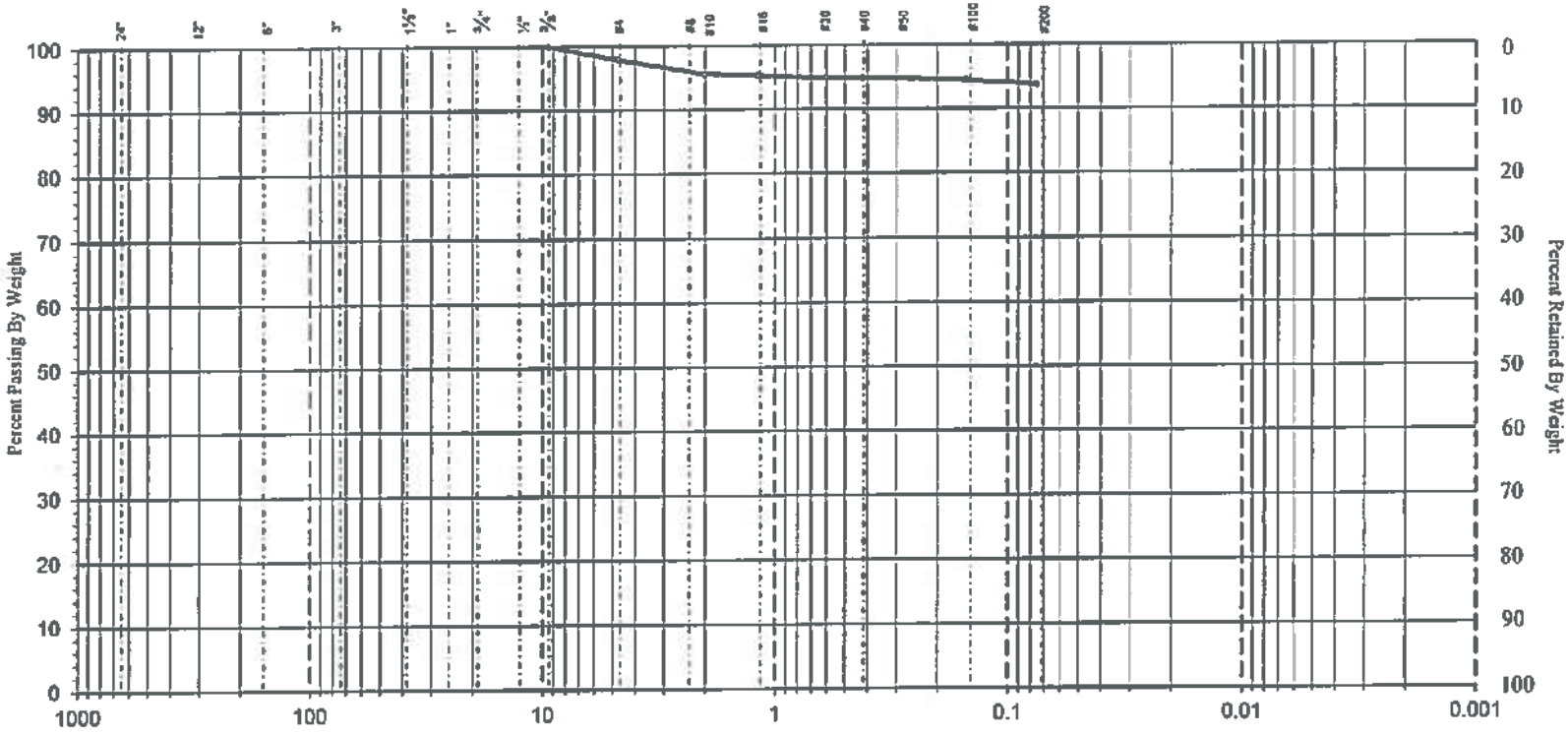
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS WAGH FROM BANJAPINDI TO MURREE	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-02	Sampled Date	-
Sample.	UDS-03	Test Started	May 9, 2025
Sample Depth (m)	22.50-22.90	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 2.09 %		Sand = 4.19 %			Silt + Clay = 93.72 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	97.91	95.54	95.30	94.96	94.85	94.50	93.72	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

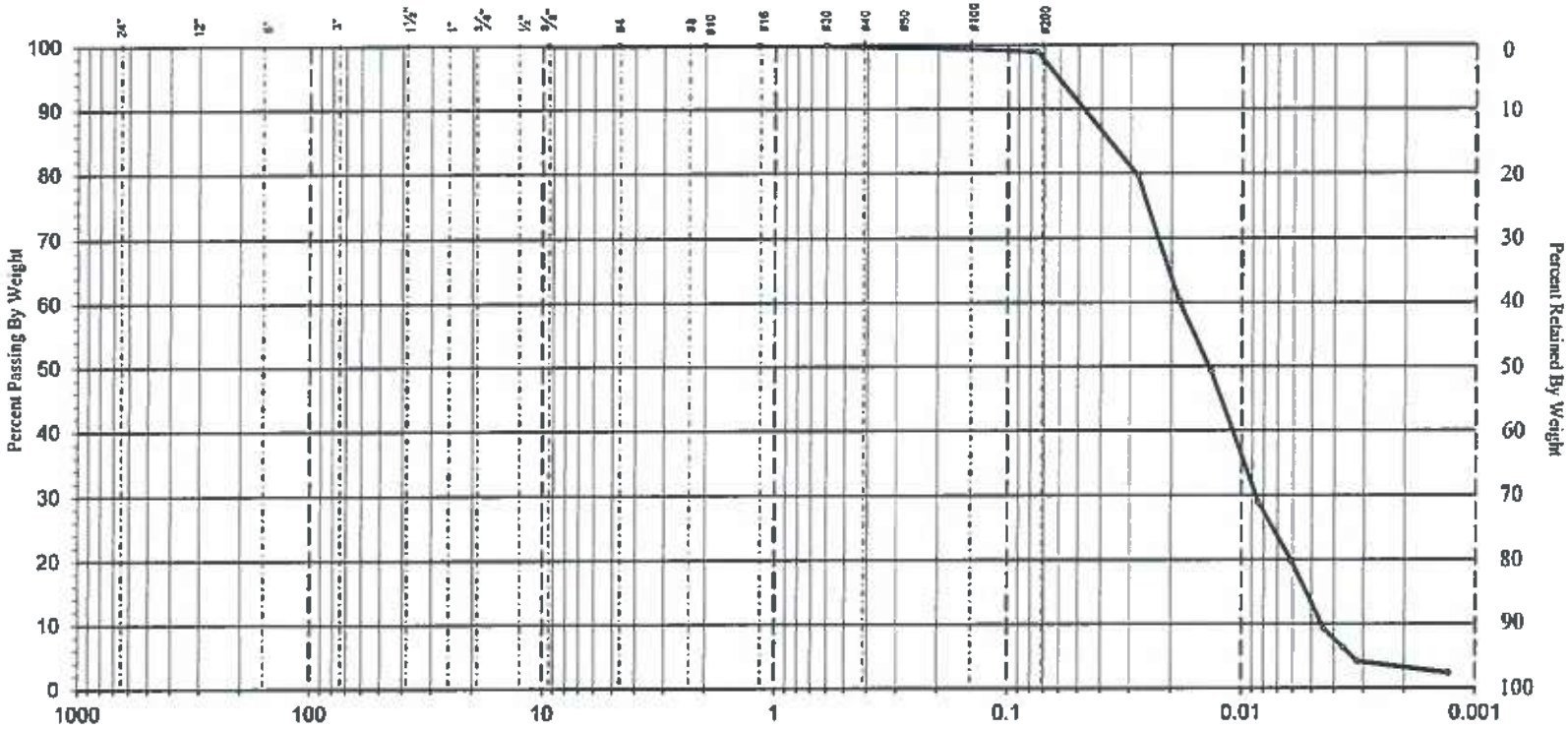
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-03	Sampled Date	-
Sample.	UDS-01	Test Started	May 9, 2025
Sample Depth (m)	2.50-3.00	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.00 %		Sand = 1.08 %			Silt = 85.71 %	Clay 13.21 %
		Coarse	Fine	Coarse	Medium	Fine		

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	100.00	100.00	100.00	99.94	99.69	99.41	98.92	91.02	36.23	13.21	3.15

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

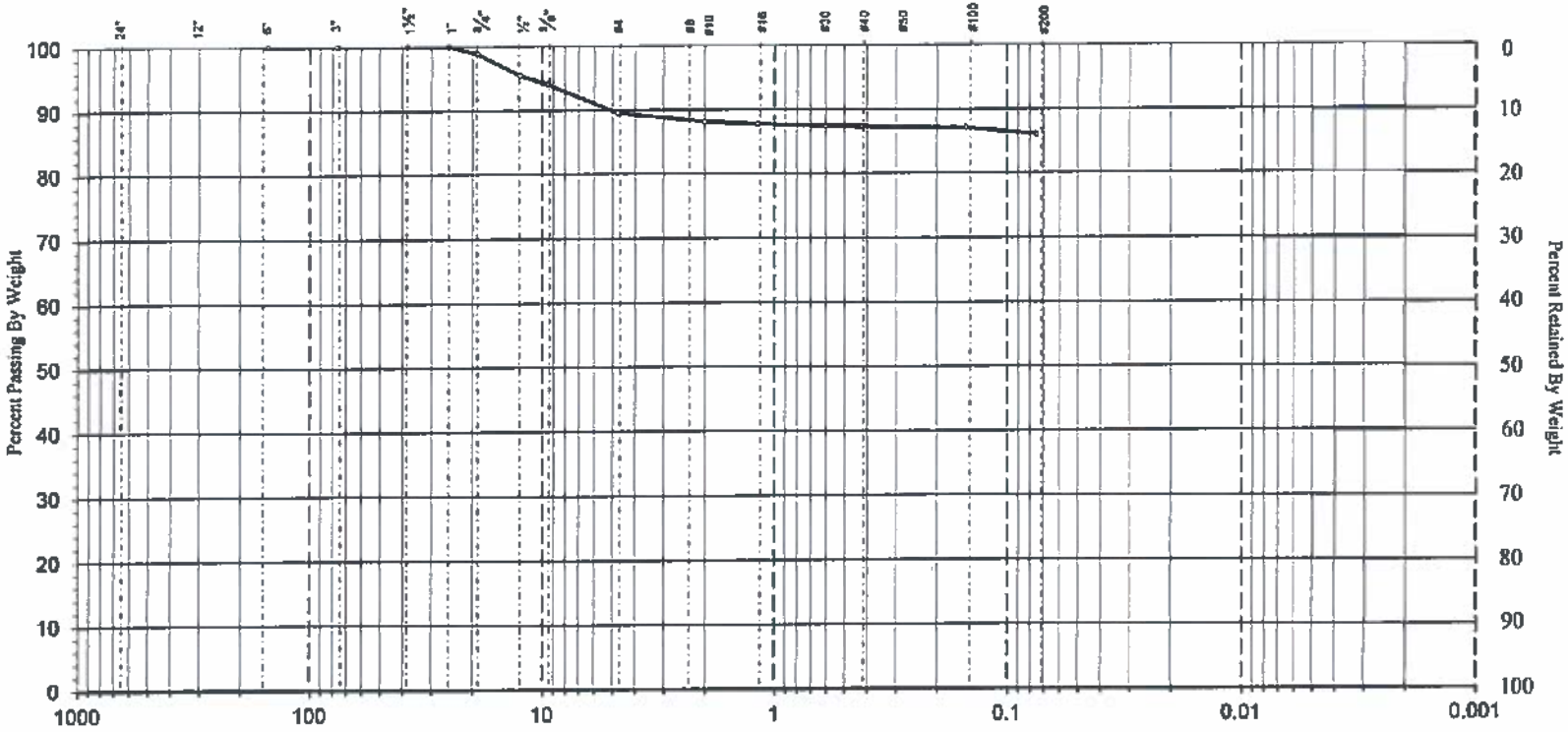
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST CLASS TRAIN / NOM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE II : GEOTECHNICAL INVESTIGATION FOR RAILWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-03	Sampled Date	-
Sample.	SPT-08	Test Started	May 9, 2025
Sample Depth (m)	8.00-8.45	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 10.39 %		Sand = 3.54 %			Silt + Clay = 86.07 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	100.00	100.00	98.88	95.51	94.10	89.61	88.18	87.77	87.41	87.30	87.06	86.07	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

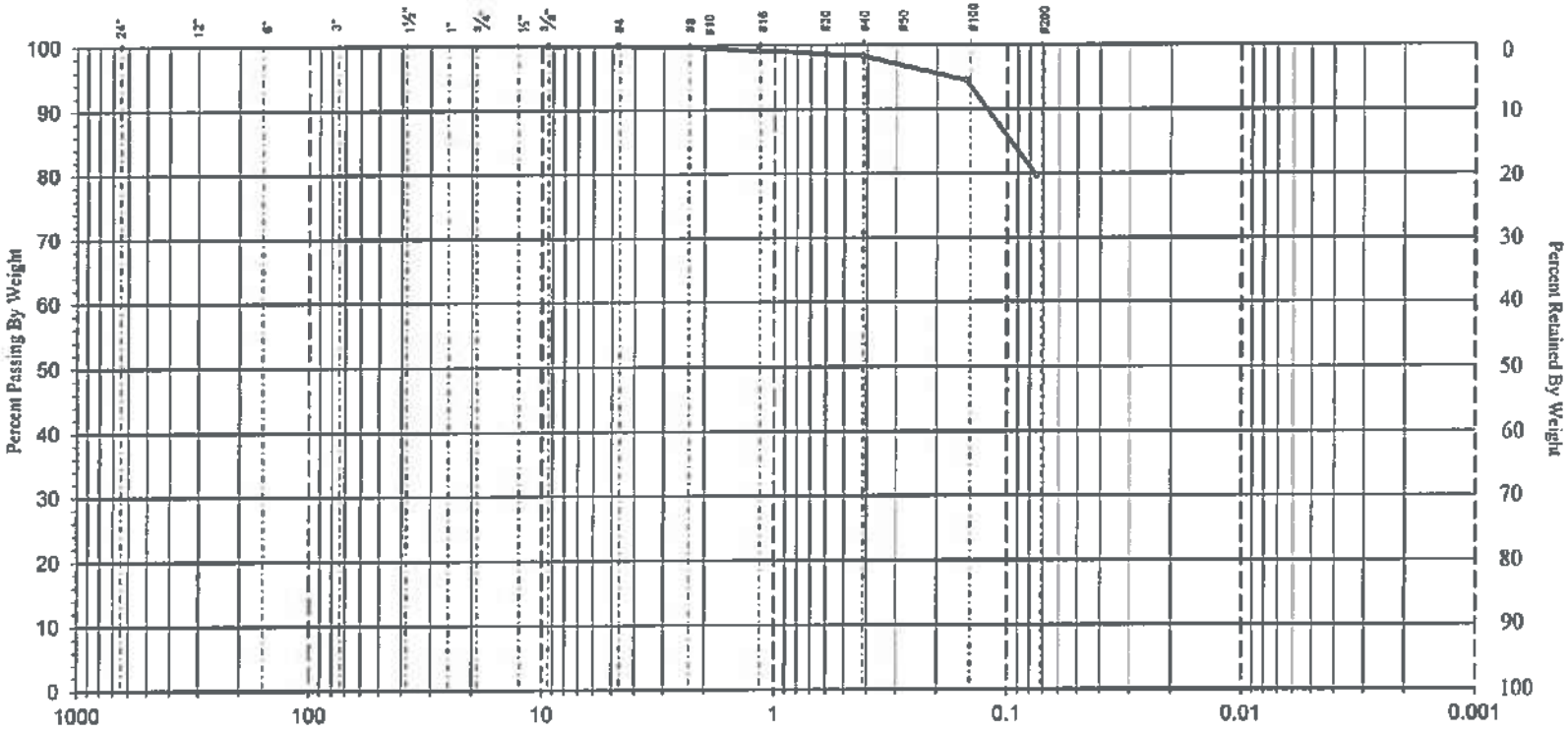
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE II: GEOTECHNICAL INVESTIGATION FOR RAILWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-03	Sampled Date	-
Sample.	SPT-10	Test Started	May 9, 2025
Sample Depth (m)	10.00-10.45	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.00 %		Sand = 20.32 %			Silt + Clay = 79.68 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	100.00	99.59	99.18	98.65	98.32	94.51	79.68	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

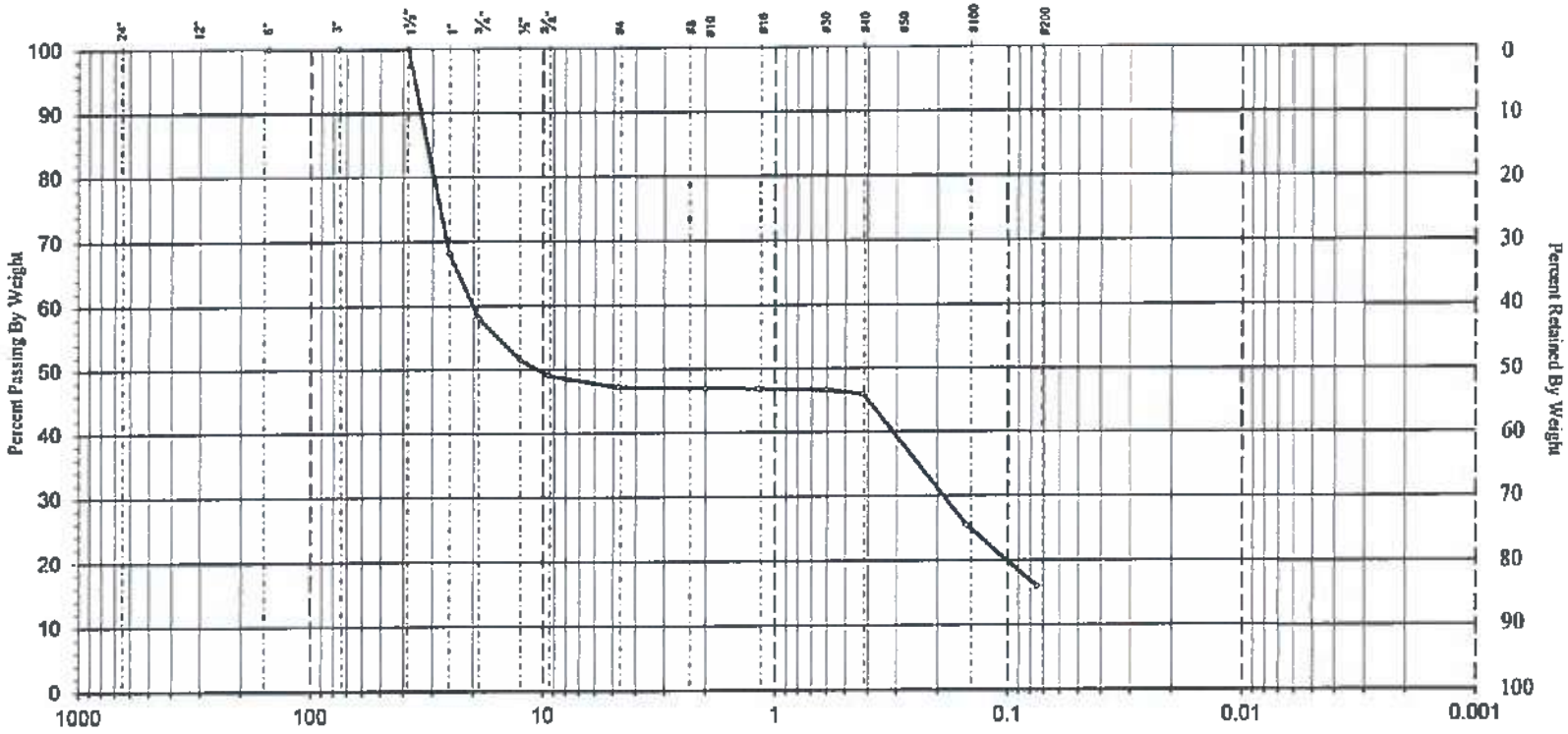
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM NAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-03	Sampled Date	-
Sample.	DS-02	Test Started	May 9, 2025
Sample Depth (m)	18.00-19.00	Test Completed	May 11, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 52.88 %		Sand = 31.12 %			Silt + Clay = 16.00 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	100.00	68.27	58.17	51.44	49.04	47.12	46.92	46.83	46.60	45.97	25.40	16.00	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

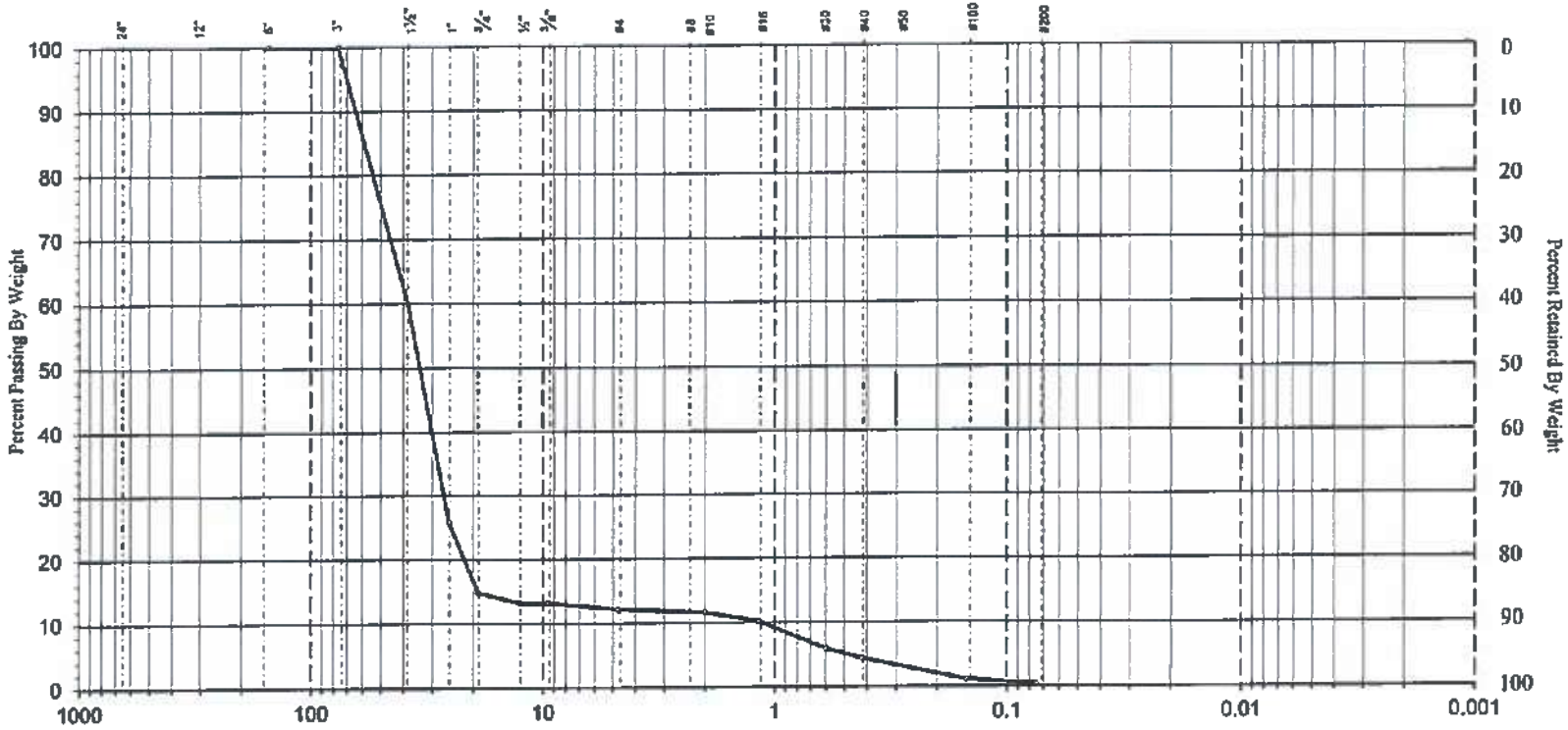
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	Job No.	-
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	Lab No.	1003
BH / TP No.	BH-03	Sampled Date	-
Sample.	DS-07	Test Started	May 9, 2025
Sample Depth (m)	23.00-24.00	Test Completed	May 11, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 87.89 %		Sand = 11.74 %			Silt + Clay = 0.37 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	60.00	25.79	14.74	13.16	13.16	12.11	11.63	10.24	5.89	4.37	1.15	0.37	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

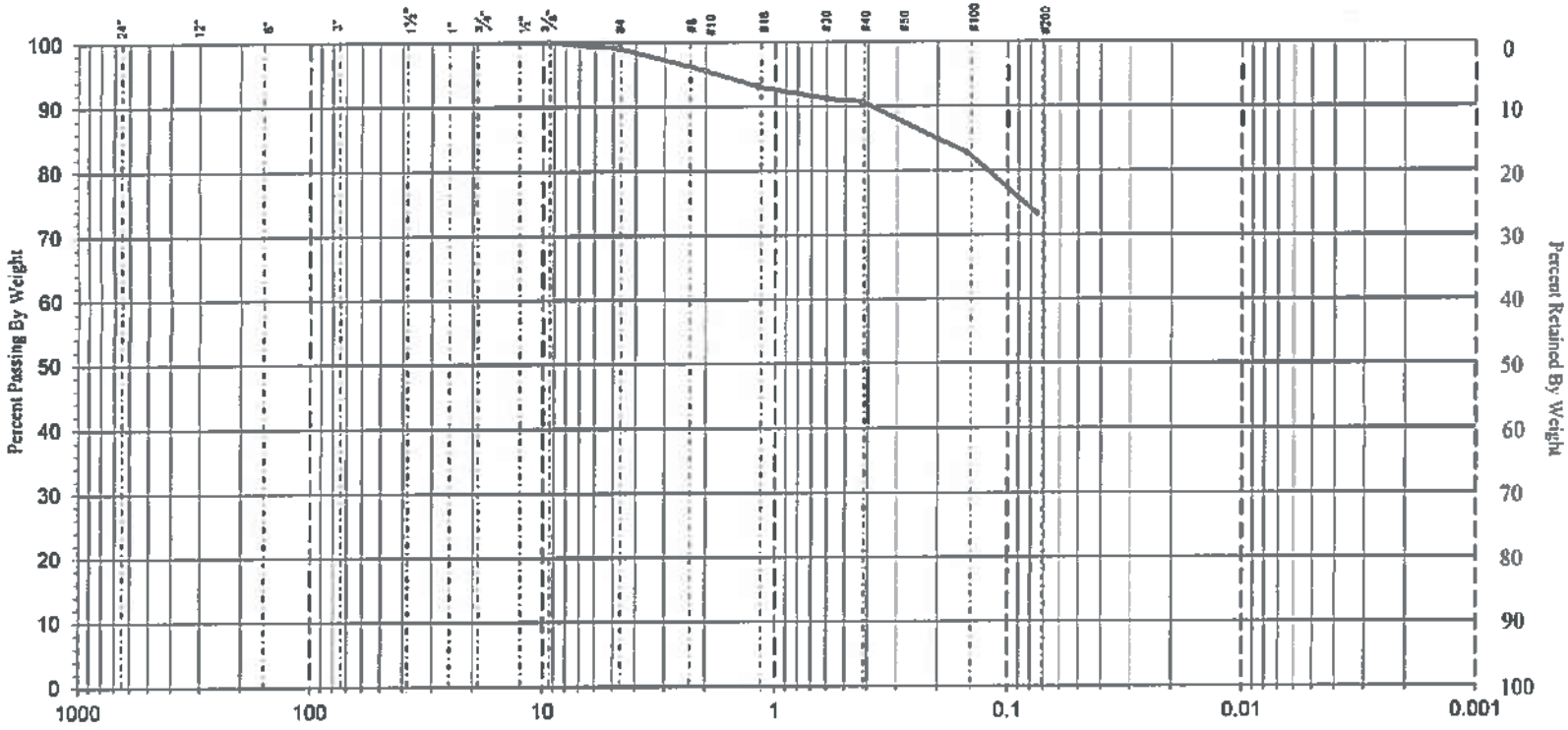
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
	NESPAK	M/s Driller,Lahore

Project	Feasibility Study for Tourist Glass Train PKG4:	Job No.	-
Location	Rawalpindi to Murree.	Lab No.	989
BH / TP No.	BH-08	Sampled Date	-
Sample.	SPT-01	Test Started	March 22, 2025
Sample Depth (m)	1.00-1.45	Test Completed	March 24, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.91 %		Sand = 25.77 %			Silt + Clay = 73.32 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	99.09	95.57	93.06	91.22	90.64	82.89	73.32	-	-	-	-

Tested By	Yasir Arif	Checked By	-	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

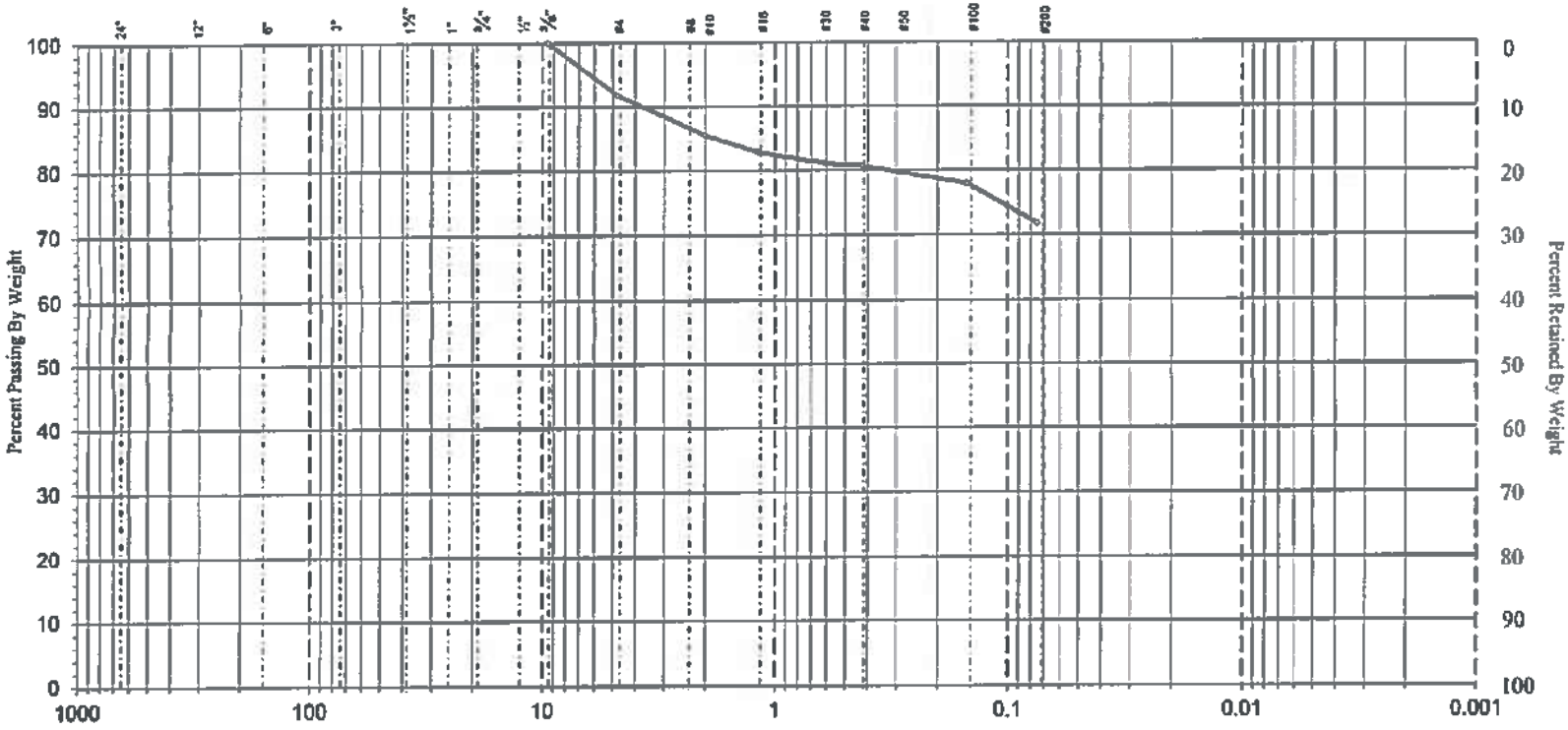
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
	NESPAK	M/s Driller, Lahore

Project	Feasibility Study for Tourist Glass Train PKG4:	Job No.	-
Location	Rawalpindi to Murree.	Lab No.	989
BH / TP No.	BH-09	Sampled Date	-
Sample.	SPT-01	Test Started	March 22, 2025
Sample Depth (m)	1.00-1.45	Test Completed	March 24, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 8.21 %		Sand = 20.04 %			Silt + Clay = 71.75 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	91.79	85.59	82.86	81.05	80.63	77.99	71.75	-	-	-	-

Tested By	Yasir Arif	Checked By	-	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

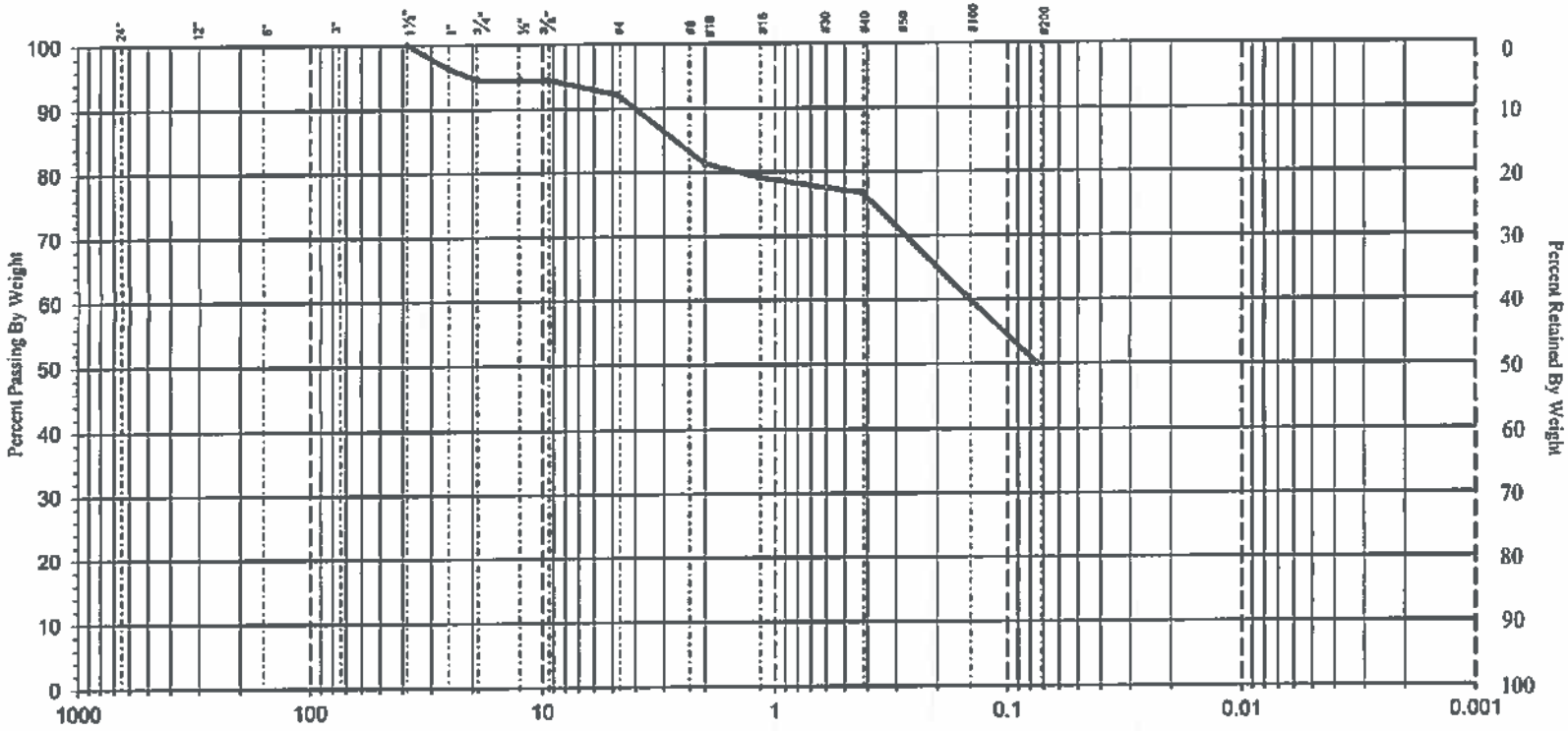
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
	NESPAK	M/s Driller,Lahore

Project	Feasibility Study for Tourist Glass Train PKG4:	Job No.	-
Location	Rawalpindi to Murree.	Lab No.	989
BH / TP No.	BH-10	Sampled Date	-
Sample.	SPT-02	Test Started	April 8, 2025
Sample Depth (m)	2.00-2.45	Test Completed	April 10, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 7.80 %		Sand = 42.09 %			Silt + Clay = 50.11 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	100.00	96.31	94.61	94.61	94.61	92.20	81.32	79.18	77.56	76.69	60.51	50.11	-	-	-	-

Tested By	Yasir Arif	Checked By	Noman Maqbool	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

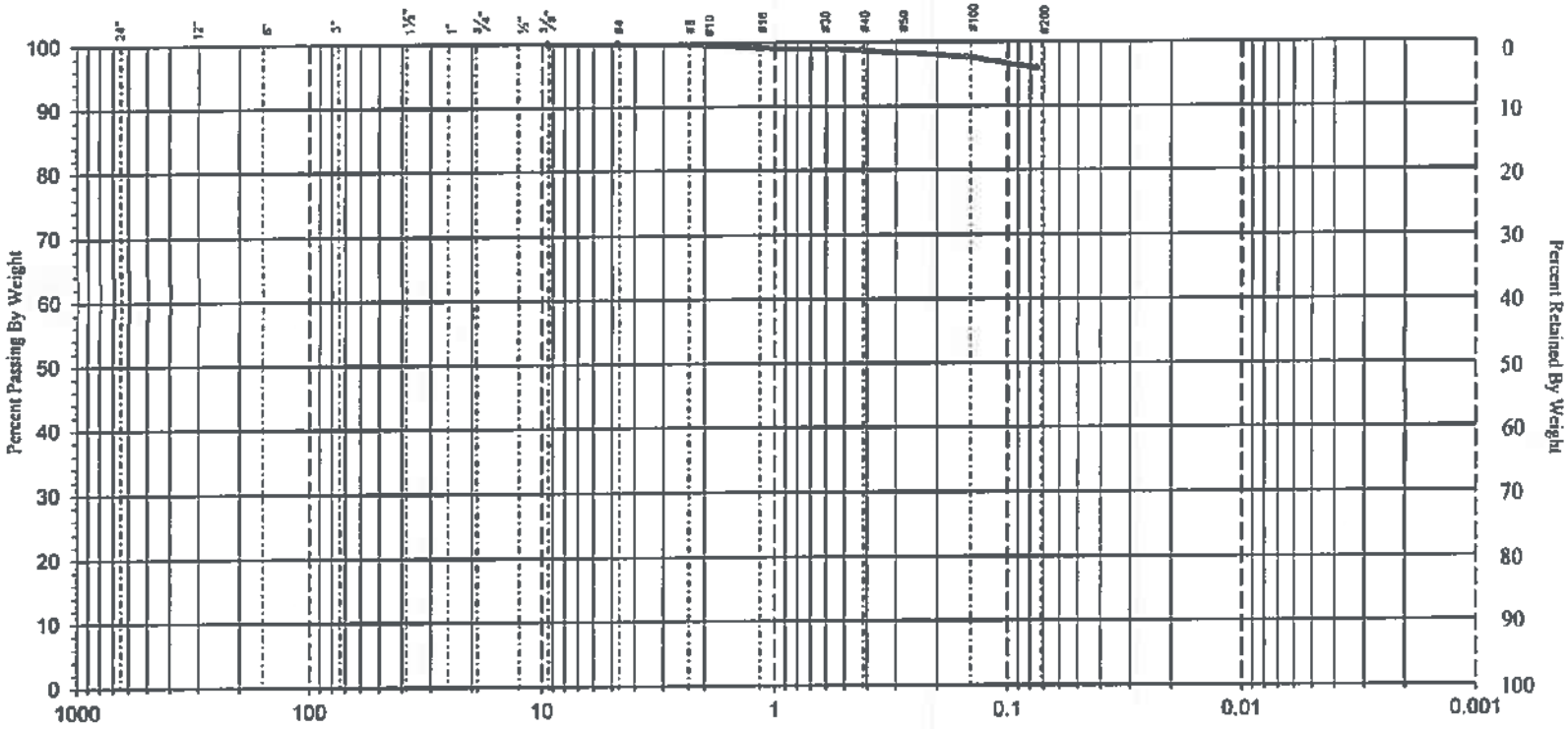
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
	NESPAK	M/s Driller,Lahore

Project	Feasibility Study for Tourist Glass Train PKG4:	Job No.	-
Location	Rawalpindi to Murree.	Lab No.	989
BH / TP No.	BH-11	Sampled Date	-
Sample.	SPT-01	Test Started	April 8, 2025
Sample Depth (m)	1.00-1.45	Test Completed	April 10, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.00 %		Sand = 4.05 %			Silt + Clay = 95.95 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	100.00	99.66	99.30	99.00	98.81	97.72	95.95	-	-	-	-

Tested By	Yasir Arif	Checked By	Noman Maqbool	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

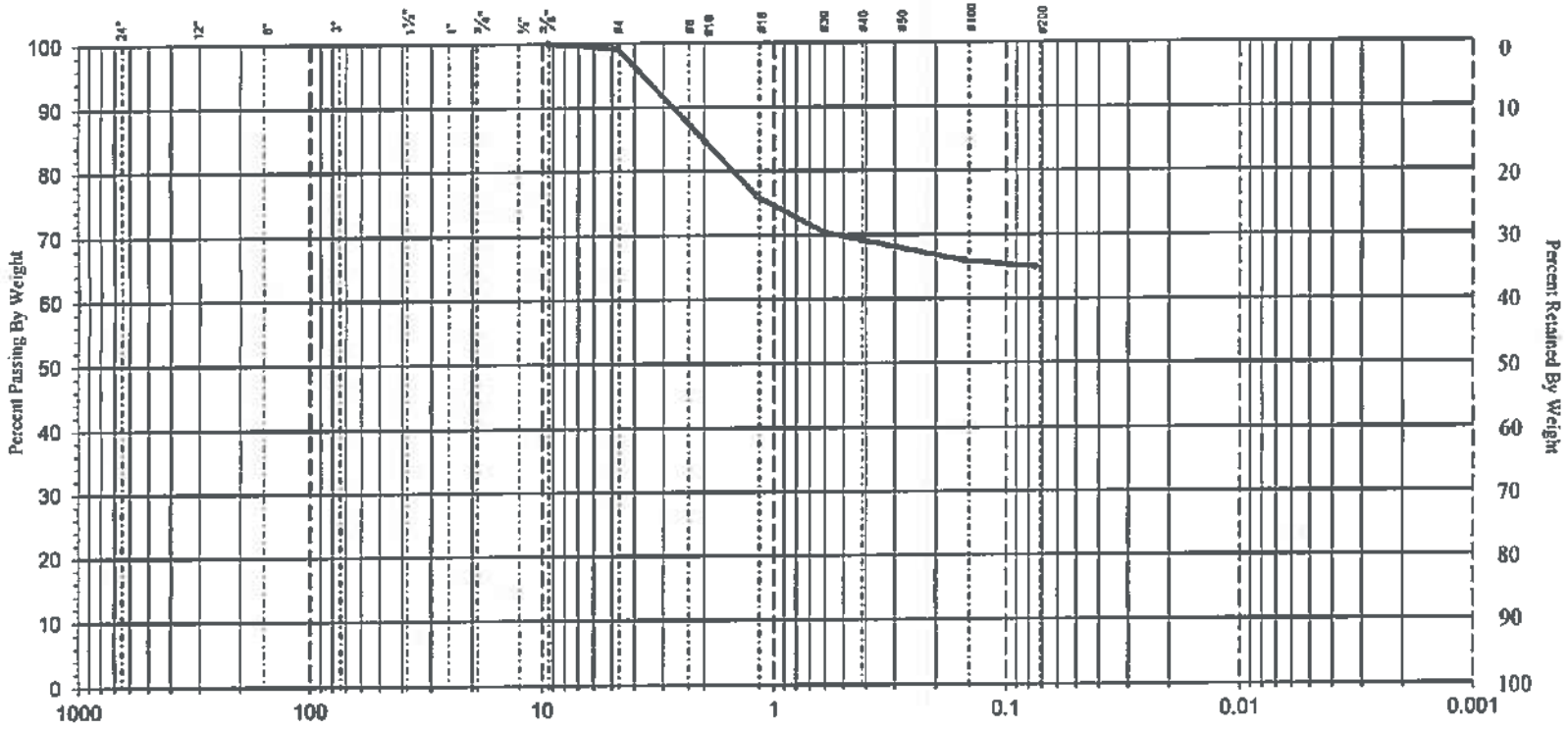
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
	NESPAK	M/s Driller,Lahore

Project	Fesibility Study for Tourist Glass Train PKG4:	Job No.	-
Location	Rawalpindi to Murree.	Lab No.	989
BH / TP No.	BH-12A	Sampled Date	-
Sample.	SPT-02	Test Started	April 8, 2025
Sample Depth (m)	2.00-2.45	Test Completed	April 10, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.81 %		Sand = 34.27 %			Silt + Clay = 64.92 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	99.19	84.79	75.96	70.37	69.19	65.91	64.92	-	-	-	-

Tested By	Yasir Arif	Checked By	Noman Maqbool	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

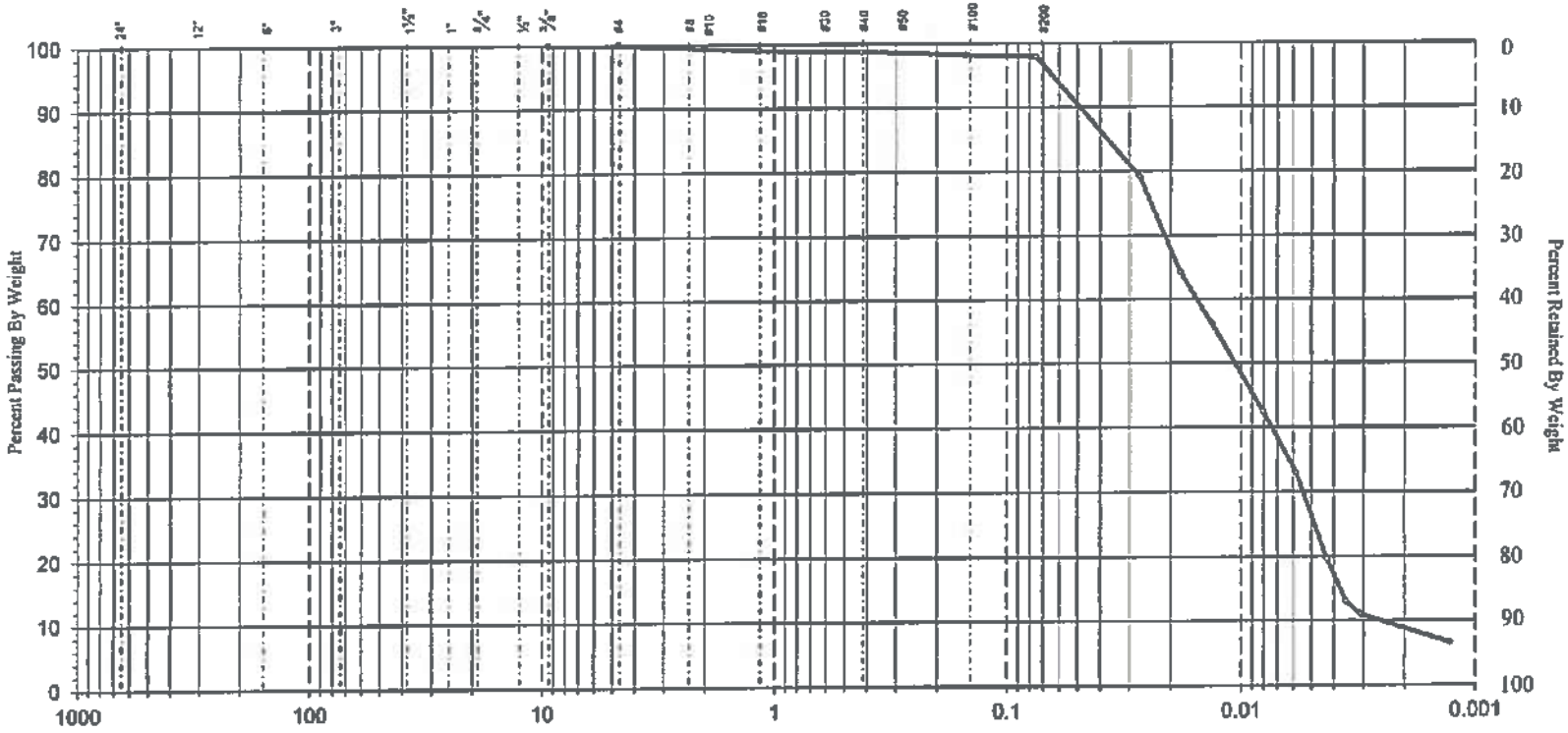
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to	Job No.	-
Location	Mansar Package 5 : Geotechnical Investigation for Trackway, Stations, and Structures	Lab No.	1006
BH / TP No.	BH-17	Sampled Date	-
Sample.	SPT-03	Test Started	May 22, 2025
Sample Depth (m)	3.00-3.45	Test Completed	May 23, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 0.00 %		Sand = 2.09 %			Silt = 71.65 %	Clay 26.26 %
		Coarse	Fine	Coarse	Medium	Fine		

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	100.00	99.40	99.11	98.87	98.77	98.28	97.91	90.46	48.32	26.26	8.81

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

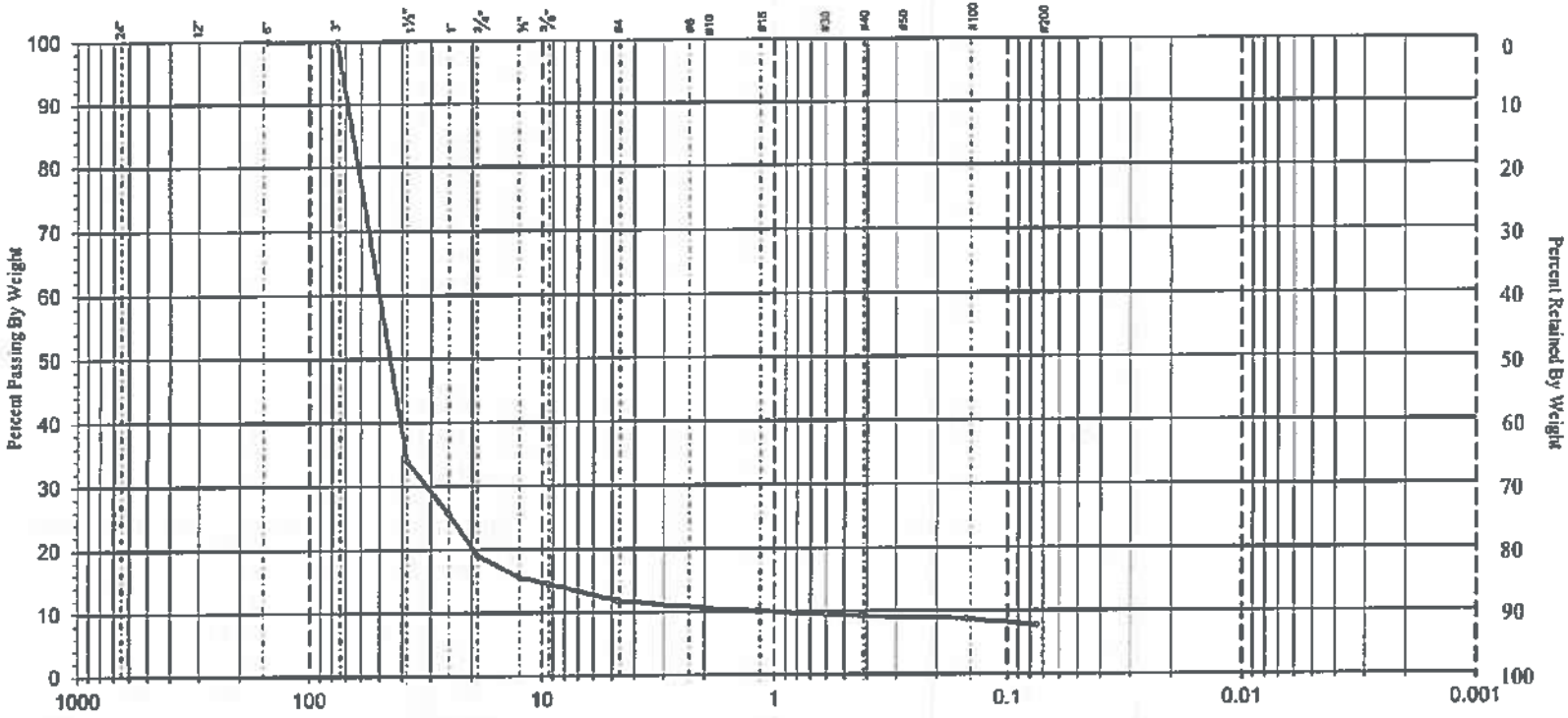
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to	Job No.	-
Location	Murree Package 5: Geotechnical Investigation for Trackway, Stations, and Structures	Lab No.	1006
BH / TP No.	BH-18	Sampled Date	-
Sample.	DS-01	Test Started	May 9, 2025
Sample Depth (m)	1.00-2.00	Test Completed	May 12, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 68.17 %		Sand = 4.13 %			Silt + Clay = 7.70 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	33.94	25.75	19.32	15.60	14.56	11.83	10.61	10.08	9.50	9.26	8.70	7.70	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

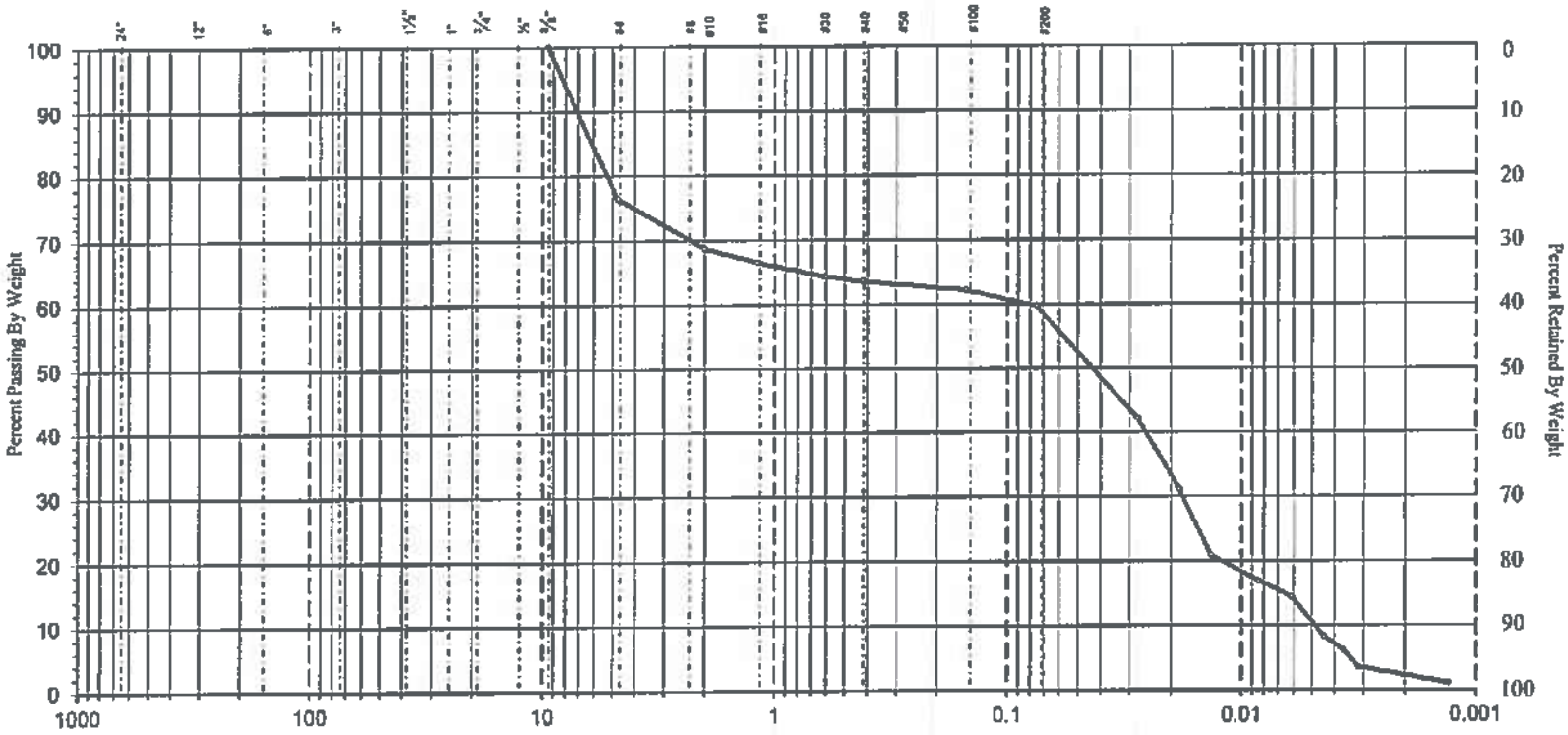
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to	Job No.	-
Location	Murree Package 5 : Geotechnical Investigation for Trackway, Stations, and Structures	Lab No.	1006
BH / TP No.	BH-18	Sampled Date	-
Sample.	SPT-04	Test Started	May 9, 2025
Sample Depth (m)	5.00-5.45	Test Completed	May 12, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 23.51 %		Sand = 16.78 %			Silt = 49.17 %	Clay 10.54 %
		Coarse	Fine	Coarse	Medium	Fine		

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	76.49	68.73	66.59	64.39	63.66	62.20	59.73	52.52	38.34	10.54	2.24

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

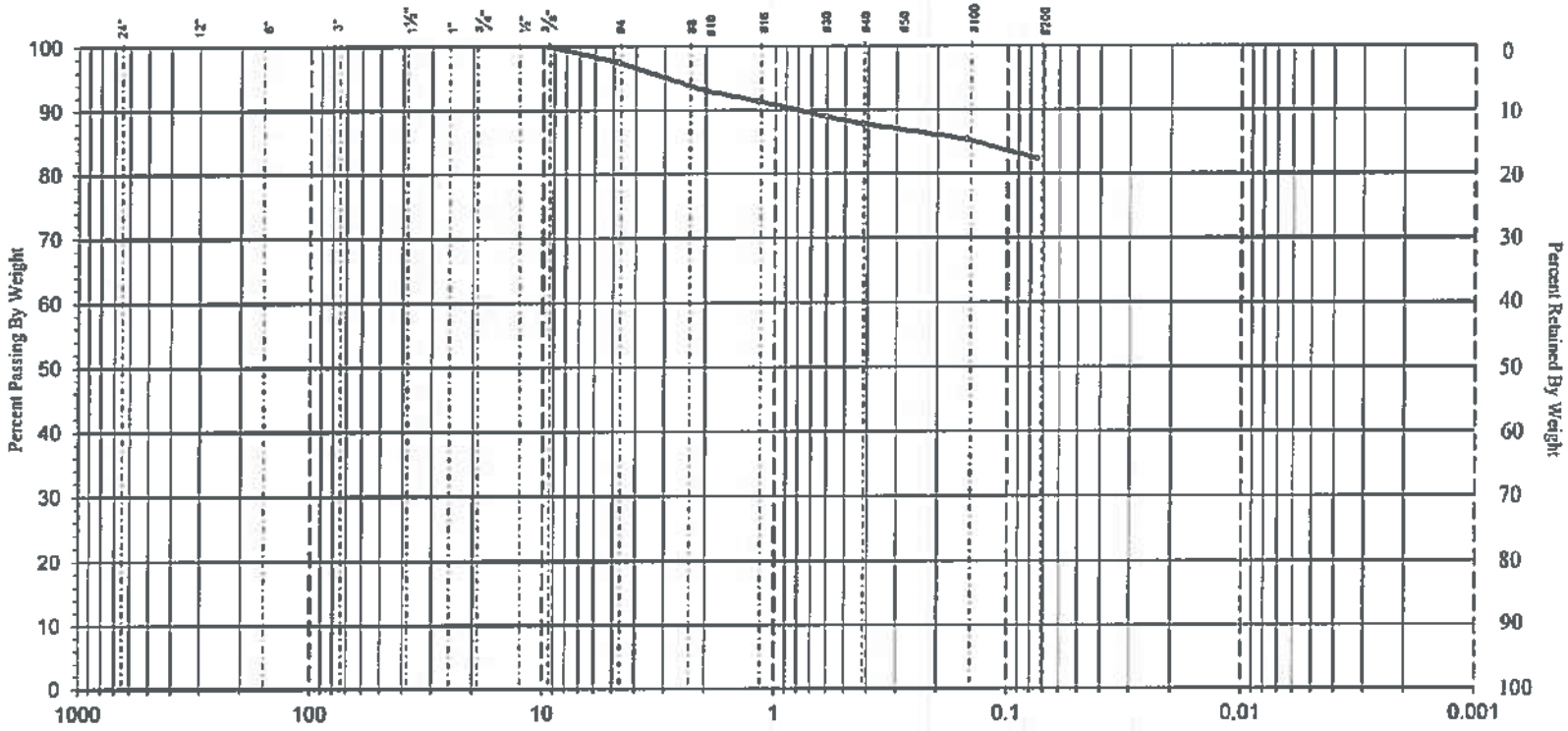
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to	Job No.	-
Location	Murree Package 5: Geotechnical Investigation for Trackway, Stations, and Structures	Lab No.	1006
BH / TP No.	BH-18	Sampled Date	-
Sample.	SPT-06	Test Started	May 9, 2025
Sample Depth (m)	7.00-7.45	Test Completed	May 12, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 2.48 %		Sand = 15.16 %			Silt + Clay = 82.36 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	# 4	# 10	# 16	# 30	# 40	# 100	# 200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	-	-	-	-	-	-	100.00	97.52	93.09	91.42	88.98	87.86	83.47	82.36	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

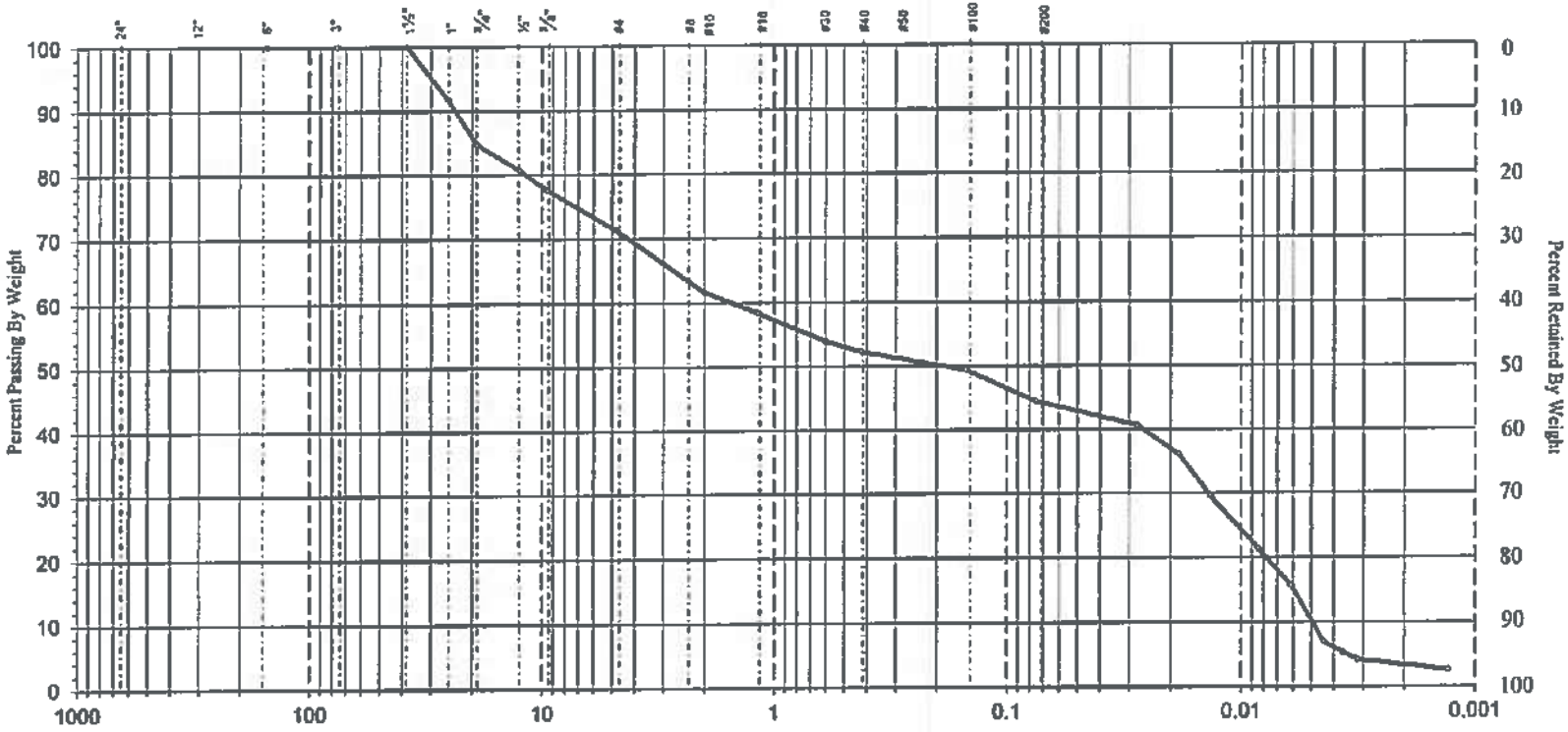
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to	Job No.	-
Location	Murree Package 5 : Geotechnical Investigation for Trackway, Stations, and Structures	Lab No.	1006
BH / TP No.	BH-19	Sampled Date	-
Sample.	SPT-01	Test Started	May 9, 2025
Sample Depth (m)	1.00-1.45	Test Completed	May 12, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 28.75 %		Sand = 26.78 %			Silt = 34.28 %	Clay 10.19 %
		Coarse	Fine	Coarse	Medium	Fine		

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	100.00	91.86	84.73	80.66	77.61	71.25	61.65	58.45	53.96	52.34	49.41	44.47	42.91	24.30	10.19	3.31

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

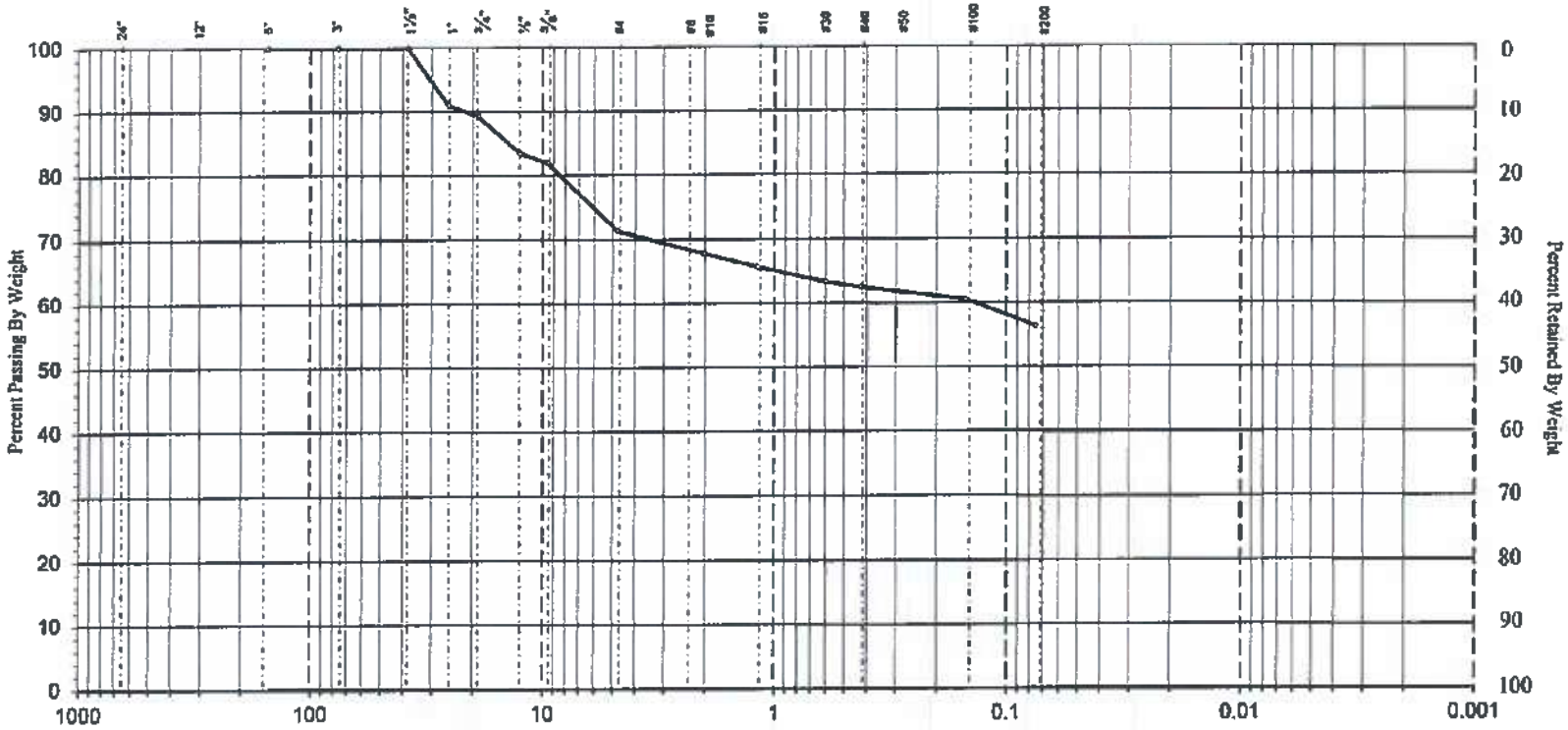
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to	Job No.	-
Location	Murree Package 5: Geotechnical Investigation for Trackway, Stations, and Structures	Lab No.	1005
BH / TP No.	BH-19	Sampled Date	-
Sample.	DS-03	Test Started	May 9, 2025
Sample Depth (m)	7.40-8.00	Test Completed	May 12, 2025

decon
Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 28.70 %		Sand = 14.95 %			Silt + Clay = 56.35 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#15	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	100.00	98.98	89.26	83.39	81.82	71.30	67.72	65.65	63.30	62.45	60.50	56.35	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

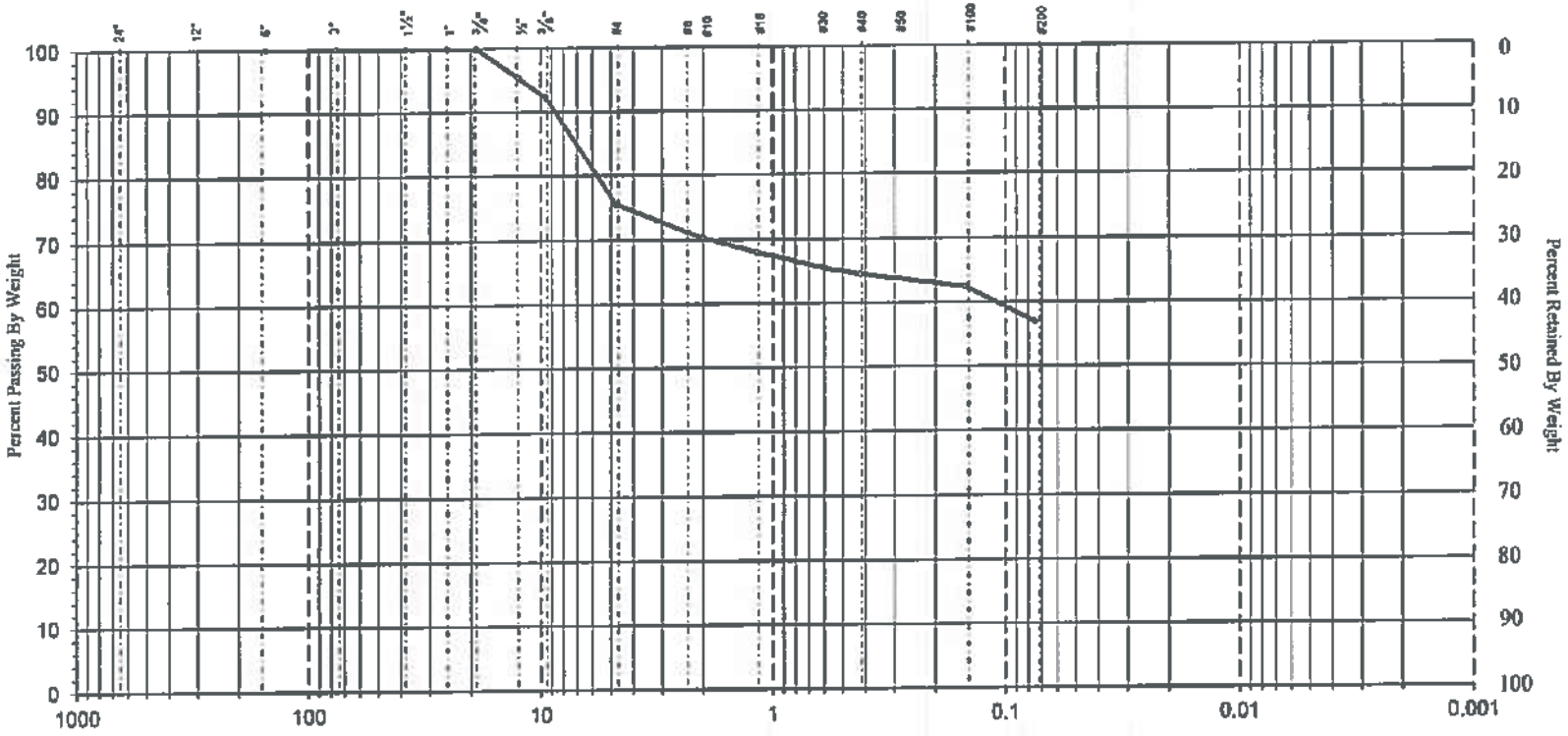
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to	Job No.	-
Location	Murree Package 5: Geotechnical Investigation for Trackway, Stations, and Structures	Lab No.	1006
BH / TP No.	BH-19	Sampled Date	-
Sample.	SPT-09	Test Started	May 9, 2025
Sample Depth (m)	11.00-11.45	Test Completed	May 12, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 24.43 %		Sand = 18.66 %			Silt + Clay = 56.91 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	100.00	100.00	100.00	95.43	92.27	75.57	70.29	68.04	65.47	64.55	62.50	56.91	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

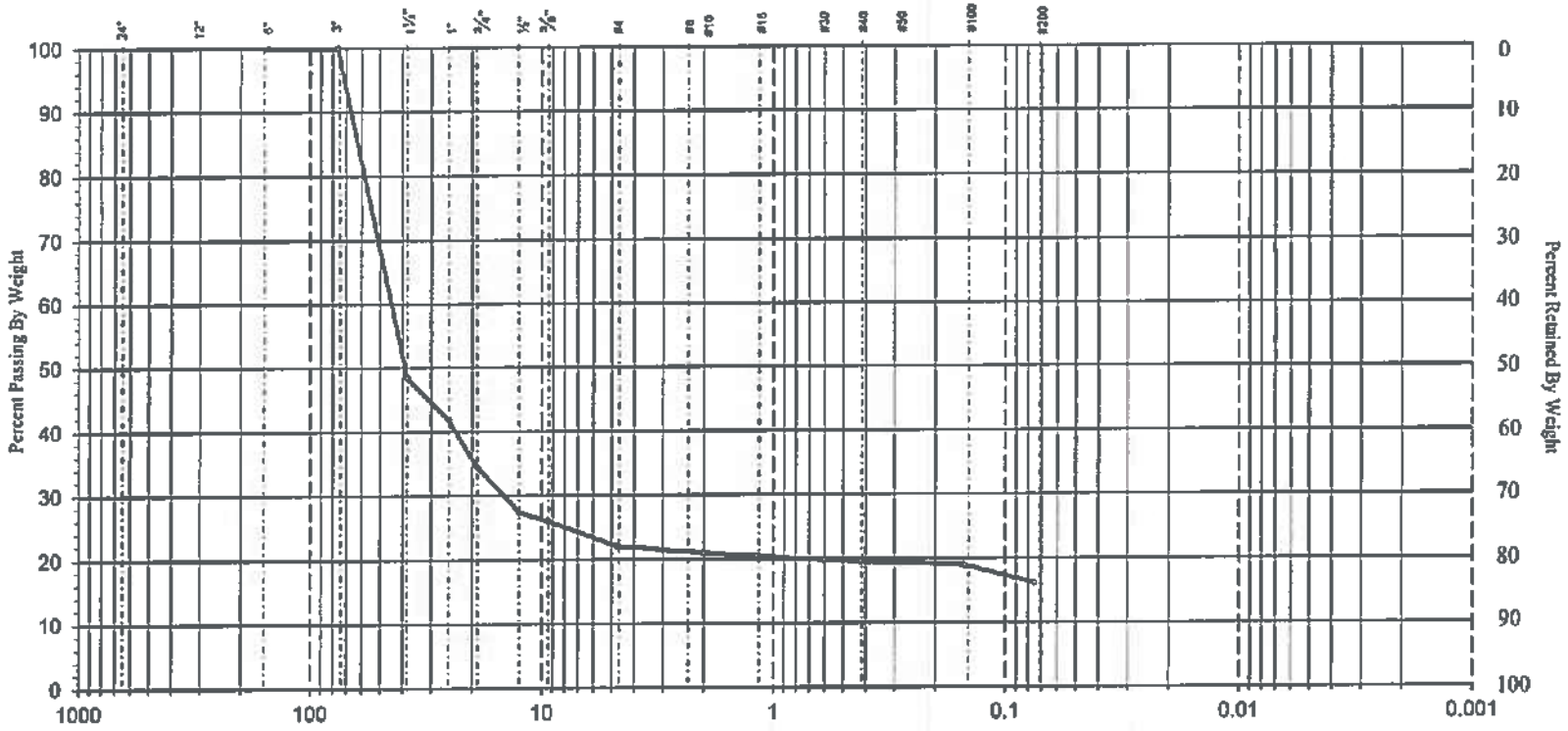
Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to	Job No.	-
Location	Murree Package 5: Geotechnical Investigation for Trackway, Stations, and Structures	Lab No.	1006
BH / TP No.	BH-19	Sampled Date	-
Sample.	DS-06	Test Started	May 9, 2025
Sample Depth (m)	15.00-16.00	Test Completed	May 12, 2025

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Geotechnical Testing Laboratory

GRAIN SIZE ANALYSIS (ASTM D 422)



Boulders	Cobbles	Gravels = 77.97 %		Sand = 5.86 %			Silt + Clay = 16.17 %
		Coarse	Fine	Coarse	Medium	Fine	

Sieve Size	6"	3"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#16	#30	#40	#100	#200	0.05mm	0.01mm	0.005mm	0.002mm
Passing %	100.00	100.00	48.37	41.92	34.41	27.43	26.10	22.03	20.91	20.46	19.83	19.58	18.99	16.17	-	-	-	-

Tested By	Yasir Arif	Checked By	Jawad Nasir	Approved By	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

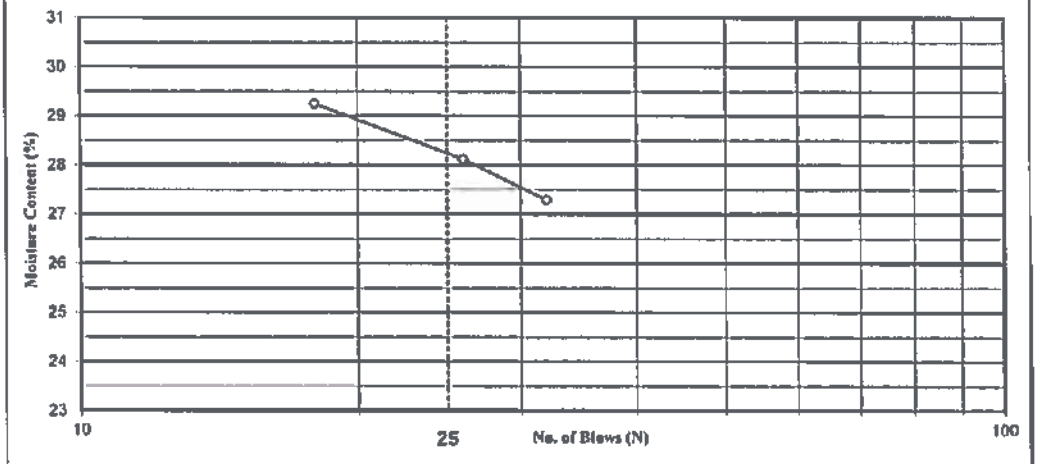
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-01	Job No.	-
Sample No.	SPT-01	Lab No.	1003
Sample Depth (m)	1.00-1.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

	LIQUID LIMIT					PLASTIC LIMIT	
No. of Blows (N)	18	26	32				
Container No.	D-30	D-04	D-19			D-83	D-64
Weight of Container (g)	18.55	17.86	19.38			11.86	11.57
Weight of Container + Wet Soil (g)	31.63	30.16	32.86			16.89	16.09
Weight of Container + Dry Soil (g)	28.67	27.46	29.97			16.01	15.30
Weight of Dry Soil (g)	10.12	9.60	10.59			4.15	3.73
Weight of Water (g)	2.96	2.70	2.89			0.88	0.79
Moisture Content (%)	29.25	28.13	27.29			21.20	21.18

Liquid Limit	28	Plastic Limit	21	Plasticity Index	7



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

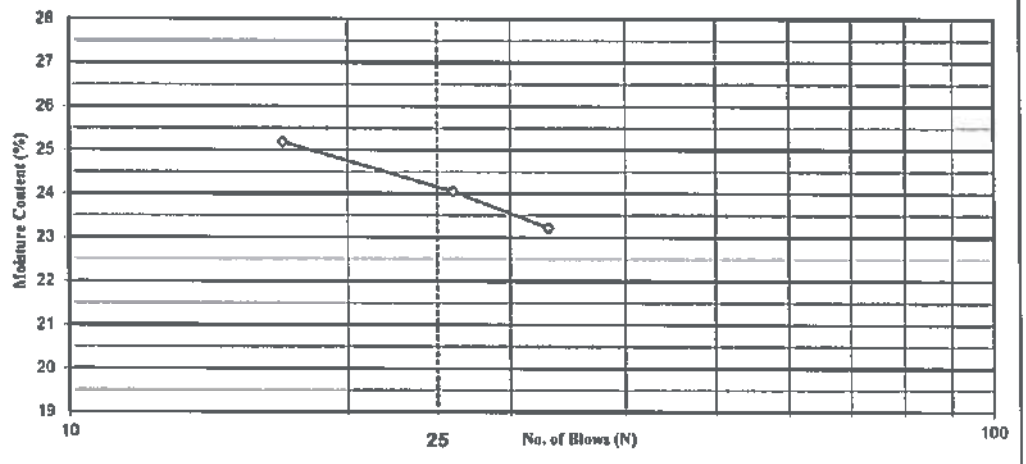
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-01	Job No.	-
Sample No.	SPT-08	Lab No.	1003
Sample Depth (m)	8.00-8.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

	LIQUID LIMIT					PLASTIC LIMIT	
No. of Blows (N)	17	26	33				
Container No.	D-13	D-24	D-37			D-87	D-95
Weight of Container (g)	18.54	18.87	10.57			11.76	10.88
Weight of Container + Wet Soil (g)	31.76	30.06	22.51			15.10	15.68
Weight of Container + Dry Soil (g)	29.10	27.89	20.26			14.56	14.91
Weight of Dry Soil (g)	10.56	9.02	9.69			2.80	4.03
Weight of Water (g)	2.66	2.17	2.25			0.54	0.77
Moisture Content (%)	25.19	24.06	23.22			19.29	19.11

Liquid Limit 24	Plastic Limit 19	Plasticity Index 5



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

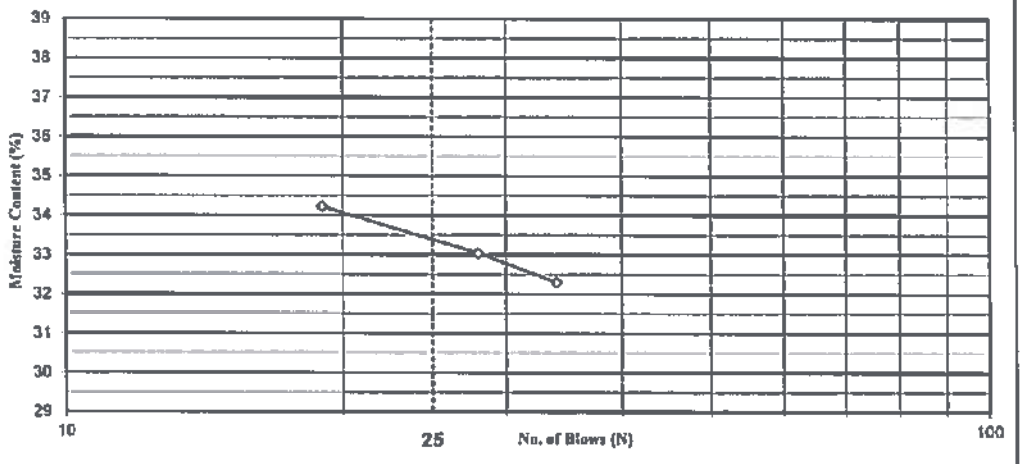
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BH / TP No.	BH-01	Job No.	-
Sample No.	UDS-01	Lab No.	1003
Sample Depth (m)	13.50-14.00	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

	LIQUID LIMIT					PLASTIC LIMIT	
No. of Blows (N)	19	28	34				
Container No.	D-49	D-28	D-35			D-105	D-75
Weight of Container (g)	23.95	19.27	10.48			9.91	11.26
Weight of Container + Wet Soil (g)	35.48	33.12	23.71			15.45	16.75
Weight of Container + Dry Soil (g)	32.54	29.68	20.48			14.45	15.76
Weight of Dry Soil (g)	8.59	10.41	10.00			4.54	4.50
Weight of Water (g)	2.94	3.44	3.23			1.00	0.99
Moisture Content (%)	34.23	33.05	32.30			22.03	22.00

Liquid Limit	33	Plastic Limit	22	Plasticity Index	11



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

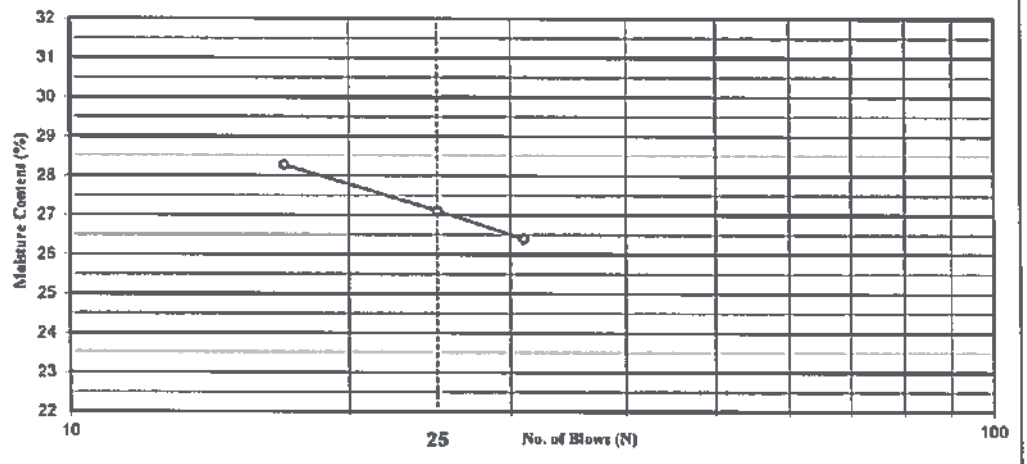
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-02	Job No.	-
Sample No.	SPT-01	Lab No.	1003
Sample Depth (m)	1.00-1.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	17	25	31				
Container No.	D-40	D-07	D-15			D-85	D-56
Weight of Container (g)	10.70	19.07	18.45			10.85	11.29
Weight of Container + Wet Soil (g)	23.31	31.82	31.28			15.09	16.32
Weight of Container + Dry Soil (g)	20.53	29.10	28.60			15.25	15.51
Weight of Dry Soil (g)	9.83	10.03	10.15			4.40	4.22
Weight of Water (g)	2.78	2.72	2.68			0.84	0.81
Moisture Content (%)	28.28	27.12	26.40			19.09	19.19

Liquid Limit	27	Plastic Limit	19	Plasticity Index	8



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

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CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

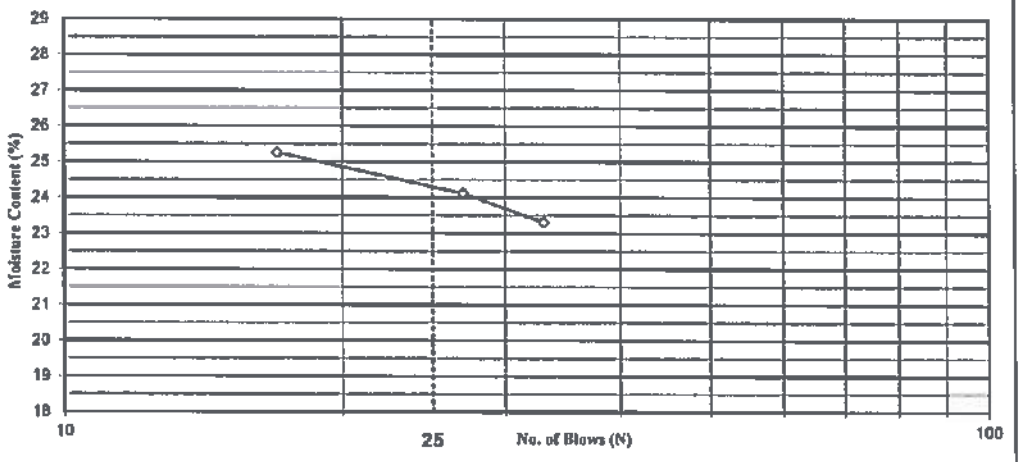
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-02	Job No.	-
Sample No.	SPT-04	Lab No.	1003
Sample Depth (m)	4.00-4.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	17	27	33				
Container No.	D-09	D-38	D-22			D-77	D-102
Weight of Container (g)	19.08	10.45	15.06			11.67	9.68
Weight of Container + Wet Soil (g)	32.42	24.19	29.55			15.88	15.23
Weight of Container + Dry Soil (g)	29.73	21.52	26.81			15.23	14.38
Weight of Dry Soil (g)	10.65	11.07	11.75			3.56	4.70
Weight of Water (g)	2.69	2.67	2.74			0.65	0.85
Moisture Content (%)	25.26	24.12	23.32			18.26	18.09

Liquid Limit 24	Plastic Limit 18	Plasticity Index 6



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

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CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

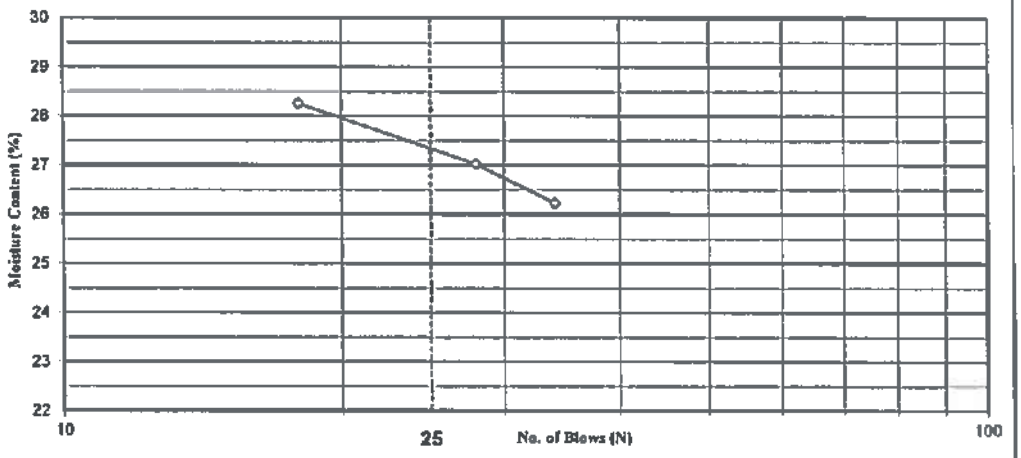
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-02	Job No.	-
Sample No.	UDS-01	Lab No.	1003
Sample Depth (m)	6.50-7.00	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

	LIQUID LIMIT					PLASTIC LIMIT	
No. of Blows (N)	18	28	34				
Container No.	D-46	D-26	D-01			D-108	D-62
Weight of Container (g)	17.81	18.63	19.35			11.64	9.48
Weight of Container + Wet Soil (g)	30.11	30.85	32.39			16.67	16.28
Weight of Container + Dry Soil (g)	27.40	28.25	29.68			15.86	15.19
Weight of Dry Soil (g)	9.59	9.62	10.33			4.22	5.71
Weight of Water (g)	2.71	2.60	2.71			0.81	1.09
Moisture Content (%)	28.26	27.03	26.23			19.19	19.09

Liquid Limit 27	Plastic Limit 19	Plasticity Index 8



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

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CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

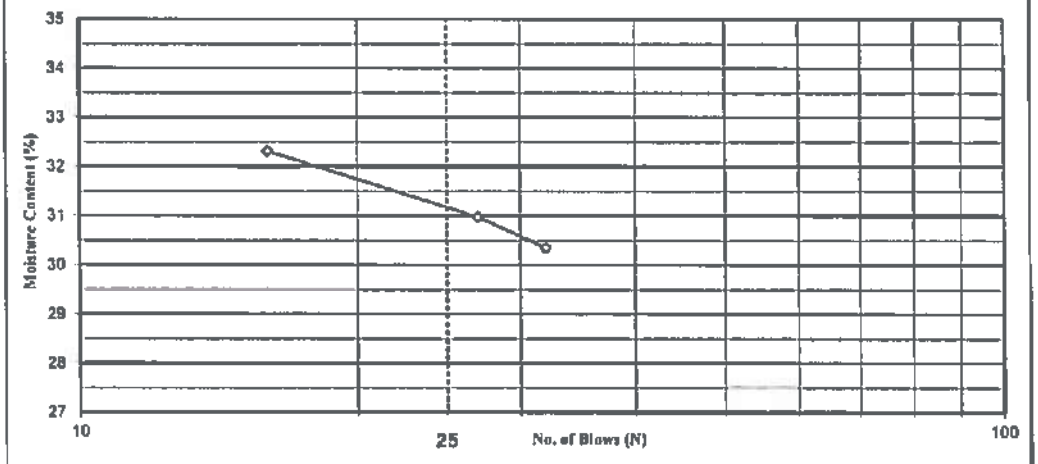
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-02	Job No.	-
Sample No.	UDS-03	Lab No.	1003
Sample Depth (m)	22.50-22.90	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	16	27	32				
Container No.	D-33	D-21	D-48			D-104	D-81
Weight of Container (g)	18.79	15.62	23.68			11.38	9.84
Weight of Container + Wet Soil (g)	31.36	28.77	36.25			16.05	15.39
Weight of Container + Dry Soil (g)	28.29	25.66	33.37			15.23	14.42
Weight of Dry Soil (g)	9.50	10.04	9.49			3.85	4.58
Weight of Water (g)	3.07	3.11	2.88			0.82	0.97
Moisture Content (%)	32.32	30.98	30.35			21.30	21.18

Liquid Limit	31	Plastic Limit	21	Plasticity Index	10



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

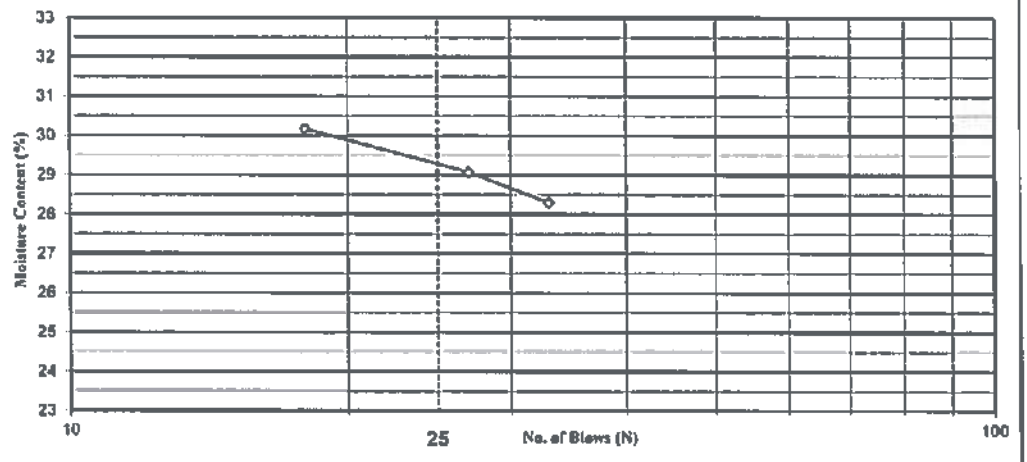
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BH / TP No.	BH-03	Job No.	-
Sample No.	UDS-01	Lab No.	1003
Sample Depth (m)	2.50-3.00	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	18	27	33				
Container No.	D-08	D-42	D-16			D-96	D-67
Weight of Container (g)	17.98	10.65	19.04			9.90	9.71
Weight of Container + Wet Soil (g)	29.11	23.48	31.96			15.38	15.98
Weight of Container + Dry Soil (g)	26.53	20.59	29.11			14.50	14.97
Weight of Dry Soil (g)	8.55	9.94	10.07			4.60	5.26
Weight of Water (g)	2.58	2.89	2.85			0.88	1.01
Moisture Content (%)	30.18	29.07	28.30			19.13	19.20

Liquid Limit 29	Plastic Limit 19	Plasticity Index 10



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

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CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

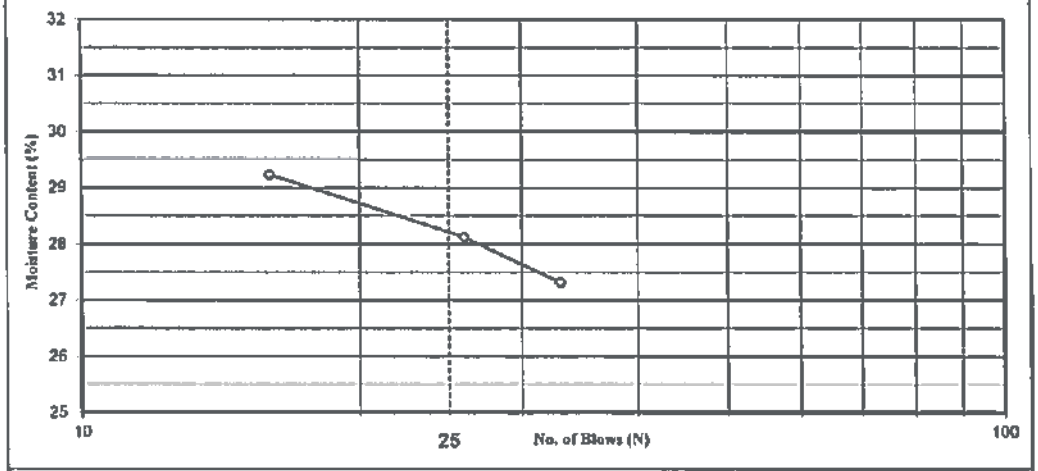
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-03	Job No.	-
Sample No.	SPT-08	Lab No.	1003
Sample Depth (m)	8.00-8.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

	LIQUID LIMIT					PLASTIC LIMIT	
No. of Blows (N)	16	26	33				
Container No.	D-52	D-27	D-44			D-59	D-78
Weight of Container (g)	11.93	18.27	10.54			11.64	11.25
Weight of Container + Wet Soil (g)	23.38	30.89	24.01			16.56	15.90
Weight of Container + Dry Soil (g)	20.79	28.12	21.12			15.70	15.09
Weight of Dry Soil (g)	8.86	9.85	10.58			4.06	3.84
Weight of Water (g)	2.59	2.77	2.89			0.86	0.81
Moisture Content (%)	29.23	28.12	27.32			21.18	21.09

Liquid Limit	28	Plastic Limit	21	Plasticity Index	7



Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S The Driller,Lahore

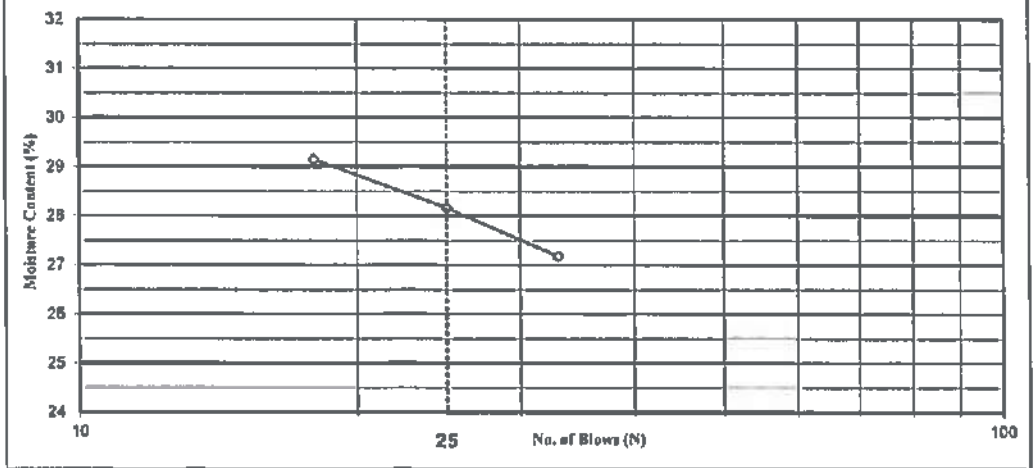
Project	Feasibility Study for Tourist Glass Train Package 4: Geotechnical Investigation for Trackway	decon Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.	

BH / TP No.	BH-08	Job No.	-
Sample No.	SPT-01	Lab No.	989
Sample Depth (m)	1.00-1.45	Test Started	22-Mar-25
Sampled Date	-	Test Completed	23-Mar-25

ATTERBERG LIMITS (ASTM D 4318)

	LIQUID LIMIT					PLASTIC LIMIT	
No. of Blows (N)	18	25	33				
Container No.	D-47	D-14	D-28			D-74	D-63
Weight of Container (g)	15.31	17.28	19.27			11.44	11.53
Weight of Container + Wet Soil (g)	29.71	31.16	32.84			17.28	16.13
Weight of Container + Dry Soil (g)	26.46	28.11	29.94			16.30	15.36
Weight of Dry Soil (g)	11.15	10.83	10.67			4.86	3.83
Weight of Water (g)	3.25	3.05	2.90			0.98	0.77
Moisture Content (%)	29.15	28.16	27.18			20.16	20.10

Liquid Limit 28	Plastic Limit 20	Plasticity Index 8



Tested By	Checked By	Approved By
Nasrullha Khan	-	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S The Driller,Lahore

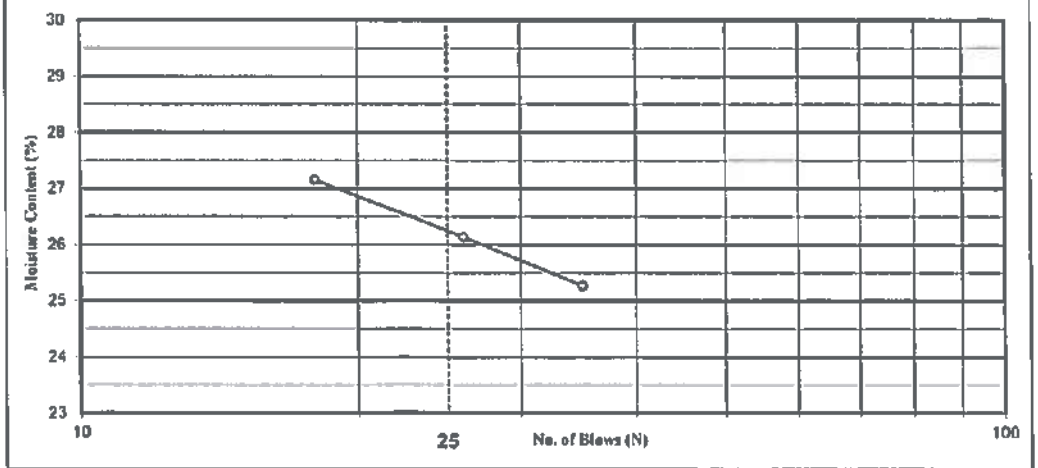
Project	Feasibility Study for Tourist Glass Train Package 4: Geotechnical Investigation for Trackway	**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.	

BH / TP No.	BH-09	Job No.	-
Sample No.	SPT-01	Lab No.	989
Sample Depth (m)	1.00-1.45	Test Started	22-Mar-25
Sampled Date	-	Test Completed	23-Mar-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	18	26	35				
Container No.	D-38	D-23	D-44			D-90	D-77
Weight of Container (g)	10.45	17.92	10.54			9.82	11.67
Weight of Container + Wet Soil (g)	23.56	32.83	24.37			15.91	16.28
Weight of Container + Dry Soil (g)	20.76	29.74	21.58			14.94	15.54
Weight of Dry Soil (g)	10.31	11.82	11.04			5.12	3.87
Weight of Water (g)	2.80	3.09	2.79			0.97	0.74
Moisture Content (%)	27.16	26.14	25.27			18.95	19.12

Liquid Limit	26	Plastic Limit	19	Plasticity Index	7



Tested By	Checked By	Approved By
Nasrullha Khan	-	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

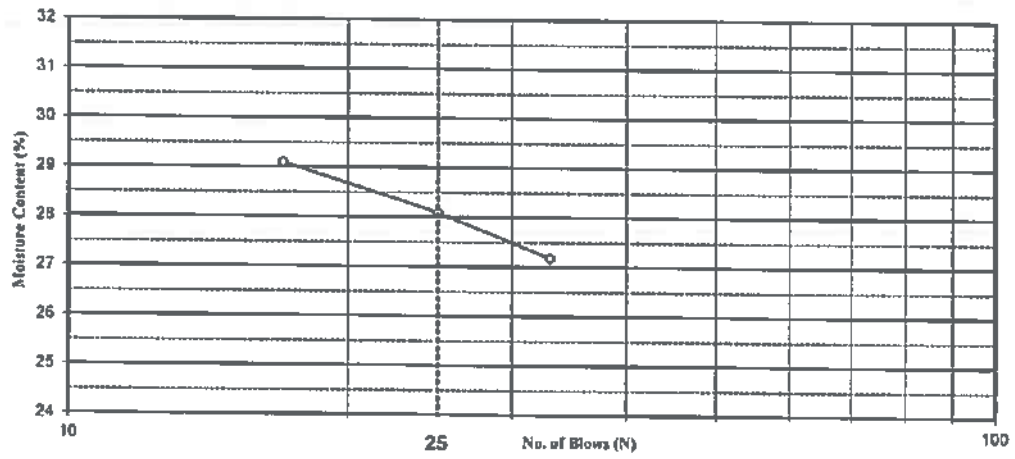
CLIENT	CONSULTANT	CONTRACTOR
–	NESPAK	M/S The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train Package 4: Geotechnical Investigation for Trackway		decon Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
BH / TP No.	BH-10	Job No.	-
Sample No.	SPT-02	Lab No.	989
Sample Depth (m)	2.00-2.45	Test Started	10-Apr-25
Sampled Date	-	Test Completed	11-Apr-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	17	25	33				
Container No.	D-29	D-13	D-03			D-52	D-60
Weight of Container (g)	17.92	19.13	20.64			23.08	22.47
Weight of Container + Wet Soil (g)	30.43	31.76	34.21			28.62	26.78
Weight of Container + Dry Soil (g)	27.61	28.99	31.31			27.69	26.06
Weight of Dry Soil (g)	9.69	9.86	10.67			4.61	3.59
Weight of Water (g)	2.82	2.77	2.90			0.93	0.72
Moisture Content (%)	29.10	28.09	27.18			20.17	20.06

Liquid Limit	28	Plastic Limit	20	Plasticity Index	8



Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

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CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S The Driller,Lahore

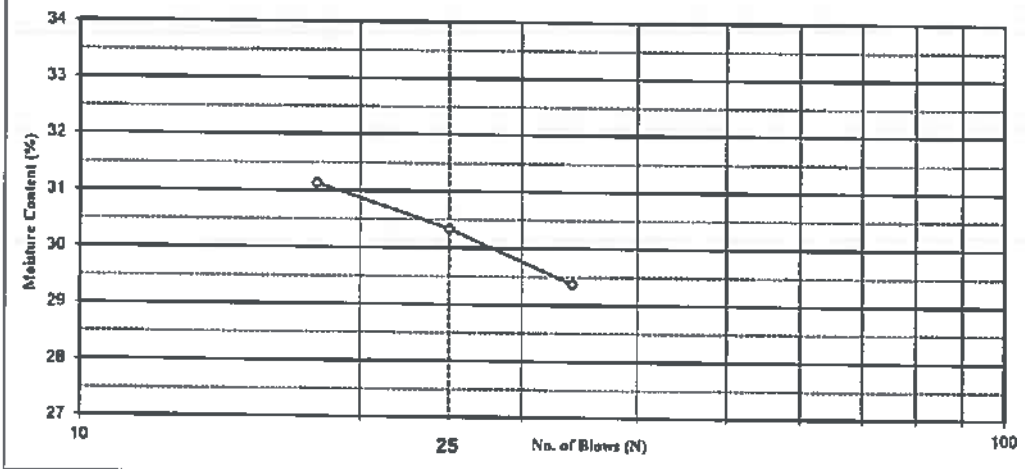
Project	Feasibility Study for Tourist Glass Train Package 4: Geotechnical Investigation for Trackway	**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.	

BH / TP No.	BH-11	Job No.	-
Sample No.	SPT-01	Lab No.	989
Sample Depth (m)	1.00-1.45	Test Started	07-Apr-25
Sampled Date	-	Test Completed	08-Apr-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	18	25	34				
Container No.	D-135	D-301	D-301			D-40	D-21
Weight of Container (g)	23.37	29.74	29.74			10.70	15.62
Weight of Container + Wet Soil (g)	30.11	33.22	33.66			15.22	16.55
Weight of Container + Dry Soil (g)	28.51	32.41	32.77			14.43	16.39
Weight of Dry Soil (g)	5.14	2.67	3.03			3.73	0.77
Weight of Water (g)	1.60	0.81	0.89			0.79	0.16
Moisture Content (%)	31.13	30.34	29.37			21.18	20.78

Liquid Limit	30	Plastic Limit	21	Plasticity Index	9



Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

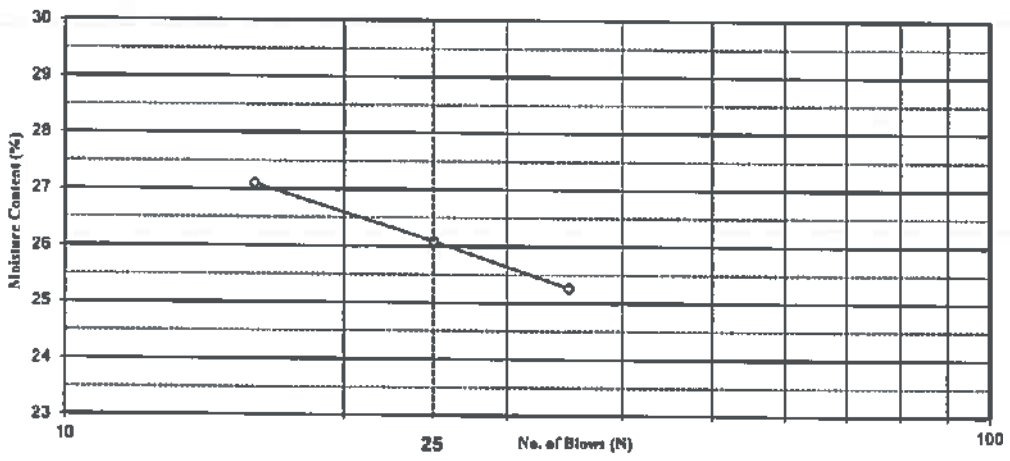
CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/S The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train Package 4: Geotechnical Investigation for Trackway		**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
BH / TP No.	BH-12A	Job No.	-
Sample No.	SPT-02	Lab No.	989
Sample Depth (m)	2.00-2.45	Test Started	10-Apr-25
Sampled Date	-	Test Completed	11-Apr-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	16	25	35				
Container No.	D-15	D-19	D-46			D-57	D-50
Weight of Container (g)	20.23	20.19	17.75			26.68	24.52
Weight of Container + Wet Soil (g)	33.69	32.37	30.84			31.39	30.93
Weight of Container + Dry Soil (g)	30.82	29.85	28.20			30.64	29.90
Weight of Dry Soil (g)	10.59	9.66	10.45			3.96	5.38
Weight of Water (g)	2.87	2.52	2.64			0.75	1.03
Moisture Content (%)	27.10	26.09	25.26			18.94	19.14

Liquid Limit	26	Plastic Limit	19	Plasticity Index	7



Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

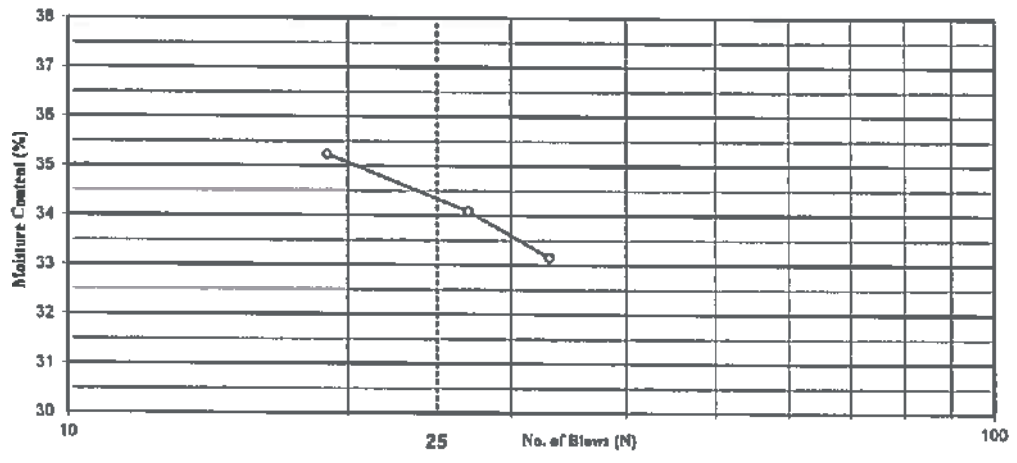
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**decon** Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-17	Job No.	-
Sample No.	SPT-03	Lab No.	1006
Sample Depth (m)	3.00-3.45	Test Started	22-May-25
Sampled Date	-	Test Completed	23-May-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	19	27	33				
Container No.	D-11	D-03	D-18			D-43	D-37
Weight of Container (g)	18.21	18.53	18.31			10.32	10.57
Weight of Container + Wet Soil (g)	29.34	32.18	33.05			15.49	16.02
Weight of Container + Dry Soil (g)	26.44	28.71	29.38			14.55	15.03
Weight of Dry Soil (g)	8.23	10.18	11.07			4.23	4.46
Weight of Water (g)	2.90	3.47	3.67			0.94	0.99
Moisture Content (%)	35.24	34.09	33.15			22.22	22.20

Liquid Limit	34	Plastic Limit	22	Plasticity Index	12



Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

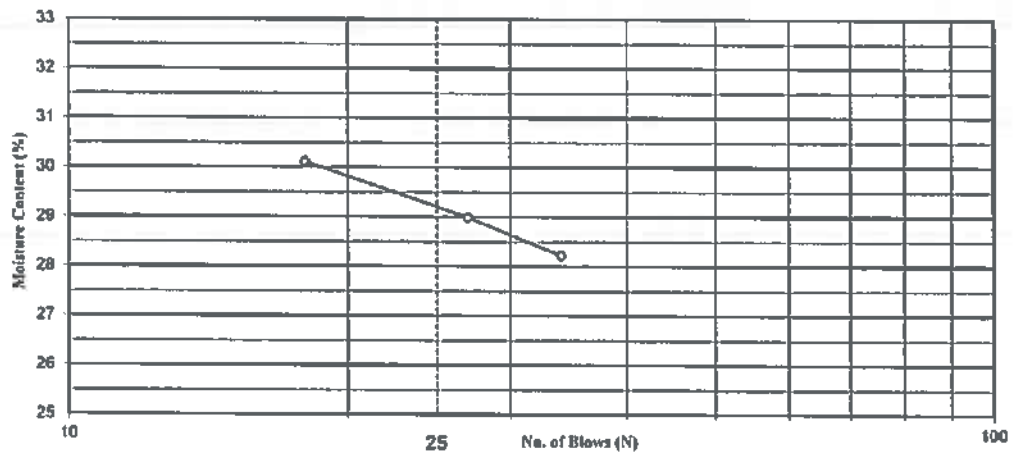
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-18	Job No.	-
Sample No.	SPT-04	Lab No.	1006
Sample Depth (m)	5.00-5.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	18	27	34				
Container No.	D-22	D-39	D-45			D-60	D-96
Weight of Container (g)	15.06	10.41	10.20			9.94	9.90
Weight of Container + Wet Soil (g)	29.10	24.96	22.42			15.88	15.09
Weight of Container + Dry Soil (g)	25.85	21.69	19.73			14.89	14.22
Weight of Dry Soil (g)	10.79	11.28	9.53			4.95	4.32
Weight of Water (g)	3.25	3.27	2.69			0.99	0.87
Moisture Content (%)	30.12	28.99	28.23			20.00	20.14

Liquid Limit	29	Plastic Limit	20	Plasticity Index	9



Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

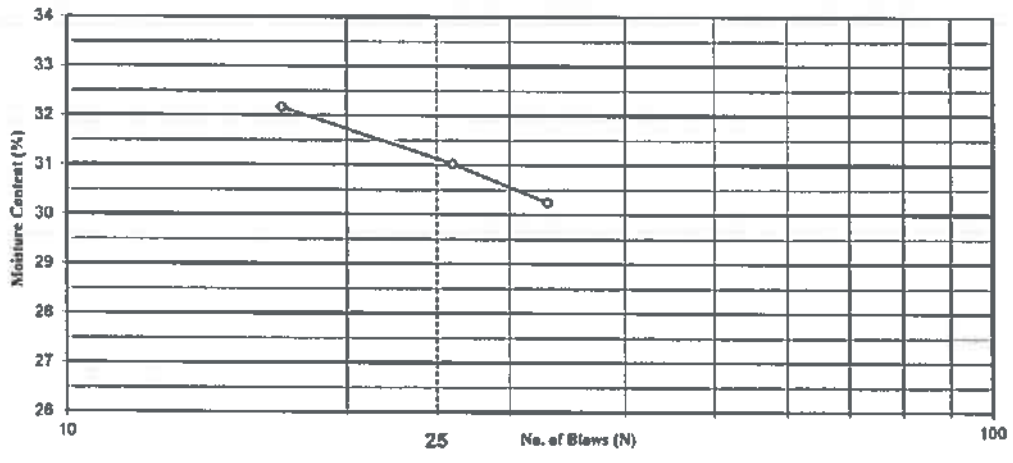
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-18	Job No.	-
Sample No.	SPT-06	Lab No.	1006
Sample Depth (m)	7.00-7.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	17	26	33				
Container No.	D-07	D-43	D-16			D-76	D-85
Weight of Container (g)	19.07	10.32	19.04			9.38	10.85
Weight of Container + Wet Soil (g)	31.52	23.16	31.83			15.66	16.98
Weight of Container + Dry Soil (g)	28.49	20.12	28.86			14.56	15.91
Weight of Dry Soil (g)	9.42	9.80	9.82			5.18	5.06
Weight of Water (g)	3.03	3.04	2.97			1.10	1.07
Moisture Content (%)	32.17	31.02	30.24			21.24	21.15

Liquid Limit	31	Plastic Limit	21	Plasticity Index	10



Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

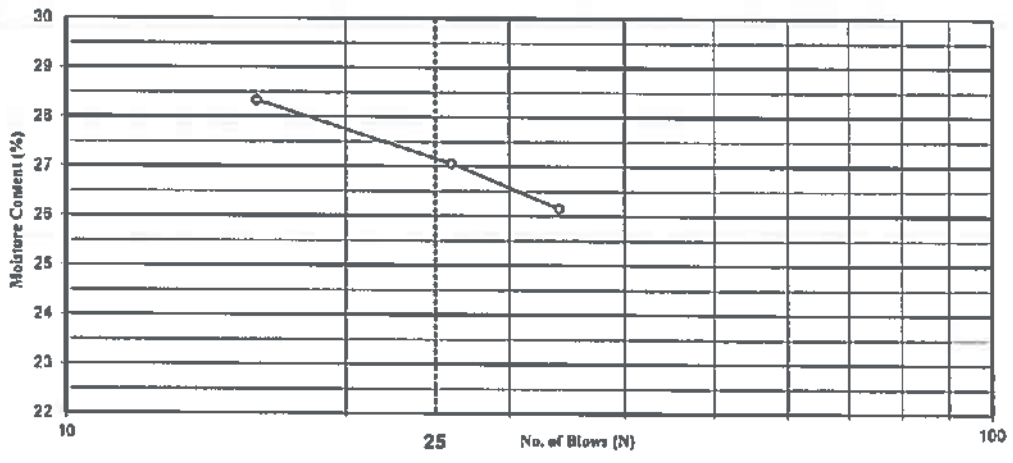
CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
BH / TP No.	BH-19	Job No.	-
Sample No.	SPT-01	Lab No.	1006
Sample Depth (m)	1.00-1.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

LIQUID LIMIT						PLASTIC LIMIT	
No. of Blows (N)	16	26	34				
Container No.	D-37	D-11	D-32			D-65	D-89
Weight of Container (g)	10.57	18.21	18.10			10.58	11.11
Weight of Container + Wet Soil (g)	22.39	32.06	31.75			15.38	16.58
Weight of Container + Dry Soil (g)	19.78	29.11	28.92			14.61	15.70
Weight of Dry Soil (g)	9.21	10.90	10.82			4.03	4.59
Weight of Water (g)	2.61	2.95	2.83			0.77	0.88
Moisture Content (%)	28.34	27.06	26.16			19.11	19.17

Liquid Limit	27	Plastic Limit	19	Plasticity Index	8



Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

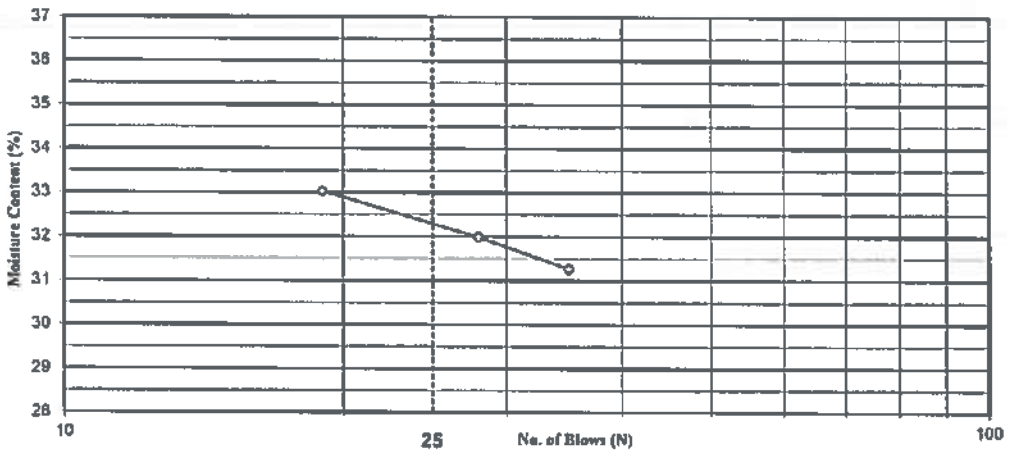
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-19	Job No.	-
Sample No.	DS-03	Lab No.	1006
Sample Depth (m)	7.40-8.00	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

	LIQUID LIMIT					PLASTIC LIMIT	
No. of Blows (N)	19	28	35				
Container No.	D-21	D-27	D-14			D-99	D-107
Weight of Container (g)	15.62	18.27	17.28			9.75	11.28
Weight of Container + Wet Soil (g)	30.04	31.39	29.79			15.43	15.89
Weight of Container + Dry Soil (g)	26.46	28.21	26.81			14.44	15.09
Weight of Dry Soil (g)	10.84	9.94	9.53			4.69	3.81
Weight of Water (g)	3.58	3.18	2.98			0.99	0.80
Moisture Content (%)	33.03	31.99	31.27			21.11	21.00

Liquid Limit	32	Plastic Limit	21	Plasticity Index	11



Tested By	Checked By	Approved By
Nasrullah Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

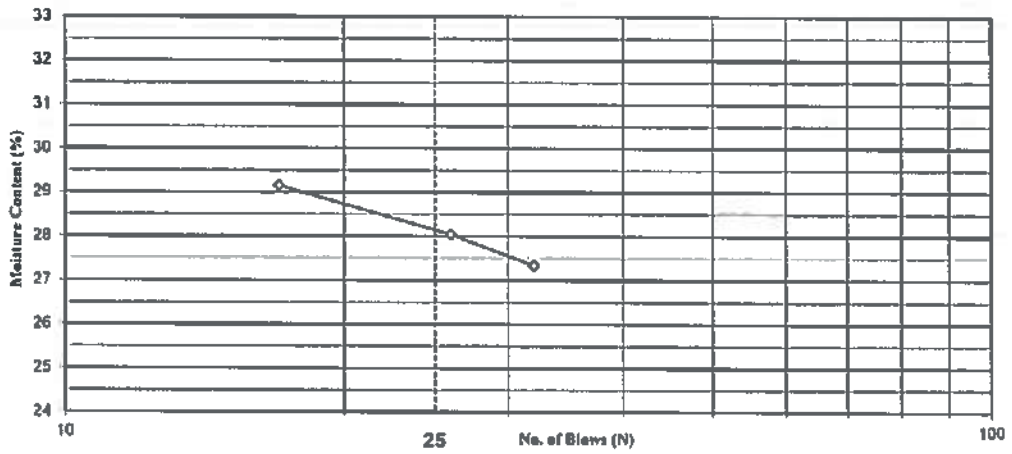
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-19	Job No.	-
Sample No.	SPT-09	Lab No.	1006
Sample Depth (m)	11.00-11.45	Test Started	12-May-25
Sampled Date	-	Test Completed	13-May-25

ATTERBERG LIMITS (ASTM D 4318)

	LIQUID LIMIT					PLASTIC LIMIT	
No. of Blows (N)	17	26	32				
Container No.	D-51	D-25	D-38			D-79	D-57
Weight of Container (g)	13.00	18.22	10.45			11.10	9.67
Weight of Container + Wet Soil (g)	26.91	32.42	23.77			16.52	16.08
Weight of Container + Dry Soil (g)	23.77	29.31	20.91			15.65	15.05
Weight of Dry Soil (g)	10.77	11.09	10.46			4.55	5.38
Weight of Water (g)	3.14	3.11	2.86			0.87	1.03
Moisture Content (%)	29.16	28.04	27.34			19.12	19.14

Liquid Limit 28	Plastic Limit 19	Plasticity Index 9



Tested By	Checked By	Approved By
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FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND ST	

BH / TP No.	BH-01	Job No.	-
Sample No.	UDS-01	Lab No.	1003
Sample Depth (m)	13.50-14.00	Test Started	May 5, 2025
Sampled Date	-	Test Completed	May 6, 2025

UNCONFINED COMPRESSION TEST (ASTM D 2166)

Details	Initial	Final	Proving Ring No.
Specimen Dia (cm)	7.00	7.56	N24887
Specimen Area (cm^2)	38.48	44.90	Proving Ring Factor
Specimen Height (cm)	14.00	12.00	0.134
Specimen Volume (cm^3)	538.78	538.78	Average Rate of Strain
Weight of Specimen (g)	1032.00		1.00 % per min
Bulk Density of Soil (g/cm^3)	1.915		
Dry Density of Soil (g/cm^3)	1.636		

Determination of Moisture Content

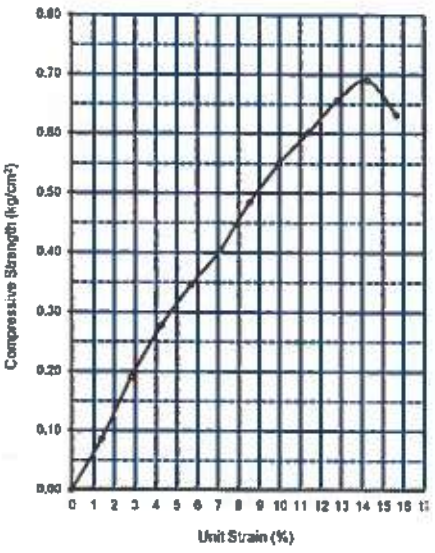
Container No.	C-644	C-612
Weight of Container (g)	20.26	19.63
Weight of Container + Wet Sample (g)	187.07	191.06
Weight of Container + Dry Sample (g)	162.77	166.00
Weight of Dry Soil (g)	142.51	146.37
Weight of Water (g)	24.30	25.06
Moisture Content (%)	17.05	17.12
Average Moisture Content (%)	17.09	

Failure Sketches

Rear Front

Determination of Stess and Strain

Strain Dial Reading	Unit Strain (%)	Load Dial Reading	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	0.00	38.48	0.00
200	1.43	25	3.35	39.04	0.09
400	2.86	56	7.50	39.62	0.19
600	4.29	83	11.12	40.21	0.28
800	5.71	105	14.07	40.82	0.34
1000	7.14	125	16.75	41.44	0.40
1200	8.57	152	20.37	42.09	0.48
1400	10.00	175	23.45	42.76	0.55
1600	11.43	195	26.13	43.45	0.60
1800	12.86	216	28.94	44.16	0.66
2000	14.29	231	30.95	44.90	0.69
2200	15.71	215	28.81	45.66	0.63



Compressive Strength	0.69 kg/cm^2	Strain	14.29 %

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND ST		
BH / TP No.	BH-02	Job No.	-
Sample No.	UDS-01	Lab No.	1003
Sample Depth (m)	6.50-7.00	Test Started	May 5, 2025
Sampled Date	-	Test Completed	May 6, 2025

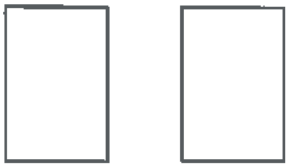
UNCONFINED COMPRESSION TEST (ASTM D 2166)

Details	Initial	Final	Proving Ring No.
Specimen Dia (cm)	7.00	7.26	N24887
Specimen Area (cm^2)	38.48	41.44	Proving Ring Factor
Specimen Height (cm)	14.00	13.00	0.134
Specimen Volume (cm^3)	538.78	538.78	Average Rate of Strain
Weight of Specimen (g)	1024.00		1.00 % per min
Bulk Density of Soil (g/cm^3)	1.901		
Dry Density of Soil (g/cm^3)	1.610		

Determination of Moisture Content

Container No.	C-45	C-12
Weight of Container (g)	22.10	19.89
Weight of Container + Wet Sample (g)	197.55	181.99
Weight of Container + Dry Sample (g)	170.76	157.19
Weight of Dry Soil (g)	148.66	137.30
Weight of Water (g)	26.79	24.80
Moisture Content (%)	18.02	18.06
Average Moisture Content (%)	18.04	

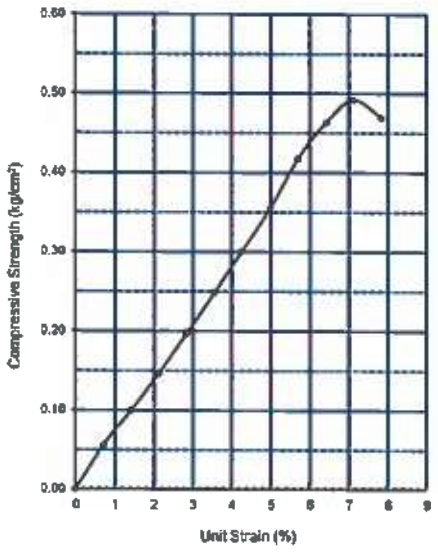
Failure Sketches



Rear Front

Determination of Stess and Strain

Strain Dial Reading	Unit Strain (%)	Load Dial Reading	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	0.00	38.48	0.00
100	0.71	16	2.14	38.76	0.06
200	1.43	29	3.89	39.04	0.10
300	2.14	43	5.76	39.33	0.15
400	2.86	58	7.77	39.62	0.20
500	3.57	74	9.92	39.91	0.25
600	4.29	90	12.06	40.21	0.30
700	5.00	107	14.34	40.51	0.35
800	5.71	127	17.02	40.82	0.42
900	6.43	142	19.03	41.13	0.46
1000	7.14	152	20.37	41.44	0.49
1100	7.86	146	19.56	41.77	0.47



Compressive Strength	0.49 kg/cm^2	Strain	7.14 %

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND ST	

BH / TP No.	BH-02	Job No.	-
Sample No.	UDS-03	Lab No.	1003
Sample Depth (m)	22.50-22.90	Test Started	May 5, 2025
Sampled Date	-	Test Completed	May 6, 2025

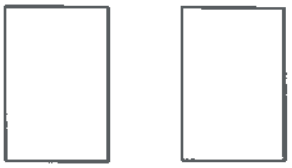
UNCONFINED COMPRESSION TEST (ASTM D 2166)

Details	Initial	Final	Proving Ring No.
Specimen Dia (cm)	7.00	7.20	N24887
Specimen Area (cm^2)	38.48	40.66	Proving Ring Factor
Specimen Height (cm)	14.00	13.25	0.134
Specimen Volume (cm^3)	538.78	538.78	Average Rate of Strain
Weight of Specimen (g)	1034.00		1.00 % per min
Bulk Density of Soil (g/cm^3)	1.919		
Dry Density of Soil (g/cm^3)	1.637		

Determination of Moisture Content

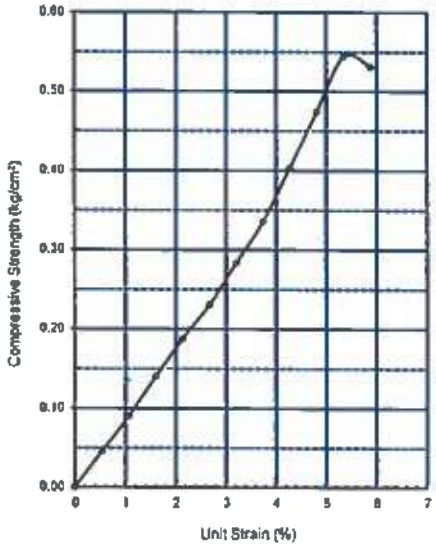
Container No.	C-242	C-01
Weight of Container (g)	23.59	32.32
Weight of Container + Wet Sample (g)	222.60	169.32
Weight of Container + Dry Sample (g)	193.38	149.13
Weight of Dry Soil (g)	169.79	116.81
Weight of Water (g)	29.22	20.19
Moisture Content (%)	17.21	17.28
Average Moisture Content (%)	17.25	

Failure Sketches



Determination of Stess and Strain

Strain Dial Reading	Unit Strain (%)	Load Dial Reading	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	0.00	38.48	0.00
75	0.54	13	1.74	38.69	0.05
150	1.07	26	3.48	38.90	0.09
225	1.61	41	5.49	39.11	0.14
300	2.14	55	7.37	39.33	0.19
375	2.68	68	9.11	39.54	0.23
450	3.21	84	11.26	39.76	0.28
525	3.75	100	13.40	39.98	0.34
600	4.29	121	16.21	40.21	0.40
675	4.82	143	19.16	40.43	0.47
750	5.36	165	22.11	40.66	0.54
825	5.89	162	21.71	40.89	0.53



Compressive Strength	0.54 kg/cm^2	Strain	5.36 %

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

decon
Geotechnical Testing Laboratory

BH / TP No.	BH-03	Job No.	-
Sample No.	UDS-01	Lab No.	1003
Sample Depth (m)	2.50-3.00	Test Started	May 5, 2025
Sampled Date	-	Test Completed	May 6, 2025

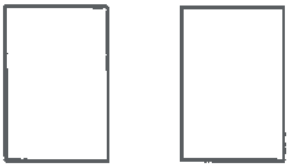
UNCONFINED COMPRESSION TEST (ASTM D 2166)

Details	Initial	Final	Proving Ring No.
Specimen Dia (cm)	7.00	7.13	N24887
Specimen Area (cm^2)	38.48	39.91	Proving Ring Factor
Specimen Height (cm)	14.00	13.50	0.134
Specimen Volume (cm^3)	538.78	538.78	Average Rate of Strain
Weight of Specimen (g)	1025.00		1.00 % per min
Bulk Density of Soil (g/cm^3)	1.902		
Dry Density of Soil (g/cm^3)	1.624		

Determination of Moisture Content

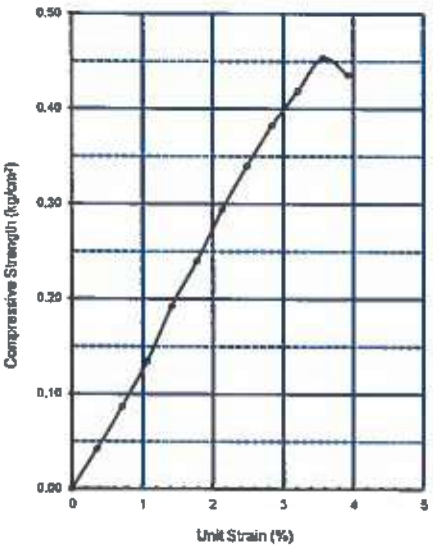
Container No.	C-682	C-655
Weight of Container (g)	20.38	20.01
Weight of Container + Wet Sample (g)	218.13	204.91
Weight of Container + Dry Sample (g)	189.18	177.88
Weight of Dry Soil (g)	168.80	157.87
Weight of Water (g)	28.95	27.03
Moisture Content (%)	17.15	17.12
Average Moisture Content (%)	17.14	

Failure Sketches



Determination of Stess and Strain

Strain Dial Reading	Unit Strain (%)	Load Dial Reading	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	0.00	38.48	0.00
50	0.36	12	1.61	38.62	0.04
100	0.71	25	3.35	38.76	0.09
150	1.07	39	5.23	38.90	0.13
200	1.43	56	7.50	39.04	0.19
250	1.79	70	9.38	39.18	0.24
300	2.14	86	11.52	39.33	0.29
350	2.50	100	13.40	39.47	0.34
400	2.86	113	15.14	39.62	0.38
450	3.21	124	16.62	39.76	0.42
500	3.57	135	18.09	39.91	0.45
550	3.93	130	17.42	40.06	0.43



Compressive Strength	0.45 kg/cm^2	Strain	3.57 %

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore
Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.	decon Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.	

Sampled Date	-	Test Started	March 23, 2025
Job No.	-	Test Completed	March 24, 2025
Lab No.	989		

UNIAXIAL COMPRESSIVE STRENGTH

Borehole Number	Sample Number	Sample Depth (m)	Diameter (cm)	Height (cm)	Area (cm^2)	L/D Ratio	Peak Load kg	Compressive Strength (kg/cm^2)
BH-07	WS-02	3.58-3.74	5.20	10.50	21.24	2.02	500	23.54
BH-07	WS-09	15.81-15.91	5.20	10.42	21.24	2.00	209	9.84
BH-07	WS-11	19.51-19.65	4.60	9.24	16.62	2.01	4131	248.57
BH-08	WS-01	2.52-2.64	4.54	9.09	16.19	2.00	1742	107.61
BH-08	WS-03	8.34-8.45	5.01	10.03	19.71	2.00	245	12.43
BH-08	WS-13	22.50-22.71	5.30	10.60	22.06	2.00	2405	109.01
BH-09	WS-05	16.00-16.22	5.50	11.00	23.76	2.00	1967	82.79
BH-09	WS-09	24.00-24.18	5.52	11.04	23.93	2.00	6700	279.97

Tested By	Checked By	Approved By
Nasrullha Khan	-	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT -	CONSULTANT NESPAK	CONTRACTOR M/s The Driller,Lahore
Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.	**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.	

Sampled Date	-	Test Started	April 18, 2025
Job No.	-	Test Completed	April 19, 2025
Lab No.	989		

UNIAXIAL COMPRESSIVE STRENGTH

Borehole Number	Sample Number	Sample Depth (m)	Diameter (cm)	Height (cm)	Area (cm^2)	L/D Ratio	Peak Load kg	Compressive Strength (kg/cm^2)
BH-09	WS-01	6.45-6.57	4.10	8.25	13.20	2.01	4969	376.37

Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		decon Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
Sampled Date	-	Test Started	April 9, 2025
Job No.	-	Test Completed	April 10, 2025
Lab No.	989		

UNIAXIAL COMPRESSIVE STRENGTH

Borehole Number	Sample Number	Sample Depth (m)	Diameter (cm)	Height (cm)	Area (cm^2)	L/D Ratio	Peak Load kg	Compressive Strength (kg/cm^2)
BH-10	WS-01	4.41-4.55	5.02	10.06	19.79	2.00	85	4.29
	WS-04	12.00-12.17	5.20	10.48	21.24	2.02	3594	169.23
	WS-06	18.11-18.21	5.01	10.06	19.71	2.01	3693	187.33
	WS-09	24.16-24.31	5.20	10.48	21.24	2.02	5981	281.63
BH-12A	WS-01	4.42-4.55	5.50	11.04	23.76	2.01	600	25.25
	WS-05	18.40-18.54	5.40	10.90	22.90	2.02	4295	187.54
	WS-08	24.53-24.76	5.30	10.81	22.06	2.04	2861	129.68
BH-09	WS-07	21.33-21.62	5.50	11.50	23.76	2.09	3646	153.46

Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT -	CONSULTANT NESPAK	CONTRACTOR M/s The Driller,Lahore
Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.	decon Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.	

Sampled Date	-	Test Started	April 9, 2025
Job No.	-	Test Completed	April 10, 2025
Lab No.	989		

UNIAXIAL COMPRESSIVE STRENGTH

Borehole Number	Sample Number	Sample Depth (m)	Diameter (cm)	Height (cm)	Area (cm^2)	L/D Ratio	Peak Load kg	Compressive Strength (kg/cm^2)
BH-11	WS-02	5.22-5.36	5.03	10.08	19.87	2.00	559	28.13
BH-11	WS-11	15.55-15.71	5.30	10.71	22.06	2.02	4629	209.82
BH-11	WS-16	24.00-24.25	5.02	10.08	19.79	2.01	3529	178.30
BH-12	WS-01	2.04-2.17	5.01	10.04	19.71	2.00	2388	121.13
BH-12	WS-02	5.30-5.43	4.50	9.15	15.90	2.03	148	9.31
BH-12	WS-11	18.00-18.31	5.50	11.02	23.76	2.00	7559	318.16

Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
Sampled Date	-	Test Started	April 18, 2025
Job No.	-	Test Completed	April 19, 2025
Lab No.	989		

UNIAXIAL COMPRESSIVE STRENGTH

Borehole Number	Sample Number	Sample Depth (m)	Diameter (cm)	Height (cm)	Area (cm^2)	L/D Ratio	Peak Load kg	Compressive Strength (kg/cm^2)
BH-12A	WS-03	14.45-14.65	4.20	8.50	13.85	2.02	40	2.89

Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AI

decon
Geotechnical Testing Laboratory

Sampled Date	-	Test Started	May 22, 2025
Job No.	-	Test Completed	May 23, 2025
Lab No.	1006		

UNIAXIAL COMPRESSIVE STRENGTH

Borehole Number	Sample Number	Sample Depth (m)	Diameter (cm)	Height (cm)	Area (cm^2)	L/D Ratio	Peak Load kg	Compressive Strength (kg/cm^2)
BH-17	WS-01	6.10-6.30	5.25	10.60	21.65	2.02	2154	99.50
	WS-03	9.28-9.43	5.10	10.25	20.43	2.01	866	42.39

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore
Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AN	

Sampled Date	-	Test Started	May 12, 2025
Job No.	-	Test Completed	May 13, 2025
Lab No.	1006		

UNIAXIAL COMPRESSIVE STRENGTH

Borehole Number	Sample Number	Sample Depth (m)	Diameter (cm)	Height (cm)	Area (cm^2)	L/D Ratio	Peak Load kg	Compressive Strength (kg/cm^2)
BH-18	WS-01	12.15-12.26	4.50	9.05	15.90	2.01	43	2.70
	WS-06	20.19-20.36	5.10	10.24	20.43	2.01	65	3.18
	WS-07	24.53-24.74	4.50	9.03	15.90	2.01	266	16.73
BH-19	WS-05	29.21-29.37	5.60	11.25	24.63	2.01	3339	135.57
	WS-06	30.14-30.32	5.60	11.20	24.63	2.00	300	12.18

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller, Lahore.

Project	Feasibility Study for Tourist Glass Train PKG4: Geotechnical Investigation for Trackway, Stations, and Structures.
Location	Rawalpindi to Murree

decon
Geotechnical Testing Laboratory

BH / TP No.	BH-07	Job No.	-
Sample No.	WS-02	Lab No.	989
Sample Depth (m)	3.58-3.74	Test Started	March 23, 2025
Sampled Date	-	Test Completed	March 24, 2025

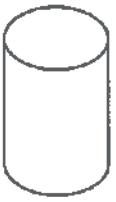
UNIAXIAL COMPRESSIVE STRENGTH

Details	Initial
Specimen Dia (cm)	5.20
Specimen Area (cm^2)	21.24
Specimen Height (cm)	10.50
Specimen Volume (cm^3)	222.99
Weight of Specimen (g)	468.00
Bulk Density of Rock (g/cm^3)	2.099
Dry Density of Rock (g/cm^3)	2.045

Determination of Moisture Content

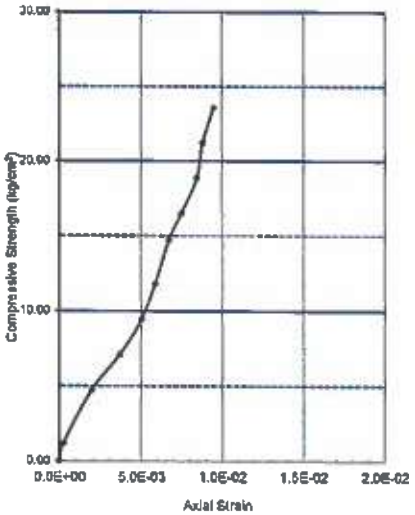
Container No.	C-16	C-84
Weight of Container (g)	22.30	23.14
Weight of Container + Wet Sample (g)	155.30	145.23
Weight of Container + Dry Sample (g)	152.01	142.01
Weight of Dry Soil (g)	129.71	118.87
Weight of Water (g)	3.29	3.22
Moisture Content (%)	2.54	2.71
Average Moisture Content (%)	2.62	

Failure Sketches



Determination of Stess and Strain

Strain Dial Reading	Unit Strain -Axial	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	21.24	0.00
3	2.857E-04	25	21.24	1.18
21	2.000E-03	100	21.24	4.71
39	3.714E-03	150	21.24	7.06
53	5.048E-03	200	21.24	9.42
62	5.905E-03	250	21.24	11.77
71	6.762E-03	312	21.24	14.69
79	7.524E-03	350	21.24	16.48
89	8.476E-03	400	21.24	18.83
93	8.857E-03	450	21.24	21.19
100	9.524E-03	500	21.24	23.54



Compressive Strength	23.54	kg/cm^2	Strain	9.524E-03
Young's Modulus	2.472E+03	kg/cm^2	Poisson Ratio	-
Rock Type (Visual Analysis)	*The rock sample appears to be Schist.*			

Tested By	Checked By	Approved By
Nasrullha Khan	Ikramullah	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree.		decon Geotechnical Testing Laboratory
Location	PKG 4: Geotechnical Investigation for Trackway, Stations, and Structures. Rawalpindi to Murree.		
BH / TP No.	BH-09	Job No.	-
Sample No.	WS-07	Lab No.	989
Sample Depth (m)	21.33-21.62	Test Started	April 9, 2025
Sampled Date	-	Test Completed	April 10, 2025

UNIAXIAL COMPRESSIVE STRENGTH

Details	Initial
Specimen Dia (cm)	5.50
Specimen Area (cm^2)	23.76
Specimen Height (cm)	11.50
Specimen Volume (cm^3)	273.22
Weight of Specimen (g)	743.00
Bulk Density of Rock (g/cm^3)	2.719
Dry Density of Rock (g/cm^3)	2.689

Determination of Moisture Content

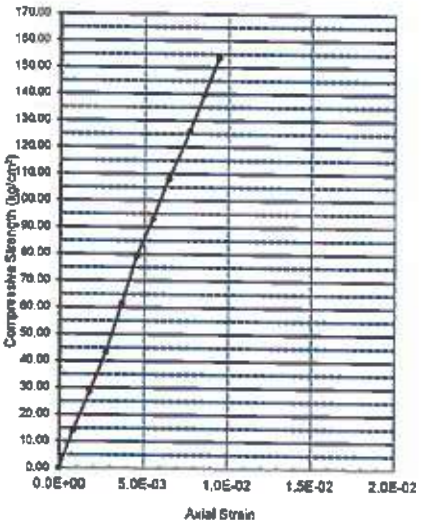
Container No.	C-16	C-84
Weight of Container (g)	22.30	23.14
Weight of Container + Wet Sample (g)	165.59	145.23
Weight of Container + Dry Sample (g)	163.92	143.89
Weight of Dry Soil (g)	141.62	120.75
Weight of Water (g)	1.67	1.34
Moisture Content (%)	1.18	1.11
Average Moisture Content (%)	1.14	

Failure Sketches



Determination of Stess and Strain

Strain Dial Reading	Unit Strain -Axial	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	23.76	0.00
10	8.696E-04	335	23.76	14.10
21	1.826E-03	678	23.76	28.54
32	2.783E-03	1026	23.76	43.18
43	3.739E-03	1458	23.76	61.37
53	4.609E-03	1878	23.76	79.04
64	5.565E-03	2207	23.76	92.89
75	6.522E-03	2564	23.76	107.91
89	7.739E-03	2989	23.76	125.80
99	8.609E-03	3314	23.76	139.48
109	9.478E-03	3646	23.76	153.45



Compressive Strength	153.45	kg/cm^2	Strain	9.478E-03
Young's Modulus	1.667E+04	kg/cm^2	Poisson Ratio	-
Rock Type (Visual Analysis)	-			

Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	Feasibility Study for Tourist Glass Train from Rawalpindi to Murree Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		decon Geotechnical Testing Laboratory
Location	Rawalpindi to Murree.		
BH / TP No.	BH-11	Job No.	-
Sample No.	WS-16	Lab No.	989
Sample Depth (m)	24.00-24.25	Test Started	April 9, 2025
Sampled Date	-	Test Completed	April 10, 2025

UNIAXIAL COMPRESSIVE STRENGTH

Details	Initial
Specimen Dia (cm)	5.02
Specimen Area (cm^2)	19.79
Specimen Height (cm)	10.08
Specimen Volume (cm^3)	199.51
Weight of Specimen (g)	501.00
Bulk Density of Rock (g/cm^3)	2.511
Dry Density of Rock (g/cm^3)	2.428

Determination of Moisture Content

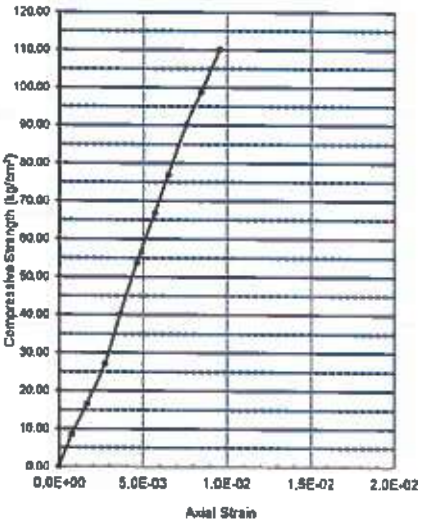
Container No.	C-167	C-05
Weight of Container (g)	28.28	29.15
Weight of Container + Wet Sample (g)	130.50	124.18
Weight of Container + Dry Sample (g)	127.12	121.02
Weight of Dry Soil (g)	98.84	91.87
Weight of Water (g)	3.38	3.16
Moisture Content (%)	3.42	3.44
Average Moisture Content (%)	3.43	

Failure Sketches



Determination of Stess and Strain

Strain Dial Reading	Unit Strain -Axial	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	19.79	0.00
8	7.937E-04	166	19.79	8.39
17	1.687E-03	326	19.79	16.47
28	2.778E-03	534	19.79	26.98
37	3.671E-03	794	19.79	40.12
47	4.663E-03	1059	19.79	53.50
58	5.754E-03	1320	19.79	66.69
66	6.548E-03	1520	19.79	76.79
77	7.639E-03	1784	19.79	90.13
86	8.532E-03	1954	19.79	98.72
97	9.623E-03	2178	19.79	110.03



Compressive Strength	110.03	kg/cm^2	Strain	9.623E-03
Young's Modulus	1.299E+04	kg/cm^2	Poisson Ratio	-
Rock Type (Visual Analysis)	-			

Tested By	Checked By	Approved By
Nasrullha Khan	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

BH / TP No.	BH-17	Job No.	-
Sample No.	WS-08	Lab No.	1006
Sample Depth (m)	16.08-16.24	Test Started	May 22, 2025
Sampled Date	-	Test Completed	May 23, 2025

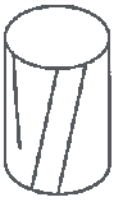
UNIAXIAL COMPRESSIVE STRENGTH

Details	Initial
Specimen Dia (cm)	5.30
Specimen Area (cm^2)	22.06
Specimen Height (cm)	10.65
Specimen Volume (cm^3)	234.96
Weight of Specimen (g)	648.00
Bulk Density of Rock (g/cm^3)	2.758
Dry Density of Rock (g/cm^3)	2.735

Determination of Moisture Content

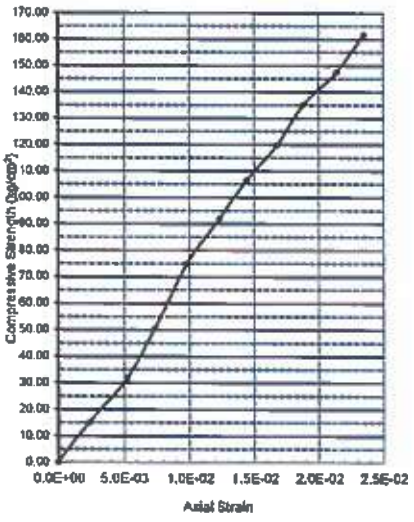
Container No.	C-119	C-74
Weight of Container (g)	29.18	21.45
Weight of Container + Wet Sample (g)	222.83	186.25
Weight of Container + Dry Sample (g)	221.14	184.98
Weight of Dry Soil (g)	191.96	163.53
Weight of Water (g)	1.69	1.27
Moisture Content (%)	0.88	0.78
Average Moisture Content (%)	0.83	

Failure Sketches



Determination of Stess and Strain

Strain Dial Reading	Unit Strain -Axial	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	22.06	0.00
25	2.347E-03	325	22.06	14.73
56	5.258E-03	695	22.06	31.50
79	7.418E-03	1112	22.06	50.40
105	9.859E-03	1649	22.06	74.74
132	1.239E-02	2026	22.06	91.82
154	1.446E-02	2347	22.07	106.37
179	1.681E-02	2635	22.07	119.42
201	1.887E-02	2978	22.07	134.96
228	2.141E-02	3247	22.07	147.15
251	2.357E-02	3564	22.07	161.51



Compressive Strength	174.42	kg/cm^2	Strain	2.357E-02
Young's Modulus	7.382E+03	kg/cm^2	Poisson Ratio	-
Rock Type (Visual Analysis)	-			

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

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Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
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Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		decon Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
BH / TP No.	BH-18	Job No.	-
Sample No.	WS-03	Lab No.	1006
Sample Depth (m)	15.12-15.28	Test Started	May 16, 2025
Sampled Date	-	Test Completed	May 18, 2025

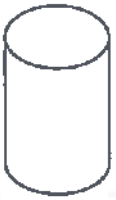
UNIAXIAL COMPRESSIVE STRENGTH

Details	Initial
Specimen Dia (cm)	5.10
Specimen Area (cm^2)	20.43
Specimen Height (cm)	10.20
Specimen Volume (cm^3)	208.37
Weight of Specimen (g)	541.00
Bulk Density of Rock (g/cm^3)	2.596
Dry Density of Rock (g/cm^3)	2.551

Determination of Moisture Content

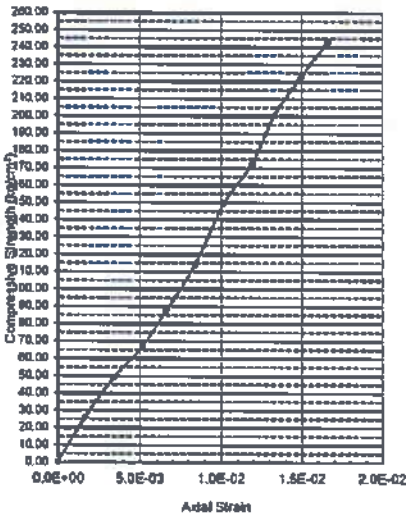
Container No.	C-273	C-84
Weight of Container (g)	22.30	23.14
Weight of Container + Wet Sample (g)	155.30	145.23
Weight of Container + Dry Sample (g)	153.00	143.12
Weight of Dry Soil (g)	130.70	119.98
Weight of Water (g)	2.30	2.11
Moisture Content (%)	1.76	1.76
Average Moisture Content (%)	1.76	

Failure Sketches



Determination of Stess and Strain

Strain Dial Reading	Unit Strain -Axial	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	20.43	0.00
17	1.667E-03	526	20.43	25.75
35	3.431E-03	993	20.43	48.61
53	5.196E-03	1365	20.43	66.82
68	6.667E-03	1784	20.43	87.32
86	8.431E-03	2323	20.43	113.71
104	1.020E-02	3048	20.43	149.19
122	1.196E-02	3516	20.43	172.09
136	1.333E-02	4088	20.43	200.09
153	1.500E-02	4545	20.43	222.45
170	1.667E-02	4959	20.43	242.71



Compressive Strength	242.71	kg/cm^2	Strain	1.667E-02
Young's Modulus	1.638E+04	kg/cm^2	Poisson Ratio	-
Rock Type (Visual Analysis)	-			

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	decon Geotechnical Testing Laboratory	
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
BH / TP No.	BH-19	Job No.	-
Sample No.	WS-01	Lab No.	1006
Sample Depth (m)	21.58-21.77	Test Started	May 16, 2025
Sampled Date	-	Test Completed	May 18, 2025

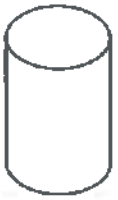
UNIAXIAL COMPRESSIVE STRENGTH

Details	Initial
Specimen Dia (cm)	5.60
Specimen Area (cm^2)	24.63
Specimen Height (cm)	11.30
Specimen Volume (cm^3)	278.32
Weight of Specimen (g)	659.00
Bulk Density of Rock (g/cm^3)	2.368
Dry Density of Rock (g/cm^3)	2.292

Determination of Moisture Content

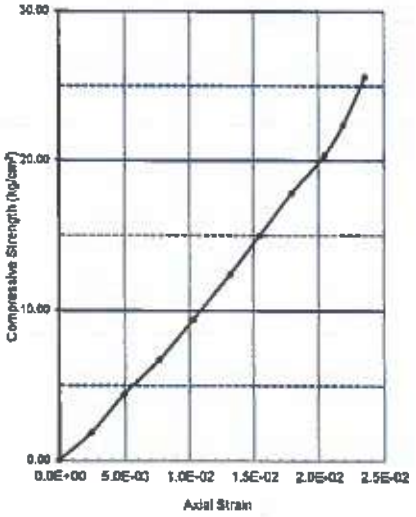
Container No.	C-58	C-14
Weight of Container (g)	21.91	21.59
Weight of Container + Wet Sample (g)	160.99	161.25
Weight of Container + Dry Sample (g)	156.65	156.68
Weight of Dry Soil (g)	134.74	135.09
Weight of Water (g)	4.34	4.57
Moisture Content (%)	3.22	3.38
Average Moisture Content (%)	3.30	

Failure Sketches



Determination of Stess and Strain

Strain Dial Reading	Unit Strain -Axial	Axial Load (kg)	Corrected Area (cm^2)	Compressive Strength (kg/cm^2)
0	0.00	0	24.63	0.00
28	2.478E-03	45	24.63	1.83
56	4.956E-03	108	24.63	4.38
87	7.699E-03	165	24.63	6.70
117	1.035E-02	231	24.63	9.38
149	1.319E-02	305	24.63	12.38
175	1.549E-02	368	24.63	14.94
203	1.796E-02	438	24.63	17.78
232	2.053E-02	501	24.64	20.34
248	2.195E-02	551	24.64	22.37
267	2.363E-02	630	24.64	25.57



Compressive Strength	25.57	kg/cm^2	Strain	2.363E-02	
Young's Modulus	1.063E+03	kg/cm^2	Poisson Ratio	-	
Rock Type (Visual Analysis)	-				

Tested By	Checked By	Approved By
Nasrullha Khan	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
Lab No	1003	**Test Started**	May 10, 2025
Sampled Date	-	**Test Completed**	May 12, 2025

Chemical Analysis of Soil

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Location	Sulphates (%)	Chlorides (%)	Organic Matter (%)	TDS (ppm)	pH
			From	To						
1	BH-01	SPT-08	8.00	8.45	-	0.01	0.02	0.11	-	-
2	BH-02	SPT-01	1.00	1.45	-	0.03	0.04	0.13	-	-

Tested By	Checked By	Approved By
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FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s Safe Services Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		**decon** Geotechnical Testing Laboratory
Location	PACKAGE 3: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
Lab No	1003	**Test Started**	May 10, 2025
Sampled Date	-	**Test Completed**	May 12, 2025

Chemical Analysis of Soil

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Location	Sulphates (%)	Chlorides (%)	Organic Matter (%)	TDS (ppm)	pH
			From	To						
1	BH-03	UDS-01	2.50	3.00	-	0.03	0.02	0.13	-	-

Tested By	Checked By	Approved By
Yasir Arif	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
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Project	Feasibility Study for Tourist Glass Train from Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree		
Lab No	989	**Test Started**	March 22, 2025
Sampled Date	-	**Test Completed**	March 23, 2025

Chemical Analysis of Soil

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Location	Sulphates (%)	Chlorides (%)	Organic Matter (%)	TDS (ppm)	pH
			From	To						
1	BH-07	WS-02	3.58	3.74	-	0.03	0.04	0.08	-	-

Tested By	Checked By	Approved By
Yasir Arif	-	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller, Lahore

Project	Feasibility Study for Tourist Glass Train from Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.	decon Geotechnical Testing Laboratory
Location	Rawalpindi to Murree	

Lab No	989	Test Started	April 10, 2025
Sampled Date	-	Test Completed	April 11, 2025

Chemical Analysis of Soil

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Location	Sulphates (%)	Chlorides (%)	Organic Matter (%)	TDS (ppm)	pH
			From	To						
1	BH-10	SPT-02	2.00	2.45	-	0.03	0.04	0.08	-	-
2	TP-01	CS-01	0.00	1.20		0.01	0.02	0.06		

Tested By	Checked By	Approved By
Yasir Arif	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller, Lahore

Project	Feasibility Study for Tourist Glass Train from Package 4: Geotechnical Investigation for Trackway, Stations, and Structures.		**decon** Geotechnical Testing Laboratory
Location	Rawalpindi to Murree		
Lab No	989	**Test Started**	April 9, 2025
Sampled Date	-	**Test Completed**	April 10, 2025

Chemical Analysis of Soil

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Location	Sulphates (%)	Chlorides (%)	Organic Matter (%)	TDS (ppm)	pH
			From	To						
1	BH-11	SPT-01	1.00	1.45	-	0.03	0.04	0.09	-	-

Tested By	Checked By	Approved By
Yasir Arif	Noman Maqbool	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE		**decon** Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		
Lab No	1006	**Test Started**	May 23, 2025
Sampled Date	-	**Test Completed**	May 24, 2025

Chemical Analysis of Soil

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Location	Sulphates (%)	Chlorides (%)	Organic Matter (%)	TDS (ppm)	pH
			From	To						
1	BH-17	SPT-03	3.00	3.45	-	0.05	0.02	0.14	-	-

Tested By	Checked By	Approved By
Yasir Arif	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

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CLIENT	CONSULTANT	CONTRACTOR
-	NESPAK	M/s The Driller,Lahore

Project	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**decon** Geotechnical Testing Laboratory
Location	PACKAGE 5: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	

Lab No	1006	Test Started	May 13, 2025
Sampled Date	-	Test Completed	May 14, 2025

Chemical Analysis of Soil

Sr No	BH / TP No	Sample Detail	Sample Depth (m)		Location	Sulphates (%)	Chlorides (%)	Organic Matter (%)	TDS (ppm)	pH
			From	To						
1	BH-18	SPT-04	5.00	5.45	-	0.03	0.04	0.13	-	-
2	BH-19	SPT-01	1.00	1.45	-	0.03	0.02	0.11	-	-

Tested By	Checked By	Approved By
Yasir Arif	Jawad Nasir	Shahzaib Khalid

FIRM decon International (Pvt) Ltd.

Shahzaib

APPENDIX-E

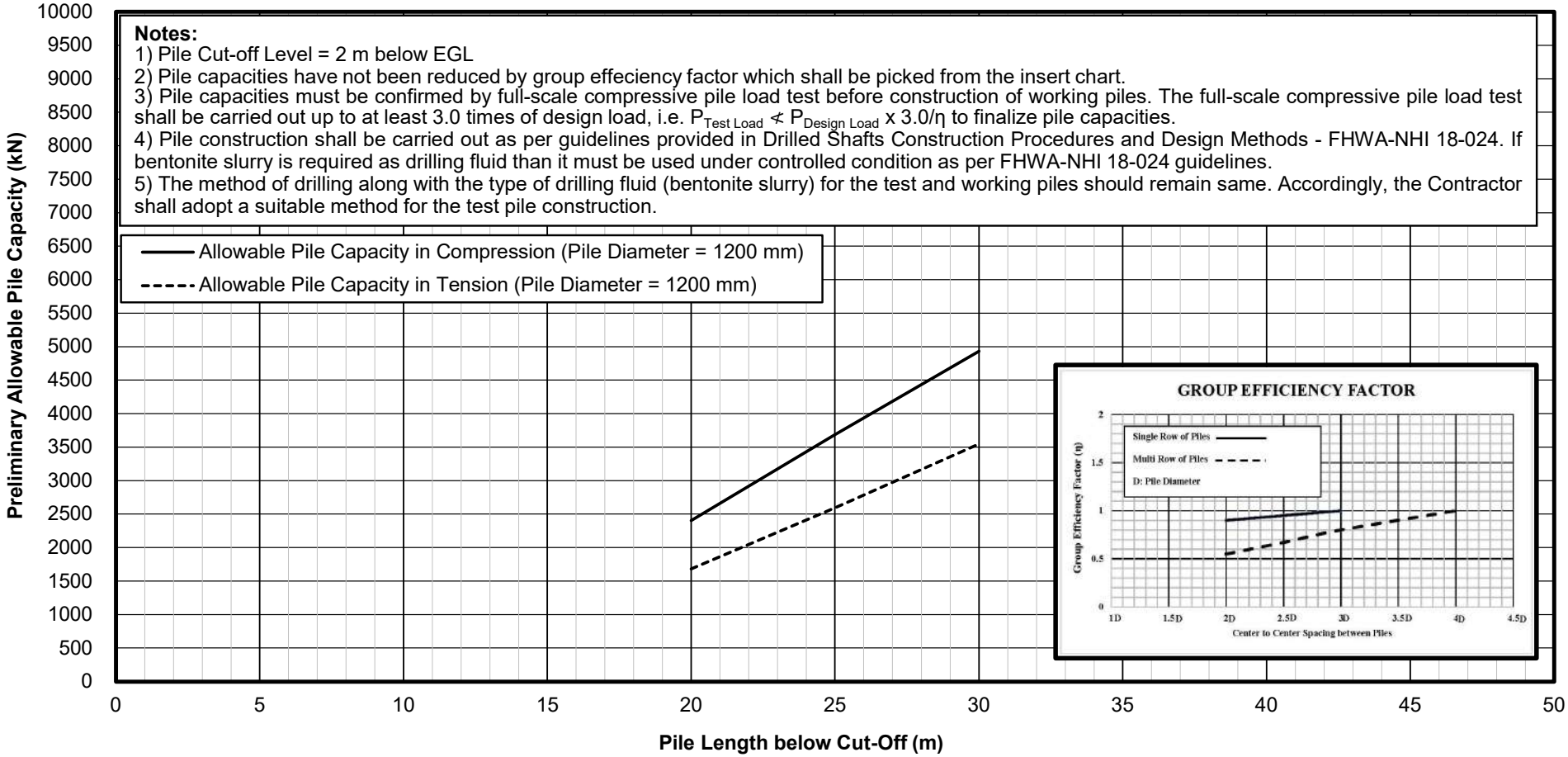
FIG. E1: PRELIMINARY ALLOWABLE LOAD CARRYING CAPACITY OF BORED RC PILES IN COMPRESSION AND TENSION FOR GROUP-1

FIG. E2: PRELIMINARY ALLOWABLE LOAD CARRYING CAPACITY OF BORED RC PILES IN COMPRESSION AND TENSION FOR GROUP-2

FIG. E3: PRELIMINARY ALLOWABLE LOAD CARRYING CAPACITY OF BORED RC PILES IN COMPRESSION AND TENSION FOR GROUP-3 and GROUP-4

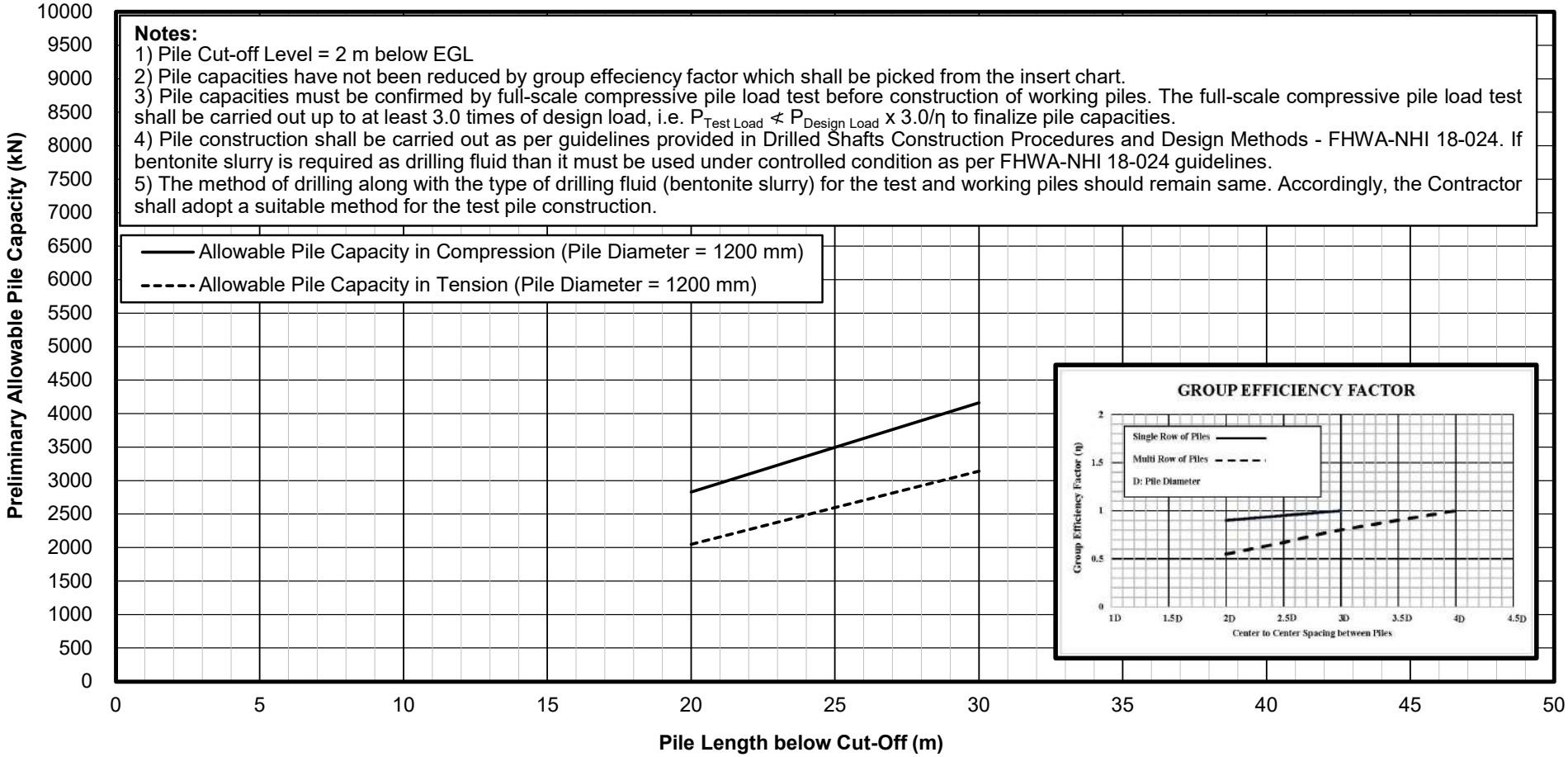
FEASIBILITY STUDY FOR THE TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

PRELIMINARY ALLOWABLE LOAD CARRYING CAPACITY OF BORED RC PILES IN COMPRESSION AND TENSION FOR GROUP-1



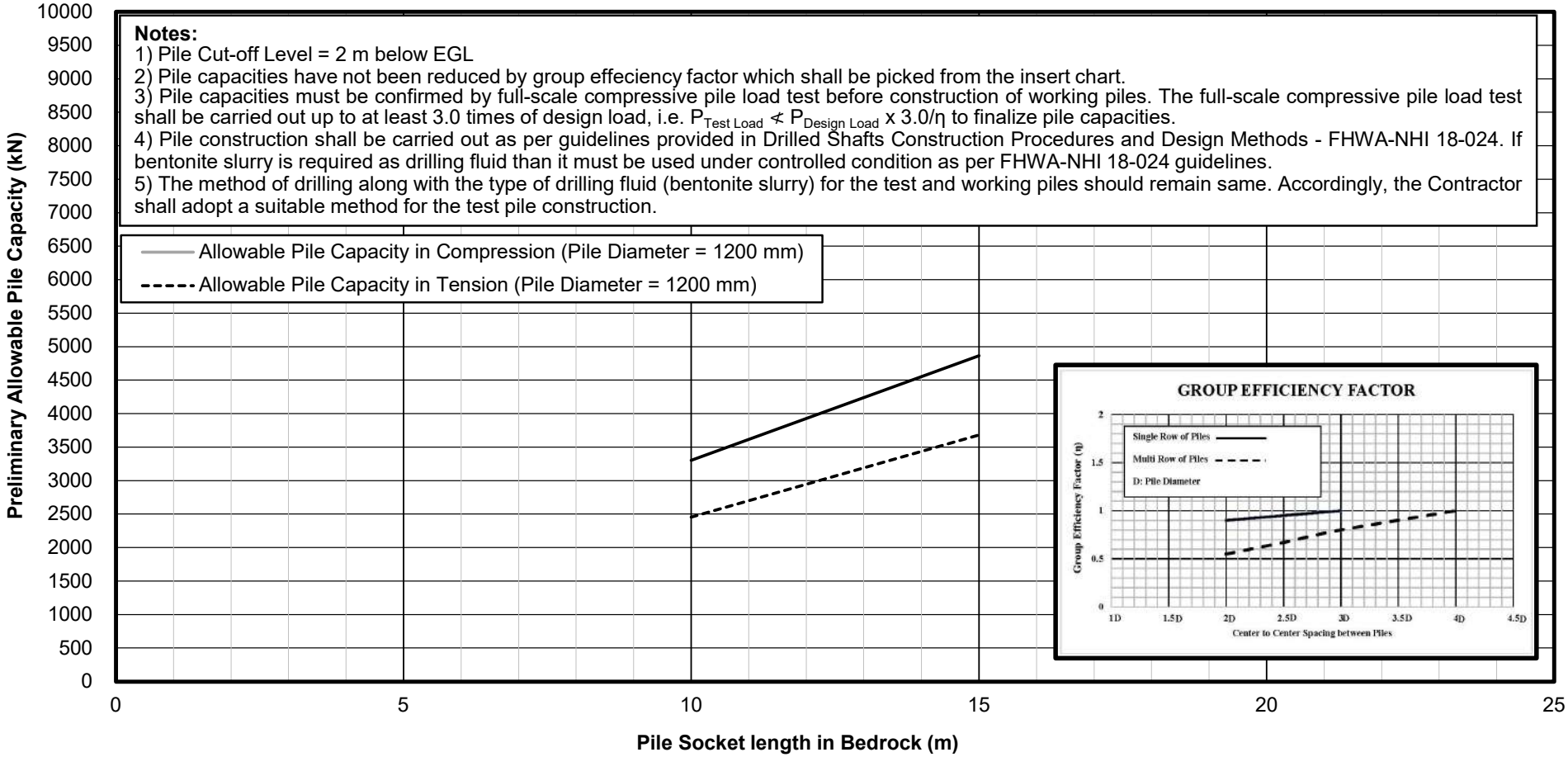
FEASIBILITY STUDY FOR THE TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

PRELIMINARY ALLOWABLE LOAD CARRYING CAPACITY OF BORED RC PILES IN COMPRESSION AND TENSION FOR GROUP-2



FEASIBILITY STUDY FOR THE TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

PRELIMINARY ALLOWABLE LOAD CARRYING CAPACITY OF BORED RC PILES IN COMPRESSION AND TENSION FOR GROUP-3 and GROUP-4



APPENDIX-F

SITE PHOTOGRAPHS



Plate-1: View of the Project Area near BH-06



Plate-2: View of the Project Area near BH-05



Plate-3: View of the Project Area between BH-08 and BH-09



Plate-4: View of the Project Area between BH-08 and BH-09



Plate-5: View of the Project Area between BH-09 and BH-10



Plate-6: Drilling at BH-04 with Percussion Drilling Rig



Plate-7: Drilling at BH-06 with Percussion Drilling Rig



Plate-8: Drilling at BH-07 with Straight Rotary Drilling Rig



Plate-9: Drilling at BH-08 with Straight Rotary Drilling Rig



Plate-10: Drilling at BH-09 with Straight Rotary Drilling Rig



Plate-11: Drilling at BH-10 with Straight Rotary Drilling Rig



Plate-12: Drilling at BH-12 with Straight Rotary Drilling Rig



Plate-13: Drilling at BH-12A with Straight Rotary Drilling Rig



Plate-14: Performance of Standard Penetration Test (SPT) in BH-07



Plate-15: Soil Sample recovered from Split Spoon Sampler from BH-12A

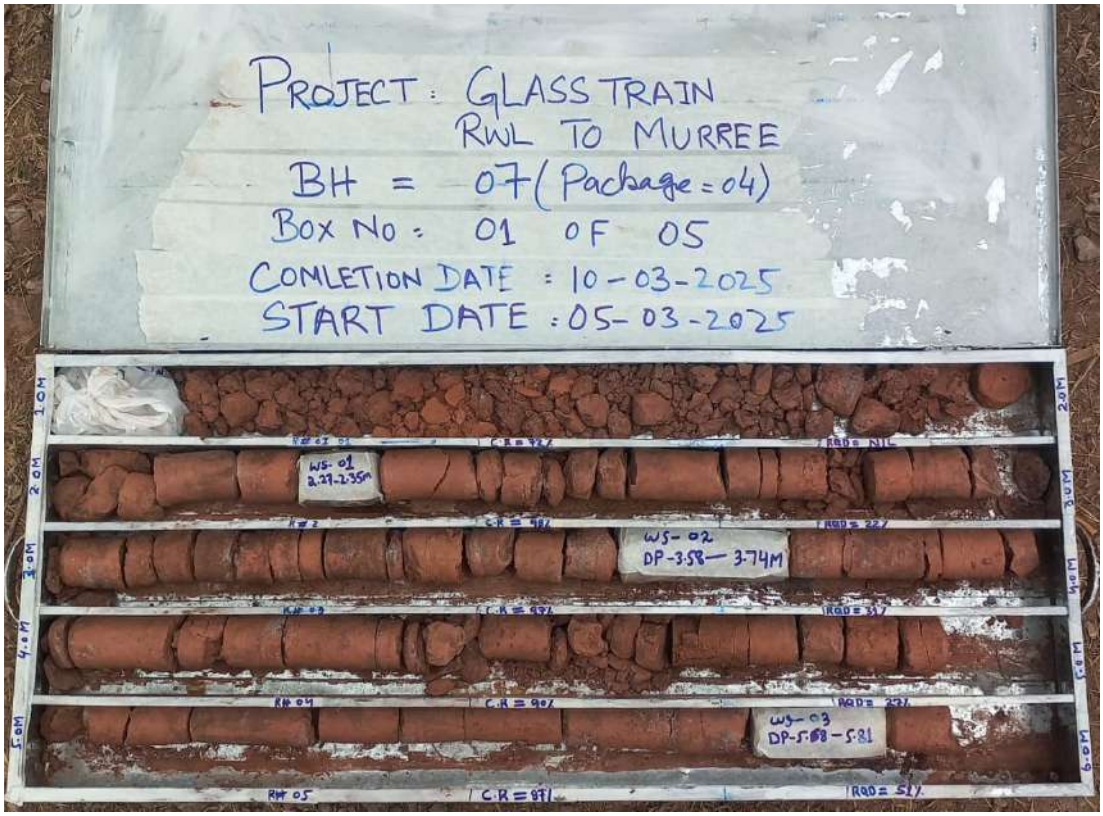


Plate-16: Rock Core obtained from BH-7 and Preserved in a Core Box



Plate-17: Rock Core obtained from BH-12A and Preserved in a Core Box



Plate-18: Surveying for Geotechnical Investigation Points

Feasibility Study for Tourist Glass Train from Islamabad to Murree

Study Report



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Abbreviations

Abbreviation	Full Name
AC	Alternating current
ACB	Air Circuit Breaker
ACI	American Concrete Institute
ACV	Aggregate Crushing Value
AMF	Automatic Mains Failure
AOI	Area of Influence
ASR	Alkali-Silica Reaction
ASTM	American Society for Testing and Materials
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
ATS	Automatic Transfer Switching
BCP	Building Code of Pakistan
BEV	Battery Electric Vehicles
BGML	Broad Gauge Main Line
BOT	Build-Operate-Transfer
BS	British Standard
CAPEX	Capital Expenditure
CBI	Computer-Based Interlocking
CBR	California Bearing Ratio
CBRN	Chemical, Biological, Radiological, Nuclear
CBTC	Communication-Based Train Control
CCTV	Closed-Circuit Television
CDA	Capital Development Authority
CENELEC	European Committee for Electro Technical Standardization
CITES	Convention on the International Trade of Endangered Species
CMC	Computer-Mediated Communication

CMS	Migratory Species
COI	Corridor of Influence/Impact
COTS	Commercial Off-The-Shelf products or systems
COVID-19	Coronavirus Disease
CRRC	China Railway Rolling Stock Corporation
CTs	Current Transformers
DAS	Driver Advisory System
DB	Distribution Board
DC	direct current
DEM	Digital Elevation Model
DG	Diesel generator
DLP	Digital Light Processing, Data Loss Prevention.
DOS	Disrupt Operations Safety
EBI	Electronic Braking Intermittent
EDS	Explosive Detection Systems
EGL	Existing Ground Level
EHV	Extra-high voltage
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
ELCB	Earth Leakage Circuit Breaker
EMMM	Environmental Mitigation and Management Matrix
EMP	Environmental Management Plan
CCD	Climate Change Department
EPA	Environmental Protection Agency
EPC	Engineering, Procurement, and Construction
ERP	Emergency Response Plan
ES	Environmental and Social Expert
ESIA	Environmental and Social Impact Assessment
ETCS	European Train Control System
FAR	Floor Area Ratio
FBCR	Financial Benefit-Cost Ratio
FHWA	Federal Highway Administration
FIRR	Financial Internal Rate of Return
FM	Fineness Modulus
FNPV	Financial Net Present Value
GBV	Gender-Based Violence
GHG	Greenhouse Gas
GIS	Gas Insulated Switchgear
GIS	Geographic Information System
GMT	Gross Million Tonnes
GNI	Gross National Income

GNSS	Global Navigation Satellite System
GOA	Great of Automation.
GPS	Global Positioning System
GSM	Global System for Mobile Communications.
GTO	Gate Turn off
HEC-RAS	Hydrologic Engineering Centre River Analysis System.
HIV/AIDS	Human immunodeficiency virus
HKS	Hazara Kashmir Syntaxis
HSE	Health, Safety & Environment
HSLA	High-strength low alloy
HT	High Tension.
HV	High Voltage.
HVAC.	Heating, Ventilation and Air-Conditioning
ICT	Information & Communications Technology
ICT	Islamabad Capital Territory
IEC	International Electrotechnical Commission
IEE	Initial Environmental Examination,
IESCO	Islamabad Electric Supply Company
IMC	Islamabad Metropolitan Corporation
ISRM	International Society for Rock Mechanics
IWMB	Islamabad Wildlife Management Board
KV	Kilo volt.
kVA	kilovolt-ampere.
kWh	kilowatt-hour.
LAN/VLAN	Local Area Network/ Virtual Local Area Network,
LED	Light-Emitting Diode.
LiDAR	Light Detection and Ranging
LL	Liquid Limit
LLB	Low Loss Ballast
LRT	Light Rail Transit
LT	Low Tension.
LTE-R	Long-Term Evolution - Railway
LV	Low voltage.
MASW	Multichannel Analysis of Surface Waves
MBT	Main Boundary Thrust
MCB	Miniature Circuit Breaker.
MCC	Motor Control Centre.
MCC	Manual Classified Traffic Counts
MCCB	Moulded Case Circuit Breaker.
MCM	Million Cubic Meters
MDD	Maximum Dry Density

MDG	Millennium Development Goals
MDOA	Monorail Development & Operating Authority
MHNP	Margalla Hills National Park
MMI	Man-Machine Interface.
MV	Megavolt, Medium Voltage.
NAVFAC	Naval Facilities Engineering Command
NDC.	Nationally Determined Contributions
NEQS	National Environmental Quality Standards
NESPAK	National Engineering Services Pakistan
NOC	No Objection Certificates
NPO	No Project Option
NPV	Net Present Value
NTDC	National Transmission and Dispatch Company Limited.
NTP	Network Time Protocol
O&M.	Operation & Maintenance
OC/EF	Overcurrent/ Earth Fault
OCC	Operation control center
OCR	Operation Control Room
O-D	Origin- Destination
OEMs	Original Equipment Manufacture
OHE	Overhead Equipment
OHS	Occupational Health & Safety
OPC	Ordinary Portland Cement
PA	Public Address
PAP	Project Affected Persons
PCV	Passenger Carrying Vehicle
PEQS	Punjab Environmental Quality Standards
PGA	Peak Ground Acceleration
PGS	Power Grid Stations
PI	Plasticity Index
PIDS	Passenger Information Display Systems
PL	Plastic Limit
PMA	Punjab Mass Transit Authority
PMSM	Permanent Magnet Synchronous Motors
PMU	Project Management Unit.
PPE	Personal Protective Equipment
PPP	Public-Private Partnership
PPPU	Public-Private Partnership Unit
PPRA	Public Procurement Regulatory Authority
PTDC	Pakistan Tourism Development Corporation
PTP	Precision Time Protocol

PTs	Potential Transformers.
PV	Photovoltaic.
PVC	Polyvinyl Chloride
QGIS	Quantum Geographical Information System
RAMS	Reliability, Availability, Maintainability, and Safety.
RCCB	Residual Current Circuit Breaker,
RCD	Residual Current Device
RMSE	Root-Mean Square Error
RMU	Ring Main Unit.
ROW	Right of Way
RQD	Rock Quality Designation
RSS	Received Signal Strength.
RTU	Remote Terminal Unit
RWMC	Rawalpindi Waste Management Company
SC	Supervision Consultant
SCADA	Supervisory Control and Data Acquisition.
SDB	Sub-Distribution Board.
SERF	Shadow Exchange Rate Factor
SIL	Safety Integrity Levels
SMD	Static Media Display
SMS	Short Message Service.
SMRV	Straddle Monorail Recovery Vehicle.
SNMP	Simple Network Management Protocol.
SOP	Standard Operating Procedure
SPD	Surge Protective Devices
SPD	Strategic Planning Division
SPT	Standard Penetration Test
SPV	Special Purpose Vehicle
SRG	Signal Reference Grid
SWA	Steel Wire Armored.
T&D	Transmission and Distribution.
TAZ	Traffic Analysis Zone
TCMS	Train Control Management System
TDCP	Tourism Development Cooperation of Punjab
TDS	Total Dissolved Solids
TMA	Tehsil Municipal Administration Murree
TOR	Terms of Reference
TPSS	Traction Power supply substation.
TRT	Third Rail Traction
UK	United Kingdom

UNFCCC	United Nations Framework Convention on Climate Change
UPS	Uninterruptible Power Supply.
UPVC	Unplasticized Polyvinyl Chloride.
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
UTO	Unattended train operation
VCB	Vacuum circuit breakers
VDU	Visual Display Unit
VHF/UHF	Very High Frequency/ Ultra High Frequency,
VOC	Vehicle Operating Cost
VoIP	Voice over Internet Protocol
VOT	Value of Time
VT	Voltage Transformers
VVVF	variable voltage & variable frequency inverters
WAPDA	Water and Power Development Authority.
WHO	World Health Organization
Wi-Fi	wireless fidelity
WSR	Water Sufficiency Ratio
XLPE	Cross-linked Polyethylene cable.

1. Chapter

1.1 Introduction

The Islamabad–Murree corridor represents one of Pakistan's most frequented tourism and commuter routes, offering access to the scenic hills of Murree, Patriata, and beyond to Muzaffarabad. As a major gateway to the country's northern tourist belt, Murree attracts millions of visitors annually. However, the existing transportation infrastructure, primarily the Murree Expressway and the older Kashmir Road, has become increasingly overwhelmed by high volumes of vehicular traffic, especially during peak tourism seasons. Congestion, long delays, road safety risks, and environmental degradation have become routine challenges. These limitations not only inconvenience travelers but also hinder the sustainable development of tourism and regional economic activity.

Recognizing the need for an alternative and more sustainable transport solution, the Government of Pakistan approved PC-II in March 2014 to conduct a detailed feasibility study for establishing a rail-based link from Islamabad to Murree and onward to Muzaffarabad. The study, commissioned under the administrative control of the Ministry of Railways and executed by the newly established Kashmir Railway (Private) Limited, aimed to explore technical, environmental, economic, and social viability of a railway system in the mountainous terrain.

This was the first ever in-depth assessment of such nature of this corridor in the Draft Feasibility Study Report (May 2015). A consortium (ILF Austria and ILF Pakistan) conducted the study, which consisted of several geological exploration activities, topography, seismic risk access, and market demand surveys. It decided that–although the possible demand especially in passenger traffic was very heavy, terrain between Islamabad and Murree was very restricted to a broad-gauge railway or electric-diesel trains. A ruling gradient of 2.5%, a train speed of 55km/h and a 400-ton trailing load that was to be pulled by two locomotives of 3000-horse power was adopted in proposed track alignment in the feasibility report. This alignment however, failed to reach up to the Murree hilltop hence, a connection to Murree Hill by cable car link through Lower Topa was suggested. This cable car scheme was not approved, later the consultant proposes to retain already approved alignment with conventional broad-gauge track from Islamabad to Bastal Morr with gradient of 2.5%. From Bastal Morr a revised alignment proposed, connecting Gohra Gali, Muree (Ghika Gali), Bhurban, Ocha and Temuthian with rack track system up to Kohala (50 km length) and from Kohala up to Muzaffarabad again used already approved alignment. This revision of alignment reduces the length of conventional rail track from Islamabad to Muzaffarabad to 105.7 km instead of 117.90

km these recommendations of consultant approved, however, possibility of connection of Muzaffarabad with Dhudial via Gari Habibullaha were to be examined. For adoption of new system (rack track) in order to connect Murree Hill, a new alignment having length of 50km between Bastal Morr and Kohala , required new activities for which scope of feasibility study needs to be revised along with cost. A revised PC-11 prepared by Pakistan Railways was accordingly approved on 7 February 2017 at a cost of Rs. 115.244 million. The additional work of feasibility study was also entrusted to same consultant on 3rd January 2018 at a cost of Rs 51.142 million. Planning Commission during meeting on 25 September 2018 dissolved Kashmir Rail Company, and asked Ministry of Railways to complete the feasibility study by deleting the scope of the extended portion from Muzaffarabad to Dhudial.The study on revised reduced scope i.e. new alignment from Bastal Morr to Kohala by connecting Murree Hill remained held up due to the reason that Ministry of Defense convey their apprehensions that revised proposed alignment passes through some portion of their restricted areas.

The Government of Punjab revived the project as Tourist Glass Train in October 2024. This service specialty had more to do with providing panoramic view of the beautiful terrain that could only be equated with other tourist trains like the other countries like Switzerland, Canada, and Japan which have the same. It would also aid the diversification of the transportation mode since this elevated railway line would help to connect Rawalpindi/Islamabad and Murree via a direct train connection rather than relying solely on road transport.

The Punjab Mass Transit Authority awarded the task of Feasibility Study for Tourist Glass Train from Rawalpindi – Murree to M/S NESPAK on 28th, October, 2024. M/S NESPAK started the work on selection of the route alignments for the proposed Railway Track. During feasibility studies, the consultant has analyzed various alternatives of alignments of a traditional railway, and they all had insurmountable impediments. At a meeting held on 7th march 2025 a route starting by H- 9 Islamabad via Blue area, Lake view, Bara Khau, Baroha, Company Bagh, Ghora Gali to Sunny Bank Murree was approved which has 44.6 Km length and 6.1 percent gradient of progression and a 5.5 Km run of tunnel. Issues arose during reconnaissance survey of the accepted route as in the case of the alignment shifting because of existent military and SPD settlements along Trett and a likely geo-hazard i.e. 5KM proposed tunneling had started to move in parallel along the hill which was not acceptable geo-technically.

Later on, another Murree Line Route was identified but it also faced severe gradient constraints, widespread slope instability, and prohibitively high construction costs due to necessary retaining structures. Then another route-was proposed having two large

tunnels of 3 km and 2 km each just before Ghora Gali with a gradient of 4.8%, but this alignment also passed through geo-hazard red zones, Unstable slopes and low soil stability at grade, high risk of landslides in deeper cuts. During Geo-tech study subsurface drilling at the portal of the tunnel revealed crushed limestone, loose soil with high vibration risk posing danger to nearby village and making tunneling unfeasible.

The steep gradients, sharp curves, and complex hydrological and geological conditions meant that conventional railway systems would require extensive tunneling, large viaducts, and heavy infrastructure investments, making them technically difficult and economically non-viable. As a result, the focus shifted toward exploring alternative modes of transport better suited to the unique physical and environmental conditions of the region. Aerial Ropeways (Cable Car), Light Rail Transit (LRT) and Straddle-Type Monorail system were studied as an alternate. Straddle Mono Rail System emerges as the most suitable due to high gradient tolerance (6 – 10%), having grade separation, tight turning capability (50 m radius), low structural footprint, and ability to operate on elevated guide ways with minimal land acquisition and environmental disturbance.

In summary, the Glass Train project is a natural evolution of the findings and limitations identified in the original PC-II feasibility study. It combines technical innovation, environmental sensitivity, and tourism-centric planning to offer a transformative solution for one of Pakistan's most iconic travel routes.

1.2 Award of Contract for Feasibility Study

The Punjab Government is going to carry out a Comprehensive Feasibility Study to establish direct rail-link between Rawalpindi/Islamabad and the top of the Murree hill which would take into consideration those areas that had been left incomplete in previous studies. The feasibility study into a Tourist Glass Train on this route was awarded by the Punjab Mass Transit Authority (PMA) to M/S NESPAK on 28th October, 2024 after which NESPAK commenced the task of locating possible route routes on this line, of the proposed new railway line. PMA, under the guidance and the supervision of the Transport Planning Unit of the Transport & Mass Transit Department, will support the conduct of the study and preliminary engineering design will also be included within the study. The study shall investigate the existing situation of the outlined alignment (Annexure-A) in the previous study and if required, proposed optional analysis for the re-alignment from Rawalpindi / Islamabad – Murree as titled in the nomenclature of the scheme, reaching an elevation of about 2000 meters. It will also consider the best suited railway technology that will suit such terrain and the operational and tourism principal of the introduction of a Glass Train, especially it's potential on meeting the tourist access to Murree and traffic de-congestion of vehicles.

1.3 Post-Feasibility Developments

Since the submission of the 2015 feasibility report, the following key developments have occurred:

1.4 Shift toward Alternative Transport Solutions

The feasibility findings led project stakeholders especially Kashmir Railway (Pvt.) Ltd. and Ministry of Railways to consider alternative transit technologies. International case studies and local conditions led to the prioritization of straddle-type monorail systems, particularly for the Islamabad–Murree section.

1.5 Emergence of the Glass Train Concept

With tourism as a central theme, the concept of a Glass Train a monorail system with panoramic coaches running on elevated tracks was proposed. This system would offer not only technical feasibility in hilly terrain but also become a premium tourist attraction.

1.6 Proposal Integration into Tourism Policy

The concept of the Glass Train began gaining traction in federal and provincial tourism development circles. It aligns with national strategies for eco-tourism, green infrastructure, and public-private partnership (PPP) models.

1.7 Follow-up Actions

- Finalization and approval of updated PC-I
- Environmental clearance and updated ESIA **(**Environmental and Social Impact Assessment**)** under the revised scope.
- Alignment validation using modern surveying technologies (e.g., LiDAR)
- Station and prototype vehicle design for public presentation

1.8 Key Gaps Relevance to the Current Study

Despite the strengths of the previous study, key gaps remain. It did not assess the specific technological needs of a glass train system such as energy efficiency, passenger comfort, and tourism-oriented innovations, focusing instead on conventional railway parameters. Socio-economic aspects, including community impacts, economic opportunities, and cultural considerations, were also insufficiently addressed. This study therefore aims to fill these gaps by evaluating tourist-related technologies, electric traction, socio-economic impacts, and market trends to ensure the successful implementation of a glass train that enhances regional tourism.

In summary, while the previous feasibility study provides essential insights and groundwork for the proposed glass train project, the current study aims to fill critical

gaps related to tourist-related technology assessment, electric traction, socio-economic impacts, and market trends to ensure a successful implementation that enhances tourism in the region.

1.9 Objectives

The objectives of the Feasibility Study are:

- To assess the passenger (tourist and local residents) and freight demand between Rawalpindi/Islamabad - Murree from adjoining areas for provision of modern railway system/ technology (rack track, funicular etc.) including Glass Train to improve connectivity, ease congestion and cater tourist demand within the Rawalpindi/Islamabad - Murree region
- To select the most viable route alignment for the proposed Glass Train from Islamabad to Murree hilltop to facilitate the passengers & tourists' movement and freight
- To ensure integration and track standards compliance of proposed railway line and allied infrastructure with the existing infrastructure of Pakistan Railways
- To evaluate different procurement options including but not limited to Public Private Partnership (PPP), Engineering Procurement & Construction (EPC) and develop Business Models in order to recommend suitable mode for execution and operations of the project
- To assist the Client in identifying potential investors / donors and contractors for execution of the project
- To develop preliminary designs and specifications for stations and rolling stock for safe and affordable mobility of passengers
- To propose Legal and Institutional Framework for design, construction, operations & maintenance of the project

1.10 Terms of References (TORs)

The Scope of Services for the proposed feasibility study included the following activities:

- Review of the previous Studies / Available Data
- Feasibility Study including optional analysis for selection of route alignment, rail track technology, train technology, economic/ financial, environment analysis and social impact analysis for the proposed railway line and option analysis for public private partnership
- Submission of Preliminary Design and Preparation of PC-1.

- In case of EPC, preparation and submission of the relevant procurement documents including Client's Requirements.

1.11 Scope of Feasibility Study

Scope of for the Services for the proposed Feasibility Study According of the above referred Consultancy Agreement, the Scope of feasibility study includes the following activities Route and alignment Selection

- Reconnaissance Survey & Route Selection
- Traffic and Commercial Survey
- Topographic Strip Survey and Design of Alignment
- Geological, Geotechnical and Seismological Studies
- Hydrological Studies
- Environmental and Resettlement Impact Studies
- Signalling and Telecommunication Study
- Rolling Stock Study
- Electrical Traction Study
- Electric Power Study
- Economic and Financial Analysis
- Cost Estimate
- Draft Feasibility Study Report
- Feasibility Study Report
- Preparation and submission of PC-I
- Preparation and submission of Tender Documents

2. Chapter

2.1 Executive Summary

The Islamabad–Murree corridor is one of Pakistan's busiest tourism and commuter routes, serving as the gateway to Murree, Patriata, and Gallyiat and onward to Muzaffarabad. Current road infrastructure, namely the Murree Expressway and Kashmir Road, is unable to cope with peak tourist demand, resulting in congestion, delays, safety concerns, and environmental degradation. To address these challenges, multiple feasibility studies have been undertaken since 2014 to explore rail-based alternatives.

The initial feasibility study (2015), conducted by ILF Austria and ILF Pakistan, assessed broad-gauge rail options but found the steep terrain and restricted geometry between Islamabad and Murree unsuitable for conventional heavy rail. Although passenger demand was projected to be high, technical constraints limited the alignment to Bastal Morr, with Murree Hill proposed to be connected via cable car. Subsequent revisions (2017–2018) introduced a rack railway alignment between Bastal Morr and Kohala; however, the alignment passed through restricted defense areas, and the extended scope toward Dhudial was eventually dropped.

In October 2024, the Government of Punjab revived the concept as a Tourist Glass Train to provide a panoramic, tourism-oriented transport solution comparable to scenic train systems in Switzerland, Canada, and Japan. The Punjab Mass Transit Authority (PMA) engaged NESPAK to conduct a fresh feasibility study. Multiple alignment options were analyzed, including routes from Islamabad via Blue Area, Lake View, and Ghora Gali to Sunny Bank Murree. However, reconnaissance and geotechnical surveys revealed significant obstacles: excessive gradients (up to 6.1%), unstable slopes, crushed limestone, and geo-hazard red zones along proposed tunneling sections. These conditions rendered traditional railway solutions technically and economically unfeasible due to high tunneling costs, slope instability, and unacceptable safety risks. As a result, the study shifted focus to alternative transport technologies more compatible with topography of Murree. Among the options assessed Aerial Ropeways (Cable Car), Light Rail Transit (LRT), and Straddle-Type Monorail, the Straddle Monorail system emerged as the most viable. Its key advantages include:

- Capability to operate on steep gradients (6–10%) and tight curves (50m radius).
- Elevated guideway system requiring minimal land acquisition and reduced environmental footprint.
- Grade separation ensuring safety and uninterrupted operation.
- Scalability for both commuter and tourist demand while enhancing scenic value.

In conclusion, the Tourist Glass Train project represents a logical evolution of prior feasibility efforts. By transitioning toward a straddle-type monorail system, it aligns technical feasibility with environmental protection and tourism promotion. This solution not only addresses traffic congestion and safety concerns but also positions Murree as a sustainable, world-class tourist destination through an iconic and innovative transport system.

3. Chapter

3.1 Reconnaissance Survey and Route Selection

3.2 Reconnaissance Survey of the Potential Route Corridors

The reconnaissance phase is a critical step in establishing the feasibility and alignment of the Islamabad to Murree Glass Train project. The primary objective of this phase is to conduct a preliminary examination of the proposed corridor to identify potential challenges, opportunities, and constraints for the rail alignment, ensuring a sustainable and viable project framework. Following the desk study, field reconnaissance survey and preliminary field studies comprising geological, hydrological and social impact assessment were carried out by a multidisciplinary team comprising civil engineers, environmental specialists, geotechnical experts and planners from Jan, 2025 to Fab 2025, along the potential route corridors. The team also identified potential physical challenges, such as steep gradients, landslide-prone areas, or water bodies, which could affect the alignment or construction in later stage.

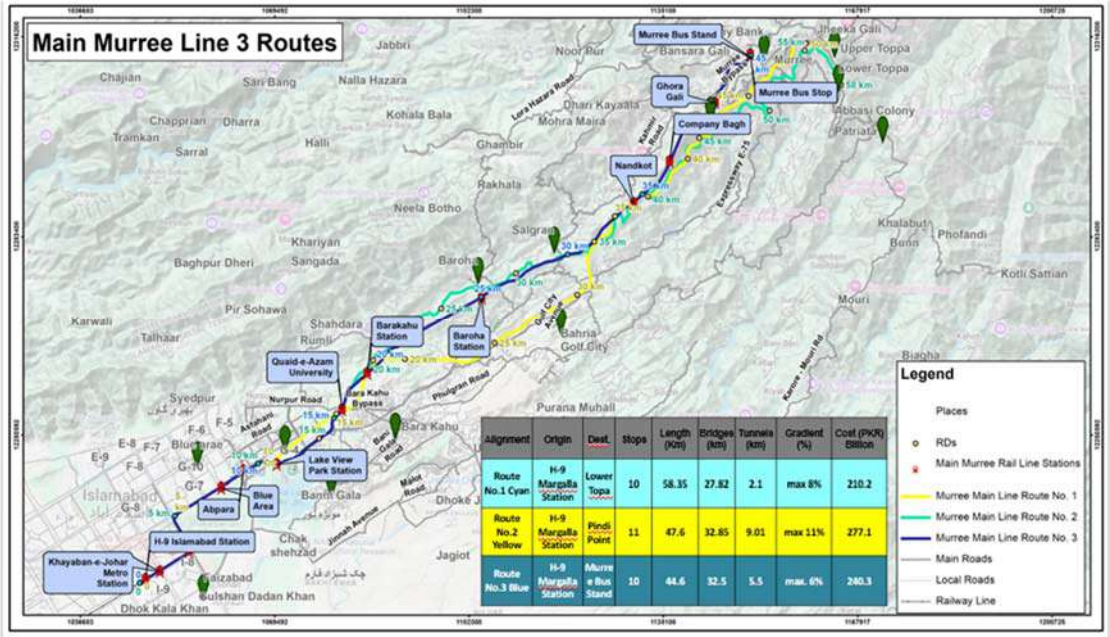
3.2.1 Methodology Adopted for Route / Alignment Selection & Evaluation

The primary objective of the route selection was to identify the most suitable alignment for the Tourist Glass train from Islamabad to Murree. The methodology adopted was a qualitative and non-monetized cost-benefit analysis. Each alignment was assessed in terms of its technical and engineering challenges, as well as its regional and environmental impacts, and these were compared against the anticipated cost magnitude and associated risks. A key component of this analysis was the development of a list of generalized criteria and indicators to measure impacts, costs, and risk. Each of the route /alignment option is to be assessed against a set of indicators such as; Design parameters, Length, Energy, Time of Travel, Safety, Regional Development and Connectivity, Hydrology, Geology, Ecological and Environmental impacts, Capital cost, O& M costs and the Associated Risks.

3.2.2 Alignment Options for Conventional Railway between Islamabad and Murree

As part of the feasibility study for establishing a rail-based tourism corridor between Islamabad and the Murree Hills, multiple alignment options were explored out of which four alignment options were carefully examined shown in **Figure 3.1** below. The unique topography and environmental constraints of the region number of challenges were encountered during survey which provided reasoning and rational for the rejection of these alignments.

Figure: 3.1



3.2.3 Islamabad Railway Station – Bhara Kahu – Nanadkot - Lower Topa – Murree (Cyan line)

The first alignment studied i.e. **(Route no 1, Cyan line)** was the most direct corridor from Islamabad Railway Station to Murree, via Bhara Kahu and Lower Topa. This route was 58 km long and expected to serve as the primary access spine for tourists and commuters traveling to Murree with ten stops. The line passed through semi-urban areas near Islamabad before entering the steeply ascending hills toward Murree. The ruling gradient of the route was 8%. The technical and environmental challenges are as under:

- **Excessive Gradient**: The alignment required negotiating gradients of up to 8 %, well above the conventional railway's safe operating limit of 2.5–3%. Such steep gradients would necessitate extensive tunneling, switchbacks, or complex viaduct systems, all of which would add significantly to cost and complexity.
- **Geological Instability:** The last five kilometers approaching Murree were marked by fragile slopes and frequent landslides. Geological hazards in this stretch posed risks to both construction and long-term operational safety.
- **Tunneling Requirements**: Two long tunnels were proposed to reduce the gradient to acceptable levels. However, tunneling through soft sedimentary rock formations carried high risks of collapse and water ingress.

- **Land Acquisition and Security**: The alignment intersected with thickly forested zones and sensitive defense areas, including army check posts and SPD settlements. The need for relocation or bypassing these areas created additional complications.

Given the combined impact of excessive gradients, geological hazards, and socio-environmental disruptions, this alignment was deemed unfeasible for a conventional railway system.

3.2.4 Islamabad – Bhara Kahu – Bahria Golf City – Pindi Point Murree (Yellow line)

The second alignment option i.e. **(Route No. 2 yellow line)** of 47.6 KM with a maximum gradient of 11% was designed with eleven stops to traverse till Murree hilltop. This corridor does capture both the traditional Murree-bound traffic as well as the tourist inflow for recreational zones. The technical and environmental challenges of the route are as under;

- **Geological Weaknesses**: Subsurface drilling indicated the presence of crushed limestone and loose soils, creating serious stability risks for tunneling. Vibrations from railway operations could compromise the integrity of nearby settlements and infrastructure.
- **Hydrological Hazards**: The corridor traversed valleys prone to flooding and high-water ingress. Tunnel sections of approximately 9KM were considered unsafe due to potential seepage and poor rock support conditions.
- **Community Displacement:** The alignment crossed semi-urban and rural settlements, where land acquisition costs and community resettlement would be prohibitively high.
- **Operational Smoothness:** Tourist rail services require a smooth and comfortable ride experience. However, the unavoidable steep gradients and sharp curves along this alignment would have compromised passenger comfort and system efficiency.

  For the above reasons this route was not found feasible and turned down.

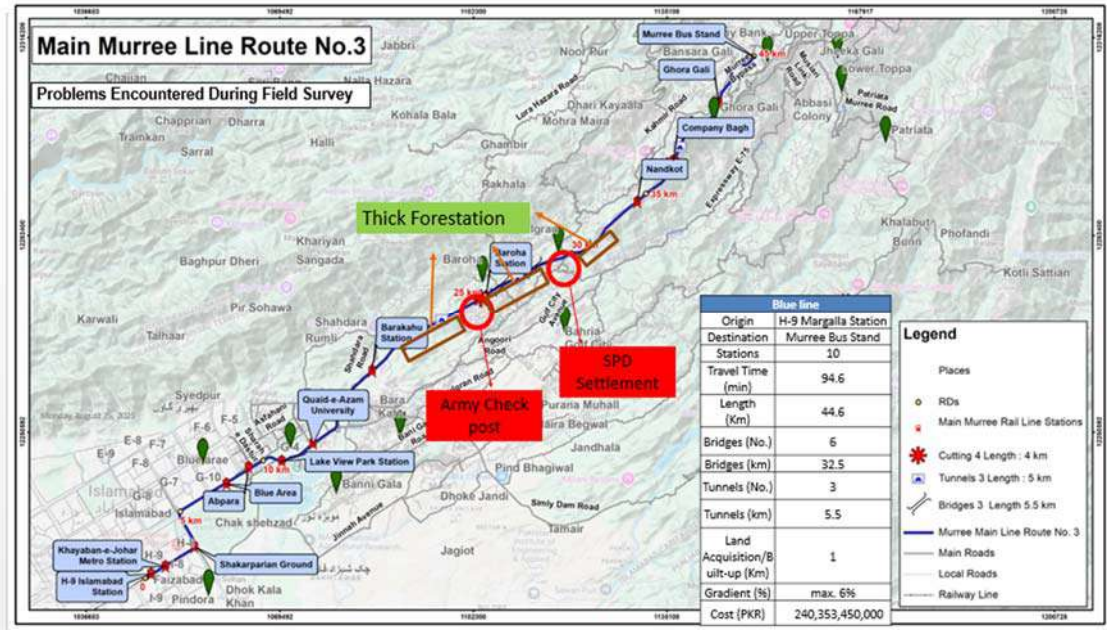
3.2.5 Islamabad – Lake view- Bhara Kahu- Company Bagh- Ghora Gali- Murree (Blue line)

The **(Route No. 3 Blue line)** was one of the three conventional railway alignments proposed from Islamabad to Murree as shown in **Figure 3.2** below. The route originated at H-9 Margalla Station in Islamabad and terminated at the Murree Bus Stand, covering a total length of 44.6 km. The alignment was designed to follow a northwesterly

direction, passing through key urban and suburban nodes before climbing steeply into the Murree Hills. Ten stations were proposed on this alignment. This alignment was designed with maximum 6% gradient having six bridges and 3 tunnels of total length of 5.5KM. The field survey revealed several critical challenges along the Blue Line alignment, both technical and non-technical

- **Thick Forestation**: Large stretches of the alignment passed through dense forested areas in the Margalla Hills and Murree foothills. This raised environmental concerns, including deforestation, habitat disruption, and regulatory restrictions.
- **Army Check Post**: The proposed alignment crossed sensitive defense installations, requiring re-routing or clearance from military authorities. This created major security and operational challenges that could delay or prevent construction.
- **SPD Settlement (Strategic Planning Division)**: The alignment directly intersected with settlements and facilities associated with Pakistan's SPD, a highly sensitive security zone. Relocation was not permissible, effectively making this alignment infeasible without major re-routing.
- **Geological Hazards**: The terrain beyond Baroha and Nandkot featured fragile slopes and landslide-prone zones. Construction of deep cuts and tunnels in these areas risked slope failure, endangering both construction workers and future operations.
- **High Cost of Construction:** With three tunnels totaling 5.5 km and multiple bridges, civil engineering costs were significantly higher than the other two alignments. Land acquisition in semi-urban areas near Islamabad further increased financial burdens.

Figure: 3.2



The reasons for rejection as Final Alignment are as under

Although the (**Route No. 3 blue line)** offered the shortest distance (44.6 km) and relatively lower estimated cost compared with the yellow and cyan alternatives, it was ultimately rejected as the final alignment due to the under mentioned reasons.

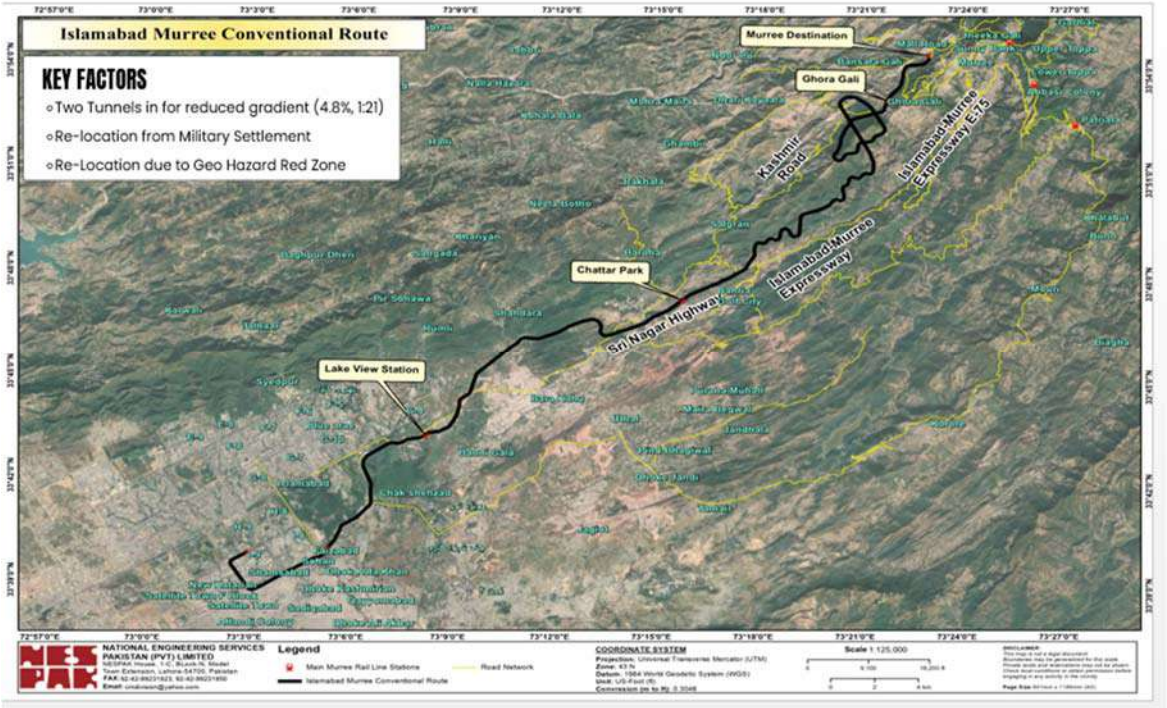
- **Security Restrictions:** Direct conflict with army checks posts and SPD settlements made approvals highly unlikely.
- **Environmental Concerns:** Thick forestation areas required large-scale clearing, contrary to conservation policies.
- **Technical Risks:** Geological hazards in the final approach to Murree created unacceptable construction and operational risks**.**
- **Gradient Constraint:** Even at a reduced design gradient of 6%, this remained at the upper threshold for conventional rail systems, compromising safety and passenger comfort.

3.2.6 Islamabad–Murree Conventional Rail (Route no 4 Black line)

It originates from Islamabad, passing near Lake View Station, Chatter Park, and Ghora Gali, before reaching Murree as shown in **Figure: 3.3** below. It is designed to follow the Srinagar Highway and Islamabad–Murree Expressway corridor, with deviations to manage elevation. The alignment opts two major tunnels to reduce steep gradients from

6.5% to around 4.8% (1:21). It also involved multiple bridge structures and relocation of alignment in sensitive areas.

Figure (3.3)



Despite the engineering measures, the alignment encountered several critical constraints. The final stretch near Murree passed through a geo-hazard red zone prone to landslides and slope instability, posing significant construction and operational risks. Additionally, portions of the alignment overlapped with sensitive military settlements, necessitating relocation and clearance that would be difficult to obtain. The corridor also traversed dense forested areas, requiring extensive slope cutting and deforestation, thereby raising serious environmental concerns. During Geo-tech study subsurface drilling at the portal of the tunnel revealed crushed limestone, loose soil with high vibration risk posing danger to nearby village and making tunneling unfeasible.

Moreover, the requirement of bridges, and costly land acquisition significantly increased the financial burden, making the alignment uneconomical for a conventional rail system. For these reasons, this route was not selected, and emphasis shifted toward adopting an alternate mass transit system that could more effectively address the terrain, geological, and environmental challenges of the Murree corridor.

3.2.7 Selection of Final Alignment for Straddle Monorail

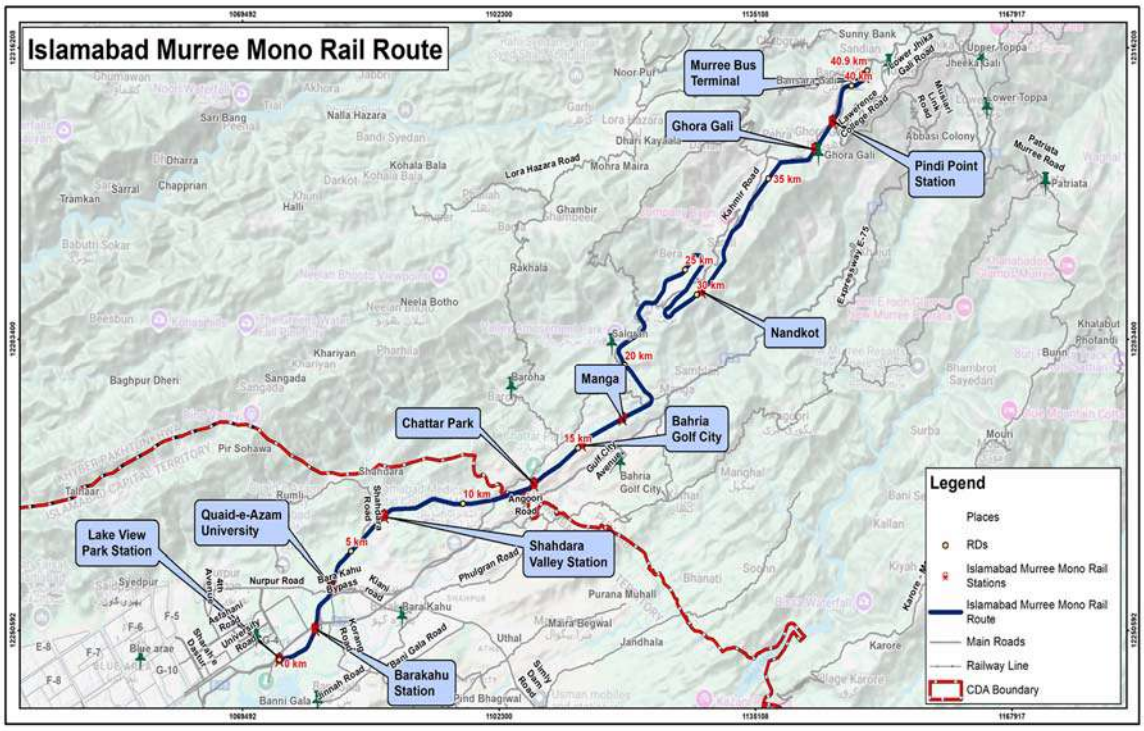
Combiningly, these above route alignments and survays revealed that the traditional railway method was not able to offer a technically secure, ecologically sustainable as well

as economically feasible solution to the Islamabad Murree corridor. The steep gradients, the geology which was delicate, the environmental sensitivities, the security restraints, or high costs of construction, combined to reject all conventional alignments. The results of this, finally supported the move to use an alternative mass transit system of straddle monorail, which is much more adaptive to the topography, needs less land, and offers a scenic, tourist-oriented solution to the terrain concerns, as per the vision of the project.

The proposed alignment for the tourist Glass Train corridor originates from Lake View Park in Islamabad, located within the administrative jurisdiction of the Capital Development Authority (CDA), in accordance with directives. This location provides a scenic and accessible departure point that is well-connected to both urban populations and incoming visitors from Rawalpindi and Islamabad. From Lake View Park, the alignment traverses toward the Barakahu Bypass, avoiding the heavily congested core of Barakahu. A proposed station at Barakahu is located along this bypass to serve as a primary boarding point for suburban residents and to minimize disruption to densely populated zones. This strategic alignment continues along the natural contours of Shahdara Valley, which allows the train to bypass the urban buildup of Barakahu while still maintaining proximity to the area's population. The alignment then curves back toward a central zone between Kashmir Road (the old Murree Road) and the E-75 Murree Expressway. From here onwards, the alignment remains roughly equidistant between the two main roadways, gradually ascending through Bahria Golf City and continuing toward Manga, preserving its scenic value while ensuring construction feasibility. At Tret, a station is proposed near the Valley Amusement Park, which serves as both a tourist attraction and a population cluster. This stop would facilitate recreational access and serve as a tourism development node along the alignment. The alignment then moves through hilly terrain, passing Company Bagh, Nandkot, and Ghora Gali, eventually reaching Murree near the Sunny Bank area. The chosen alignment of this Straddle Monorail traverse the hilly mountainous terrain with a ruling gradient of 6.1%. The proposed Murree terminal is approximately 600 meters from the existing Murree Bus Stand, with an elevation gain of 223 meters. This terminal is strategically located to provide access to central Murree while minimizing congestion impacts within the core tourist district. It is expected to function as a gateway for tourists, offering integrated services including last-mile connectivity, tourist facilitation, and panoramic viewpoints. **Figure: 3.4** below shows the final alignment Plan for proposed tourist glass train link between Islamabad starting from Lake View Park and ending at Sunny Bank area without any disturbance to thick forest cover and sparsely distributed human settlements. The elevated straddle-beam structure of the monorail has minimized land acquisition requirements, eliminated large scale earthworks and retained scenic appearance, which

renders the monorail a technically viable and tourist friendly alternative. In total, the alignment combines technical viability with tourist appeal, traversing diverse terrain while providing critical access to urban peripheries, natural valleys, residential belts, and tourism hotspots. Station locations have been selected based on their potential to serve high-demand catchments, integrate with road-based feeder systems, and promote scenic and environmental value which is a hallmark of Glass Train systems worldwide.

Figure (3.4)



4. LiDAR–UAV Integrated Topographic & Elevation Modeling Report for the Murree Glass Train Corridor

4.1 Project Overview

The Murree Glass Train (MGT) Project, led by the Punjab Mass Transit Authority (PMA), involved a high-resolution topographic and alignment survey along the Rawalpindi–Murree corridor. Using integrated LiDAR scanning and drone photogrammetry, the survey captured detailed terrain data over steep and forested areas. The results produced accurate Digital Elevation Models (DEMs), contour maps, and 3D terrain models essential for engineering design and environmental evaluation. LiDAR's canopy-penetrating ability enabled precise ground mapping along the proposed MGT alignment, supporting route refinement, slope stability analysis, and safe corridor planning. The dataset provides a dependable geospatial foundation for the sustainable development of this landmark transport project.

The Murree Glass Train (MGT) Project is a landmark initiative that combines tourism development, sustainable mobility, and modern civil engineering. The proposed earlier alignment partly leverages the existing right-of-way of Srinagar Highway and passes through rugged, high-altitude terrain. Recognizing the unique topographic and environmental challenges of the region, the project demands high-precision geospatial investigation to guide final alignment, structural form, environmental mitigation, and cost-effective construction. To really, to capture the full complexity of the terrain under tree cover, steep slopes, and variable elevation regimes. Later on, in the reconnaissance and geotechnical surveys revealed significant obstacles: excessive gradients (up to 6.1%), unstable slopes, crushed limestone, and geo-hazard red zones along proposed tunneling sections. The New alignment was proposed started from Lake View Park Islamabad, Barakahu, Shahdara Valley, Nandkot, and Ghora Gali, eventually reaching Murree near the Sunny Bank area. After completion of the feasibility study, there are active plans for a largely elevated track spanning around 40 km, with potential extension to Islamabad International Airport to enhance connectivity for both commuters and tourists.

4.2 Background & Objectives

The MGT initiative responds to the need for a reliable and eco-friendly transport solution connecting the capital region with Murree. Its corridor runs through mountainous zones that demand accurate elevation and slope information for technical and safety reasons. The key objectives of the LiDAR–UAV survey was to capture detailed topography for route

planning, locate potential instability zones, and provide verified elevation data for engineering design. The output supports feasibility evaluation, geometric design, and risk reduction through early identification of critical terrain features.

4.3 Scope of the Project

The Murree Glass Train (MGT) Project required a complete program of geospatial surveying and terrain analysis along the proposed Islamabad–Murree rail alignment. The goal was to develop a high-accuracy topographic database that could support engineering design, route planning, and environmental assessment in the corridor's steep and forested landscape.

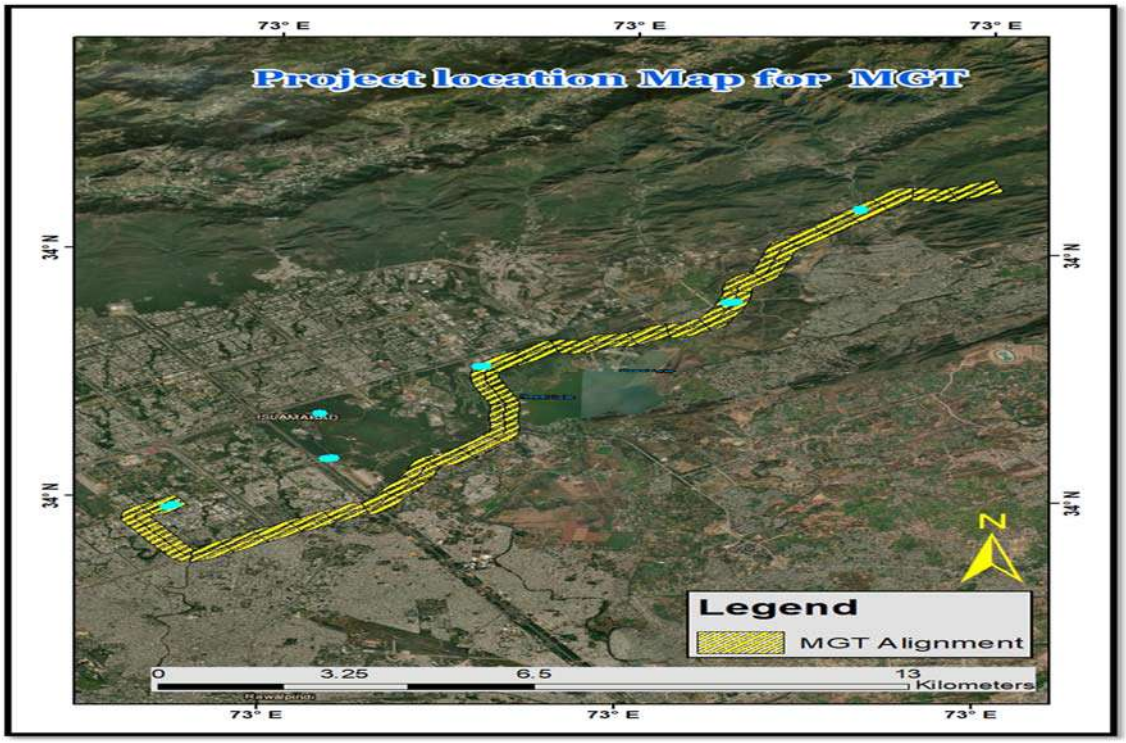
The survey combined aerial LiDAR scanning, UAV-based photogrammetry, and ground control surveys to ensure precise geo-referencing and full spatial coverage. Together, these techniques provided the detailed elevation and surface data needed for sound engineering decisions.

4.3.1 Main Activities

- Flight Planning and Data Capture: LiDAR and UAV flight missions were carefully planned with adequate overlap to achieve seamless coverage of the corridor and nearby terrain.
- Ground Control Network: Reference points were installed and surveyed using high-precision GNSS equipment to anchor aerial data accurately.
- LiDAR Data Processing: Point clouds were generated, classified, and refined to distinguish ground, vegetation, and built structures for precise elevation modeling.
- Photogrammetric Mapping: High-overlap imagery from UAVs was processed to create ortho mosaics and integrate them with LiDAR results for visual and analytical use.
- 3D Terrain Modeling: Detailed Digital Elevation Models (DEMs), Digital Surface Models (DSMs), contour maps, and 3D terrain views were produced to guide design and assessment.
- Quality Control: Data accuracy was verified through independent ground checks to ensure compliance with project specifications.
- Final Deliverables: The outputs include DEMs, DSMs, contour datasets, classified point clouds, and geo-referenced orthophotos for engineering, structural, and environmental applications.

This integrated approach ensures the MGT alignment is developed on a scientifically accurate, environmentally conscious, and technically reliable foundation.

Figure:4.1 Location Map of MGT Alignment



4.4 Technical Feasibility

The proposed Murree Glass Train (MGT) alignment passes through highly variable and mountainous terrain, with elevation differences exceeding 1,000 meters between Islamabad and Murree. The corridor includes steep slopes, dense forest cover, and natural drainage channels that demand precise topographic understanding for safe and stable design.

Using LiDAR scanning integrated with UAV photogrammetry, the survey successfully captured fine-scale elevation and surface features across the corridor. The data helped identify terrain breaks, forest canopy density, drainage networks, and potential landslide-prone areas. These insights are being used to refine slope geometry, select stable alignment zones, and minimize earthwork and environmental disturbance during construction.

4.5 Operational Effectiveness of LiDAR

The rugged terrain and dense forests along the **Murree Glass Train (MGT)** corridor made traditional surveys difficult. **LiDAR-equipped** drones offered a faster and more accurate alternative, capturing millions of elevation points within minutes. This technology provided centimeter-level mapping of slopes, ridges, and drainage lines, even in

inaccessible areas. The combined **LiDAR** and aerial imagery delivered a detailed 3D view of the corridor, ensuring reliable data for alignment design, slope analysis, and environmental planning.

LiDAR (Light Detection and Ranging) is an active remote-sensing system that measures distance by emitting rapid pulses of laser light toward the ground and recording the time each pulse takes store turn. By combining these time-of-flight measurements with precise GPS and inertial data, the system produces a dense point cloud a three-dimensional collection of surface points that accurately represents the Earth's topography. Unlike cameras or satellites, LiDAR can penetrate through tree canopies, making it especially effective for mountainous and vegetated regions like the Islamabad–Murree corridor. Each scan reveals the bare-earth surface beneath vegetation, allowing engineers to generate detailed **Digital Elevation Models (DEMs)** and **Digital Surface Models (DSMs)** for design, drainage, and stability studies.

Figure :4.2 Drone with LiDAR senser for surveying



4.6 LiDAR Survey Methodology

Aircraft-mounted LiDAR sensors emitted thousands of laser pulses per second, capturing precise elevation data. Drone-based photogrammetry complemented LiDAR by providing high-resolution surface imagery for visual validation.

4.6.1 Data Processing with DJI Terra

LiDAR data from UAV flights were processed in DJI Terra, an advanced software for mapping and 3D modeling. The workflow included importing raw point clouds, synchronizing GPS and IMU data, and filtering noise for cleaner results. The software automatically classified ground, vegetation, and structural features, then generated accurate DEMs, DSMs, contour maps, and ortho mosaics. These outputs were exported to GIS and CAD platforms for alignment design, earthwork estimation, and

environmental assessment. Through this process, DJI Terra converted raw LiDAR data into precise, actionable terrain models, forming the technical base for the Murree Glass Train (MGT) corridor's design and planning.

Figure:4.3 Point Clouds: Dense 3D Mesh of spatial points derived from LiDAR, showing elevation and feature details



Figure :4.4 High Resolution Digital Elevation Model by LiDAR senser

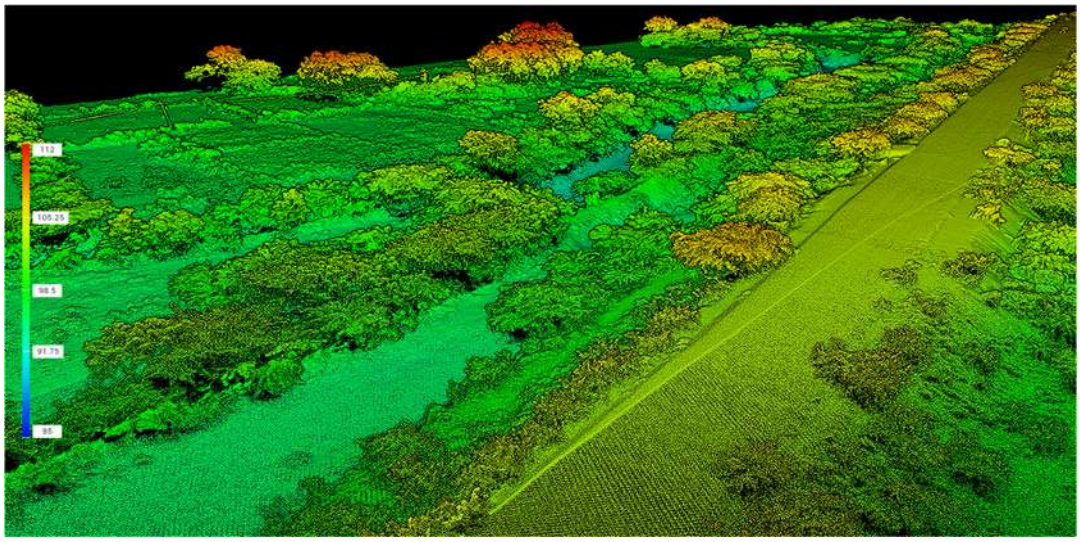


Table:4.1 Topographic Survey Summary

Topographic Survey Summary (LiDAR-Based)	
Section	**Details**
Data Acquisition	
Scan Density	~20 pulses/m²
Flight Altitude	~800–1000 meters AGL
Swath Overlap	30–40% for redundancy
GPS Control Points	Fixed base stations for geo-referencing
Data Processing	
Point Cloud Classification	Separated into ground, vegetation, and man-made features
DEM/DSM Generation	Created elevation models of terrain (DEM) and surface (DSM)
3D Terrain Models	Visualized slope, aspect, and elevation variations
Cross-Sectional Profiles	Generated for critical engineering points

4.6.2 Flight Plan and Control Points Network

The control network comprised fixed GPS base stations along the corridor. These provided geo-referencing for LiDAR data and ensured positional consistency. Flight paths were optimized for maximum overlap and terrain coverage. The detail of the control points and grids has been shown in **Table 4.3.**

Figure:4.5 Flight plan (grids) for Drone of given Alignment



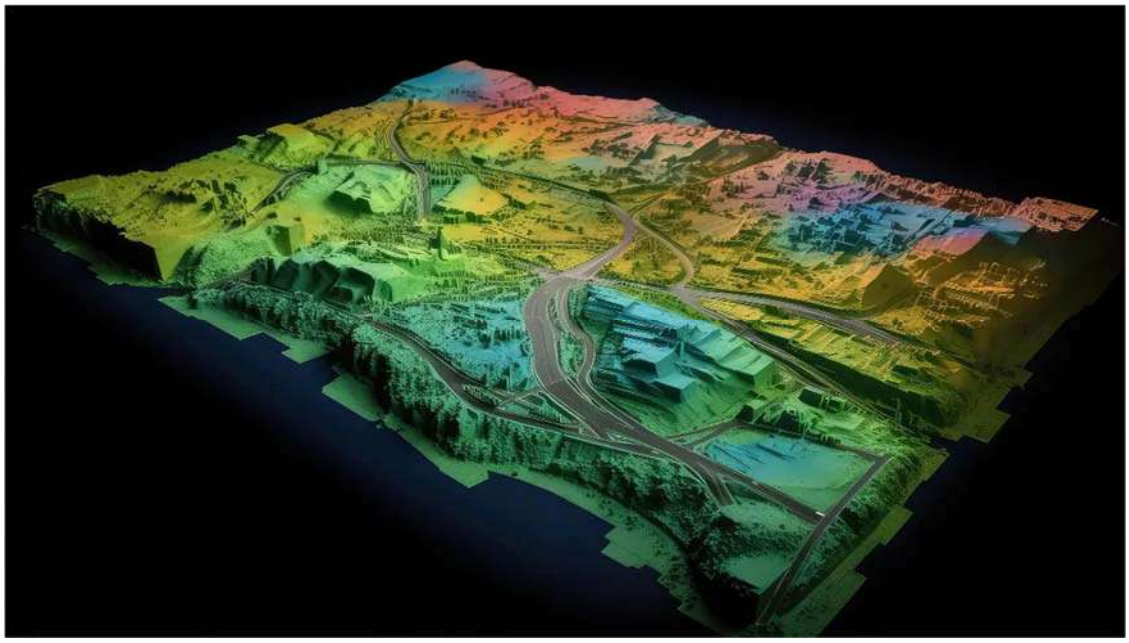
Table:4.3 Control Network for Flight plan (grids) for Drone

List of Control Network			
Control Network	***Latitude***	***Longitude***	***Elevation***
SOP Point	*33.69473*	*73.07633*	*588*
MGT-01	*33.77332*	*73.22819*	*689*
MGT-02	*33.77297*	*73.22734*	*685*
MGT-03	*33.77829*	*73.25024*	*659*
MGT-04	*33.77953*	*73.25037*	*690*
MGT-05	*33.80624*	*73.29555*	*786*
MGT-06	*33.80682*	*73.29618*	*794*
MGT-07	*33.83124*	*73.32353*	*920*
MGT-08	*33.83113*	*73.3231*	*917*
MGT-09	*33.88245*	*73.33922*	*1544*
MGT-10	*33.88348*	*73.33995*	*1538*
MGT-11	*33.87877*	*73.36341*	*1817*
MGT-12	*33.87909*	*73.36392*	*1812*
MGT-13	*33.91192*	*73.38157*	*1906*
MGT-14	*33.91198*	*73.3809*	*1905*
MGT-15	*33.76464*	*73.17599*	*644*
MGT-16	*33.76497*	*73.17591*	*649*
MGT-17	*33.73363*	*73.15319*	*574*
MGT-18	*33.73324*	*73.15176*	*578*
MGT-19	*33.71152*	*73.10672*	*547*
MGT-20	*33.7113*	*73.10586*	*545*
MGT-21	*33.67962*	*73.07787*	*529*
MGT-22	*33.67991*	*73.07894*	*523*
MGT-22	*33.67991*	*73.07894*	*523*
MGT-23	*33.66379*	*73.04968*	*515*
MGT-24	*33.66323*	*73.0486*	*515*

4.7 Conclusion

The LiDAR-enabled topographic survey successfully captured high-resolution elevation data vital for route planning, engineering design, and hazard assessment. The integration of 3D terrain modeling with drone imagery established a technical benchmark for precision surveying in Pakistan's mountainous terrain as shown in **Figure 4.6.**

Figure:4.6 Product of LiDAR sensor.



5. Chapter

5.1 Traffic and Commercial Study Report.

Murree being a premier tourist destination in Pakistan, especially during summer and winter seasons, the road network connecting the twin cities to the hill station experiences significant congestion and environmental stress. The traffic and commercial study form a core component of the project's feasibility assessment. It provides a Data-driven evaluation of mobility demand, travel patterns, tourism flows, market preferences, and commercial opportunities along the Islamabad / Rawalpindi - Murree corridor. Its findings offer critical inputs for engineering design, financial modeling, and institutional planning.

The Feasibility Study, led by the Punjab Mass Transit Authority (PMA) and undertaken by National Engineering Services of Pakistan (NESPAK), will comprehensively evaluate the project. The study will focus on:

- Assessing passenger demand within the region.
- Identifying the most viable route alignment and technology to support the operations of the Glass Train.
- Exploring procurement models, Engineering, Procurement, and Construction (EPC), to recommend the best execution and operational strategy.
- Developing preliminary engineering designs and specifications for stations and rolling stock to ensure safe, efficient, and affordable mobility.
- Proposing a comprehensive legal and institutional framework for the design, construction, operation, and maintenance of the project.

This Feasibility Study will also assist in paving the way for a modern, scenic, and efficient railway system to meet the region's growing demand for connectivity and sustainable tourism.

5.2 Purpose of the Study

This study seeks to quantify the demand and determine whether a rail-based alternative could sustainably absorb a sizeable chunk of that traffic thereby, reducing pressure on existing infrastructure & improve the travel experience for both tourists and residents. . By conducting detailed field surveys, including origin-destination studies, parking assessments, and tourism flow data from hotels, the study aims to capture a multi-dimensional understanding of current and future passenger needs. This evidence base is

essential for designing a service that aligns with user expectations, ensures operational efficiency and also foster economic returns. In addition to demand estimation, the study also explores the commercial landscape along the proposed alignment, identifying potential for transit-oriented development, logistics hubs, tourism nodes, and commercial partnerships. It evaluates the market potential of the Glass Train by assessing passenger willingness to pay, preferences for comfort and frequency, and potential fare structures. These insights will directly advise about formulation of the financial model and policy recommendations of the broader feasibility study, helping stakeholder i.e. public & private to make informed decisions about infrastructure investment, public-private partnerships, and long-term system sustainability.

5.3 Key Objectives of Traffic and Commercial Study

Traffic and Commercial Study is a critical component of the feasibility study, following are few key objectives / activities

5.3.1 Understanding current transport patterns

Current transportation patterns between Rawalpindi / Islamabad and Murree are examined for both passenger and freight traffic volumes, the distribution between transport modes (e.g., private vehicles, vans, buses and trucks), trip purposes, frequency, and overall travel behavior. The study will capture daily commuting, tourism-related movement with seasonal variation. Public and private transport surveys both have to be conducted across public and private modes.

5.3.2 Origin-Destination Surveys

Field surveys for origin-destination (O-D) are conducted at key points using suitable sampling approaches. These surveys helped to determine the primary travel generators and attractors, route selections, trip frequencies, and group travel behavior. The data gave insight for mapping travel flows and understanding passenger and freight logistics within the corridor.

5.3.3 Quantifying Future Travel demand

Another objective of the study is to project and forecast future ridership potential by using the collected data, future land use and socio-economic projections over the project horizon. This traffic modeling will account for the demographic growth, urban expansion, tourism trends, and economic activity. Seasonal & peak or lowest ridership factors are derived from the toll statistics and hotel occupancy data.

5.3.4 Analyzing user behavior

In this activity targeted market surveys are conducted to assess public preferences, willingness to shift to rail, including willingness-to-pay and service levels expectations (comfort, travel time, frequency). The surveys to bifurcate between tourist and daily commuter segments and incorporate socio-demographic profiling.

5.3.5 Identification & Development of Tourist and Commercial Strategies

In order to support and enhance the project's revenue generation, marketing, and sustainable operations, the Consultant is to identify, assess and map potential commercial development zones along the proposed alignment. This exercise includes prospects for commercial and retailer zones near station, passenger amenities including parking, rest areas, food services as well as suggesting logistics hubs and freight handling facilities.

5.3.6 Modal Share and Market Assessment

By using primary and secondary data sources, the market share of each existing mode of transport is assessed for competitiveness levels, the possible synergizing or shifting to the proposed Tourist Glass Train mode. It also includes framing of commercial and marketing strategy encompassing revenue & pricing models, service level benchmarks, partnerships, and incentive schemes to attract traffic.

5.4 Methodology

5.4.1 Study Design and Approach

The methodology for the Traffic and Commercial component of the Glass Train Feasibility Study was designed to capture a complete picture of mobility, tourism flows, and commercial potential along the Rawalpindi/Islamabad–Murree corridor. Since the project had two objectives, namely sustainable mobility and tourism improvement, the research used a combination of quantitative and qualitative approaches. They were intended to provide information about the selection of alignments, the planning of stations, demand projections and economic analysis. The strategy involved a mixture of large-scale field surveys, spatial and statistical modelling, consultation with stakeholders and a systematic screening of the available evidence base data, ensuring a well-versed evidence base for decision-making.

5.4.2 Surveys and Data Collection

The study was based on field surveys, where six major kinds of surveys were used to document the movements of traffic and tourism. This also included complications connected to untrained human operators during the automated system transition.

- Manual Classified Traffic Counts (MCC)
- Origin Destination (O-D) roadside interviews.
- Parking surveys and terminal occupancy survey.
- Hotel and tourism flow data collection.
- Surveys of boarding and alighting of transport.
- Interviews with the users of public transport.

These combined to give specific details on the purpose of the trip, the frequency of travel, modal split, vehicle occupancies and seasonal tourism demand. As a spatial analysis tool, GIS-based land use and access mapping was performed using the District Master Plan that is available with the local administration. Terrain analysis was also gathered using drone and **LiDAR** imagery to help in alignment planning but with minimal environmental impact. The surveys were well distributed in six sites on MCC and O-D counts, seven sites on parking, and three transport terminals on user interviews. Three surveys on boarding and alighting were held in each of six trips of the day, and hotel information was received on 100 registered hotels, out of which over 40 percent of the accommodation stock in Murree was represented. The surveys were conducted in February and March, and two weekdays and two weekends in each site. Year around toll data at the Phulgran Toll Plaza (NHA) were included to explain seasonal difference.

5.4.3 Sampling Techniques

An effective sampling plan was used to make sure that data was representative of all the key groups of users. Twelve-hour surveys of MCC were conducted at 16 hours a day at every location to record changes in traffic during the day. O-D interviews were conducted using systematic sampling, in which every 10th vehicle was chosen to provide an accurate profile of trip purposes, frequency of traveling, occupancy, and share bound to Murree. Hotel surveys were done on monthly occupancy rates, rental rates, parking capacity and what the operators thought of the effect of the Glass Train. The operators were also questioned about whether they were interested in commercial activity, including station-side retail, or hotel-and-rail packages. This combination of quantitative and qualitative information supplemented the data with both statistical and stakeholder thinking.

5.4.4 Tools for Analysis and Forecasting

A suite of advanced tools supported analysis and modeling. Quantum Geographical Information System (QGIS) was employed to examine accessibility of the proposed alignment to key land-use zones, including residential, commercial, institutional, and recreational areas. Transport modeling and demand forecasting relied on Trans CAD, data cleaning, validation and visualization were performed using Excel and advanced Excel tools. Topographical evaluations made possible by drone and LiDAR imagery were used

to optimize route design and reduce ecological footprint. Collectively these tools offered an analytical framework of demand estimation, scenario modelling and feasibility analysis.

5.4.5 Stakeholder Engagement

Stakeholder engagement was considered essential & integral to the methodology. The District Commissioner Office, the Capital Development Authority (CDA) and the Tourism Development Corporation of Punjab (TDCP) were consulted to consider policy related perspectives. The study was also enriched with sectorial input by additional interviews with hotel operators, the Assistant Director of Tourism, and the people that run public transport. The informal communications at the community meeting points and terminals also gave additional feedback about the needs of travelling in the area and the general attitude towards the Glass Train. This participatory approach ensured that the project design mirrored not only technical feasibility, but also institutional support as well as public & community acceptance.

5.4.6 Review of Previous Studies and Data Sources

The study relied on existing sets of data and earlier studies so that assumptions could be verified and establishes contextual baseline. The most significant of these resources was the monthly National Highway Authority data set on tolls at the Phulgran Toll Plaza, which was disaggregated by class of vehicle on an annual basis. This allowed a comparison of survey results with more general trends in traffic and identified times of peak tourist demand by season. The Capital Development Authority's master plans, transport frameworks, and zoning regulations were reviewed to understand urban expansion, land use patterns, and regulatory contexts. These insights guided station planning and assessed how the Glass Train could complement regional mobility. Additionally, the ILF feasibility study for the Islamabad–Murree rail corridor provided historical insights into terrain challenges, alignment sensitivity, and station siting logic. While this earlier study lacked updated data on tourism trends, it offered valuable lessons for refining current methodologies. Finally, GIS-based master planning documents from the Murree District Administration were analyzed to avoid environmentally sensitive areas such as forest reserves and protected zones, reinforcing the project's sustainability objectives.

5.4.7 Survey Planning and Strategy.

The survey design adopted, best practices in transportation planning, including representative sampling, coverage over a period, and flexibility to the site-specific situation. The plan took into consideration the peculiarities of Murree, especially its overreliance on seasonal tourism and mountainous landscape**.**

5.4.8 MCC and O–D Survey Sites

There are six control points selected to mark the main entry and dispersal points on the proposed corridor which are as under:

- Srinagar E75 intersection
- 17 Mile Toll Plaza
- Phulgran Toll Plaza
- Musyari Link Road
- Lower Topa intersection
- Kuldanna Chowk

A series of surveys made at these points, recorded inter-urban convergence, preference of traditional routes, seasonal variation and dispersal to Murree and further. Observations of each site were made during 16 hours of a 4-day period (two weekdays and two weekends) to represent the whole operation period of the proposed Glass Train. MCC data categorized vehicles according to the type, direction and time of the day. At the same time, O-D interviews were conducted in every 10th vehicle, covering the origin, destination, purpose of trip, frequency, and occupancy. This gave information on commuter traffic, the behavior of tourist groups, and travel motivation.

5.4.9 Hotel and Tourism Flow Surveys

Hotel surveys targeted a stratified sample of 100 hotels across different zones of Murree, including Mall Road, Bhurban, Lower Topa, and GPO. Data collected covered occupancy rates, room rents, parking capacity, guest origin, and seasonal fluctuations. Importantly, qualitative perspectives were gathered on the likely impact of the Glass Train, with several operators highlighting opportunities for integrated ticketing, station-side investments and hotel–rail tourism packages.

5.4.10 Public Transport and User Surveys

Public transport surveys centered on Faizabad Terminal, the main dispatch point for Murree-bound buses and vans from Rawalpindi and Islamabad. Surveys included departure counts, occupancy tracking, and user interviews capturing fare sensitivity, satisfaction, and openness to rail alternatives. Boarding–alighting surveys conducted on six trips per day provided further substance on demand distribution along routes. This information was critical for evaluating potential intermediate station sites and understanding, how the Glass Train could complement existing public transport.

Table: 5.1 Sampling Strategy Overview

Survey type	Sample Size/ Sites	Duration/Frequency	Notes
MCC + O–D	6 sites	16 hours × 4 days/site	Every 10th vehicle for O–D
Hotel Surveys	100 hotels (of 240 total)	Monthly average + perception	Across all Murree zones
Public-Transport Terminal	Faizabad + 3 terminals	Weekday & weekend, 100 interviews/day	Vehicle types + user profile
Boarding-Alighting Surveys	12 trips/day	Weekdays & weekends	Passenger flow analysis
Parking Surveys	7 sites	Manual counts	Peak & off-peak Monitoring

5.5 Stakeholder Consultation Approach

Stakeholder engagement and consultation process was a cornerstone of the Traffic & Commercial Study. The planning of the proposed Tourist Glass Train stayed responsive to the tourism, land use, ecology, and mobility specifics in Murree, which was part of the Traffic and Commercial Study. To match the study and operational realities, regulatory requirements and institutional priorities, a formal engagement strategy was applied.

It was also consulted at the individual and institutional levels such as the top officials of the district administration, the transport regulators, the mass transit authorities, and the tourism organizations. These discussions helped in verifying the field observations, calibration of survey instruments and compatibility of policies.

To further enrich these discussions a multi-stakeholder meeting at the high level, presided by the Punjab Minister of Transport, was held on December 24 bringing together the representatives of the Transport and Tourism Departments, CDA, RTA, TDCP, and the Islamabad, Rawalpindi and Murree district administrations. The project team presented the Glass Train concept, alignment options, and initial findings and the stakeholders provided their suggestions regarding the location of the stations, integration requirements and regulation matters.

These consultations gave good feedback and extensive political/administrative support of the project based on its capacity to alleviate congestion, promote tourist movement and sustainable travel. They also gave rise to inter-organizational co-ordination and institutional ownership that prepared a smooth passage to design, approval and implementation.

5.6 Demand Forecasting Technique

The Glass Train demand forecasting approach was meant to generate a realistic, behaviorally constrained forecast of ridership potential. It used a combination of primary survey data, trip segmentation, mode-wise analysis, and origin-destination (O-D) modeling to estimate how current travelers would switch between using a combination of public and private transportation and the proposed service. The strategy aimed at creating ridership forecasts in daily, monthly and annual basis.

5.6.1 Public Transport User Segment

In the case of the public transport segment forecasting, surveys and manual counts were carried in key terminals and Faizabad Terminal was determined as the hub point of Murree bound buses and vans of Rawalpindi city as well as Islamabad city. Data collection was done on weekday and weekend operations to record variation in the movement of passengers. The Surveys provided insights on vehicle occupancy, boarding and alighting behavior, and user willingness to adopt the Glass Train, considering factors such as comfort, fare, travel time, and frequency. A utility function was developed from interview responses to estimate the proportion of public transport users likely to shift, which was then applied to traveler counts to derive daily ridership estimates.

5.6.2 Private Transport User Segment

In the case of the private transport segment, the demand forecasting was based on the results of O–D interviews at six strategic points. The data measured are trip purpose, frequency, occupancy and willingness of the user to utilize the train. A Traffic Analysis Zone (TAZ) coded every origin-destination pair, allowing a finer O-D matrix to be constructed to visualize the trip distributions in the corridor. This pattern of mapping not only local flows (Islamabad/Rawalpindi–Murree), but also longer regional flows (northwards and Kashmir to Murree). In a bid to make it realistic, only a few trip purposes i.e. recreation, social visits, and home-based travel were included for the ridership potential. Mode specific utility factors were used in relation to the type of private vehicle, cars, jeeps, and vans.

5.6.3 Aggregation of Final Ridership

The final ridership forecast was obtained by aggregating estimates from both public and private transport segments. Figures were computed separately for weekdays and weekends, scaled into monthly volumes, and further converted into annual estimates. To capture seasonal variations, the model was calibrated against 2024 traffic counts from the Phulgran Toll Plaza, provided by the National Highway Authority. Monthly adjustment

factors were applied to reflect peak summer and winter tourist seasons, as well as off-peak periods.

This integrated approach of combining empirical field surveys, behavioral modeling, and macro-level calibration produced a context-sensitive ridership forecast. The results serve as a foundation for financial analysis, service frequency planning, and long-term investment decision-making for the Tourist Glass Train corridor.

5.6.4 Market and Commercial Analysis

An extensive market and commercial study were conducted to assess the financial feasibility of the Tourist Glass Train and its appeal in terms of private investment or partnerships with the government (PPP). The model was based on four pillars, namely tourism demand profiling, income group segmentation, willingness-to-pay analysis, and commercial development opportunities along the corridor. These, combined, gave rise to a multi-stream revenue model which is not limited to fare box recovery.

5.6.5 Tourism Demand Profiling

The analysis focused on tourism demand profiling because the economy of Murree is tourism-oriented. A sample size of 100 hotels was used (approximately 42 % of all registered hotels in large areas like Mall Road, Bhurban, Lower Topa, and New Murree). The questionnaires identified seasonal occupancy rates, visitor origin, availability of parking and booking trends. Findings supported steep seasonal variations, with occupancy rates increasing over 80 percent in summer and during the winter holidays and decreasing to less than 30 % in non-peak months. These results supported the necessity of an operation model of trains that could be scaled and adapted to the season. Hotel managers showed an interest in the possibilities of using the Glass Train to boost high-end tourism and expressed interest in partnerships like hotel-train bundling, joint promotions, and terminal station kiosks.

5.6.6 Income Segmentation and Fare Affordability

The commercial model needed an understanding of the income-level distribution of current travelers, which was captured during O–D and public transport user interviews. These surveys gave more insight into user affordability and willingness to change. The results showed that low and lower-middle-income customers (40 -45%), who mainly use public transport, are strongly price-sensitive and might not be willing to pay a much higher price. The upper-middle-income (approximately 35 percent) traveler valued safety, comfort, and scenic travel and would be willing to pay a moderate premium to experience improved service. The interest in switching was exhibited by high-income travelers (approximately 20%), who mainly travel by their own cars, and who showed

interest in switching to premium services such as panoramic views, safe parking, and regular schedules. On this basis, it was suggested that a tiered ticketing model would be implemented: cheap base fares would be offered to commuters, whereas the premium-priced services would be aimed at tourists and higher-income groups.

5.6.7 Willingness-to-pay modeling

Ridership and revenue forecasting was further refined on willingness-to-pay modelling. Users of public and private transport were questioned on mode-shift conditions, such as allowable fare levels, time trade-offs during travel and quality of service. They used a utility function to calculate probabilities of a mode shift between user groups. Findings revealed that upper-middle-income tourists traveling by vans had the greatest probability of conversion, and daily wage earners who relied on informal transport had the least probability of conversion. These were the direct data used in financial modeling and revenue sensitivity testing.

5.6.8 Commercial Development Potential

Beyond fares, the study identified substantial commercial development potential at high-footfall terminal and intermediate stations. Lake View Park (Islamabad) and Sunny Bank (Murree) were highlighted as anchor hubs suitable for retail, food courts, and tourism service centers. Intermediate stops such as 17 Mile, Valley Amusement Park, and Lower Topa were seen as opportunities for joint ventures in parking, shuttle services, rest areas, and eco-tourism lodges. These could be structured under revenue-sharing models or long-term leases, creating robust ancillary income streams. Overall, the market and commercial analysis demonstrated that the Glass Train has the potential to generate sustainable financial returns by blending fare revenue with diversified commercial opportunities. By leveraging tourism demand, user segmentation, and station-based ventures, the project strengthens its investment case and provides a solid foundation for engaging private operators and investors.

5.7 Data Collection

5.7.1 Traffic Volume Counts (Manual Classified Counts - MCC)

As discussed above, the six cordon points i.e. Srinagar-E 75 Intersection, 17 Mile Toll Plaza, Phulgran Toll Plaza, Musyari Link Road, Kuldanna Chowk and Lower Topa Intersection were determined where traffic enters from all 4 directions into the Murree vicinity and thus all those trips have been counted that originated from Murree and have a destination in Murree, as well as passing trips coming from other cities are transferring through Murree region. The MCC consists of the vehicles count with a modal split in an interval of every 15 minutes. The data has been collected for two weekdays and two

weekends separately for 16 hours per day i.e. 6: AM to 10: PM. Simultaneously, O–D surveys were executed using a systematic sampling approach: every 10th vehicle was stopped and interviewed. The survey instrument captured origin and destination, trip purpose (e.g., work, education, and recreation), travel frequency, Murree-bound share, and vehicle occupancy, which was especially important to estimate group-based tourist behavior, consistent with literature findings on leisure travel trends in resort corridors.

The MCC Questionnaire, site activity photos and the count results for all locations has been described in Table 2 to Table 31 and direction wise MCC is shown in Figure 4 to Figure 13 in the already submitted detail Commercial and Traffic Study to the client.

5.7.2 Origin Destination (O-D) Surveys.

Origin-Destination (O–D) surveys were a core part of the traffic and commercial data gathering initiative, which was to be used to obtain in-depth information about the travel behavior, spatial movement modes, and user preferences along the Rawalpindi-Murree route. It was the aim of these roadside interview surveys to develop an evidence-based concept of the reasons, methods and by whom trips are taken specifically in the Murree-bound travel. Six strategic points were surveyed during the weekdays and weekends. At these locations, interviews were conducted over a 16-hour timeframe, over a four-day period with every 10th vehicle being sampled systematically to provide a wide representation. In the interviews, a complete list of travel characteristics was collected including:

- Modes of transport (car, van, public bus, motorcycle)
- Occupancy of the vehicle (number of people in the vehicle)
- Trip origin and destination (both districts and specific locality).
- Trip frequency (daily, weekly, monthly, occasional)
- Trip purpose (recreation, work, education, social, shopping)
- Home area (to differentiate commuter and tourist flows)
- Household income bracket
- Readiness to use the proposed Glass Train (Yes/No)
- Motives of willingness/unwillingness (comfort, cost, time, convenience)
- Fare range that is preferable or acceptable.

This data was critical not only for building the regional Origin–Destination Matrix (OD Matrix) but also for segmenting potential users by income group, purpose of travel, and willingness to shift modes. For instance, tourists showed higher interest in using the train for recreational purposes, while work-based commuters were more sensitive to travel time and fare structures. Spatial analysis of the trip generation and attraction zones was

also achievable with the help of the dataset since it would provide the opportunity to delineate Traffic Analysis Zones (TAZs) in the area of the study. These areas were further used in demand modeling to predict ridership, define the catchment areas of a station and analyze the market potential of the train using actual origin destination links.

Overall, O-D surveys carried out during four days (two weekdays, two weekends) at six locations provided travel data on over 7900 users. The resulting multi-dimensional dataset was used directly to inform alignment planning, service design, and commercial strategy of the proposed Glass Train so that its future operations can be aligned to the mobility patterns and expectations of the diverse travelers in the corridor.

5.7.2.1 Bus Terminal Surveys

To assess the operational performance, capacity, and ridership behavior of existing public transport services along the Rawalpindi–Murree corridor, a detailed Bus Terminal Survey was conducted at the Faizabad Terminal, which functions as the primary dispatch point for Murree-bound vehicles from both Rawalpindi and Islamabad. This terminal was selected for its centrality and strategic role as the convergence hub for public transport fleets originating from 26 Number Terminal, Pirwadhai, and other urban terminals before embarking toward Murree and surrounding hill stations.

The survey was conducted over both weekdays and weekends, capturing variations in service frequency and passenger load due to daily commuting and tourism-driven demand, respectively. Information was collected directly from operators on bus frequency, vehicle type, seating capacity, average occupancy, fare levels, and travel times. Six key routes were observed, covering major Murree destinations including Old Murree, New Murree, Phugwari, Patriata, Upper Dewal, and Nathia Gali.

- **Weekday Survey Findings**
    - A total of 254 trips per day were operated by 6 transport providers, using Hiace vans with an average capacity of 18 passengers per vehicle.
    - The average occupancy was 100% across all routes, with slight variations observed on the New Murree route (83% occupancy.
    - The total weekday ridership recorded was 4,476 passengers per day.
    - Fares ranged from PKR 280 to 500, depending on destination distance, with an average travel time of 1:20 to 2:00 hours.
- **Weekend Survey Findings**
    - On weekends, the total number of trips increased to 262, reflecting higher demand due to recreational and leisure travel.

- Vehicle occupancy reached full capacity (18 passengers per vehicle) across all routes, including the previously under loaded New Murree route.
- The total weekend ridership rose to 4,716 passengers per day, indicating an approximate 5.4% increase over weekday volumes.
- Fare structures remained consistent, but trip frequency on key routes such as New Murree and Nathia Gali was notably higher, indicating their popularity among tourists.

- **Key Observations**
  - Old Murree remains the dominant destination, recording approximately 85 trips on weekdays and higher volumes on weekends, confirming its role as the core tourist hub. Nathia Gali, despite being the farthest destination and having the highest fare (PKR 500), shows strong occupancy, particularly on weekends, highlighting sustained demand for longer leisure trips.
  - The exclusive use of Hiace vans reflects limited service diversity and low per-trip capacity, which exacerbates congestion and fails to adequately serve group travelers or peak tourist demand. Overall, the data indicates substantial latent demand for a higher-capacity, reliable, and comfortable transport mode, such as the proposed Glass Train.
  - The bus terminal survey further confirms that existing public transport is near saturation on weekends, with constrained capacity and limited comfort acting as key deterrents for family and higher-income travelers. These findings underscore the strategic value of the Glass Train in managing tourism surges, reducing road congestion, and significantly enhancing the travel experience between Islamabad/Rawalpindi and Murree.

5.7.2.2 Public Transport User Interview Surveys

To supplement quantitative traffic and operational data, targeted Public Transport User Interview Surveys were conducted to capture qualitative insights into passenger behavior, preferences, and expectations along the Rawalpindi–Murree corridor. The surveys aimed to assess users' socio-economic profiles, travel purposes, and willingness to shift to the proposed Glass Train.

Interviews were carried out at four key terminals—Faizabad, General Bus Stand Murree, 26 Number Bus Stand, and Pirwadhai Bus Stand. A sample of 100 passengers per day was surveyed on both weekdays and weekends, ensuring representation of regular commuters as well as leisure and tourist travelers.

The survey collected the following key variables:

- Trip Purpose (e.g., work, education, recreation, social, shopping)
- Trip Frequency (daily, multiple daily, weekly, monthly, occasional)
- Vehicle Ownership (to determine reliance on public transport by necessity or choice)
- Reason for Using Public Transport (e.g., affordability, no personal vehicle, convenience, direct access)
- Average Waiting Time for Bus (to evaluate service reliability and scheduling gaps)
- Usability of Proposed Train Service (Yes/No response to whether the user would prefer the Glass Train)
- Reason for Usability Response (e.g., time-saving, comfort, cost, convenience, accessibility, skepticism)
- Fare Preference (maximum fare user is willing to pay for the train)

These interview-based survey provided a qualitative insight into passenger perceptions of existing services, particularly long waiting times, overcrowding, overloading and travel discomfort as well as expectations from the proposed Glass Train, including faster travel, improved comfort, and higher reliability. The survey also enabled segmentation of users by income level, travel frequency, and vehicle ownership, which are key determinants of modal shift behavior. Survey responses were systematically coded and analyzed to identify behavioral trends, which were subsequently incorporated into the utility functions and ridership forecasting models. The findings further informed fare structuring and service design recommendations in the commercial assessment.

5.7.2.3 Boarding & Alighting Survey

To analyze passenger flow patterns, stop-level demand, and intermediate travel behavior along the Rawalpindi–Islamabad to Murree corridor, a targeted Boarding–Alighting Survey was conducted. Unlike terminal-only surveys, this approach captured passenger movements throughout the route, enabling identification of mid-route demand clusters and informing potential station locations for the proposed Glass Train.

The survey was carried out on public transport vans and minibuses operating on the Murree–Islamabad route. Two trips per day were observed on both weekdays and weekends to capture variations between commuter and recreational travel demand. Trips originated from three major Islamabad terminals:

- Faizabad Terminal
- Pirwadhai Terminal
- 26 Number Terminal (Peshawar Mor)

Surveys were conducted in both directions i.e. towards Murree and back to Islamabad. Each vehicle was observed from origin to destination, with surveyors recording passenger boarding and alighting points, including stop names or nearby landmarks. Additional data collected included total passengers per trip, occupancy variations along the route, and intermediate stops with significant passenger activity.

Key Objectives

The survey was aimed for:

- Identify intermediate stops with high passenger turnover, such as Bhara Kahu, 17-Mile, Phulgran, and Lower Topa;
- Capture mid-route demand often overlooked in terminal-based surveys;
- Distinguish between full-trip and short-distance passenger segments; and
- Support the planning and prioritization of intermediate Glass Train stations to align with the most active demand nodes.

5.7.2.4 Hotels Tourist Survey

Given Murree's heavy reliance on tourism, a targeted Hotels Survey was undertaken to inform the demand and commercial assessment for the proposed Glass Train. A stratified sample of 100 hotels was selected across key tourism zones—Mall Road/GPO, Bhurban, Lower Topa, Patriata (New Murree), Company Bagh, Sunny Bank, and selected peripheral areas—covering budget, mid-range, boutique hotels, guesthouses, and resorts.

Data collected included occupancy rates, average room tariffs, parking capacity, guest origin, and seasonal demand patterns. In addition, qualitative inputs were obtained on transport-related challenges and perceptions of the Tourist Glass Train, including interest in integrated ticketing, station-adjacent investments, and bundled Hotel-Rail packages, consistent with global rail-tourism integration practices.

The sample represented a cross-section of small, mid-sized, and large hotels, including guesthouses, lodges, and resorts. Surveys were conducted through structured, in-person interviews, with hotel identities kept anonymous. Findings from this survey provide critical inputs to the ridership forecasts, fare strategy, and tourism-oriented service design of the proposed Glass Train.

5.7.2.5 Survey Structure and Data Collected

The hotel survey was structured to capture operational, tourism, transport, and commercial insights relevant to the Murree Glass Train feasibility.

- **Hotel Operations and Visitor Profile**
  Data covered hotel location, room inventory, average rents, guest origin (98% domestic, 2% international), and length of stay, luggage volume, and check-in/out patterns. Monthly visitor data (Jan 2024–Feb 2025) was collected to assess seasonal tourism trends and demand fluctuations. During June, July & August frequency of the visitors remained high than other months i.e. Avg.40, 000 on the other hand in the month of Jan & Fab the visitors' number remained in 30,000.
- **Guest Transport Behavior**
  Information was gathered on preferred travel modes to Murree and key access issues such as parking shortages and road congestion, helping evaluate the potential modal shift to rail.
- **Perceptions of the Glass Train Project**
  Hotel operators shared views on expected business impacts, perceived benefits (improved access, higher occupancy), and concerns (congestion, environmental effects), providing direct stakeholder feedback on risks and opportunities.
- **Fare Expectations and Commercial Partnerships**
  Respondents indicated acceptable fare ranges and willingness to participate in bundled hotel–train packages and joint marketing, informing fare strategy and private-sector collaboration potential.
- **Parking Facilities**
  Data on parking capacity and occupancy levels was collected to assess peak-season pressure and the potential of the train to reduce parking demand in congested areas.
- **Freight and Supply Logistics**
  The survey examined supply types, sources, delivery modes, frequency, and openness to rail-based light freight, supporting assessment of ancillary revenue and logistics integration.

Overall, the hotel survey provided critical inputs for ridership forecasting, commercial structuring, station access planning, and evaluation of tourism and freight synergies for the proposed Glass Train project.

5.7.3 Travel Characteristics and Analysis of the Data

The data analysis phase translated field surveys into actionable insights for ridership estimation, corridor performance assessment, and scenario modelling for the Rawalpindi–Murree Glass Train. An integrated framework combined manual traffic counts, origin to destination (O–D) surveys, and passenger interviews within a geospatial and behavioral context to capture interactions between private and public travel,

corridor capacity, and tourism-driven variability. Given the corridor's dual role serving commuters and seasonal tourists, a multi-layered approach was adopted to reflect both average and peak conditions.

- **Data Validation and Quality Assurance**
  All datasets underwent systematic validation to ensure accuracy and consistency. Initial field checks addressed missing or inconsistent entries, followed by digital cleaning and logical balance checks. Traffic counts were cross-verified against National Highway Authority toll data, yielding an error margin within ±5%, consistent with international survey standards. Isolated anomalies, mainly during weekend peaks, were smoothed using interpolation to preserve temporal continuity.
- **Data Structuring and Classification**
  Validated data were classified by vehicle type, direction, and time interval to develop detailed temporal and directional profiles. O–D responses were coded into defined Traffic Analysis Zones (TAZs) and standardized trip-purpose categories, enabling consistent segmentation and robust forecasting.
- **Traffic Composition and Temporal Patterns**
  Analysis showed private vehicles dominating the corridor (≈58%), followed by vans/Hiace (22%) and buses (10%), confirming its passenger- and tourism-oriented nature. Peak outbound flows toward Murree occurred in the morning, with return peaks in the afternoon and evening. Weekend traffic was nearly 1.8 times weekday volumes, reflecting recreational demand.
- **Seasonality and O–D Insights**
  Monthly toll data highlighted strong seasonality, with summer and winter holiday peaks nearly doubling shoulder-month traffic. Accordingly, seasonal adjustment factors were applied in ridership forecasts. O–D results indicated that about 83% of trips originated from the Rawalpindi–Islamabad area, with 68% being recreational, underscoring the suitability of a scenic, comfortable Glass Train tailored to leisure travel demand.

5.7.3.1 Origin–Destination Pattern Analysis

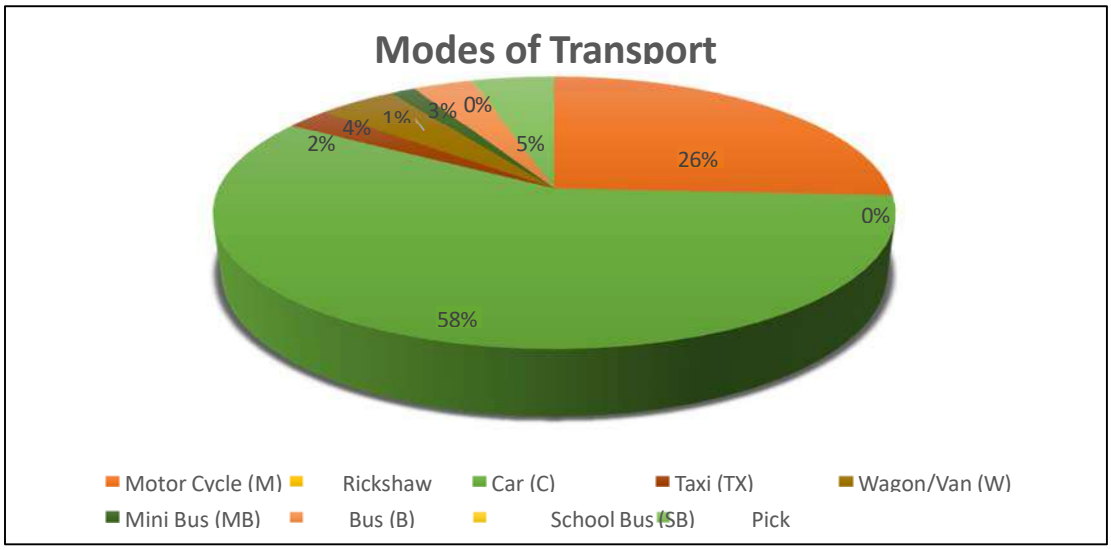
O–D survey results provided deep insight into spatial connectivity within the corridor. Approximately 83% of surveyed trips originated from the Rawalpindi–Islamabad metropolitan area, confirming it as the principal generator of Murree-bound travel. Another 10% represented through-traffic from the north (Abbottabad, Muzaffarabad, and Bagh) traveling toward Islamabad or using Murree as a stopover. The remaining 7% originated from smaller settlements along the E-75 corridor.

In terms of purpose, 68% of trips were recreational, 18% were social or family visits, 9% were work-related, and 5% fell into other categories (educational or commercial). These distributions clearly established the corridor's leisure-dominated profile, reinforcing the rationale for a scenic, comfort-oriented rail mode such as the Glass Train.

5.7.3.2 Modes of Transport

The mode of the users was recorded to make the correlations required for the mode. The results of the mode of transport are being shown in **Figure: 5.1** below. The mode share analysis indicates that private vehicles dominate travel along the corridor, with cars representing nearly 50% of total traffic and motorcycles contributing another 26%. In comparison, public transport use is minimal, with wagons accounting for only 4% and buses just 3% of the modal split. This stark imbalance between private and public transport highlights the pressing need for a high-capacity, reliable alternative to reduce reliance on private vehicles.

Figure: 5.1 Mode share of Vehicles in Project Region



5.7.3.3 Occupancy of the vehicle

The O-D interviews were conducted with a view to recording vehicle occupancy in each of the surveyed vehicles in order to learn the number of travel group and the efficiency of transport modes across various modes. The given metric is especially vital within the tourism destinations such as Rawalpindi-Murree, where group travel and recreational activities are popular. The data showed some differences in occupancy behavior of the modes, with public transport mode (wagons, buses) having higher average occupancies, whereas a private car and motorcycle more likely had fewer passengers on the vehicle. This data is essential to the estimation of the volumes of the person-trip and the assessment of the possible shift of the ridership to the offered Glass Train. The summary

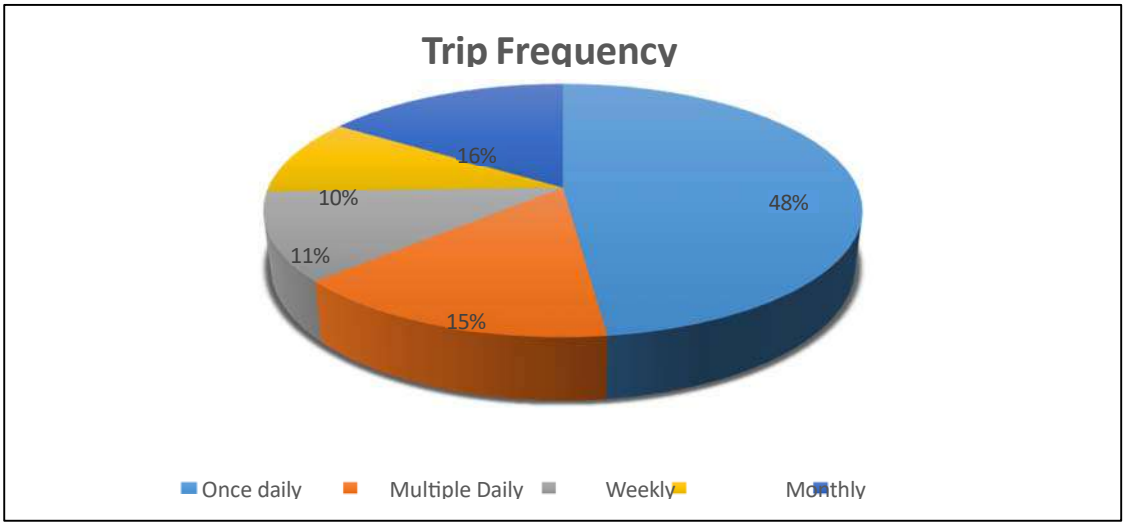
Table 5.2 of average occupancy by mode is be displayed in detail as listed below to be used in further modeling of demand. **Table: 5.2**

Average occupancy by Mode		
Vehicle	Code	Average Occupancy
Motor Cycle (M)	M	2
Rickshaw (R)	R	2
Car (C)	C	3
Taxi (TX)	TX	4
Wagon/Van (W)	W	11
Mini Bus (MB)	MB	14
Bus (B)	B	29
School Bus (SB)	SB	18
Pick up (PK)	PK	6

5.7.3.4 Trip frequency

The graphical representation of O-D survey as shown in **Figure: 5.2** below indicates that there were specific travel modalities in the Rawalpindi-Murree corridor. Almost all trips (48 percent) were made daily and 15 percent were made more than once a day- mostly commuters, service providers and commercial drivers. By contrast, 16 percent were occasional ones as they indicated tourism and leisure travel in places like Muzaffarabad, Bagh, Abbottabad and Gallyiat. This segmentation brings out the dual purpose of this corridor as both a commuter line and a tourism gateway to serve as an important input to Glass Train ridership modelling, service planning, and peak-period capacity management.

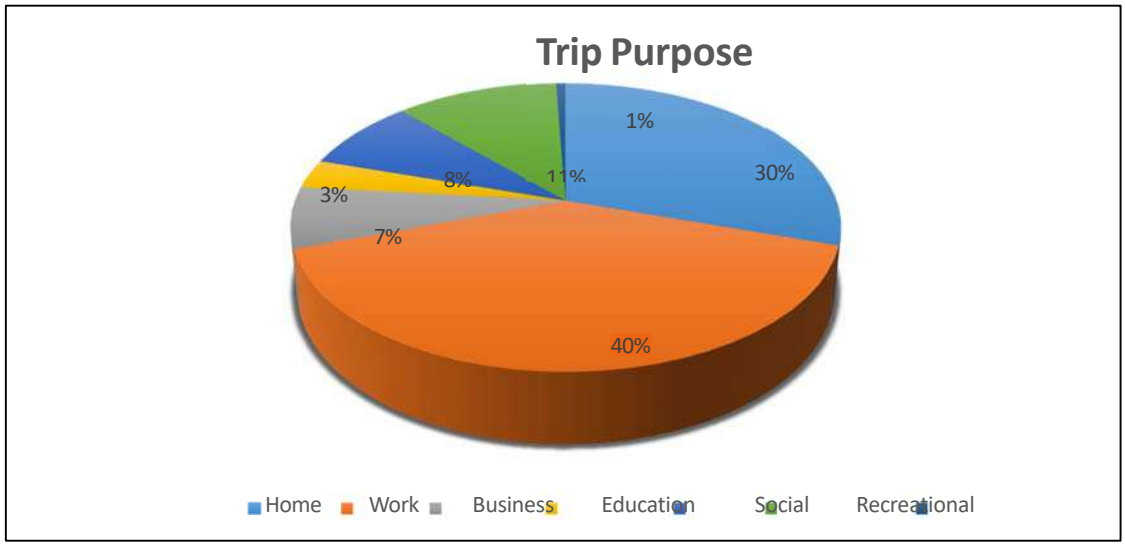
Figure: 5.2



5.7.3.5 Trip Purpose

Trip purpose was a key variable collected through the O–D survey to understand the motivation behind travel across the study corridor, to gain an insight into the reasons that motivated people to travel within the study area, including travels between the City of Rawalpindi/Islamabad and Murree and its neighboring areas, including Azad Kashmir and Abbottabad. The O-D survey represented in **Figure 5.3** below shows that the services used across the Rawalpindi-Murree corridor fulfil need in terms of commuting and tourism. There is a high rate of commuter demand in suburban areas to Islamabad as well as Murree and work trips take the lead at 40% home-based travels with 30% Leisure/Recreational 11% and social 8% tours highlight the tourist attraction of Murree whereas business tours 7%, education tours 3% and shopping tours 1% represent

Figure (5.3) smaller/ lesser share. This distribution is critical for ridership forecasting,

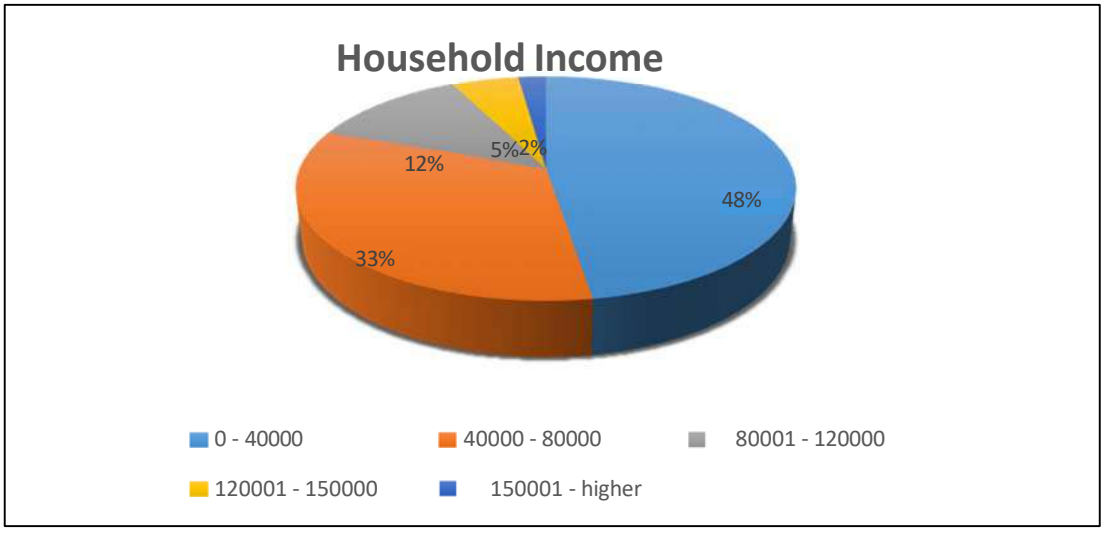


because the potential of tourism- and leisure-oriented users to switch to the proposed scenic train represents the highest potential to inform service design and fare strategy.

5.7.3.6 Household Income

Household income data was collected during the Origin–Destination (O–D) surveys to assess the socio- economic profile of travelers using the Rawalpindi–Murree corridor and its adjoining routes from Azad Kashmir, Abbottabad, and other northern regions. The O-D survey outlined in **Figure 5.4** shows a largely low to middle-income travelling market in the Rawalpindi-Murree route.

Figure: 5.4

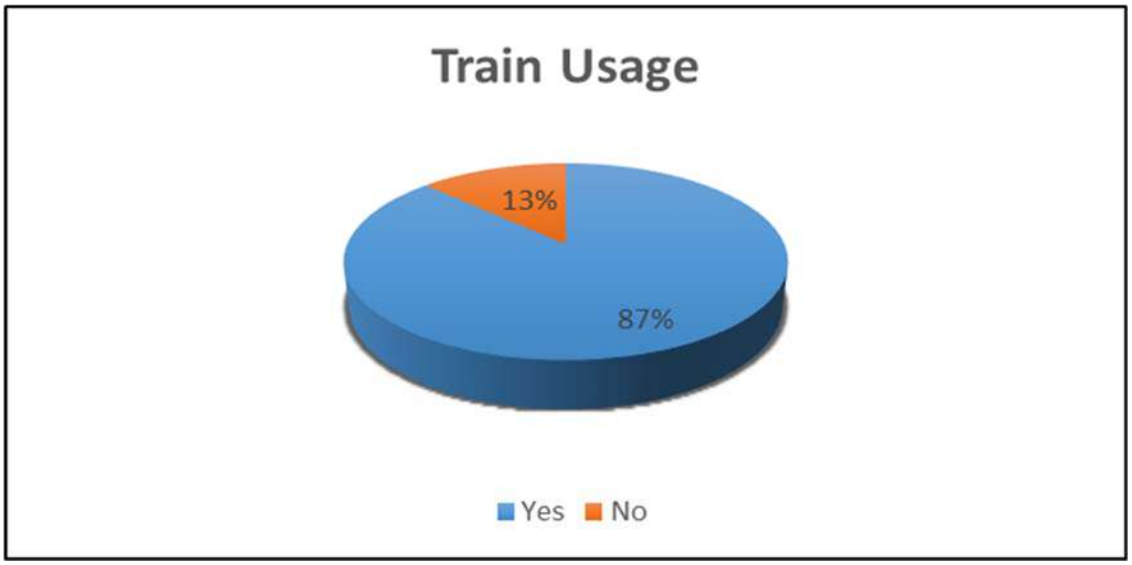


A significant proportion of interviewees 48 % indicated monthly household earnings as less than PKR 40,000, and depended mostly on common and communal transport. The other 33 % were in the PKR 40,001- 80,000 range, the heart of the core middle-income range that swings between modes. The higher income groups, 12% PKR 80,001-120,000 income and 7.3% above PKR 120,000 are mainly the users of private vehicles, but have the potential to use Leisure/ Tourist trains, when guaranteed of comfort and reliability. This income stratification was critical for developing a tiered fare strategy for the Glass Train—balancing affordability for lower-income users and enhanced service offerings for higher-paying segments. It also supported the identification of ridership clusters most likely to convert from road to rail, especially within the middle-income recreational travel market.

5.7.3.7 Willingness for Using the Proposed Train

In these Origin–Destination (O–D) surveys travelers were asked whether they would be willing to use the proposed Glass Train service, and if so, what factors would influence their decision. The objective was to assess market receptiveness, understand mode shift potential, and identify key service attributes that drive user preferences as shown in **Figure 5.5**

Figure: 5.5



The O-D survey showed high responsiveness for usage of the proposed Tourist Glass Train i.e. 87% which come out to be 6,732 out of 7,719 travelers expressing their interest to use it.

Figure: 5.6

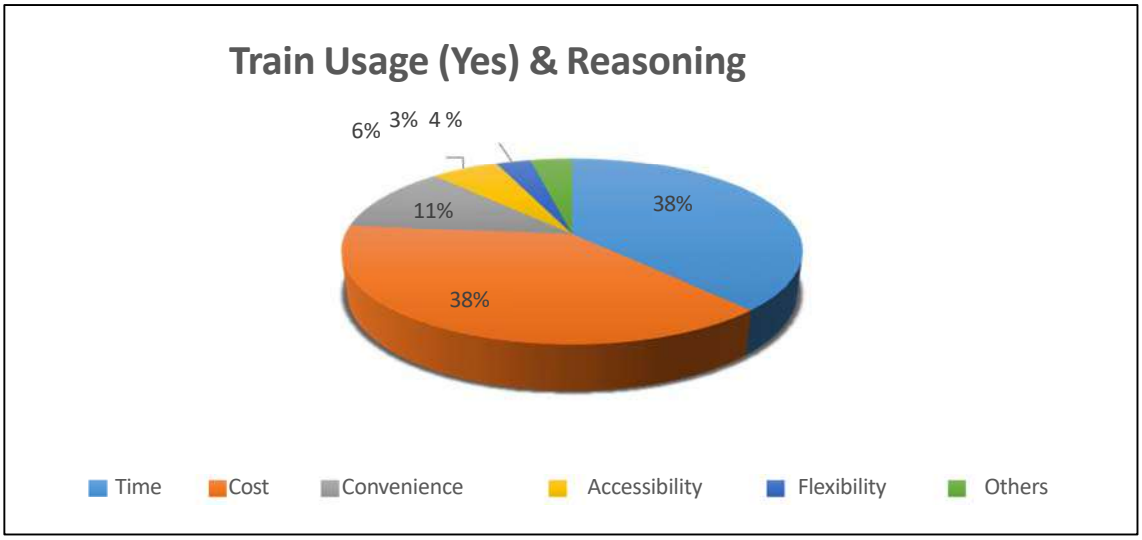
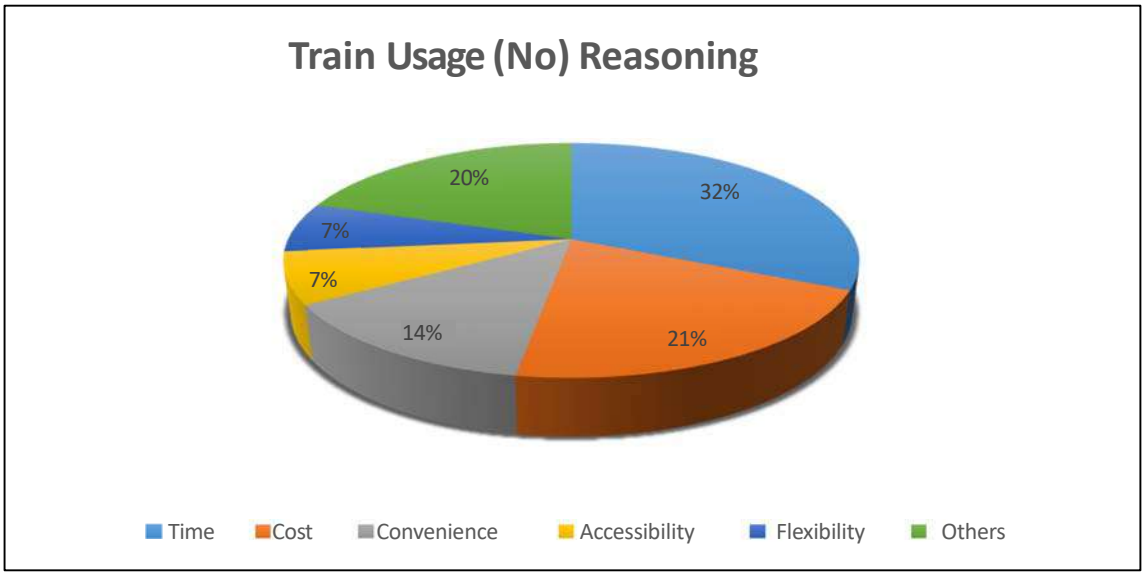


Figure 5.6 above shows the key motivators which are cost efficiency 38%, time savings 38%, then came convenience 11%, accessibility 6%, accessibility 4% and other issues like comfort and scenic value.

Figure: 5.7

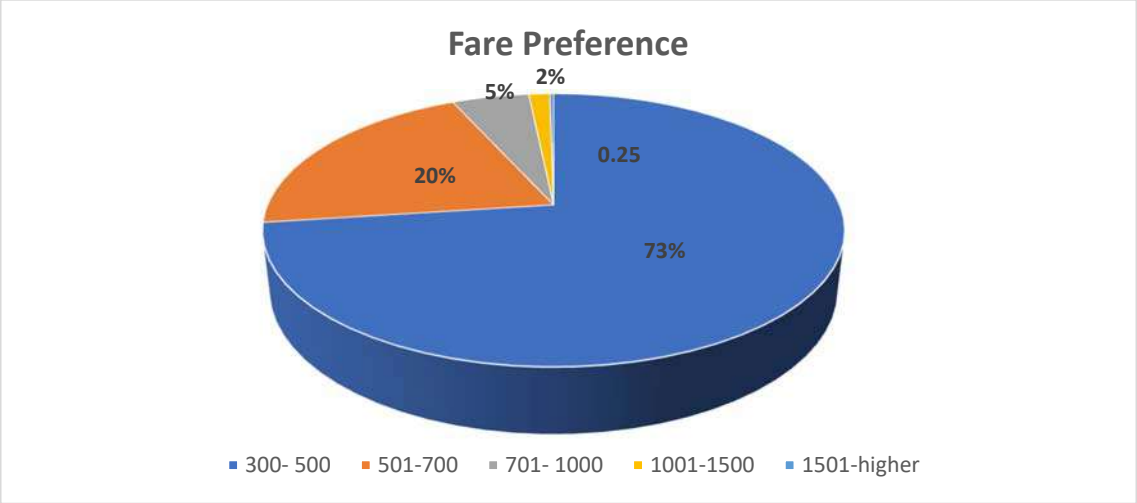


On the other hand, **Figure 5.7** explains train usage, those who expressed unwillingness to shift to the train i.e. 13% of respondent provided different reasoning such as time of travel 32%, cost 21%, convenience 14%, accessibility 7% and flexibility 7%. These lessons highlight the relevance of competitive fares, shorter journey times, planning of stations for enhanced accessibility as well as designing the services. On the whole, the results support the significant latent demand and offer a clear blueprint, how to organize the pricing, operations and user experience approaches of the Glass Train.

5.7.3.8 Fare Range & Preferences

During the interviews of O-D survey, respondents were requested to mention the highest price that they could pay to take the proposed Tourist Glass Train in the service. This is a vital input in the development of a fare structure that is based on income levels and motivations of travel and the value of the service. Figure (4.7) explains fare range and preference pattern. The findings indicate that 73 percent of the sampled population (5,773 out of 7,920) were satisfied with fares between PKR 300-500 which is in line with the existing fares in the Rawalpindi - Murree route. Approximately 20 percent (1,610) were willing to pay PKR 501-700 because there was a demand to have extensive comfort, safety, or reliability. Increasing price dispensation elicited a modest response: 5 percent (407) above PKR 701-1,000, 1.4 percent up to PKR 1,500, and just 0.2 percent above that, usually amongst high-end travelers or tourists

Figure: 5.8



The results underline a high level of price sensitivity and the necessity to use a tiered fare model i.e. standard fares remain competitive in order to attract mass ridership and premium-priced fares are used in the case of higher-paying groups. These insights are essential in the development of the revenue model, ridership forecast and competitive positioning of the service.

5.7.3.9 Analysis of Origin–Destination Travel Patterns – (Week days)

With the help of collected data, weekday O-D matrix is constructed attached as (**Annexure: A&A1)** provided a detail picture of interregional and intra-corridor travel behavior across the Rawalpindi–Murree region and its adjacent zones (Rawalpindi, Abbottabad, northern Khyber Pakhtunkhwa, as well as southern Punjab). It determines the dominance patterns, concentrations of ridership and priority corridors in the proposed Glass Train service.

The key findings are;

- Islamabad and Rawalpindi dominate demand, with 18.15% of weekday trips from Islamabad to Murree and 5.74 % from Rawalpindi to Murree, underscoring strong tourism and commuting flows that currently relies on private cars and vans along the E-75 corridor. These flows represent the primary ridership base for the proposed train service, particularly for recreational, social, and home-based trips.
- Return trips are significant, with 9.9% of Murree-origin trips to Islamabad and 6.76% to Rawalpindi, confirming bidirectional demand.

- Murree acts as both a destination and transit point, generating through traffic to Abbottabad (3.11%), Nathiagalli (1.18%), and Azad Kashmir (0.48%).
- Interregional connectivity is evident, including flows from Islamabad to Abbottabad (3.61%) and Kashmir (0.81%), and Rawalpindi to Kashmir (1.09%).
- Southern city connections (e.g., Lahore, Gujranwala) contribute modest but relevant flows, with 4.19 % traveling to Murree via Islamabad and Rawalpindi.

Overall, the matrix confirms a radial flow structure centered on Murree, with strong ties to Islamabad and Rawalpindi and secondary links to northern and southern regions. This provide an insight for train routing, station placement, and service frequency, while weekend patterns are analyzed separately to capture tourism-driven demand peaks.

5.7.3.10 Analysis of Origin–Destination Travel Patterns – (Week End)

Similarly, the weekend O–D matrix developed from the collected data attached **(Annexure: B& B1)** highlighted a sharp shift toward recreational and tourism-driven travel, significantly amplifying demand across the Rawalpindi–Murree corridor. The key findings are;

- Islamabad (14.49 %) and Rawalpindi (7.01%) dominate Murree-bound trips, both higher than weekday levels, confirming increase in the weekend tourism.
- Return flows are strong, with 12.07% of trips from Murree to Islamabad and 7.56 % to Rawalpindi, reflecting day trips and post-stay returns.
- Murree serves as a hub for onward tourism, channeling flows toward Nathiagalli (0.49%), Abbottabad/northern KPK (2.75%), and Kashmir (0.11%).
- Southern Punjab travel also rises sharply, with 7.81% of trips from Lahore, Gujranwala, and Sialkot, nearly double that of weekday levels i.e.3.25 %.
- Islamabad remains a key distributor, sending flows toward Murree, Kashmir (2.26 %), Abbottabad/northern KPK (2.52 %), and southern cities (0.19 %).
- Increased weekend travel from Murree to Rawalpindi (8.59%) and Islamabad (12.07%), indicating day trips or return movement after overnight stays.
- A marginal rise in flows from Murree to southern Punjab cities (2.08 %), reflecting tourist departures post-weekend stays.

Overall, weekend data emphasize role of Murree as a regional tourism anchor and connector, with the highest ridership potential for the Tourist Glass Train expected on weekends. These insights support flexible scheduling, increased weekend frequencies, and targeted fare or tourism promotions to capture peak demand.

5.8 Bus Terminal Survey – Weekday vs. Weekend Operations

In order to assess the operational performance, capacity, and ridership behavior of existing public transport services along the Rawalpindi–Murree corridor, a detailed Bus Terminal Survey was conducted at the **Faizabad Terminal**, the primary hub for Murree-bound public transport, highlight consistent demand during weekdays and a notable surge on weekends. Findings across six major routes (Old Murree, New Murree, Phugwari, Patriata, Upper Dewal, and Nathiagalli) are summarized below:

5.8.1 Weekday Findings

- 254 daily trips operated by six providers, primarily 18-seat Hiace vans.
- Full occupancy (100%) across routes, except New Murree (83%).
- Total ridership: 4,476 passengers/day.
- Fares: PKR 280–500
- Average travel time 1:20–2:00 hours.

5.8.2 Weekend Findings

- 262 daily trips, reflecting higher tourism and leisure demand.
- Full occupancy (18 passengers/vehicle) across all routes, including New Murree.
- Total ridership: 4,716 passengers/day (+5.4% vs. weekdays).
- Fares unchanged (PKR 280–500); increased frequency on New Murree and Nathiagalli routes, highlighting tourist preference.
- Travel times longer (1:30–2:15 hours) due to congestion.

5.8.3 Key observations &Implications

The survey confirms consistent demand & capacity saturation on both weekdays and weekends, with demand spikes on leisure days. This underscores the need for the proposed Glass Train to offer greater capacity, shorter travel times, and congestion resilience, particularly during peak tourist periods.

It further transpires that Old Murree is the most frequented destination as it has more than 85 trips in daily, while Nathiagalli attracts strong weekend demand despite higher fares and longer travel times, underscoring its tourism appeal. The use of 18-seat Hiace vans only shows the lack of service diversity and capacity, which partially causes congestion and excludes the possibility of organizing groups and providing services to travelers with higher income. As the ridership of the weekend approaches saturation, the results indicate that there is latent demand of a more capacity, reliable and comfortable alternative. The Glass Train is strategically located to accommodate the demands of the tourism to reduce road congestion and to increase the overall travel experience between the Islamabad/Rawalpindi and Murree.

5.8.4 Public Transport User/Boarding-Alighting Surveys

User interviews and boarding–alighting studies were used to supplement traffic counts and terminal surveys in order to capture the behavior of the traveler, service perceptions, and the distribution of demand along the Rawalpindi-Murree corridor. The graphical representation of Boarding and Alighting on three main routes have been shown in the already submitted Traffic and Commercial study to the client, whereas the complete summery of the same is shown in the table 5.3 below as ready reference.

Table: 5.2 Boarding and Alighting Summary Data

Route	Direction	Day	Total Boarding	Total Alighting	Net Load	Peak Boarding Stop	Peak Alighting Stop
1	26 no. stop to Murree	Weekend	85	88	-3	Faizabad	Murree
		Weekdays	48	46	2	Murree	Bara Kahu
	Murre to 26 no. stop	Weekend	47	42	5	Potohar	Faizabad
		Weekdays	47	42	5	Potohar	Faizabad
2	Faizabad to Murre	Weekend	57	41	16	Faizabad	Chitta Morr & Village Tramana
		Weekdays	40	40	0	Faizabad	Murree
	Murre to Faizabad	Weekend	74	36	38	Bara Kahu	Bara Kahu
		Weekdays	74	36	38	Bara Kahu	Bara Kahu
3	Peer Wadhai to Murree	Weekend	54	54	0	Faizabad	Bara Kahu
		Weekdays	71	53	18	Bara Kahu	Bara Kahu
	Murree to Peer Wadhai	Weekend	42	22	20	Bara Kahu	Faizabad
		Weekdays	42	22	20	Bara Kahu	Faizabad

Interviewing 100 users each weekday and weekend day on four main terminals (Faizabad, Murree GBS, Pirwadhai and 26 Number) i.e. in all 401 respondents provided information on purpose of trip, frequency of use, vehicle ownership, rationale of using the public transport, waiting time, preferences of fare rate, and intent to transfer to the Tourist Glass Train. Results indicated a high level of dissatisfaction with existing services- especially overcrowding, queuing, and discomfort- and a high degree of interest in a quicker, more comfortable, and reliable service. Coding of responses was done to assist in the utility function, ridership prediction and fare strategy.

Meanwhile, boarding-alighting surveys were conducted on the van and minibus journey between Islamabad and Murree, including weekdays and weekends. It was observed that a significant proportion of the passengers make journeys of only a portion of the route, and that the nodes that experience high turnover are Bhara Kahu, 17 Mile, Phulgran and Lower Topa. There was a greater touristic demand during the weekends and a commuter demand during the weekdays. This information played a significant role in the determination of intermediate station sites, clusters of demand, and spacing plans of the proposed train.

The combination of these surveys provided more detailed impression of the needs of users and their preferences in traveling, whereas, the Glass Train being higher capacity, reliable and user-oriented train should be seen as an opportunity to reach the needs of both the commuter and the tourist audience and relieve the congestion in the corridors.

5.9 Findings of Hotels Tourist Survey

To capture tourism-driven demand and hospitality perspectives, a survey of 100 hotels across key zones of Murree i.e. (Mall Road, Bhurban, New Murree, Company Bagh, Sunny Bank, Lower Topa, Upper Dewal, and Kashmir Point) was conducted. The sample included, large hotels, small guesthouses, mid-sized lodges, and large resorts, ensuring broad sector representation. Following information is gathered in survey covering six focus areas:

Hotel Operations & Visitor Profile – location, room capacity, tariffs, visitor profile & origins, room rents, share of domestic and foreigner guest, length of stay and luggage volume and seasonal fluctuations.

Guest Transport Behavior – dominant reliance on private cars, vans, tour buses and ride sharing with widespread concerns about parking and congestion. Table below show the Customer Travel Patterns which confirms strong dependence on private vehicles, contributing to congestion, especially during peak tourist seasons.

Table 5.4 Customer Travel Patterns to Murree

Customer Travel Patterns to Murree					
	Private Cars	Public Buses	Ride-Sharing Services	Tour Buses	Other Transport
Yes	87%	38%	2%	12%	0%
No	13%	62%	98%	88%	0%

Perceptions of the Glass Train – most operators expect positive impacts such as increased bookings and better guest access, though some raised concerns about congestion and competition. Table 5.5 to 5.7 show perceptions of the interviewee.

Table: 5.5 Positive Impact of Murree Glass Train Project on Hotel Businesses

Positive Impact of Murree Glass Train Project on Hotel Businesses	Number of Respondents	Percentage of Respondents
Yes	163	71%
No	9	4%
Maybe	58	25%
	230	100%

Table: 5.6 Benefits from Murree Glass Train Project

Benefits from Murree Glass Train Project					
	Increased Tourist Footfall	Better Connectivity for Guests	High Hotel Bookings	Improved Local Infra structure	Other
Yes	76%	58%	73%	49%	0%
No	24%	42%	27%	51%	0%

Table: 5.7 Concerns Regarding Project

Concerns Regarding Project				
	Increased Traffic Congestion	Environmental Impact	Higher Competition for Local Businesses	Other
Yes	47%	62%	38%	0%
No	53%	38%	62%	0%

Perceptions regarding the Murree Glass Train Project **Tables 5.5 – 5.7** are largely positive among hotel stakeholders. As shown in **Table 5.5**, about 71% of respondents believe that the project will have a positive impact on hotel businesses, while only 4% expressed a negative view. Approximately 25% were uncertain, indicating cautious optimism. In terms of anticipated benefits **Table 5.6**, increased tourist footfall is the most commonly expected outcome, supported by 76% of respondents. Higher hotel bookings are expected by 73%, while 58% anticipate improved connectivity for guests. Nearly half of

the respondents' i.e.49% also expect improvements in local infrastructure as a result of the project. However, respondents also expressed certain concerns **Table 5.7**, with environmental impact being the most significant, cited by 62% of respondents. Increased traffic congestion is a concern for 47%, while 38% fear higher competition for local businesses, indicating the need for careful environmental and traffic management planning.

Fare & Partnership Preferences – suggested ticket fare ranges for train, willingness to engage in bundled stay-and-travel packages. The data collected in this section supports the commercial structuring of the project. The fare preference and commercial partnership responses **Tables 5.8 and 5.9** reveal strong price sensitivity and business collaboration potential. As shown in **Table 5.8**, a majority of hotel respondents i.e. 66% consider a fare below PKR 500 to be reasonable for the Glass Train, while 32% support a fare range between PKR 500 and 1,000. Only 2% favor fares above PKR 1,000, emphasizing the importance of affordable pricing. Furthermore, **Table 5.9** shows strong interest in integrated tourism offerings, with 89% of respondents expressing willingness to participate in stay-and-travel packages, indicating significant potential for public-private partnerships between hotels and the Glass Train service

Table 5.8 Reasonable Price Range for Murree Glass Train

Reasonable Price Range	Number of Respondents	Percentage of Respondents
< PKR 500	152	66%
PKR 500-1000	74	32%
> PKR 1000	5	2%
	230	100%

Table 5.9 Customers Interested in Stay-and-Travel Packages

Interested in Stay-and-Travel Packages	Number of Respondents	Percentage of Respondents
Yes	205	89%
No	25	11%
Maybe	0	0%
	230	100%

Parking Facilities. Parking facility conditions at hotels **Table 5.10** reflects seasonal demand pressures. Nearly half of the respondents i.e. 49% reported high parking occupancy during peak tourist seasons and low occupancy during off-peak periods. About 22% reported moderate occupancy levels, while 8% experience consistently high

parking demand. These findings underscore the strain on parking infrastructure during peak periods and highlight the potential role of the Glass Train in reducing reliance on private vehicles. Limited capacity in central zones, accentuating the potential of train service to ease pressure.

Table 5.10 Average Parking Occupancy in Hotels

Average Parking Occupancy	Number of Respondents	Percentage of Respondents
High	18	8%
Moderate	51	22%
Low	25	11%
High during Peak Season, Low during off-peak Season	113	49%
Blanks	23	10%
	230	100%

Freight & Supply Logistics – Supply chains primarily from Islamabad/Rawalpindi, with moderate openness can use train-based freight only if cost-effective. The freight and supply chain logistics assessment **Tables 5.11 –5.14** shows that most hotels rely on local and regional supply networks. As per **Table 5.11**, 61% of hotels source their supplies from local vendors within Murree, while 38% depend on suppliers from Islamabad and Rawalpindi. Only 1% source supplies from other cities. **Table 5.12** indicates that hotel supplies are predominantly transported using local transport within Murree i.e. 85%, with limited use of private tracks i.e. 12% and 3% of third-party logistics services. Bulk supply deliveries are mainly conducted on a weekly basis i.e. 46%, followed by 23% bi-weekly and 21% of daily deliveries, as shown in **Table 5.13**.

Finally, interest in using train-based freight services **Table 5.14** is relatively strong, with 52% of respondents expressing clear interest. An additional 34% indicated conditional interest depending on cost and convenience, while only 14% were not interested. This suggests that, if designed efficiently and competitively, a freight component of the Murree Glass Train could support hotel supply chains and reduce road congestion.

Table: 5.11 Freight Primary Supply Source

Primary Supply Source	Number of Respondents	Percentage of Respondents
Local Vendor from Murree	140	61%
Suppliers from Islamabad/Rawalpindi	87	38%
Suppliers from other cities	2	1%
	230	100%

Table: 5.12 Hotel Supplies Transport Mode for Freight

Hotel Supplies Transport Mode	Number of Respondents	Percentage of Respondents
Local transport in Murree from Vendor	196	85%
Private Trucks	28	12%
Third-Party Logistics	7	3%
Other	0	0%
	230	100%

Table: 5.13 Freight Bulk Supply Delivery Frequency

Bulk Supply Delivery Frequency	Number of Respondents	Percentage of Respondents
Daily	48	21%
Weekly	106	46%
Bi-Weekly	53	23%
Monthly	21	9%
Seasonally	2	1%
	230	100%

Table: 5.14 Interest in Train Freight Service

Interest in Train Freight Service	Number of Respondents	Percentage of Respondents
Yes	120	52%
No	32	14%
Maybe depending on Cost and Convenience	78	34%
	230	100%

Findings confirm that hospitality sector of Murree region faces seasonal surges, parking shortages, and logistical challenges, all of which could be alleviated by the proposed Tourist Glass Train. The survey provides critical input for ridership estimates, station planning, commercial integration, and potential light-freight applications, reinforcing tourism as a central driver of project viability.

5.9.1 Data Integration and Model Preparation

Cleaned and coded datasets were integrated within a GIS platform, linking O–D pairs, survey locations, and proposed Glass Train stations. Trips were assigned to Traffic Analysis

Zones and base-year directional trip matrices were developed. This structured database formed the basis for mode choice analysis and demand forecasting, translating the observed travel behaviors i.e. vehicle volumes, trip purpose, occupancy levels, and willingness to shift into quantitative framework to derive ridership estimates under alternative operating scenarios.

5.9.2 Market and Commercial Analysis Framework

The market and commercial analysis assesses the Glass Train's financial viability and suitability for PPP participation. It is structured around four pillars i.e. (i) tourism demand profiling, (ii) income-based user segmentation, (iii) willingness-to-pay and modal shift, and (iv) corridor based commercial development. This analysis draws on hotel surveys, passenger interviews, and land-use assessments.

5.9.2.1 Tourism Market Profiling

Tourism is the primary demand driver. The surveys of 100 hotels (≈42% of Murree's registered stock) across Mall Road, GPO, Bhurban, Lower Topa, and New Murree captured occupancy, visitor origins, parking constraints, and seasonality. Results confirm strong seasonality, with peak occupancies exceeding 80% in summer and winter holidays and falling below 30% off-peak—supporting a scalable, season-responsive operating model. Hotel operators largely view the Glass Train positively and expressed interest in partnerships such as bundled tickets, digital promotions, and station kiosks, informing revenue diversification strategies.

5.9.2.2 Income Segmentation and Fare Affordability

The commercial model also required understanding the income-level distribution of current travelers, which was captured during O–D and public transport user interviews. Respondents were segmented into income brackets (low, lower-middle, upper-middle, and high income), allowing an estimation of fare elasticity and service expectation across groups. The findings indicated that:

- Passenger surveys segmented users by income to assess fare elasticity:
- Low to lower-middle income (≈40 – 45%): price-sensitive public transport users.
- Upper-middle income (≈35%): willing to pay moderate premiums for comfort and reliability.
- High income (≈20%): predominantly private car users, open to premium rail services.

These insights support tiered ticketing pricing, base fares targeting commuters and premium offerings for tourists and families, benchmarked against the vehicle / car operating costs.

5.9.2.3 Willingness-to-Pay and Modal Shift

Survey responses were used to derive a utility-based mode-choice model estimating shift probabilities by mode i.e. (public van, private car, coaster & wagon) and fare/service attributes i.e. (fare, travel time, comfort, safety). Conversion potential is highest among upper-middle-income tourists using public vans and lowest among informal transport users. Sensitivity testing informed ridership and revenue forecasts.

5.9.2.4 Commercial Development Potential

Beyond fares, the project offers ancillary revenue through station-area retail, advertising, and tourism services. Major terminals (e.g., Lake View Park and Sunny Bank) are suited for high-footfall commercial uses, while intermediate stations (e.g., 17 Mile, Valley Amusement Park & Lower Topa) enable PPP opportunities in parking, shuttles, themed amenities, and eco-tourism. Overall, this framework supports a multi-stream revenue model, reducing reliance on fare box recovery and strengthening the investment case for private sector participation.

5.9.3 Survey findings and Demand forecasting Results

5.9.3.1 Overview

The chapter is a summary of the multimodal survey results and passenger projections of the Rawalpindi-Murree Glass Train. The results are a combination of MCC, O-D and passenger interviews to determine the current travel trends, user behavior, modal shift potential, and demand during the season-adjusted basis- technical and financial appraisal.

5.9.3.2 Vehicular Flow Results and Corridor Load Profiles

The statistics at four locations (17 Mile, Phulgran, Lower-Topa & Kuldana) show that daily traffic was necessary of 34,000-39,000 vehicles with a high of above 42,000 during the weekends. Phulgran Plaza has the highest number of Murree bound traffic with a percentage of about 60 percent which confirms the E-75 as the major route. The area is dominated by private cars with Lower Topa and Kuldana having mixed traffic which serves the local hotels and businesses.

5.9.3.3 Demand Estimation Approach

The estimation of ridership involved a segmented trip-purpose-based model, which involves the observed volumes of traffic and adjustment of the stipulated preferences. Two markets were evaluated:

Public transport users (buses, wagons, Hiace)

Private transport users (Using private vehicle) For each segment, a multi-step process was applied to estimate the proportion of existing travelers likely to shift to the proposed rail service, accounting for trip purpose, origin-destination patterns, and stated willingness-to-use

5.9.3.4 Public Transport User Demand Estimation

Total (PuT) passengers/day = Σ (Vehicles × Average Occupancy)

= 254 vehicles × 17.6 average occupancy

= 4,476 passengers/day (weekday average)

The surveys of bus terminals in Faizabad show that there are an estimated 4,476 passengers of transport/day (weekday, two-way traffic). Although 80 percent indicated readiness to change, whereas, Primary motivation factors reliability (35%), availability (35%), affordability (21%), and accessibility (15%) are considered. Conservative calibration was used to consider the hypothetical bias, fare competitiveness with existing transport operators, and access constraints, which is in line with TRB guidance

5.9.3.5 Private Transport Demand

A Methodology Framework is developed & the Estimation involves sequential procedure to determine attraction of ridership from PrT users of the corridor to proposed rail link. Private transport demand estimation employed a spatially disaggregated origin-destination (O-D) analysis using data collected at four strategic Manual Classified Count (MCC) and O-D survey locations:

- 17 Mile Toll Plaza (Old Murree Road)
- Phulgran Toll Plaza (Murree Expressway)
- Lower Topa Intersection (Murree-Kohala junction)
- Kuldanna Chowk (Murree-Abbottabad/Nathiagalli divergence)

The MCC data were used for volume Expansion O-D surveys (n=7,960 interviews) on the above locations and transformed into Person-Trips through observed occupancies. Spatial filtering separated corridor-filtering trips with a high penalty on transfer between the north and Kashmir-bound movements. The shift propensities were taken into account by segregating trips according to their purpose.

5.9.3.6 Trip Purpose based Segmentation and Modal Shift

The recreational and social trips demonstrate the greatest shift potential i.e. 86% because it is flexible and oriented towards comfort and beauty. Low- propensity shift rates in work and routine trips are because of time (32%), access (7%), and flexibility constraints (7%); in these cases, the model was based on the utility-based adjustment, but not just on stated willingness.

5.9.3.7 Base-Year Ridership Estimates

Calibrated model is used to obtain a base weekday ridership of 6,132 passengers/day (March) and a weekend ridership of 9,643 passengers/day. These are the foundation of seasonal and long term projections.

5.9.3.8 Seasonality Adjustments

Demand is extremely seasonal, with two peaks: summer (May -August) due to school vacations and heat escape and winter (December -January) due to snowfall tourism. Peak demand may be 2.0 -2.5 times off-peak. There is moderate and weekend-based travel in shoulder months. To generate realistic annual ridership predictions and serve to guide service planning, monthly adjustment factors were used to create monthly predictions.

To calibrate base ridership derived from the March 2025 surveys, monthly traffic data from the **NHA Phulgran Toll Plaza** were analyzed. Located on the E-75 Murree Expressway, about 22 km from Islamabad, Phulgran captures the majority of Murree-bound traffic and serves as a reliable control point for the Murree corridor.

5.9.3.9 Calibration Benchmarking & Rational

Phulgran data were used as the benchmark because it provides

- **Complete coverage through 24/7 automated vehicle classification;**
- **Spatial representativeness, as traffic composition closely matches the proposed Glass Train market;**
- **Temporal continuity, with full monthly records for 2024; and**
- **Revealed behavior, free from survey timing or response bias.**

5.9.3.10 Seasonal Patterns 2024 NHA Data

Monthly volumes show strong seasonality consistent with Murree's tourism cycle. Summer season peaks dominate, with July reaching ~1.59 the annual average (June ~1.48, August ~1.38). This pattern reflects strong recreational travel to Murree during peak summer months.

A secondary winter peak occurs in December–January (~1.31 and 1.18, respectively). It is comparatively lower and more volatile than summer peaks, largely due to weather-related uncertainty and intermittent road accessibility.

March aligns closely with the annual mean of (~0.99), confirming it as a neutral baseline month. February is the trough (~0.71), yielding a peak-to-trough ratio of ~2.24:1. Shoulder months (April, September, and November) remain stable at ~0.78–0.93 of the annual average, these months represent moderate and predictable demand conditions, which are particularly relevant for routine operations, maintenance planning, and baseline service scheduling.

5.9.3.11 Ridership Calibration and Forecast

Using March daily weekday (6,132) and weekend (9,643) ridership estimates, **March monthly ridership** is **212,051**, which is calibrated against **March NHA traffic (244,402)**. By applying monthly multipliers on NHA monthly ridership yields the **2025 forecast** below in **Table 5.15.** Total forecasted ridership of year (2025): 3.68 million passengers

Table: 5.15

MONTH	TRAFFIC (NHA) 2024	FORECAST RIDERSHIP 2025
January	268734	233162
February	310169	269112
March	244402	212051
April	326166	282992
May	351214	304724
June	479309	415863
July	535536	464647
August	748311	414997
September	358026	310634
October	303458	263289
November	293461	254616
December	286889	248914
	42356475	**3675000**

Table: 5.4			
FORECASTED LOWEST RIDERSHIP MARCH 2025			
	Daily Ridership	**Days**	**Total**
Week days	6132	22	134909
Week ends	9643	8	77142
		TOTAL	**212051**
FORECASTED PEAK RIDERSHIP JULY 2025			
Week days	13437	22	265613
Week ends	21129	8	169034
		TOTAL	**464647**

5.10 Recommendations and Conclusions

5.10.1 Conclusions

In the proposed study on the Traffic and Commercial Study of the proposed Tourist Glass Train Rawalpindi / Islamabad to Murree, travel demand, modal nature, user behavior and commercial viability were evaluated along the route. The latter is based on a strong empirical foundation of data over a wide range of primary surveys and secondary NHA traffic information on which the analysis is based.

The results validate that the area is largely tourism-related, and the high peaks of weekends and seasons. Traffic and O D surveys indicate a high number of Murree bound traffic and high number of O D traffic especially during peak visiting seasons and hotel surveys reaffirm steady visitor flow with high monthly oscillation.

The type of vehicles that are overly used in the corridor is that of private vehicles, particularly cars and small vans. The current level of public transport is already at full capacity, with minimal potential to increase the capacity rates or the quality of services in the road network. This justifies the need of an alternative that is a higher capacity and of higher quality. O-D surveys and interview with users show that there is a significant desire to switch to the rail mode of transportation, particularly when it comes to leisure travel. They are comfort, safety, scenic value, and congestion avoidance. The fare analysis demonstrates willingness to pay the fares which are at the same level or moderately higher than the existing public transport as long as the quality of the services is better.

The demand forecasting, which combines public transport analysis with privately owned transport analysis, trip-purpose segmentation, and seasonal calibration based on NHA data, shows that enough ridership is supporting a passenger-oriented rail service, especially when the operations have a pattern of weekdays and weekends as well as seasonal demand. Market research proves that the only possible source of revenue is the

passenger demand. There is no potential of freight and lack of consistency making it justified that the Glass Train should be built out as a purely tourist-focused passenger train.

In general, the research concludes that the suggested Tourist Glass Train is reasonable in terms of demand and market and can be considered a successful business that is a passenger-oriented, tourism-oriented railroad service, provided that proper service design and operations are provided.

5.10.2 Recommendations

- Move to the next round of feasibility, such as detailed engineering, financial analysis, and environmental analysis.
- Create the Glass Train as a passenger only, tourism oriented service, focusing on comfort, safety and panoramic view in rolling stock and station design; no freight services.
- Implement demand-reactive operations where there is increased frequency on the weekend and peak tourism seasons and streamlined off-peak services.
- Establish competitive, transparent prices based on user willingness-to-pay and tourism travelling behavior as opposed to commuter pricing conditions.
- Make sure that last-mile connectivity is high especially at Murree, feeder services and efficient terminal area control are also tried to minimize congestions.
- Inclusiveness of environmental and land-use protection in future plans, elaborate environmental and social evaluation to facilitate environmentally sustainable application in the sensitive ecologically Murree area.

6. Chapter

6.1 Geological, Geotechnical and Seismological Studies

6.2 General Introduction to Project Site

In planning and execution phase of the geotechnical investigation, a conventional rail line was under consideration, running from Islamabad Sector H-9 to Murree Bus Stand. This alignment, is shown in yellow on the geotechnical investigation plan **(Appendix-A)**, covered 62.8 km and involved a number of bridges, tunnels and mixed sections at grade or in cut-and-fill through mountainous terrain. However, as the investigation neared completion and findings from parallel studies became available, the project management team adopted an alternative Straddle Monorail System with revised alignment for the Tourist Glass Train. This revised route is shown in black on the geotechnical investigation plan (Appendix-A), starts from semi-urban outskirts of Islamabad, Lake View Park and moves into the Margalla and Murree Hills, characterized by steep, mountainous terrain with dense forest cover and undulating topography to Murree Bus Stand, with a reduced total length of approximately 40 km. Land use varies from urban and institutional areas near the origin to largely natural and protected zones in the upper stretches. The alignment lies in a geo-hazard- prone region, with risks of landslides and unstable slopes, particularly beyond Ghora Gali up to the Murree Hill top. The proposed monorail will be constructed as a fully elevated system. This elevated option is more suitable for steep, hazardous terrain. This report presents the field and laboratory investigation results conducted for the earlier proposed alignment (shown in yellow on the plan). However, preliminary geotechnical recommendations have been provided in consideration of the revised monorail alignment (indicated in black on the plan). The location plan of the proposed glass train project is appended as **Fig. A-1 (Appendix-A).**

The field geotechnical investigation was conducted under the supervision of the Consultant's Engineering Geologists from March 8 to May 29, 2025. Selected soil, rock and water samples collected during the field geotechnical investigations are being tested at the geotechnical laboratories of DECON, CMTL, SOILCON and UET Lahore, in accordance with the laboratory testing programs developed by the Consultant. This report presents the findings of the geotechnical investigation carried out for the track way, stations and structures, including field and laboratory test results, evaluation of subsurface conditions and geotechnical recommendations to support the feasibility-level design of the project.

The preliminary geotechnical recommendations presented in this report are based on a limited, feasibility-level geotechnical investigation carried out in accordance with standard geotechnical practices. These findings are intended to inform the overall planning and evaluation of development options. As the proposed alignment passes through mountainous terrain with complex geological formations, regional active faults and both existing and potential landslide zones, these critical aspects are being assessed by specialized geological and geo hazard experts, with findings presented in their respective technical reports. The finalization of the alignment should be carried out in accordance with the recommendations of these studies. Furthermore, the estimated costs for geo hazard mitigation measures should be duly incorporated in the project cost estimates.

6.3 Objectives of Geotechnical Investigation

The geological, geotechnical and seismological investigation was undertaken to meet the following objectives:

- To identify the major subsurface soil and rock types along the proposed alignment
- To evaluate the overall suitability of ground conditions along the route.
- To estimate soil and rock parameters and develop geotechnical recommendations to guide feasibility-level foundation design and assess construction feasibility.
- To assess potential aggressiveness of subsurface materials on underground reinforced concrete works.

6.4 Scope of Geotechnical Investigation

The following scope of work for the feasibility-level geotechnical investigation was developed to meet the outlined objectives

- Execution of twenty (20) boreholes at selected locations along the proposed alignment, with depths ranging from 25 to 35 m below existing ground level (EGL), including continuous core drilling in bedrock up to 25 m below rock strike level.
- Performance of Standard Penetration Tests (SPTs) in boreholes at 1 m intervals.
- Collection and preservation of disturbed and undisturbed soil samples from boreholes.

- Collection and preservation of rock core samples from boreholes.
- Registering the ground water occurrence in boreholes & collection and preservation of groundwater samples.
- Laboratory testing of selected soil and rock samples to determine classification, strength, compressibility and chemical characteristics along with chemical analysis of groundwater.
- Estimation of soil and rock parameters and formulation of preliminary geotechnical recommendations to support feasibility-level foundation design.
- Preparation of a Geotechnical Investigation Report presenting key findings and baseline data for use in the feasibility study.

6.5 Geological, Geotectonic and Seismic Characteristics of area.

6.5.1 Geological, Geo-hazard and Seismic Risk

The project corridor is located in a geologically unstable and tectonically active area; Hazara Kashmir Syntaxis (HKS) of Lesser Himalayas. The alignment is mainly through the Miocene-aged Murree Formation, which is made of molasse-type deposits i.e. shale and siltstone, sandstone, which is overlaid in certain areas by the Quaternary deposits of colluvium, alluvium, and landslide debris. The region is affected by significant structural aspects, especially the Main Boundary Thrust (MBT) and the Jhelum Fault rendering it seismically susceptible. Landslides are a chronic geo-hazard caused by loose rock masses, steep slopes, excessive rainfall and seismic triggers especially in final stretch of the alignment from Ghora Gali-Murree Bus Stand where topographic and geological conditions are especially adverse. In light of these factors, comprehensive understanding of terrain instability and seismic risk was essential for terrain characterization. For a detailed appraisal of geological hazards and seismic parameters, crucial for defining appropriate mitigation strategies and ensuring that structural design aligns with site-specific seismic demands, reference should be made to the Geological and Geo-hazard Assessment Report and the Seismological Studies Report being prepared as part of this feasibility.

6.5.2 Field Geotechnical Studies

6.5.2.1 Planning

As part of the feasibility-level investigation, boreholes were drilled along the proposed alignment at relatively wider intervals, consistent with the scope of this preliminary assessment. While this spacing is sufficient for feasibility-level foundation design, closer spacing and more detailed investigations will be required during the detailed design

phase to support final foundation design and construction planning. The geotechnical investigation plan showing locations of the boreholes is appended to this report as **Figure A-2 (Appendix-A)**. The photographs of field activities are available in **(Appendix-F)** of Geotechnical Investigation Report already submitted to the client.

6.5.2.2 Drilling of Boreholes

A total of twenty (20) boreholes were drilled along the proposed alignment, to depths ranging from 25 to 35 me below EGL, including 15 to 25 m of continuous coring in bedrock. Straight rotary drilling method was employed to drill the boreholes with bentonite slurry as the drilling fluid. Fish tail / Tricon roller bit with a diameter of 125 mm was used to drill the boreholes. Field borehole logs were developed based on the material encountered at the site and were later verified through laboratory test results. The complete borehole logs & subsurface soil profile have been provided in the Geotechnical Investigation Report in **(Appendix-B)** and **Figure A-3 (Appendix-A)** respectively.

6.5.2.3 Standard Penetration Test

Standard Penetration Tests (SPTs) were conducted at 1 m intervals in all boreholes following ASTM D1586. A 63.5 kg donut hammer with a 0.76 m drop was used. In clayey soils, a split spoon sampler without liner was applied, while in gravelly strata a solid 60° cone was used due to coarse material. The hammer was manually operated with a rope and cathead mounted on a tripod. The SPT-N values were recorded in borehole logs **(Appendix-B)**, and depth-wise plots of field and corrected N-values are provided in **Figures C1 and C2 (Appendix-C)** of the Geotechnical Investigation Report already provided to client.

6.5.2.4 Disturbed Soil Sampling

Disturbed soil samples were collected from boreholes using methods suited to the soil type. In clayey soils, samples were obtained from the split spoon sampler, while in gravelly soils material was recovered using a percussion bailer. All samples were properly labeled, preserved and transported to the approved laboratories in accordance with ASTM D4220.

6.5.2.5 Undisturbed Soil Sampling

Six (6) relatively undisturbed soil samples were recovered from boreholes using Shelby tubes and Denison samplers in accordance with ASTM D1587. After determining the in-situ density, the soil samples were properly waxed, labeled, preserved and transported to the approved laboratories in accordance with ASTM D4220.

6.5.2.6 Undisturbed Rock Sampling

The rock cores recovered using double tube core barrel were placed in secured wooden boxes. The selected rock cores were properly waxed, labeled, preserved and transported to the approved laboratories in accordance with ASTM D5079. Photographs of the rock cores, preserved in wooden boxes, are provided in (**Appendix-B)** alongside the corresponding borehole logs.

6.5.2.7 Groundwater

Groundwater was generally not encountered during the geotechnical investigation conducted from March 8 to May 29, 2025. However, seepage was observed in two boreholes: BH-04 at a depth of 5.7 m and BH-06 at 18.5 m. These observations indicate localized zones of seepage rather than a continuous groundwater table.

6.5.3 Laboratory Testing

Selected soil, rock and water samples collected from boreholes are being subjected to the following tests as per laboratory testing programs prepared by the Consultant, in accordance with ASTM, BS, ISRM or equivalent standards, at the geotechnical laboratories of DECON, CMTL, SOILCON and UET Lahore:

- Grain Size Analysis (ASTM D421, 422)
- Atterberg Limits (ASTM D4318)
- Natural Moisture Content (ASTM D2216)
- Density (ASTM D7263)
- Direct Shear (ASTM D3080)
- Unconfined Compression (ASTM D2166)
- Consolidation with Swell Pressure Measurement (ASTM D2435)
- Uniaxial Compression and Elastic Modulus (ASTM D7012)
- Hoek Shear (ISRM, 1981)
- Sulfate Content (BS 1377 Part 3)
- Chloride Content (BS 1377 Part 3)
- Organic Matter Content (BS 1377 Part 3)
- Chemical Analysis of Water (BS 1377 Part 3)

A summary of laboratory test results completed to date is appended to this report as **Table D-1 (Appendix-D)** along with test result sheets.

6.5.4 Testing on Soil Samples

6.5.4.1 Classification Tests

Grain size analysis was proposed for fifty-four (54) soil samples collected from boreholes, with twenty-six (26) tests completed so far. The percentage of fines (i.e. passing sieve no. 200) for coarse grained soils ranged between 1 and 44 %, while the percentage of fines for fine grained soils varied from 50 to 100 %. Hydrometer analysis was proposed for ten (10) soil samples collected from boreholes, with four (4) tests completed so far. The tested samples contained 58 to 96 % silt-sized particles (0.002 to 0.075 mm) and 2 to 9 % clay-sized particles (<0.002 mm). Atterberg limits tests were proposed for thirty-seven (37) soil samples, with twenty (20) tests completed so far. The test results indicated liquid limit (LL) as 24 to 34 and plasticity index (PI) as 5 to 12.

The results indicated that on-site soils generally comprised Lean Clay/Lean Clay with Sand/Gravelly Lean Clay with Sand (CL), Silty Clay/Silty Clay with Sand/Gravelly Silty Clay with Sand (CL-ML), Clayey Gravel with Sand (GC), Silty Clayey Gravel with Sand (GC-GM and Poorly Graded Gravel with Clay and Sand (GP-GC) as per Unified Soil Classification System (USCS).

6.5.4.2 Natural Moisture Content and Dry Density Tests

Natural moisture content (NMC) and dry density tests were proposed for seven (7) relatively undisturbed soil samples collected from boreholes, with four (4) tests completed so far. The test results indicated that the NMC ranged from 17.1 to 18.1 % and dry density ranged from16.1 to 16.4 kN/m3.

6.5.4.3 Specific Gravity Tests

Specific gravity tests were proposed for five (5) relatively undisturbed cohesive soil samples extracted from boreholes, with three (3) tests completed so far. The test results indicated specific gravity as 2.68

6.5.4.4 Direct Shear Tests

Direct shear tests were proposed on three (3) soil samples obtained from boreholes using the split spoon sampler. These samples are to be remolded at their natural moisture content and in-situ bulk density and tested under a slow rate of shearing to ensure drained conditions. Test results have not yet been received.

6.5.4.5 Unconfined Compression Tests

Unconfined compression tests were proposed on seven (7) relatively undisturbed cohesive soil samples extracted from boreholes, with four (4) tests completed so far. The test results indicated unconfined compressive strength ranging from 45 to 69 kPa and failure strain ranging from 3.6 to 14.3 %.

6.5.4.6 Consolidation Test

Consolidation tests were proposed on five (5) relatively undisturbed cohesive soil samples extracted from boreholes, with three (3) tests completed so far. The test results indicated initial void ratio (eo) ranging from 0.63 to 0.66, compression index (Cc) ranging from 0.09 to 0.14 and coefficient of volume compressibility (mv) ranging from 0.13 x 10^{-3} to 0.24 x 10^{-3} m^2/kN at 160 kPa pressure. The swell pressure was recorded as 9 to 10 kPa.

6.5.5 Chemical Tests

Chemical tests were proposed for fourteen (14) soil samples collected from boreholes, with nine (9) tests completed so far. The test results indicated soluble sulphate content ranging from 0.01 to 0.05 %, chloride content ranging from 0.02 to 0.04 % and organic matter ranging from 0.08 to 0.14 %. Chemical tests were also proposed for two (2) seepage water samples collected from boreholes. Test results have not yet been received.

6.5.6 Testing on Rock Samples

6.5.6.1 Natural Moisture Content and Dry Density Tests

Natural moisture content (NMC) and dry density tests were proposed for thirty-two (32) intact rock core samples collected from boreholes, with twenty-four (24) tests completed so far. The test results indicated that the NMC ranged from 0.8 to 10.0 % and dry density ranged from 18.4 to 30.0 kN/m3.

6.5.6.2 Specific Gravity Tests

Specific gravity tests were proposed for sixteen (16) intact rock core samples collected from boreholes, with ten (10) tests completed so far. The test results indicated specific gravity ranging from 2.68 to 2.73

6.5.6.3 Uniaxial Compression Tests

Uniaxial compression tests were proposed for forty-eight (48) intact rock core samples collected from boreholes, with thirty-four (34) tests completed so far. The test results indicated uniaxial compressive strength ranging from 0.26 to 10.79 MPa for shale, 1.22 to 27.63 MPa for siltstone and 8.12 to 36.92 MPa for sandstone.

6.5.6.4 Elastic Modulus Tests

Elastic modulus tests were proposed for six (6) intact rock core samples collected from boreholes, all of which have been completed. The test results indicated elastic modulus as 104 and 1273 MPa for shale, 1607 and 2472 MPa for siltstone and 724 and 1634 MPa for sandstone.

6.5.6.5 Hoek Shear Tests

Hoek shear tests were proposed on seven (7) intact rock core samples collected from boreholes and prepared by saw-cutting the cores into matched halves for shearing. Test results have not yet been received.

6.5.7 Site Geo-technics

6.5.7.1 Subsurface Stratigraphy & Material Characteristic

The engineering characteristics of soils and rocks along the proposed monorail alignment, from Lake View Park to Murree Bus Stand, were assessed through a feasibility-level geotechnical investigation. Although a total of twenty (20) boreholes were drilled during the investigation, only sixteen (16) boreholes, BH-5 to BH-19, are relevant to the revised 39 km monorail alignment from Lake View Park to Murree Bus Stand. Since the monorail alignment begins from Lake View Park, the initial four boreholes (BH-1 to BH-4), which were located before this point, are not considered in the current assessment. Based on the subsurface conditions encountered, the boreholes were categorized into four (4) stratigraphic groups (Group-1 to Group-4) with similar lithological and geotechnical characteristics. Due to the exploratory nature and spacing of the boreholes, the lateral continuity and spatial extent of these groups along the alignment could not be reliably defined at this stage. Such delineation would require more detailed investigations with closely spaced boreholes during subsequent design phases. A summary of these groups and their corresponding stratigraphic units is provided in **Table 6.1** below.

Table: 6.1 Stratigraphy and Material Characteristics

Group No.	Layer Thickness below EGL (m)	Stratigraphy and Material Characteristics
Group-1 (BH-05)	0.0 - 18.0	Medium Stiff to Hard Lean Clay (CL) / Silty Clay (CL-ML)
	18.0 - 25.0	Very Dense Clayey Gravel with Sand (GC) / Silty Clayey Gravel with Sand (GC-GM)
	0.0 - 4.0	Stiff to Very Stiff Gravelly Lean Clay (CL) / Gravelly Silty Clay (CL-ML)

Group-2 (BH-06)	4.0 - 12.0	Dense to Very Dense Clayey Gravel with Sand (GC) / Silty Clayey Gravel with Sand (GC-GM)
	12.0 - 25.0	Hard Gravelly Lean Clay (CL) / Gravelly Silty Clay (CL-ML) with interbedded layers of Very Dense Silty Clayey Gravel with Sand (GC-GM)
Group-3 **BH-07, BH-08, BH-09, BH-10, BH-11, BH-12 and BH-12A)**	0.0 - 3.0	Stiff to Hard Lean Clay with Sand (CL) / Silty Clay with Sand (CL)
	3.0 - 25.0	Interbedded Shale, Siltstone and Sandstone, with Shale and Siltstone predominant, except in BH-09 and BH- 12 where Sandstone dominates. In general, Siltstone and Sandstone are weak to medium strong; Shale is extremely weak to very weak.
Group-4 BH-13, BH-14, BH-15, BH-16, BH-17, BH-18 **and BH-19)**	0.0 - 5.0	Stiff to Hard Lean Clay (CL) / Silty Clay (CL) with interbedded layers of Very Dense Clayey Gravel (GC) / Silty Clayey Gravel (GC-GM)
	5.0 - 10	Very Dense Clayey Gravel with Sand (GC) / Silty Clayey Gravel with Sand (GC-GM). This stratum extends to a depth of 14 m in BH-16 and 20 m in BH-19.
	10.0 - 35.0	Interbedded Shale, Siltstone and Sandstone, with Shale and Siltstone predominant, except in BH-16 where Sandstone dominates. In general, Siltstone and Sandstone are weak to medium strong; Shale is extremely weak to very weak.

6.5.8 Overburden Characteristics

6.5.8.1 Shear Strength, Compressibility and Swell Potential

Field and laboratory data indicated that the overburden soils generally exhibit medium to high shear strength, low to medium compressibility and low

swelling potential

6.5.8.2 Chemical Characteristics

Chemical testing of soil samples indicated low concentrations of sulphates and chlorides, as per the limits specified by ACI 318 (Building Code Requirements for Structural Concrete). Results of chemical testing on seepage water samples are still awaited.

6.5.9 Bedrock Characteristics

The bedrock predominantly comprises interbedded Shale, Siltstone and Sandstone, with Shale and Siltstone being the dominant lithologies. It is generally slightly - moderately weathered and exhibits moderate to high fracturing. Core recovery typically ranges from 70 to 90 %, while Rock Quality Designation (RQD) varies between 0 and 50 %, as shown in Fig. C3 and Fig. C4 (Appendix-C), respectively. According to BS 5930:2015, the uniaxial compressive strength of Siltstone and Sandstone falls within the weak to medium strong range, whereas Shale is classified as extremely weak to very weak. Based on these characteristics, the estimated Rock Mass Rating (RMR89), following Bieniawski (1989), ranges from 35 to 40, placing the rock mass on the boundary between “Poor” and “Fair” quality

6.5.10 Preliminary Geotechnical Recommendations for Feasibility-Level Foundation Design

The preliminary geotechnical recommendations for feasibility-level foundation design for the proposed fully elevated monorail system are as follows. The recommendations are based on the feasibility-level geotechnical investigation carried out through boreholes drilled along the proposed alignment at relatively wider intervals. While this spacing is sufficient for feasibility-level foundation design, closer spacing and more detailed investigations will be required during the detailed design phase to support final foundation design and construction planning.

6.5.10.1 Suitable Foundation Type & Design Criteria

At this feasibility stage, general guidance on the most suitable foundation type and design criteria is provided based on anticipated project needs. Bored cast-in-situ RC piles are anticipated to be required for supporting monorail piers and station structures, considering the anticipated load demands and performance requirements. A Factor of Safety (FOS) of 2.5 is required for pile foundations, with settlement performance verified against structural tolerance criteria.

The estimated pile capacities are based on preliminary geotechnical data and shall be validated through detailed investigations at the detailed design stage to finalize foundation design parameters and construction methods.

6.5.10.2 Subsurface Soil & Rock Parameters

The preliminary foundation recommendations are based on representative subsurface soil and rock parameters derived from the feasibility-level investigation. These parameters are selected using field and laboratory test results, supported by engineering judgment, relevant literature and experience with similar ground conditions. The derived values are presented in **Table 6.2** below.

Table: 6.2 Subsurface Soil and Rock Parameters

Group No.	Material Type	Depth below EGL	N'_{70}	γ_b	c_u	ϕ'	σ_{ci}	RMR
		(m)	-	(kN/m^3)	(kN/m^2)	(deg.)	(MPa)	-
Group-1	Lean Clay	0.0 - 3.0	4	17	30	0	-	-
	Lean Clay	3.0 - 18.0	14	20	100	0	-	-
	Clayey Gravel with Sand	18.0 - 25.0	50	22	0	40	-	-
Group-2	Gravelly Lean Clay	0.0 - 4.0	10	19	70	0	-	-
	Clayey Gravel with Sand	4.0 - 12.0	50	22	0	40	-	-
	Gravelly Lean Clay	12.0 - 25.0	50	21	150	0	-	-
Group-3	Lean Clay with Sand	0.0 - 3.0	10	19	*	*	-	-
	Bedrock	3.0 - 25.0	-	25	-	-	4	35
	Lean Clay	0.0 - 5.0	10	19	*	*	-	-

Group-4	Clayey Gravel with Sand	5.0 - 10	50	22	*	*	-	-
	Bedrock	10.0 - 35.0	-	25	-	-	4	35

***Overburden layer parameters are not considered in pile capacity calculations due to its limited thickness and potential for erosion or instability in steep or mountainous terrain.* Where, N'_{70} = Corrected SPT-N Value (with applicable corrections), γ_b = Bulk Density, c_u = Undrained Cohesion, ϕ' = Effective Angle of Internal Friction, σ_{ci} = Weighted Average Uniaxial Compressive Strength of Intact Rock, RMR = Rock Mass Rating

While the parameters in Table 5 represent the predominant subsurface conditions observe along the proposed alignment, boreholes BH-16 and BH-19 indicated comparatively thicker overburden deposits than those encountered at other locations. Given the wide spacing of boreholes at this feasibility stage, it is not practical to define the lateral extent of such variability. Therefore, representative values reflecting the more consistent conditions have been adopted to guide feasibility-level foundation design. However, the localized deviations highlight the need for detailed geotechnical investigation during the detailed design stage to validate and, if needed, refine these parameters.

6.5.11 Preliminary Pile Capacity Recommendations

The preliminary pile capacity recommendations for feasibility-level foundation design are evaluated considering the guidelines provided in U.S. Army Corps of Engineers Design Manuals, U.S. Department of Transportation, Federal Highway Administration Design Manuals and NESPAK Design Manuals.

6.5.11.1 Bored cast-in-situ

RC piles are anticipated to be required for supporting monorail piers and station structures, considering the anticipated load demands and performance requirements are detailed in **Table 6.3** below.

Table: 6.3

Type of Foundation	Bored RC Piles
Pile Cut-off Level	2.0 m below EGL
Pile Diameter	1200
Preliminary allowable pile Capacity Compression & Tension.	Refer to Fig. E1 for Group-1, E2 for Group-2 & E3 for Group-3 and Group-4

Pile capacities must be confirmed by full-scale compressive pile load tests before construction of working piles. The full-scale compressive pile load test shall be carried out up to at least 3.0 times of design load, i.e. P Test Load ≮ P Design Load x 3.0/η to finalize pile capacities.

Given the mountainous terrain and associated geo-hazards along the project corridor, particularly from Ghora Gali to Murree Bus Stand where landslide susceptibility is high, foundation design must account for more than just structural load demands. The proposed bored cast-in-situ RC piles are intended to support the elevated monorail superstructure and are not proposed to resist loads arising from unstable ground or slope movement. Therefore, in landslide-prone sections, the alignment should be carefully reviewed and mitigation measures implemented based on the recommendations of geo-hazard specialists to ensure long-term structural safety. Furthermore, once topographic survey data and site-specific geological and geomorphological mapping become available, geological and geo-hazard experts should carry out detailed slope stability analyses.

6.5.12 Soil Profile Type

The subsoil generally corresponds to soil profile type S_D for Group-1 and Group-2 and S**c** for Group-3 and Group-4, as per criteria of Building Code of Pakistan Seismic Provisions (2007), for preliminary structural design of the proposed monorail system.

6.5.13 Durability Consideration for Bored Cast -In-Situ RC-Piles

Chemical testing of soil samples indicated low concentrations of sulphates and chlorides, within the permissible limits defined by ACI 318. Based on these results, the use of Ordinary Portland Cement (OPC) may be considered acceptable. However, chemical test results of seepage water samples are still awaited and will be critical in confirming the final cement type selection. In addition, appropriate concrete cover to reinforcement, typically 75 mm for pile foundations, is recommended. However final cement type selection and mix specifications should be confirmed during the detailed design phase through a more refined geochemical evaluation.

6.5.14 Conclusions

- The on-site overburden soils generally comprised Lean Clay/Lean Clay with Sand/Gravelly Lean Clay with Sand (CL), Silty Clay/Silty Clay with Sand/Gravelly Silty Clay with Sand (CL-ML), Clayey Gravel with Sand (GC), Silty Clayey Gravel with Sand (GC-GM) and Poorly Graded Gravel with Clay and Sand (GP-GC) as per Unified Soil Classification System (USCS). The bedrock predominantly comprises interbedded Shale, Siltstone and Sandstone, with

Shale and Siltstone being the dominant lithologies. *For details, refer to Section 6.5.7.1 above.*

- Groundwater was generally not encountered during the geotechnical investigation conducted from March 8 to May 29, 2025. However, seepage was observed in two boreholes: BH-04 at a depth of 5.7 m and BH-06 at 18.5 m. These observations indicate localized zones of seepage rather than a continuous groundwater table.
- Field and laboratory data indicated that the overburden soils generally exhibit medium to high shear strength, low to medium compressibility and low swelling potential. The estimated Rock Mass Rating (RMR89), following Bieniawski (1989), ranges from 35 to 40, placing the rock mass on the boundary between “Poor” and “Fair” quality.
- The subsoil generally corresponds to soil profile type S_D for Group-1 and Group-2 and S_C for Group-3 and Group-4, as per criteria of Building Code of Pakistan Seismic Provisions (2007).
- Chemical testing of soil samples indicated low concentrations of sulphates and chlorides, within the permissible limits defined by ACI 318.

6.5.15 Recommendations

- Bored cast-in-situ RC piles are anticipated to be required for supporting monorail piers and station structures, considering the anticipated load demands and performance requirements. However, estimated pile capacities are based on preliminary geotechnical data and shall be validated through detailed investigations at the detailed design stage to finalize foundation design parameters and construction methods.
- Given the mountainous terrain and associated geo-hazards along the project corridor, particularly from Ghora Gali to Murree Bus Stand where landslide susceptibility is high, foundation design must account for more than just structural load demands. The proposed bored cast-in-situ RC piles are intended to support the elevated monorail superstructure and are not proposed to resist loads arising from unstable ground or slope movement. Therefore, in landslide-prone sections, the alignment should be carefully reviewed and mitigation measures implemented based on the recommendations of geo-hazard specialists to ensure long-term structural safety. For details, refer to Section 2.8.9.3 above.
- Based on the chemical test results of soil samples, the use of Ordinary Portland Cement (OPC) may be considered acceptable. However, chemical

test results of seepage water samples are still awaited and will be critical in confirming the final cement type selection.

7. Chapter

7.1 Multichannel Analysis of Surface Waves (MASW) Survey.

7.2 Introduction

As part of the consultancy agreement, a non-destructive, Multichannel Analysis of Surface Waves (MASW) survey was conducted along the proposed Glass Train route from Islamabad to Murree to determine the shear wave velocity profile up to 30 m depth (Vs30). Determination of Vs. and Vs30 is a mandatory input for several studies under international standards and codes, including the Building Code of Pakistan–Seismic Provisions (2007) and Uniform Building Code, such as:

- Seismic hazard assessment
- Geological/geotechnical investigations

Like site characterization, soil profile classification, material stiffness, cyclic liquefaction potential, dynamic parameters, bearing capacity etc. This MASW study provides the scientific basis for these assessments. A total of 71 MASW survey profiles were acquired by NESPAK geophysicists, each with an investigation depth of about 30 m. (MASW) Survey profile locations for Tourist Glass Train are presented with the help of satellite images in Figures 1,1a–1h, while site-specific results for each profile are shown in Figures 3–73 respectively of the already submitted (MASW) report to the client.

The coordinates of the center point of each MASW Survey profile were taken by a handheld GPS during the execution of the survey as shown in **Table 7.1** below.

Table: 7.1

Coordinates of Multichannel Analysis of Surface Waves Observation Points

MASW NO.	LOCATION	EASTING (m)	NORTHING (m)	GEOLOGY
MASW-01	H9/Margala Station	33.663517°	73.047939°	Silty clay/clayey silt was present along the profile
MASW-02	H9/Margala Station	33.663699°	73.047949°	Silty clay/clayey silt was present along the profile
MASW-03	Existing Bridge In front of NUML	33.666803°	73.054374°	Silty clay/clayey silt was present along the profile
MASW-04	Khyaban e Johar Station	33.668227°	73.057315°	Silty clay/clayey silt was present along the profile
MASW-05	Khyaban e Johar Station	33.670734°	73.062121°	Silty clay/clayey silt was present along the profile
MASW-06	Near Existing Bridge In front of Al Shifa	33.673083°	73.066337°	Silty clay/clayey silt was present along the profile
MASW-07	Existing Bridge Near Faizabad Chowk	33.668241°	73.088968°	Silty clay/clayey silt was present along the profile
MASW-08	Along the Proposed Route option no.4	33.675353°	73.093401°	Silty clay/clayey silt was present along the profile

MASW-09	Along the Proposed Route option no.4	33.681188°	73.098337°	Silty clay/clayey silt was present along the profile
MASW-10	WAPDA Colony Station	33.686256°	73.110597°	Silty clay/clayey silt was present along the profile
MASW-11	WAPDA Colony Station	33.690759°	73.111610°	Silty clay/clayey silt was present along the profile
MASW-12	Lake View Park Station	33.717329°	73.124547°	Silty clay/clayey silt/gravel and boulder was present along the profile
MASW-13	Near Existing Bridge Jinnah Stream	33.720106°	73.129358°	Silty clay/clayey silt was present along the profile
MASW-14	Along the Proposed Route option no.4	33.729394°	73.138311°	Silty clay/clayey silt was present along the profile
MASW-15	Existing Bridge along QAU road	33.736067°	73.144944°	Silty clay/clayey silt was present along the profile
MASW-16	Existing Bridge along QAU road	33.736581°	73.145905°	Silty clay/clayey silt was present along the profile
MASW-17	Along the Proposed Route Shahdra Valley	33.751734°	73.160989°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-18	Along the Proposed Route Shahdra Valley	33.755810°	73.166232°	Silty clay/clayey silt was present along the profile
MASW-19	Bharakhu Station	3.759919°	73.172771°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-20	Bharakhu Station	33.760568°	73.172448°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-21	Along the Proposed Route Shahdra Valley	33.764257°	73.179356°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-22	Along the Proposed Route Shahdra Valley	33.759899°	73.183931°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-23	Along the Proposed Route Shahdra Valley	33.754157°	73.187764°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-24	Existing Bridge	33.754872°	73.203869°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-25	Proposed Bridge Bharakhu	33.765975°	73.214586°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-26	Along the Proposed Route	33.767489°	73.220989°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-27	Existing Bridge Korang river	33.772525°	73.236997°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-28	Chatar park Station	33.777006°	73.243408°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-29	Chatar park Station	33.777217°	73.242808°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-30	Bahria Golf City Station	33.794731°	73.276631°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-31	Bahria Golf City Station	33.795092°	73.276142°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-32	Proposed Bridge	33.805655°	73.294044°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-33	Manga Station	33.809453°	73.295736°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-34	Manga Station	33.809629°	73.295351°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-35	Shakarparian Station	33.681943°	73.075331°	Silty clay/clayey silt was present along the profile
MASW-36	Shakarparian Station	33.681816°	73.076116°	Silty clay/clayey silt was present along the profile
MASW-37	Aabpara Station	33.705282°	73.087353°	Silty clay/clayey silt was present along the profile
MASW-38	Aabpara Station	33.704099°	73.087100°	Silty clay/clayey silt was present along the profile
MASW-39	Barakhu Station	33.732047°	73.147767°	Silty clay/clayey silt was present along the profile
MASW-40	Barakhu Station	33.731173°	73.148597°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-41	Qauid e Azam University Station	33.744415°	73.158701°	Silty clay/clayey silt was present along the profile
MASW-42	Qauid e Azam University Station	33.744191°	73.159091°	Silty clay/clayey silt was present along the profile

MASW-43	Shahdara Valley Station	33.766126°	73.180359°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-44	Shahdara Valley Station	33.766295°	73.179946°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-45	Proposed Cut near Shahdara Valley	33.772069°	73.186410°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-46	Proposed Tunnel (Inlet) near Shahdara Valley	33.781377°	73.191620°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-47	Proposed Tunnel (center) near Shahdara Valley	33.784701°	73.203598°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-48	Proposed Tunnel (outlet) near Shahdara Valley	33.787189°	73.200613°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-49	Proposed Bridge adjacent to Judicial colony	33.800825°	73.242911°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-50	Proposed Tunnel (inlet) near Judicial colony	33.800531°	73.254146°	Silty clay/clayey silt and gravel/boulder was present along the profile
MASW-51	Proposed Tunnel (center)	33.800327°	73.255493°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-52	Proposed Tunnel (outlet) near Judicial colony	33.806814°	73.263716°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-53	Proposed Bridge near Judicial colony	33.806597°	73.265145°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-54	Tret Valley Amusement Park Station	33.814683°	73.281501°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-55	NandKot station	33.840803°	73.318324°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-56	NandKot station	33.840319°	73.317473°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-57	Track Crossing from Road at Nandkot	33.841483°	73.320670°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-58	Proposed Cut	33.856666°	73.335896°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-59	Proposed Tunnel (inlet)	33.857903°	73.337030°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-60	Proposed Tunnel (center)	33.858593°	73.338401°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-61	Proposed Tunnel (outlet)	33.860202°	73.339114°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-62	Proposed Cut	33.874746°	73.345365°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-63	Ghora Gali Station	33.881161°	73.360590°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-64	Ghora Gali Station	33.881190°	73.360974°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-65	Pindi Point Station	33.881190°	73.360974°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-66	Pindi Point Station	33.893340°	73.367751°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile

MASW-67	Proposed Tunnel (inlet) near Pindi Point	33.895135°	73.368376°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-68	Proposed Tunnel (center) near Pindi Point	33.893825°	73.374468°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-69	Proposed Tunnel (outlet) near Pindi Point	33.892928°	73.378508°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-70	Murree Terminal	33.906942°	73.382416°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile
MASW-71	Murree Terminal	33.908300°	73.382661°	Silty clay/clayey silt/gravel/boulders and alternate beds of sandstone/shale were present along the profile

7.2.1 Scope of Work

- In order to investigate the shear wave velocity profile up to 30 meters depth (Vs.30), the following scope of services is planned.
- Site reconnaissance to assess the site conditions and selection of MASW Survey profile locations along the proposed glass train.
- Data acquisition at selected locations which were proposed by the seismologist.
- Processing, analysis and inversion of shear wave data recorded at the site.
- Preparation of site specific MASW Survey report which includes
- Inverted cross sections of shear wave velocities with respect to depth each MASW Survey profile location up to a depth of investigation of 30 m.
- Site characterization/soil profile type of the project area as per Building Code of Pakistan-Seismic Provisions 2007, which will further support to Geotechnical expert/studies.

7.2.2 Principle of Multichannel Analysis of Surface Waves (MASW) Survey

The Multichannel Analysis of Surface Waves (MASW) method utilizes seismic surface waves, which propagate parallel to the ground surface without dissipating energy into the subsurface. More than two-thirds of seismic energy is concentrated in surface waves, with Rayleigh waves being the dominant component in seismic records. These waves are therefore preferred for MASW surveys due to their strong energy and ease of acquisition.

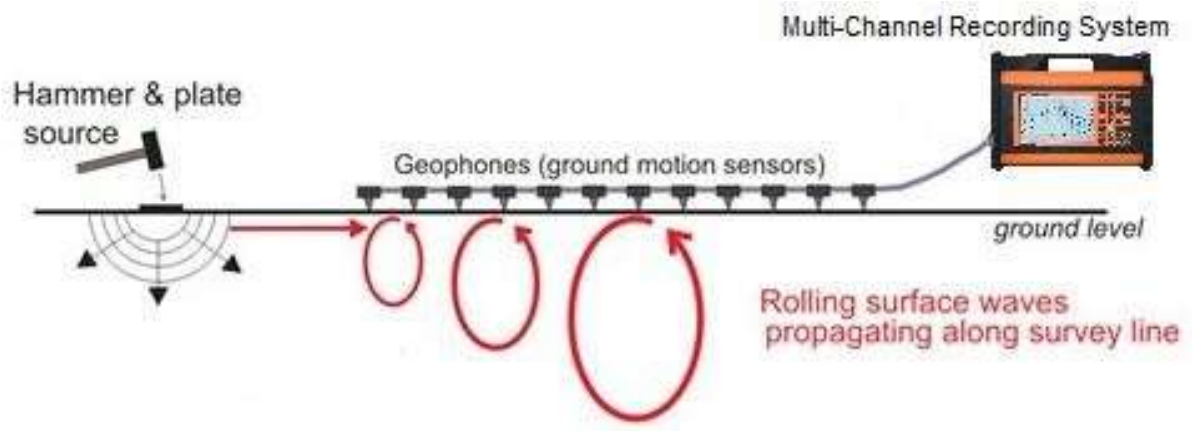
The method is governed by two fundamental principles.

- Seismic waves travel at different velocities in different geological strata.
- Significant velocity contrasts exist across geological boundaries.

In active MASW surveys, a seismic source (e.g., steel plate with sledgehammer, or weight drop) and an array of receivers are deployed in a linear (in-line) profiling system. Ground vibrations are detected by low-frequency vertical geophones (4.5 Hz), converted to electrical signals, and transmitted to a seismograph equipped with amplification, multichannel recording, and triggering devices.

The acquired records are processed to isolate Rayleigh wave dispersion characteristics. Using frequency–wavenumber (f–k) or slowness–frequency (p–f) transformations, dispersion images are generated. From these images, the fundamental-mode dispersion curve is extracted and subsequently inverted to obtain a 1D shear wave velocity (Vs) profile. Final interpretation provides depth–velocity relationships of subsurface layers. Reliability is enhanced by recording seismic signals in both directions along the receiver spread. A schematic representation of the MASW survey is provided in **Figure 7.1** below**.**

Figure: 7.1 Schematic Diagram of MASW Survey



7.2.3 Field Progression

A twenty-four (24) channel Signal Enhancement Seismograph “TERRALOC Pro-2” of ABEM, Sweden was used in the field for the recording of the arrival time of seismic waves.

Figure: 7.2



For the multichannel analysis of surface waves, twenty-four (24) geophones (4.5 Hertz vertical) were placed on the ground surface in a straight line at different intervals of about 2, 2.5 and 3 meters along the profile line. The seismic waves were produced at the source point by striking a sledge-hammer on a steel plate. The number of impacts (i.e. stacks) at each shooting point was taken five (5) to increase the signal-to-noise ratio to improve the data quality. Variable number of shots at offset distances of 4m, 5m, 6m, 7m, 8m, 9m and 12m were taken at one side of the spread while the lengths of spread are taken as 46.57.5& 69 meters. The method of reverse shooting was adopted in which seismic waves are produced on both ends of the geophones spread and the Rayleigh waves are recorded from both directions at the same offset distance. The sampling interval of 1000 micro sec is adopted.

Since the working conditions at site were very bad in terms of signal to noise ratio disturbed by heavy traffic, loose surface material and noise generated by blowing wind, therefore best possible maximum efforts were made to improve the signal to noise ratio for acquiring good quality data at site. Efforts were made during data processing / interpretation process to achieve the optimum results

7.2.4 Data Evaluation

The MASW data was being imported into Seismic Pro 9.3 Inversion program (Geogiga Technology Inc.) The overtone images (phase velocity vs. frequency) were investigated on every shot collected and the fundamental mode of surface waves was selected.

Repeated calculations of the phase velocities in the target frequency range were done under different input parameters to maximize the signal to noise ratio.

A profile of 1D shear-wave velocity (Vs) was obtained then by inverting all the dispersion curves. The process of inversion was repeated to align theoretically and experimentally generated dispersion curves; minimization of root-mean square error (RMSE). The ensuing Vs30 profiles that indicate the shear-wave velocities at a depth of 30 m were considered as the most representative of shear-wave velocities at a depth of 30m under geophone spreading in the subsurface. These results were correlated with Building Code of Pakistan, Seismic Provisions 2007 (BCP-SP 2007) to group the soil profiles as follows:

- **S_A:** Hard rock, Vs > 1500 m/s
- **S_B:** Medium hard rock, 750 < Vs < 1500 m/s
- **S_C:** Solid dirt/solid rock, less than 350 Vs, less than 750 m/s, or N less than 50, or su less than 100 kPa.
- **S_D:** Stiff, 175 < Vs <350 m/s, or 15 < N <50, or 50 < su 100 kPa.
- **S_E**: Soft soils, Vs < 175 m/s, or N < 20, wmc > 40, su < 25 kPa.
- **S_F:** Soils requiring site specific evaluation, like liquefiable soils, peats, highly organic soils or plastic clay as well as the thick soft to medium stiff clay deposit

7.2.5 Results & Findings

The following results are inferred from the Multichannel Analysis of Surface Waves (MASW) Survey based on their locations

7.2.5.1 Surface Geology: Soil

The average Vs30 for soil profiles is interpreted as 416.6 meters/second (say 420 m/sec.

7.2.5.2 Surface Geology: Rock

The average Vs30 for rock profile is interpreted as 705.84 meters/second meters/second (say 700 m/sec.) Both the Soil and Rock profiles lies under soil profile type **"Sc"** as per BCP-SP 2007, So, overall, the average Vs30 for the project area is interpreted as 558 (Say 560 m/s)

7.2.6 Conclusion

As per MASW survey results from the site, shear wave velocity derived is Vs30 570 m/sec. As per Building Code of Pakistan 2007, the subsoil falls under the category of **"Sc"** as per requirements provided in Section 2.9.5 of this report.

7.2.7 An Initial Assessment of Construction Materials Availability

7.2.7.1 Introduction

Tourist Glass Train is a visionary project in line with the national goals of enhancing sustainable tourism and the growth of the economy in the region. The suggested alignment cuts across complicated mountainous terrain with extreme steepness, geological formations, and areas of environment sensitivity. Consequently, the successful execution of this project necessitates meticulous planning, robust engineering design, and the prudent selection and utilization of locally sourced construction materials.

In planning and execution phase of the geotechnical investigation, a conventional rail line of 62.8 km remained under consideration, running from Islamabad Sector H-9 to Murree Bus Stand. This alignment, involved a number of bridges, tunnels and mixed sections at grade or in cut-and-fill through mountainous terrain. However, as the investigation neared completion and findings from parallel studies became available, the project management team adopted an alternative Straddle Monorail System with revised alignment of approximately 40 km starting from semi-urban outskirts of Islamabad, Lake View Park and moves into the Margalla and Murree Hills, to Murree Bus Stand.

Geomorphological conditions in the construction of a railroad in an uneven terrain are highly technical, especially when it comes to slope stability, subgrade stability, and drainage issues. There should thus be a site-specific analysis of building materials to be used so that project becomes feasible, cost effective and the long-term safety and durability of railway infrastructure. To solve this, M/S F & M Pvt. Ltd. was obtained competitively as per the PPRA procurement rules to conduct thorough investigations on the construction materials. They included the surveys in the field, on-site sampling, lab tests and assessment of the available local soil and aggregate materials that could be used in the construction of embankments, subgrades, sub-base layers, and concrete structures.

Tests along the proposed alignment chainage 0+000 -22+000 km included systematic excavations of test pits, soil profiling and categorizing of materials according to the USCS standards. The proposed alignment in first 22 km had 15 test pits. The initial inspection shows the existence of sandy silts, gravels and eroded rock fragments which could be used as rail earth works provided that they meet the gradation and compaction standards.

North of chainage 22+000 km, the alignment passes through hilly land with poor accessibility and constant rock outcrops, and excavation of test pits are impossible. In this case, the investigation plan changed to measured materials of natural drainage system, such as deposits of Dhund Haro River and other streams. Such alluvial and fluvial

formations are promising as borrow materials but they need intensive lab tests to ascertain their appropriateness.

It was also observed during field observations that there was hilly part (22 to 60 km) which consisted of shale and clay formations which were notorious to engineering performances as they were highly plastic, low in shear strength and durability. They should not be used in embankments or sub grades, unless properly stabilized.

In general, the preliminary stage of research has offered useful information about the supply of local materials and their general features. Nevertheless, laboratory tests are critical so that final engineering viability can be determined and material usage plans of the railway project can be made.

7.2.7.2 Embankment, Subgrade & Sub-base Materials

Field investigations i.e. test pits (TP-01 to TP-15) are intended to systematically characterize the in-situ geological and geotechnical conditions and to identify feasible local sources of construction materials suitable for use in embankments, subgrades, and sub-base layers. Refer **Figure 7.3** below

Figure : 7.3 Test Pit Plan (First 22 km)



7.2.8 Summary of Test Pit Findings

The findings from the excavated test pits based primarily on visual and tactile observations at this stage are summarized below to provide a preliminary understanding of the encountered material types, their physical characteristics, and anticipated performance. Further details of encountered material refer to Test Pit Logs already submitted to the client in a report i.e. *"A Preliminary Approach on Construction Materials Availability* "appended as Appendix (A).

- **TP-01 to TP-08 (except TP-07)**

Silty clay / clayey silt: Fine-grained soils of low–moderate plasticity, dry to slightly moist, cohesive, and moisture-sensitive. Prone to shrink–swell, moderate compressibility, and settlement under loading. Require laboratory testing (shear strength, compressibility and permeability) to confirm suitability.
Silty clay with gravel/cobbles: Heterogeneous soils with cohesive fines and coarse particles. Strength depends on gradation and packing; coarse fraction improves load distribution but may cause variable performance. Stabilization (lime/cement) and strict compaction control recommended. In natural state, both soil types are moisture-sensitive, settlement-prone, and of limited bearing capacity. Suitability for embankment and structural fill must be verified by Atterberg limits, Proctor, CBR, and grain size tests.

- **TP-09 to TP-13 (except TP-10 and TP-11)**

Sandy gravel with cobbles/boulders: Well-graded, granular deposits of alluvial/colluvial origin. High permeability, negligible plasticity, and good bearing capacity make them suitable for subgrade and sub-base. Oversized particles require screening/sieving. With favorable geotechnical test results (grain size, specific gravity, sand equivalent, and compaction), these gravels represent a cost-effective and locally available engineered fill source.

- **TP-10, TP-11, TP-14, TP-15**

Silty clay / clayey silt: Slightly moist to moist soils of low–moderate plasticity. Moisture-sensitive with shrink–swell behavior, moderate compressibility, and limited strength. Require stabilization and laboratory testing (shear strength, consolidation, permeability) before use.

- **Chainage 22+000 to 60+000**

Test pits were not feasible due to exposed rock. Streambed alluvium (gravels and sands) from Dhund Haro River and tributaries offers potential fill material but must be tested for gradation, shape, compaction, and bearing capacity. Only compliant materials should be approved. Weak lithologies (shale, expansive clays) underlie much of this section. They exhibit poor strength, high plasticity, and moisture-induced instability, making them unsuitable for embankments or subgrade.

Suggestions

- Ploy real-time material evaluation during construction (field classification, selective lab testing).
- Reuse only suitable in-situ materials; exclude weak or expansive soils.
- Adopt stabilization/treatment where required.
- This approach minimizes borrow needs, improves durability, reduces cost, and
- Supports environmental sustainability.

7.2.9 Borrow Areas

The possible areas of borrowing (BA-1, BA-2 and BA-3) to obtain fill material in the construction of sub-base and subgrade have been located. Geotechnical evaluation was undertaken on representative samples of soil of each location.

- BA-1: This will be situated close to the Test Pit TP-13 and it will have logistical benefits. One sample collected and sent for laboratory evaluation.
- BA-2: It is located in a valley of Shahdara, adjacent to Quaid-e-Azam University, which has natural deposits suitable for construction. One sample collected.
- BA-3: It is on the Korang River above Chhatar Park, one sample collected for testing. Early visual identification suggests that all sites have sandy gravel with a small amount of clay, which is usually suitable in sub-base and subgrade works. Compliance with project specifications will be ensured with the help of laboratory testing (grain size analysis, Atterberg limits, compaction characteristics etc.). Any borrow sources will have oversize particles which must be screened in order to achieve the gradation requirements of engineered fill.

7.2.10 Testing Requirements

All materials collected from executed test pits and borrow areas must be subjected to a comprehensive suite of standard laboratory tests to evaluate and confirm their engineering suitability for use in various structural layers of the project, such as embankments, subgrades, and sub-bases. These tests are essential for determining the physical and mechanical characteristics of the soils, which directly influence their performance under load and environmental conditions. The testing program shall include, but not be limited to, the following;

- Grain Size Distribution (ASTM D6913): This test determines the particle size distribution of soil samples, which is critical for classifying soils and understanding their drainage characteristics, compaction behavior, and suitability for various engineering applications.
- Atterberg Limits (ASTM D4318): These limits (Liquid Limit, Plastic Limit, and Plasticity Index) provide insight into the plasticity characteristics of fine-grained soils, helping to assess their workability, expansiveness, and potential for volumetric changes under varying moisture conditions.
- Standard/Modified Proctor Compaction (ASTM D698 / D1557): These compaction tests establish the optimal moisture content and maximum dry density of soils, ensuring proper compaction during field placement for achieving desired strength and stability.
- California Bearing Ratio – CBR (ASTM D1883): The CBR test evaluates the strength of embankment, subgrade and base course materials by measuring their resistance to penetration, providing a key design parameter for pavement and embankment structures.
- Specific Gravity (ASTM D854): Determining the specific gravity of soil solids helps in identifying soil type and is also essential in various calculations such as void ratio, porosity, and unit weight.
- Chemical Analysis (as required): Chemical testing may be conducted to detect the presence of potentially harmful substances such as sulfates, chlorides, or organic matter, which could adversely affect the performance and durability of soils.
- Los Angeles Abrasion Test (ASTM C131/C131M or ASTM C535T): This test assesses the hardness and abrasion resistance of aggregate materials, especially for coarse-grained soils or crushed rock intended for sub-base or base course layers.

- Sand Equivalent ASTM D2419 (as required): This test is used to measure the relative proportion of fine dust or clay-like particles in granular soils, which can impact the drainage and compaction properties of the material.
- Based on the results obtained from the above tests, soils meeting the required specifications and performance criteria will be selected and approved for use in the construction of embankments, subgrades, and sub-base layers. Any soils found to be non-conforming or unsuitable may be subjected to improvement techniques such as stabilization with lime, cement, or other additives or, if necessary, replaced entirely with more appropriate borrow material that meets the project's engineering requirement.

7.2.11 Coarse Aggregates

Margalla and Khanpur quarries are proven, large-scale sources of crushed stone, long utilized in national infrastructure projects of high-load transport infrastructure including highways, bridges, and airport pavements attests to their reliability and structural integrity.

The aggregates derived from these sources routinely exhibit high compressive strength, low Los Angeles abrasion values (indicating excellent resistance to mechanical wear), minimal water absorption (typically below 2%), and favorable particle shape characteristics conducive to proper interlocking and compaction. In compliance with ASTM, AASHTO, and National Highway Authority specifications, the materials from Margalla and Khanpur quarries have consistently met or exceeded the acceptance criteria for use in concrete and pavement layers. Parameters such as Aggregate Crushing Value (ACV), Flakiness and Elongation Index, Soundness (ASTM C88), and Alkali- Silica Reactivity (ASTM C1260/C1293) are within acceptable thresholds, ensuring both short-term mechanical performance and long-term durability. Their products offer high strength, abrasion resistance, and durability, making them suitable for concrete, track bed, and sub-base applications.

The additional quarries at Ghora Gali may reduce haulage costs, but full engineering characterization testing is needed before adoption. A comprehensive testing program is required to confirm the suitability of Ghora Gali limestone as aggregate. Standardized laboratory tests should cover physical, mechanical, and chemical properties, including:

- Aggregate Crushing Value (ACV): Resistance to fragmentation under load.
- Los Angeles Abrasion (ASTM C131/C535): Resistance to wear and mechanical degradation.

- Soundness (ASTM C88): Durability under wet–dry weathering cycles.
- Flakiness & Elongation Indices: Particle shape and packing efficiency.
- Specific Gravity & Water Absorption (ASTM C127): Density-related characteristics
- Alkali–Aggregate Reactivity (ASTM C1260/C1293): Risk of expansive reactions with cement alkalis.
- Petrographic Analysis (ASTM C295): Mineral composition, texture, and deleterious constituents.

The results of these assessments confirm that the Ghora Gali, limestone meets the specified performance and durability criteria, the site could be considered a viable alternative or supplementary source, offering substantial logistical and economic advantages. In conclusion, the availability of established, high-quality aggregate sources near the alignment particularly from Margalla and Khanpur combined with the promising potential of local sources such as Ghora Gali, provides the project with a strong foundation for meeting material supply demands

7.2.12 Fine Aggregate

Fine aggregates represent a vital component in the composition of concrete, mortar, and other construction materials, contributing significantly to the structural performance, workability, finish ability, and durability of the final product. Due to elevated alignment, challenging terrain, and structural complexity of the Tourist Glass Train Project, the selection and quality assurance of fine aggregate sources are of paramount importance. Lawrenceburg and Qibla-Bandi sands are preferred sources for concrete production due to their cleanliness, proper gradation, and consistent quality. Both sources are situated within economically viable transport distances from the project corridor. These deposits have a strong track record in dams, highways, and urban development projects. Where natural river sands are limited, manufactured sand (M-sand) from local quarries provides a reliable alternative, subject to strict quality control to ensure proper particle distribution and low deleterious fines. The suitability of fine aggregates must be verified through standardized testing before approval for use in concrete. Key evaluations include:

- Sieve Analysis (ASTM C136 / AASHTO T27): for determine particle size distribution and compliance with gradation limits.
- Fineness Modulus (FM): to assess overall coarseness (optimal 2.3–3.1 for concrete).

- Silt, Clay & Dust Content (ASTM C117 / BS 882): to verify cleanliness and impact on bond strength and water demand.
- Organic Impurities (ASTM C40): Detection of humic acids or contaminants affecting cement hydration.
- Specific Gravity & Water Absorption (ASTM C128): finding of Density and moisture characteristics relevant to batching.
- Sand Equivalent (ASTM D2419): Relative cleanliness and clay content.
- Chemical Testing (as required): Identification of sulfates, chlorides, or other harmful compounds.
- These tests collectively ensure the aggregate compliance with structural, durability, and performance requirements for concrete.

7.2.13 Manufactured Material

In addition to the awarded scope pertaining to natural construction material investigations, NESPAK proactively undertook a supplementary assessment concerning the availability of manufactured construction materials in the vicinity of the project alignment. Cement, reinforcing steel, admixtures, and other manufactured inputs are widely available from established industries in the Islamabad–Rawalpindi region. Ordinary Portland Cement (OPC) and sulfate-resisting cements can be selected according to structural and durability requirements. Fortunately, the project's location offers convenient access to several major cement manufacturing plants within a practical transportation range, all of which are capable of fulfilling large-scale construction demands in accordance with relevant ASTM and PS (Pakistan Standards) specifications. Several established cement plants are situated within a 150 to 200 km radius of the project alignment. These include facilities operated by Maple Leaf Cement, Bestway Cement, D.G. Khan Cement, and Fauji Cement.

Similarly, the project corridor lies in close proximity to several reputable steel manufacturers and rolling mills situated in and around Islamabad, Rawalpindi, Taxila, and Hattar areas known for their industrial production capacity and well-established distribution networks. These manufacturers produce reinforcement steel conforming to ASTM A615 Grade 60 and PS: 1879 standards, with in-house quality control laboratories ensuring batch consistency and compliance with engineering specifications & can meet the project demand.

The availability of concrete admixtures in the vicinity of project is well-supported by the presence of leading construction chemical suppliers and distributors operating within the Rawalpindi–Islamabad metropolitan region. Several well- established companies

such as Sika Pakistan, BASF Master Builders, Mapei, CHRYSO, Grace Construction Products and others maintain regional offices or distribution centers in Islamabad, ensuring reliable and timely access to a comprehensive range of concrete admixtures complying with international standards such as ASTM C494 and EN 934. These include high-range water reducers (super plasticizers), set retarders, accelerators, air-entraining agents, shrinkage-reducing compounds and waterproofing admixtures all critical for improving concrete performance in high-altitude, variable-climate environments such as Murree.

7.2.14 Geological Vulnerability and Construction Materials Assessment

The Murree Glass Train Project extends 60 km from the plains to elevations above 2000 m in the Himalayan foothills. The alignment traverses' steep slopes, fragile lithology, and an active seismic zone near the Main Boundary Thrust (MBT), one of the region's most critical tectonic boundaries. The corridor is exposed to frequent seismic activity, intense monsoon rainfall, and rapid drainage, all of which heighten the risks of slope instability, soil liquefaction, and foundation distress. The combined geological vulnerability, due to presence of weathered shales and sandstones that are prone to swelling, disintegration, and low shear strength, whereas, this project requires high-performance making early & exhaustive material assessment indispensable. The combination of weak lithology, high rainfall, and rugged topography demands robust engineering solutions, particularly in drainage, erosion control, and soil improvement. Material selection must therefore prioritize resilience against moisture variation, cyclic loading, erosion, and chemical attack. A comprehensive laboratory and field-testing program is essential to certify these sources, support soil stabilization strategies, and ensure that all materials contribute to the long-term safety, durability, and sustainability of the railway in this geologically sensitive corridor. The local quarries and sands provide strong potential for coarse and fine aggregates, reduces costs, logistics challenges and environmental footprint but this reliance is subjected to, rigorous testing and certification to meet international standards i.e. ASTM, AASHTO, BS, and BCP. On the other hand, the manufactured materials are readily available from nearby industries.

7.2.15 Conclusions and recommendations

7.2.15.1 Key Conclusions

- **Challenging Terrain:** The Murree Glass Train alignment crosses a geologically complex, seismically active region near the Main Boundary Thrust (MBT). Weak

rocks, steep slopes, and high rainfall significantly increase risks to slope stability, foundations, and subgrade performance.

- **Soil Conditions:** Lower alignment sections (TP-01 to TP-08, TP-10, TP-11, TP-14, TP-15) contain cohesive silty clays and clayey silts with moderate strength. Upper sections (TP-09 to TP-13, except TP-10 & TP-11) contain sandy gravel with cobbles/boulders, offering better drainage and load-bearing capacity.
- **Material Sources:** Margalla and Khanpur coarse aggregates are reliable sources whereas, Ghora Gali limestone is a potential source but requires extensive laboratory testing. Lawrencepur and Qibla Bandi sands (fine aggregates) are suitable with favorable gradation and cleanliness.
- **Manufactured Materials:** Cement, steel, and admixtures are available locally in compliance with international standards.
- **Urgent Need:** Detailed geotechnical and material investigations are required to validate suitability and ensure long-term safety and durability of the project.

7.2.15.2 Key Recommendations

- **Geotechnical & Seismic Considerations:** Undertake comprehensive investigations to address seismic risk, weak rock formations, and high-rainfall-induced slope failures. Implement slope stabilization, drainage control, and soil improvement where required.
- **Embankment & Subgrade:** Use cohesive soils cautiously; stabilize or replace if strength or plasticity limits are exceeded. Favor granular soils (TP-09 to TP-13) for subgrade, with CBR testing and controlled compaction.
- **Sub-base & Concrete:** Utilize sandy gravel (TP-09 to TP-13) for sub-base, subject to durability and gradation control. Ensure coarse aggregates meet ASTM standards; test Ghora Gali limestone thoroughly before consideration. Use fine aggregates from Lawrenceburg and Qibla Bandi, with strict batch-by-batch testing.
- **Material Supply Chain:** Secure cement from local plants (Bestway, DG Khan, Maple Leaf, etc.) and reinforcing steel from certified mills (FSL, Ittehad, Pak Steel, etc.). Procure admixtures from approved international suppliers (Sika, BASF, Mapei, etc.), ensuring compatibility with cement and climate conditions.
- **Strategic Implications:** The project's success hinges on robust geotechnical design, strict quality control, and reliable sourcing of materials. Early investment in detailed investigations and testing will minimize long-term risks, reduce maintenance costs, and safeguard operational safety. With careful material

selection and construction practices, the Glass Train alignment can achieve both durability and cost efficiency in this geologically sensitive corridor.

8. Chapter

8.1 Hydraulic Study

8.2 Hydraulic Modelling of Streams Crossing & Along the Tourist Glass Train Project

Hydraulic study and modelling of the streams and their catchment areas along the proposed route the tourist glass train is an essential deliverable of the feasibility & consultancy agreement.

8.3 Objective & Scope

The study aims to conduct hydraulic analysis and water surface profile modeling for key stream crossings along the Islamabad–Murree Tourist Glass Train alignment. The objective is to assess stream behavior under 25-, 50-, and 100-year design floods and evaluate potential impacts on rail infrastructure.

8.4 Scope of Work

- Delineation of catchments intersecting the alignment, focusing on Catchments 4 and Development of a one-dimensional hydraulic model (HEC-RAS) to simulate steady-state water surface profiles.
- Determination of flood levels at critical crossings (RD 6+350, RD 7+450, RD 12+240).
- Assessment of impacts on rail structures to guide waterway sizing, pier placement, bridge requirements, and protective measures.
- Documentation of results to support design decisions and ensure hydraulic adequacy.

8.5 Significance

This study provides essential input to detailed design by identifying hydraulically sensitive locations and supplying quantitative flood data for infrastructure sizing and clearance provision

8.6 Hydraulic Modelling & its Selection

HEC-RAS (Version 6.6) has been selected for modelling purpose. This model has been developed by the United States Army corps of Engineers and is a free ware in the public domain. It can perform steady/unsteady flow calculations, sediment transport computations and water temperature/quality modelling, etc. The latest version of HEC-RAS can be downloaded from the following link:

https://www.hec.usace.army.mil/software/hec-ras/download.aspx

8.6.1 Inputs for Modelling

- 1-D model of River Ravi has been configured in HEC-RAS with the following in puts
- Delineated Catchment Area.
- Discharge values against 25, 50 and 100 years Return Periods
- Digital Elevation Model (DEM)
- Distance between the cross – sections
- Data of the existing infrastructure (if any) in the study reach
- High banks along the river, on both sides
- Upstream/ downstream boundary conditions
- Manning's roughness coefficient

8.6.2 Catchment Areas

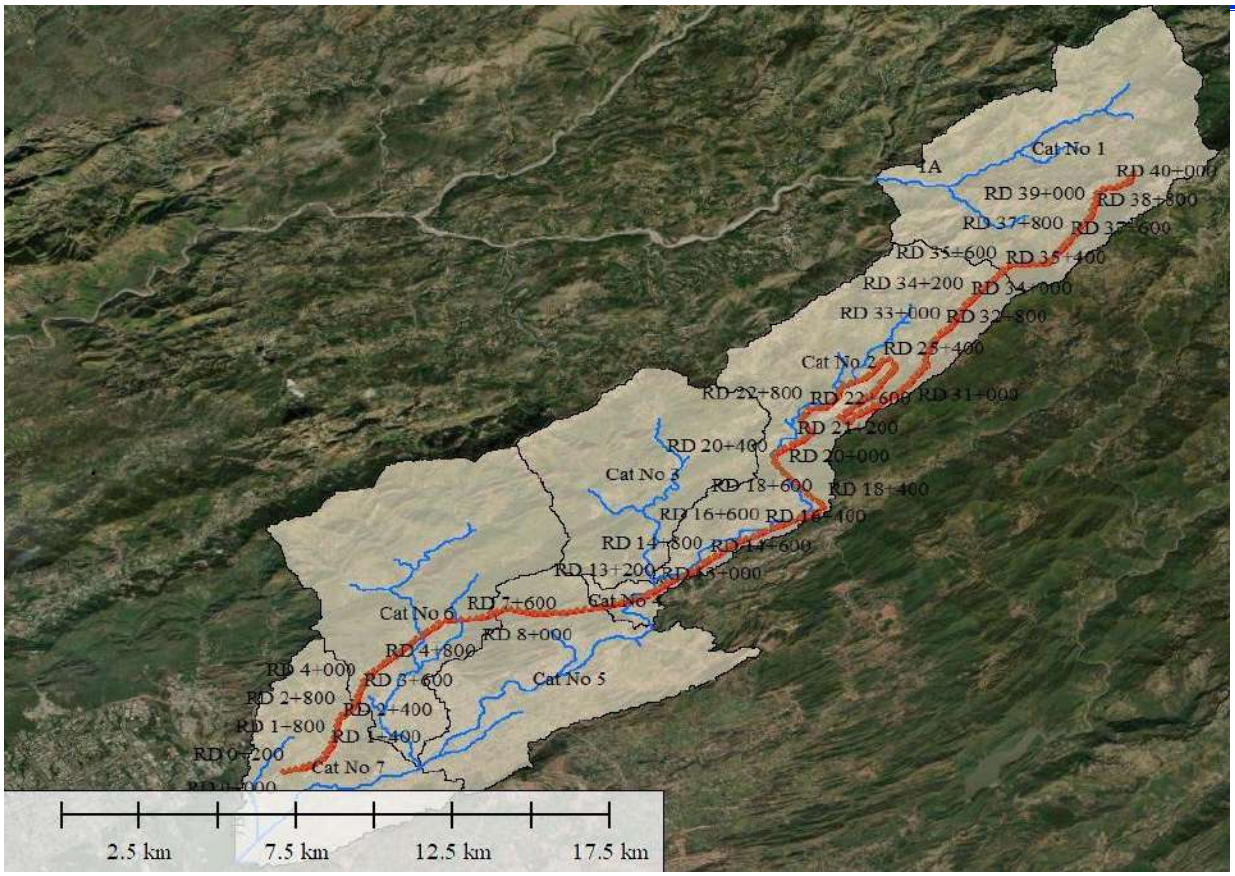
The alignment of the Glass Train Islamabad–Murree project traverses a steep, hydrologically varying terrain intersected by multiple natural streams. As part of the hydraulic analysis, two significant catchments, Catchment 4 and Catchment 6 were delineated, based on topography and stream flow paths, as shown in **Figure 8.1** (catchment delineation and crossing locations).

Catchment 6: is the larger of the two, with a total contributing area of approximately 45.04 km². It exhibits a steep gradient, with an upper elevation of 904 meters and a lower elevation of 542 meters. The main stream within this catchment has a length of 14,517.81 meters, which reflects a long and well-developed flow path. This catchment has two stream crossings along the proposed Glass Train alignment at RD 6+350 and RD 7+450, which are hydraulically critical points evaluated in this study.

Catchment 4: in comparison, is relatively smaller with a total area of 2.34 km². It ranges in elevation from 652 meters at the upper end to 609 meters at the downstream point, with a main stream length of 2,831.89 meters. The rail-stream intersection within this catchment occurs at RD 12+240. Despite its smaller size, the catchment's hydrologic response during storm events remains significant due to the steep slopes and short concentration time.

These delineated catchments form the basis of the hydraulic and water surface profile modeling using HEC-RAS for various return periods (25, 50, and 100 years), enabling the identification of potential flood risks and the estimation of water levels at each stream crossing.

Figure: 8.1 Catchment Areas



8.6.3 Hydrological Data

To facilitate accurate hydraulic modeling at stream crossing locations along the Glass Train Islamabad–Murree alignment, design flood discharges were estimated for return periods of 25, 50, and 100 years for each contributing catchment. These discharges represent peak flows derived through standard hydrological assessment procedures and reflect the anticipated magnitude of flood events within the respective catchment areas **Table 8.1** below shows the estimated discharges in the specific catchments as mentioned.

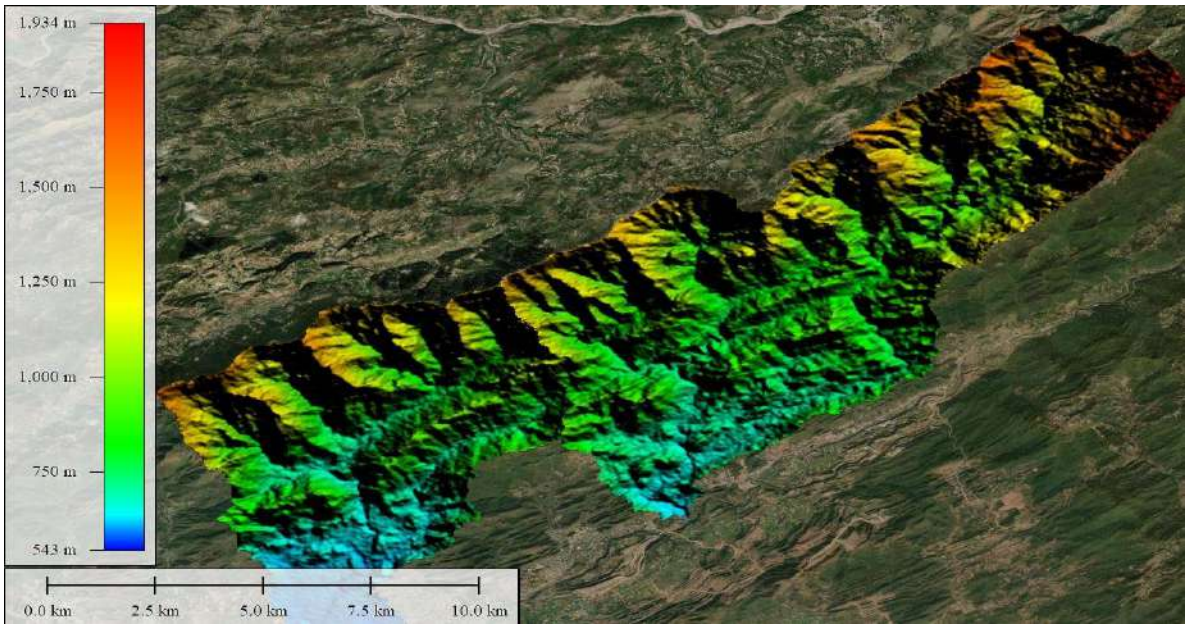
Table: 8.1 Estimated Revised Floods

T (years)	Flood (Cumecs)			
	Catchment - 2	Catchment - 3	Catchment - 4	Catchment - 6
25	616.45	594.45	67.87	611.57
50	743.26	703.03	81.06	702.55
100	868.72	810.52	94.15	792.68

8.6.4 Digital Elevation Model (DEM)

In this analysis, the Digital Elevation Model (DEM) was used within HEC-RAS to define the terrain along each stream reach and extract accurate bed slopes for hydraulic modeling. The DEM provided a continuous elevation profile, enabling the generation of realistic channel geometries where currently detailed survey data was unavailable. This helped improve the accuracy of longitudinal profiles and water surface elevation results at the stream crossings along the Glass Train Islamabad–Murree alignment. The combined DEM of all the catchments is shown in the **Figure 8.2** below.

Figure: 8.2 Digital Elevation Model (DEM)



8.6.5 Stream Bed Profiles

For the purpose of hydraulic modeling in HEC-RAS, the longitudinal bed profiles of the intersecting streams at the specified locations along the Glass Train alignment have been developed. These profiles are essential for accurate simulation of flow behavior and water surface elevations during flood events. Each stream has been modeled with an adequate upstream and downstream reach to ensure proper conveyance and boundary condition stability within the computational domain. The stream names correspond to the RDs where they intersect the proposed rail track. The catchment wise streams distribution is as follows:

8.6.5.1 Catchment – 6 contains two stream crossings:

- **RD 6+350 Stream:** This stream reach has been modeled over a length of 1,873.3 m, with bed elevations ranging from 660.68 m at the upstream end to 612.50 m at the downstream end. The profile indicates a steady decline in elevation, suggesting a relatively steep gradient allowing high-velocity flows during storm events.
- **RD 7+450 Stream:** This stream has been represented with a total length of 2,119.9 m, where the elevation varies from 685.18 m upstream to 629.38 m downstream. The profile reflects a well-defined gradient and suggests substantial energy potential in flood scenarios.

8.6.5.2 Catchment – 4 includes one stream crossing:

- **RD 12+240 Stream:** Modeled over a length of 1,480.0 m, this stream shows elevation values decreasing from 650.37 m to 632.85 m. The profile illustrates a gentler slope compared to those in Catchment 6, potentially leading to slower flow velocities and longer retention times during high-flow conditions.

Following **Figures 8.3, 8.4 & 8.5** show bed profiles of the streams indicating longitudinal slopes and terrain characteristics. These profiles formed the basis of the HEC-RAS geometry and directly influenced the simulated water surface profiles for different flood return periods.

Figure: 8.3 RD 6+350 Stream Bed Profile

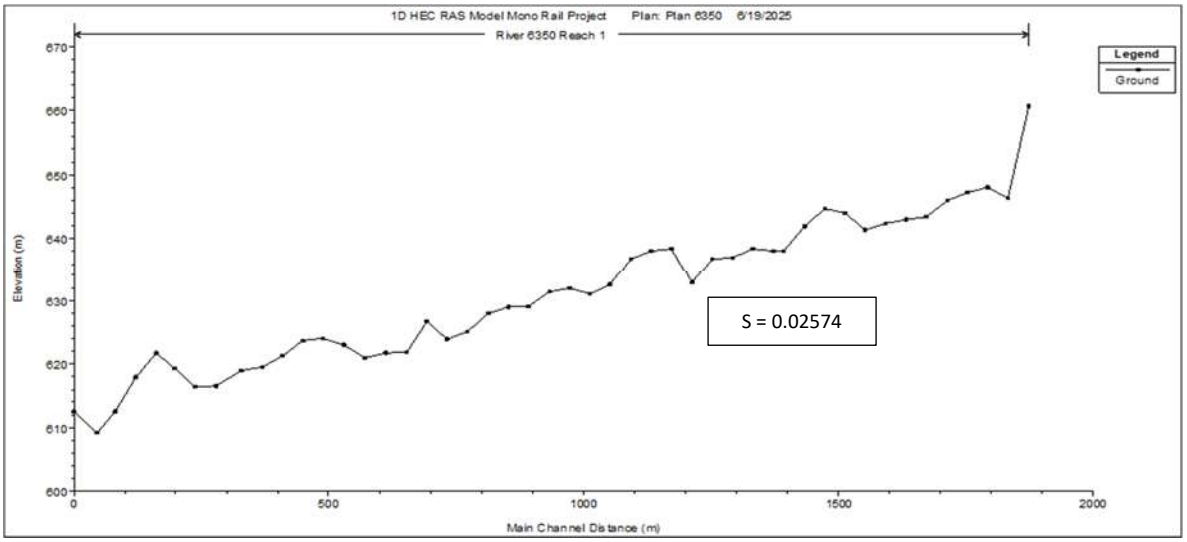


Figure: 8.4 RD 7+450 Stream Bed Profile

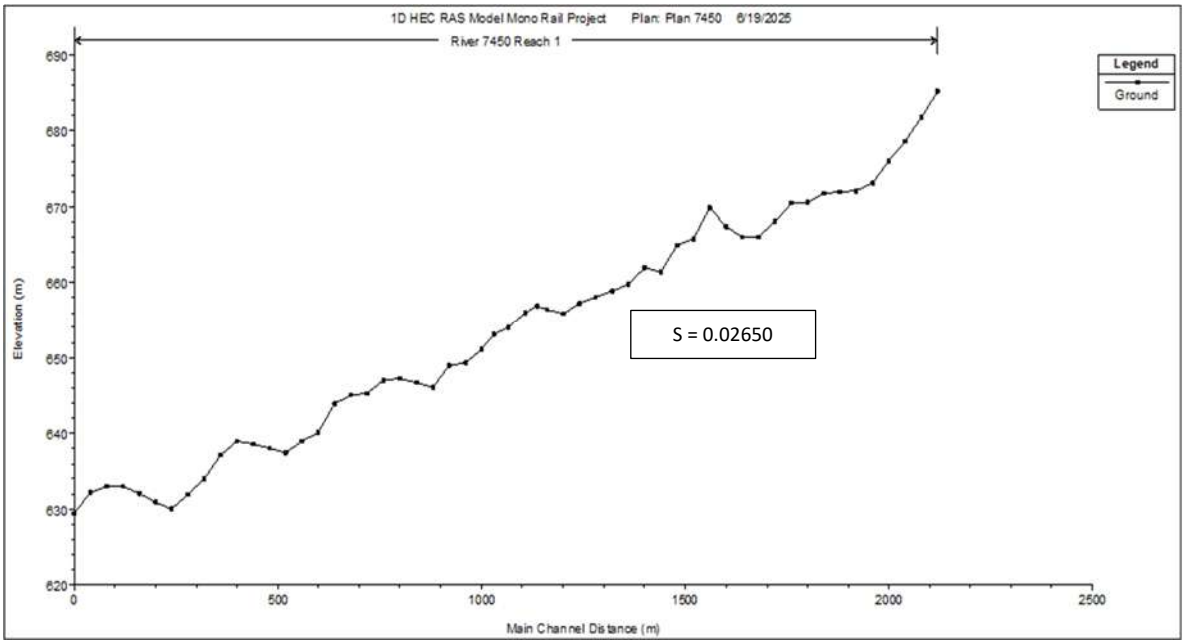
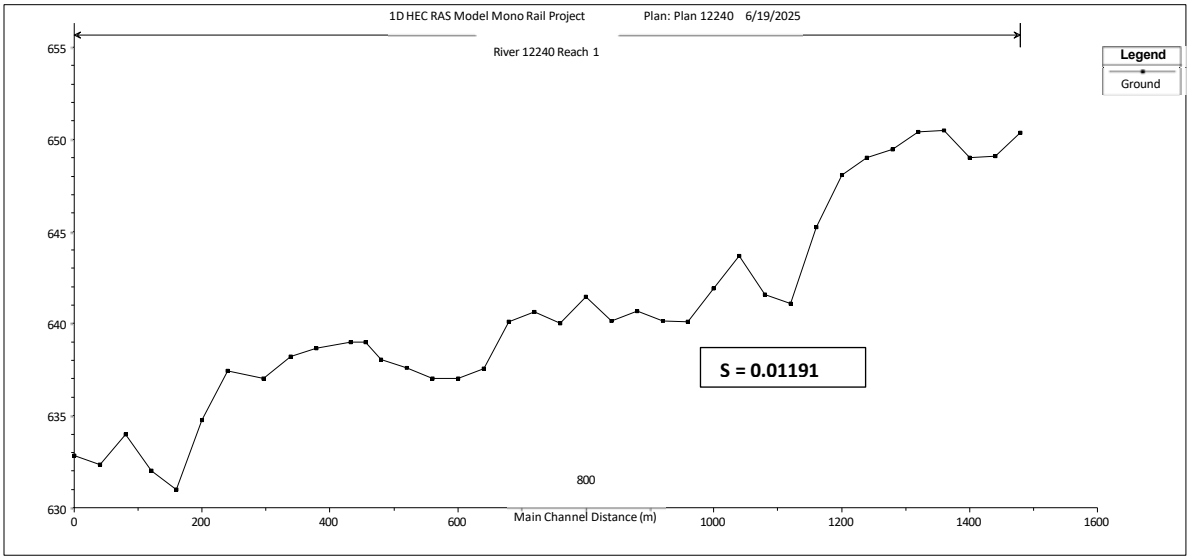


Figure: 8.5 RD 12+240 Stream Bed Profile



8.6.6 River Water Surface Profile Analysis

For the development of rating curves at critical stream crossing locations along the Glass Train Islamabad–Murree alignment, the latest version of HEC-RAS (v6.6), developed by the U.S. Army Corps of Engineers (USACE), has been utilized. The hydraulic model incorporates surveyed cross sections extracted from the Digital Elevation Model (DEM) of each catchment within the study area.

Figure 8.6, 8.7, 8.8 presents the plan view of the streams with the train alignment, overlaid on a satellite image, showing the locations of cross sections used in the modeling process. The primary objective of this analysis is to evaluate the hydraulic parameters at stream crossings, specifically at RD 6+350, RD 7+450, and RD 12+240, to support the design of glass train structure by providing accurate water level estimations for varying discharge conditions. These curves help define relationships between discharge and corresponding water surface elevation, which are critical for, **Figure 8.6** HEC-RAS model showing modelled cross sections at Stream RD 6+350

- Determining the required hydraulic capacity of waterway openings
- Setting safe clearance levels for train infrastructure,
- Ensuring resilience against extreme flood events with 25, 50, and 100-year return periods.

Figure: 8.6 HEC-RAS model showing modelled cross sections at Stream RD 6+350

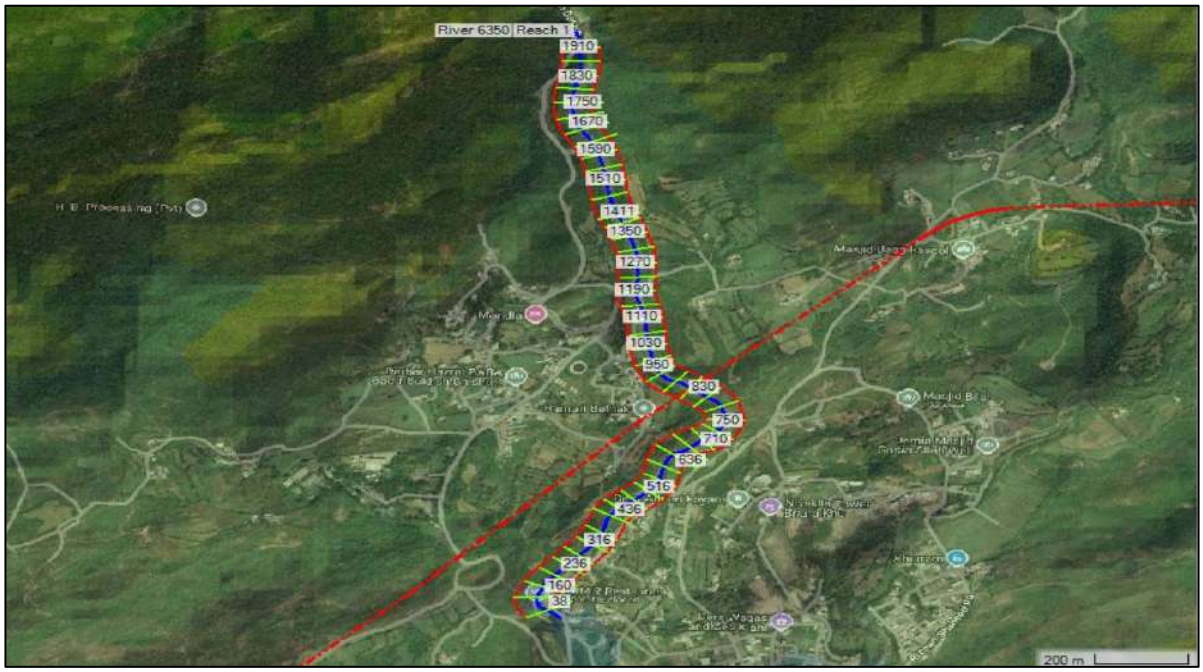


Figure: 8.7 HEC-RAS model showing modelled cross sections at Stream RD 7+450

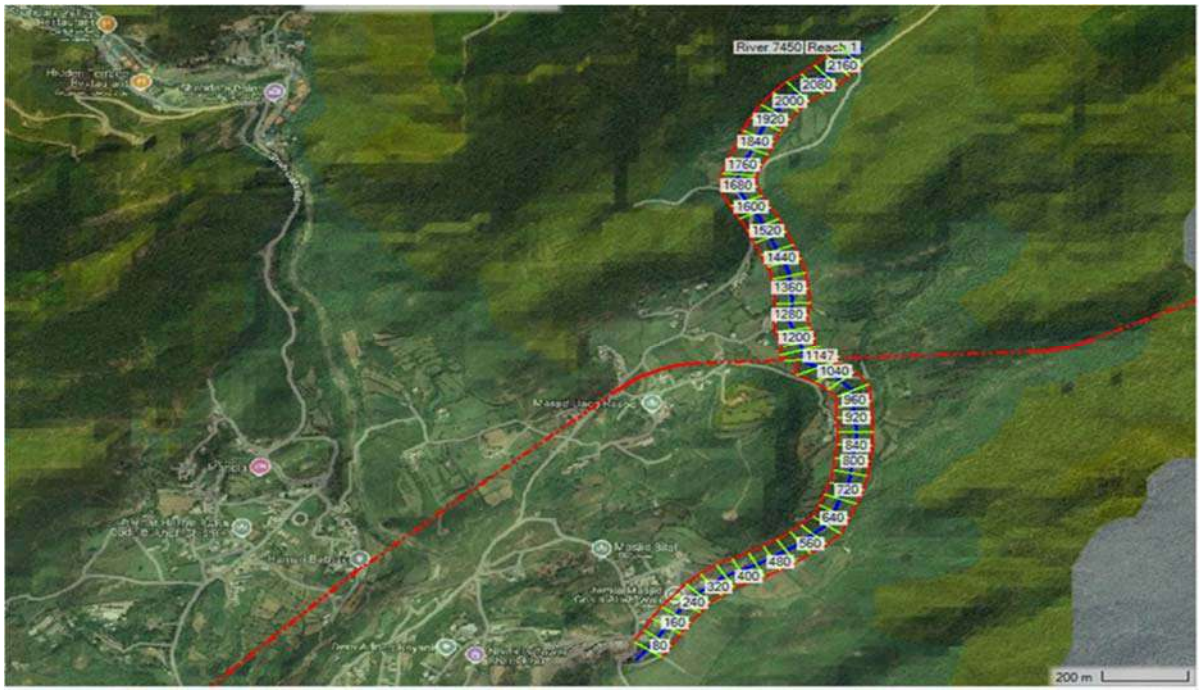


Figure: 8.8 HEC-RAS model showing modelled cross sections at Stream RD 12+24



8.6.7 Procedure and Assumption

Following assumptions made are:

- There is no change or accretion in the river/stream because of infrastructure development.
- A steady state flow has been assumed in the entire reach for each discharge.

8.6.8 HEC-RAS Analysis

For the hydraulic analysis of stream crossings along the Glass Train Islamabad–Murree alignment, a total of three stream reaches were modeled in HEC-RAS at RD 6+350, RD 7+450, and RD 12+240. The modeled reach lengths are approximately 1,873.3 meters, 2,119.9 meters, and 1,480.0 meters, respectively, covering adequate lengths upstream and downstream of each crossing to capture the full hydraulic response under flood conditions. Surveyed cross sections were incorporated from the detailed topographic survey, providing accurate channel geometry for each stream. A Manning's roughness coefficient of 0.040 was used throughout, in line with recommendations from Open-Channel Hydraulics by Ven Te Chow, and appropriate for natural mountainous streams with irregular and gravel-lined bed. For boundary condition definition, normal depth slopes were assigned at the downstream ends of each modeled reach and critical depths at the upstream ends. These were taken as 0.02574 for RD 6+350, 0.02650 for RD 7+450, and 0.01191 for RD 12+240, based on the average bed gradients derived from

longitudinal profile data. These slopes allowed realistic estimation of tail water conditions and contributed to stable and hydraulically consistent model behavior.

The streams intersecting the Glass Train alignment at RD 6+350, RD 7+450, and RD 12+240 have been modelled in HEC-RAS, with cross-sections labelled as 872, 1147, and 419, respectively. The **Figure 8.9**, **Figure 8.10** and **Figure 8.11** attached below depict these representative cross-sectional profiles, showing the water depths resulting from the design discharges provided in Section 8.1.7. These outputs help visualize flow behavior at each crossing location and serve as a basis for evaluating hydraulic clearance, inundation risk, and the structural design requirements for the proposed train – stream crossings.

Table: 8.2 Results of HEC-RAS analysis at RD

Sr. No.	Stream Name	Station	Discharge (cumecs) (100yrs RI)	Water Level (m)	Velocity (m/sec)
1	RD 6350	872	307.31	631.18	3.96
2	RD 7450	1147	485.37	657.22	6.14
3	RD 12240	419	94.15	640.10	2.22

Figure: 8.9 Cross section 872 at stream RD 6350

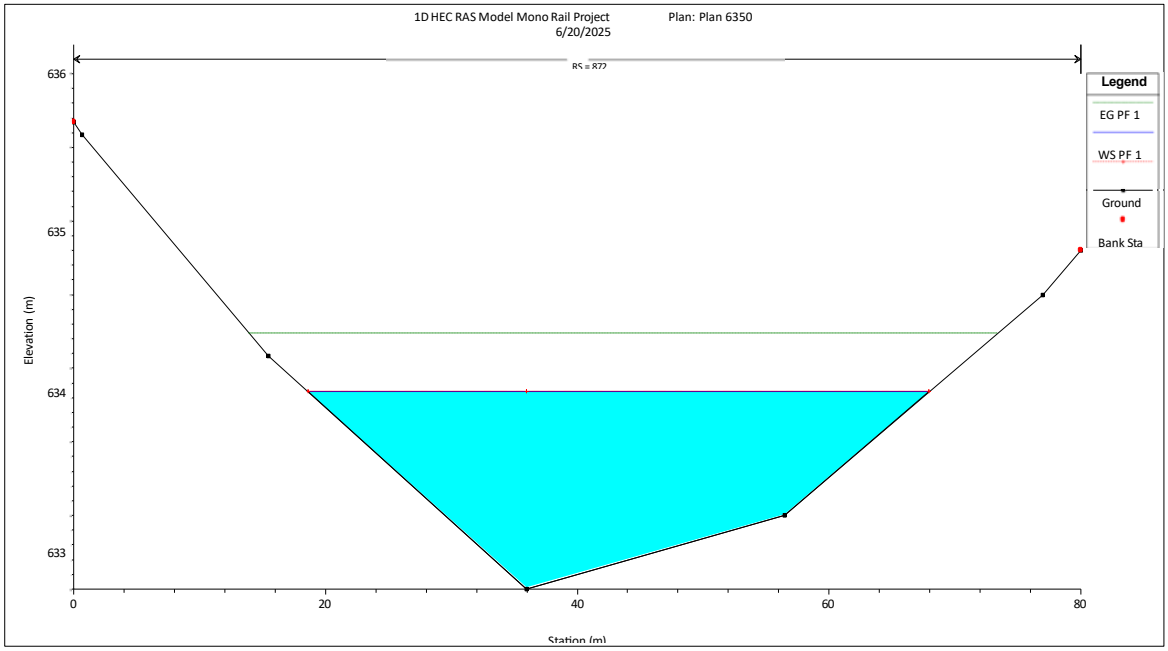


Figure: 8.10 Cross section 419 at stream RD 7450

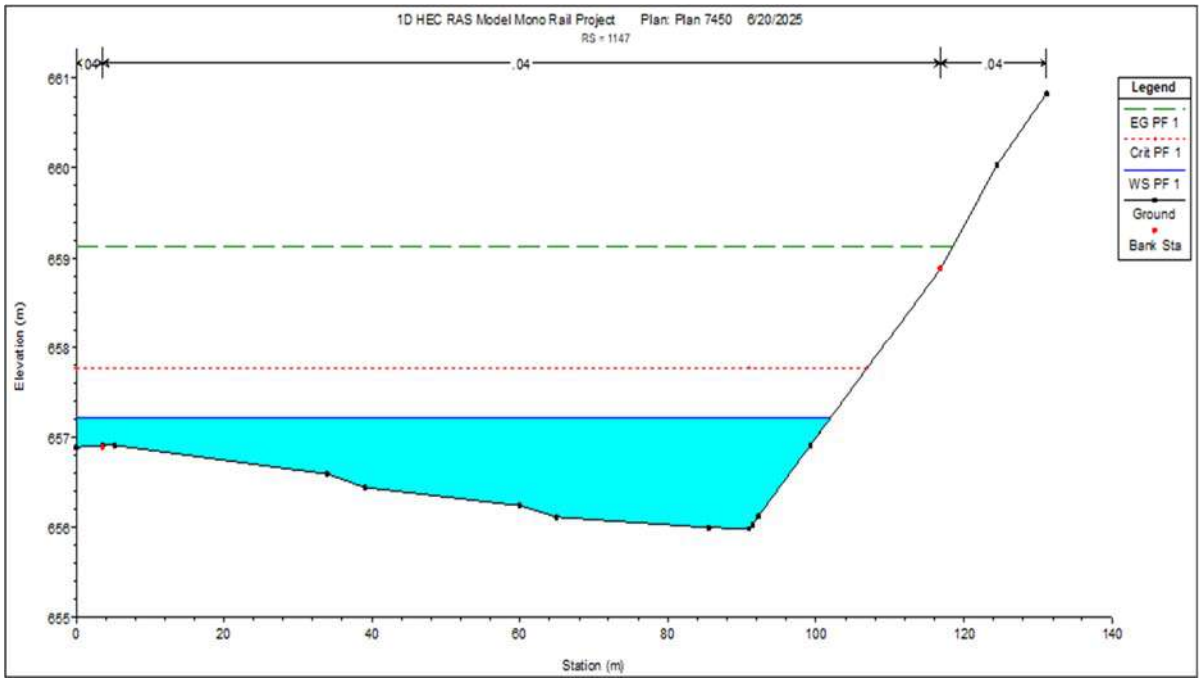
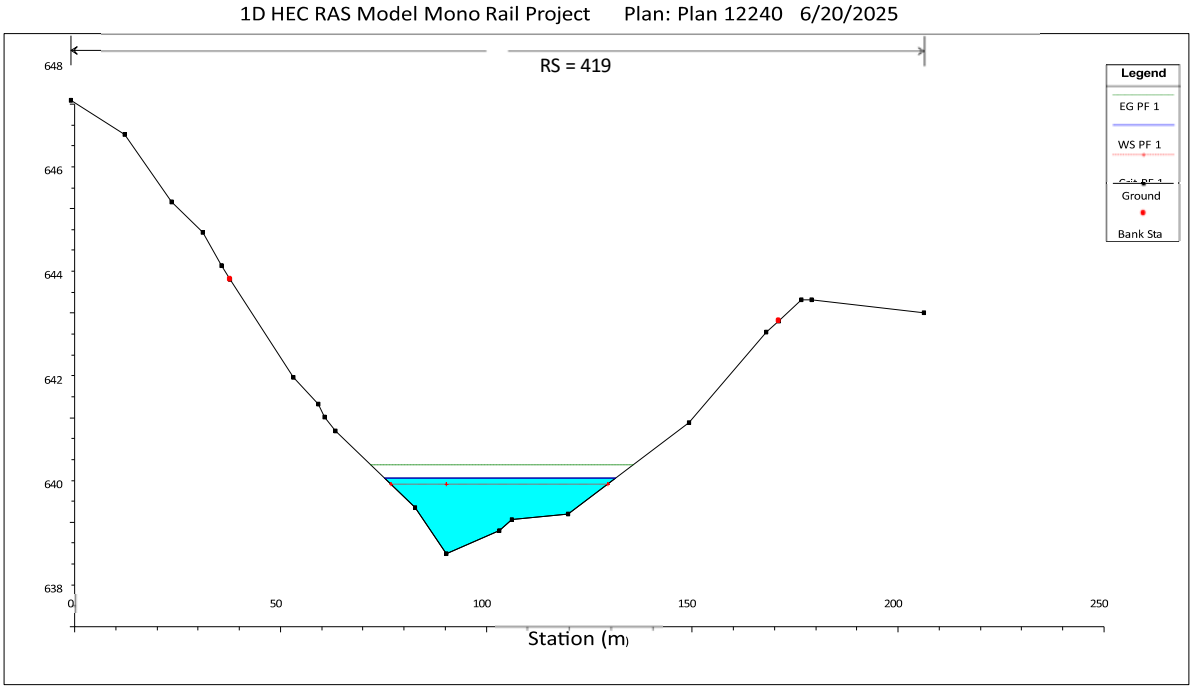


Figure: 8.11 Cross section 1147 at stream RD 12240



8.6.9 Conclusion and Recommendations

The following conclusions and recommendations are primarily derived from the HEC-RAS analysis based on the modeled stream profiles, water surface elevations, and flow velocities at the three critical stream crossings intersecting the Glass Train Islamabad–Murree alignment. This detailed assessment will aid in determining whether raising the bottom level of the Tourist Glass Train structure is required, or if not, whether additional protective measures are needed and to what extent they should be implemented.

8.6.10 Conclusion

- High Water Levels and Potential Inundation: The peak water levels simulated at the critical stream crossings are 631.18 m at RD 6+350, 657.22 m at RD 7+450, and 640.10 m at RD 12+240. These levels represent the water surface elevations during the 100-year design flood and must be carefully compared with the proposed bottom elevation of the rail structure
- Flow Velocities and Scour Potential: Flow velocities reach up to 6.14 m/s at RD 7+450, to evaluate freeboard and inundation risk which is significantly high and indicates a potential for local scour and erosion near any bridge piers, abutments, or foundation structures. RD 6+350 and RD 12+240 show velocities of 3.96 m/s and 2.22 m/s, respectively, which are moderate but still warrant protective measures, especially where soil or sediment transport is likely.
- Catchment and Terrain Influence: The modeled slopes and flow characteristics reflect steep mountainous terrain, especially in Catchment 6, suggesting rapid runoff and flashy flood response. This increases the hydraulic vulnerability of stream crossing structures during extreme events.

8.6.11 Recommendations

- Review and Adjustment of Track Bottom Elevation: At each stream crossing, the bottom level of the Glass Train structure should be reviewed in light of the simulated water levels. Where the freeboard (typically 0.5 to 1.0 m depending on design standards) is insufficient, raising the bottom elevation should be considered to ensure safety and structural resilience.
- Provision of Scour Protection: Given the high velocity at RD 7+450 and moderate velocities at the other locations, it is recommended to implement scour countermeasures, such as riprap, gabions, or concrete aprons, at the foundation zones of all crossing structures.

Regular Inspection and Maintenance Protocol: Due to the steep terrain and flash flood behavior, regular inspection and maintenance of drainage and protective works must be incorporated into the operation plan, particularly

9. Chapter

9.1 Rolling stock study

9.2 Tourist Glass Train from Islamabad /Rawalpindi to Murree.

The Government of Punjab resurrected the project as a tourist attraction Glass Train. With this service, panoramic views which are comparable to those tourist trains found in such countries as Switzerland, Canada and Japan are provided. The Transport & Mass Transit Department plan to carry out an extensive feasibility study and preliminary engineering design via the Punjab Mass Transit Authority (PMA) with assistance of Transport Planning Unit. Once established, this project will significantly reduce environmental emissions and degradation as well as travel time costs. With detailed feasibility, strong technical planning, and experienced consultancy, the project aims to deliver a world-class railway experience from Rawalpindi/Islamabad to Murree.

9.3 Train Traction Technology

In previous study choice between diesel traction & electric traction was evaluated. Three traction technologies were considered:

- Diesel-Electric Traction
- Electric Traction
- Rack Rail Traction (for steep gradients)

It was recommended therein that the provision of electric traction on the new railway line from Margala to Murree and Muzaffarabad cannot be justified due to the projected traffic on this section was much lower than breakeven point determine for the adoption of Electric Traction. There was an apprehension that the provision of electric traction only on this small section may not be economically and operationally viable and this idea was pended till the density of the rail traffic on the proposed new rail link increases to the extent of breakeven point.

Later on, for Islamabad–Murree section rack rail traction was recommended for adopted due to steep gradient beyond Bastal (up to Murree Rake rail with electric traction could be a preferred choice due to environmental sensitivity and gradient but diesel electric traction was recommended on the entire New Railway.

In order to carry out feasibility analysis of electric traction with diesel traction we have to track down the advantages and disadvantages of electric traction. Electric traction is energy efficient having lower energy consumption per unit distance. It is eco-friendly having zero emission with low maintenance cost due to fewer moving parts as that of in

diesel engines. Electric traction provides faster acceleration and deceleration and can sustain momentary overloads while starting on steep gradients in comparison to diesel traction. The specific power availability in electric locomotives (50-55 kW/ton), more than of specific power of diesel locomotive (20-25 kW/ ton). In electric traction no power drop is observed while traversing high-altitudes on the other hand power drops are observed due to insufficient air supply for combustion. Similarly in long tunnels electric traction is advantageous due to its low & limited air requirements.

9.4 Reasons for Non- Adoption of Conventional Overhead E.T System

Despite its clear advantages over diesel motive traction, conventional electric traction is dependent on grid and susceptible to power failures and also require high initial setup cost. The availability of certain level of traffic density i.e. Gross Million Tonnes (GMT) per rout km / annum is essential for adoption of conventional (OHE) electric traction systems of 25 KV AC electric lines. There are cogent reasons available for not opting conventional (OHE) 25 KV AC system in earlier study as well as in the present project of Glass Train between Islamabad and Murree, details as under.

- **Topographical Limitations:** The corridor has steep gradient of (5-6 %) which is beyond the capabilities of standard electric locomotive and rolling stock operating on broad gauge with conventional adhesion-based traction.
- **Geological Hazards:** Extensive geological surveys were carried out in earlier study which revealed large areas with unstable slopes and crushed rock formations particularly near tunnel portals. These conditions pose high risk of landslides and structural instability during the construction of heavy (OHE) support structure.
- **Alignment Constraints:** The available corridor space and the environmental sensitivity of Murree Hills, heavy forestation restricts the employment of wide rail footings, extensive cuttings & installation of tall electric polls required for the traditional ET system.
- **High Capital & Maintenance Costs:** The conventional ET rail system requires multiple substations, extensive OHE infrastructure with reinforced civil works would not be a cost-effective preposition, especially when associated with low (GMT) of traffic on tourist- oriented line.

9.5 Axle Load

The axle load is the maximum weight of a pair of wheels allowable for a given section of track including bridges. In first study, Pakistan Railways being client decided that the New Railway will be laid to Broad Gauge (1676 mm) the existing gauge on Pakistan

Railways. The track of the section was to be constructed to BGML standard of PR, with maximum axel load of 22.5 ton (22.86 tonnes)

The Glass Train being tourist / passenger & parcel-based service to be employed on mountainous terrain having steep gradient of (5 - 6 %), so light weight non-conventional rolling stock with an axle load ranging from (9 -16 tonnes) is recommended. This requires lighter but sturdy infrastructure and reduces construction and operational costs, suitable for tourist / parcel centric services.

9.6 Ruling Gradient

The steepest gradient which exists in a particular section is called the “ruling gradient” as it limits the maximum weight of the train which is hauled on that particular section. In the previous feasibility study for new Islamabad- Murree and Muzaffarabad railway line was fixed as 2.5% (1 in 40). Initially the line will run to Bastal Mor, after which a 4 km cable car connection to Murree Hilltop was proposed, while same line continue onwards to Muzaffarabad. Grades between Islamabad and Murree vary from point to point, Islamabad to Bastal gradient is up to 3% which is manageable by standard traction whereas from Bastal to Murree Hilltop is up to 12% which require intervention of other modes or rake rail traction systems. Later on, a new alignment employing rake rail system was proposed reducing total route to 105.7 km. This alignment was to handle 12% gradient and connect Baroha-Mor to Murree Hilltop via Chattar, Ghora Gali and Jhika Gali but to study this rake rail option never materialized.

Government of Punjab entrusted feasibility study of Murree Glass Train to NESPAK with clear directive that train will traverse up to Murree Hilltop. Out of three proposed route most optimal alignment with 6% gradient and length of 45 km was selected with a shift of track parameters i.e. broad gauge to standard or meter gauge and use of DMUs& EMUs instead of BG rolling stock Later on during reconnaissance survey and geological testing at the site of one of the tunnel crushed rocks formation was observed throughout the bore hole of 11meter which is detrimental for tunnel as well as the stability of nearby dwellings & shops. The problem of crushed rocks and slop instability mainly relates to geological effects, so the idea for taking train on conventional rail track with (5-6%) gradient up to the Murree Hilltop was dropped. The design must balance safety, speed and terrain constraints, hence alternate and non- conventional rail systems were explored which i.e. Sky Trains, Arial Tramways & Monorail trains. During discussion all the issues of narrow track corridor, difficult mountainous & steep terrain & unstable slopes and crushed rock formations were discussed, and option of Monorail straddle train was selected as an alternate for the conventional diesel or electric powered train.

9.7 Maximum Degree/ Minimum Radius of Curves

The maximum degree of curve is the smallest radius for which a railway track curve can be laid. It depends upon:

- Wheelbase of the vehicle.
- Maximum super-elevation that can be permitted.
- Increase in operation and maintenance costs of track and rolling stock on sharp curves.

The maximum degree of curve permitted on Broad terrain Gauge track on Pakistan Railway is 175 meters (10 degree). Curves of tight radius are required in hilly, the minimum radius of curvature of the track adopted on Islamabad - Murree and Murree - Kohala - Muzaffarabad sections were 300 meters (5.8 degrees). On the other hand, in the Rake Rail Segments 100m minimum radius is usually adopted but minimum radius of curves which can easily be managed by monorail stock is 50m.

9.8 Train Resistance and Tractive Power

Various forces offer resistance to the movement of a train on the track. These resistances may be result of movement of various parts of the locomotives as well as the friction between them, the irregularities of the track profile, or the atmospheric resistance to a train moving at great speed. The tractive power of a locomotive should be adequate enough to overcome these resistances and haul the train at the specified speed. Resistances to the movement of a Train is the main resistances faced by a train which can be summarized as under:

- Resistance due to friction is (0.0016W)
- Resistance due to wave action, track irregularities, and speed is (0.00008WV)
- Resistance due to wind, or atmospheric resistance is (0.0000006WV2)
- Resistance due to gradient (W x % of slope /100)
- Curve resistance (0.0004 W x D)
- W= Weight of the train in tonnes.
- V= velocity of the train in km/hr
- D= Degree of curve= 1750/radius of curve in m

9.9 Design Speed of Trains and Locomotive Requirement

Design speed in conventional rail track train mainly dependent on weight of the trailing and total load (rolling resistance), ruling gradient (grade resistance) and minimum curve radius (curve resistance). In the previous studies the design speed of the track was

calculated as 90 km/ h between Islamabad and Bhara Khau having grade of 0.8% and minimum curve radius of 500m but as the track to pass through populated area it was limited to 80km/h. on the other hand onwards up to Muzaffarabad where the track geometry has 2.5% gradient and minimum curve radius of 300m it was calculated as 55km/h. The total train resistance is the sum of three resistance & can be calculated by using Davis formula and for particular case it was determined as 48985 lbs.

The motive power required at rail to pull the train load of 676 tons was calculated as 5550 H.P with the consideration that efficiency of alternator and traction motors is 82%. So broadly two locomotives of 3000H.P each were required to haul the train throughout the journey to Muzaffarabad. For journey from Bastal Mor to Murree has to be covered on rake rail track with gradients up to 12% high tractive effort are needed with limited trailing loads and train speed of 25km/h. The proposal of conventional rail track train between Islamabad and Murree was dropped due to many reasons and give way to suitable alternative solution for traversing the Straddle Monorail train up to the Murree hilltop. As this system has integrated electric traction so there is no need of separate locomotives for hauling of trains.

9.10 Brake Power and Braking Distance Analysis

Special brake power arrangements are required for stopping trains on flat as well as on steeper grades to ensure safety of train operations. The braking distance is dependent on many factors i.e. weight of the locomotive, weight of trailing load, number of coaches, type of braking system & braking medium, ruling gradient, coefficient of friction of rail surface etc. The braking distance calculated for the conventional BG track train was 890m which is quite less than safe braking distance of 1.2 km employed in P.R on flat as well as steep grade of Bolan section.

9.11 Straddle Monorail System – Introduction

The straddle monorail system presents a highly suitable alternative to conventional rail track train. Presently manufacturer have built Straddle monorail system based on the terrain of the area. It is a double axel rail transit vehicle that uses rubber wheels to ride on a single beam. It has an independent right of way provides a three-dimensional transportation free from disturbance of vehicles on ground. The straddle monorail has low internal operating noise of 69dB and external noise of 73dB and do not produce exhaust emissions, suitable for areas with strict environmental controls. There are quite many reasons for adoption of straddle type monorail for the Murree Glass Train project, few are as under.

9.11.1 Worldwide Footprint

The monorail mass transit system has a wide acceptability and is under use in many countries like Germany, USA, Japan, India, Brazil, Malaysia, Singapore, Italy, UK and China as alternative and economical mean of transportation. There are 43Nos operational monorail systems and another 18Nos are under construction. In 2004 Chongqing Rail Transit China adopted a unique ALWEG- based design having wider body than most of the monorail stock. It is the busiest monorail system in the world with average ridership of 650000 passenger daily. It is the largest system with two lines with total length of 97.6 km.

9.11.2 Excellent Maneuverability in Hilly Area

As the monorail straddle beam construction adopts minimum radius for curves 50m therefore can also negotiate sharp and tight curves with ease & provide smooth ride. Monorail systems are capable of operating efficiently on gradients up to 6%, eliminating the need for rack rail systems or additional traction modifications.

9.11.3 Use of Narrow Corridor

The monorail requires minimal right-of-way, both horizontally and vertically, which reduces land acquisition costs and minimizes disruption to the surrounding terrain and communities. It will also save large number of trees than earlier option of conventional diesel/ electric traction train system, thereby providing environmental acceptability to the project.

9.11.4 Integrated Electric Traction

Powered by electric motors, the straddle monorail draws power through side-mounted conductor rails embedded in the guide beam. This eliminates the need for complex and high-maintenance OHE infrastructure, making the system more resilient and easier to maintain in harsh mountain conditions.

9.11.5 Shorter Construction Timeline

The modular and elevated nature of the monorail infrastructure allows for faster deployment, particularly important in areas where traditional excavation or heavy earthworks would be environmentally disruptive and difficult task due to unstable, crushed rock formations and slopes all along the proposed alignment.

9.11.6 Environmental Compatibility

The monorail is an energy-efficient, low-emission system, well-aligned with the project's goal of promoting sustainable tourism in an ecologically sensitive region.

9.11.7 Passenger Experience

Elevated guide-ways and panoramic window designs provide passengers with uninterrupted scenic views, enhancing the tourism value of the Glass Train concept.

9.12 Straddle Type Monorail – Technical Features

The straddle monorail system has undergone 40 years of innovation and development since its introduction of its modern version in Tokyo Japan. China built its first straddle monorail project in hilly city of Chongqing's by importing this technology. Later on, after digestion and absorption of the same they built the first straddle monorail in China by adopting original equipment manufacturer the main products / assemblies i.e. Bogie, Traction, Network System of (Hitachi Japan) and for Braking system they used Nabo products. Introduction of independent technology platform and industrial standard for monorail system paved way for effective & considerable reduction of procurement of cost vehicle materials. At present they have completely indigenized manufacturing of all important products like bogies, traction, brakes, networks, air-conditioning and interior system. In Chongqing alone, five projects were completed and a total of 546 straddle vehicle are working on these lines.

After application of advance technology iterations use of planetary gear, permanent magnet motor in bogie and introduction of lightweight robust sections, new sound absorbing heat & cold resistant materials not only improved safety and passenger comfort but overall reduction in weight of vehicle is achieved. This helped reduction of axel weights of straddle vehicle to 9 tons. Better passenger flow design was introduced by use of composite materials in interior setting and by optimization / adjustment of vehicle body structure, inside passenger area.

9.13 Monorail Bogies Configuration & Construction Features

Generally, the bogies sit astride on the concrete guide beam & Load tyres run on top of the beam to support vertical loads and provide traction and braking force through friction with the beam surface. Primary and secondary suspension system is supported through coil springs, rubber air springs & dampers to cushion vehicle mass riding vibrations. Whereas in lateral force management the guide tyres move on both sides of the beam to provide lateral guidance and stability during their movement on curves & cross wind loads. Stabilizer tyres perform anti roll function and pressed against the inner side of beam or under flange extensions to provide anti-roll stability. Large contact area of load tyres (~300 mm width) provides high adhesion and smooth ride on the guide beams.

In self-steering mechanism bogie design incorporates pivot points and flexible linkages, allowing wheels to naturally align along the curve due to force components. Overall, the compact bogie design enables integration under narrow monorail vehicles as well as provides effective lateral stability due to continuous contact of guide tyres.

Following are few key construction features of monorail bogies

- **Bogie Frame Structure** usually adopts a fabricated box structure or Compact steel welded frame which provide robust base to the complete vehicle. It Houses load wheels (tyres), guide wheels, suspensions, and traction motors within tight vertical and lateral clearances imposed by the guide beam having width of 800-900 mm. High-strength low alloy (HSLA) steel or stainless steel are used in bogie frame construction for corrosion resistance.
- **Load Wheels** are rubber tyres with steel reinforcement belts mounted directly on the motor driven axels or through reduction gear units. They carry vertical loads and responsible for traction and braking. Axles are mounted within the bogie frame through a properly designed suspension system.
- **Guide Wheels** horizontal rubber tyres mounted on both sides of the bogie frame to contact guide beam faces to provide lateral guidance and stability in curves and under crosswind forces.
- **Stabilizer Wheels** are vertical or inclined rubber tyres fixed underneath beam side flanges or inner edges. Main function is to counter act against overturning moments & enhance roll stability, especially in crosswinds or curves.
- **Traction Motors** are generally 3-phase AC induction or PMS Motors mounted directly on bogie frame, connected via reduction gearbox to load tyres.
- **Suspension System** involving primary suspension consists of rubber springs or coil springs between wheel axle and bogie frame. It absorbs high-frequency vibrations and guide beam surface irregularities. Secondary suspension Air springs or rubber-metal elements between bogie frame and car body bolster which provides riding comfort, maintains car body levels under varying loads.
- **Braking System** equipped with hydraulic disc brakes mounted on load wheel axles as well as Dynamic / regenerative brakes are provided to facilitate braking & speed control/ reduction. Full mechanical braking engaged via hydraulic actuation is used as emergency braking.
- **Steering and Articulation** are important function in monorail trains. Self-steering of bogie frame with pivoting points to align with curves, reduces tyre scrubbing and lateral forces. In articulated monorail cars, bogies are mounted at car joint points with articulation mechanisms for relative yaw and roll motion.

9.14 Traction System in Straddle Monorail Trains

Electric traction system similar to light rail transit are adopted in the monorail train vehicles with adaptation to the straddle beam riding configuration. The electric power of 1500 or 750 Volts DC runs in the third rail (bus bar) fixed along the guide beams. The traction motor of 75- 125 Kw, three phase asynchronous induction or permanent magnet synchronous motors (PMSM) are mounted on the bogies. Traction motor torque and speed is controlled through the IGBT based variable voltage & variable frequency inverters (VVVF). The traction is controlled through microprocessor-based vector control of direct torque control for efficient operations, regenerative/ dynamic braking and smooth acceleration.

Use of super capacitor for traction and energy storage in different rail transit, trams and even in monorail is not new, CRRC Zhuzhou / CSR employed super capacitor technology in light–rail vehicle and trams in 2012-14. These vehicles are charged through ground level contacts in 30-60 seconds at the stations stops. This recharge allows them to run another 4-5 km wire free and it also recovers 85% of the braking energy. This technology is also employed on Chongqing airport line and provide hassle free movement of monorail trains between two stations.

9.15 Braking System in Monorails Trains

The straddle monorail vehicles usually adopt a blend of braking type which are as under.

9.15.1 Dynamic / Regenerative Brakes

In this system the traction motors are used as generators during deceleration and kinetic energy is converted into electric energy and fed partially to the third rail and if not absorbed by grid it is dissipated through the roof mounted grid resistors. Dynamic braking generates significant heat in prolonged application requires robust resistor cooling systems for its effectiveness.

9.15.2 Hydraulic Disc Brakes

These are applied on loaded wheel axels having ventilated disc brakes. The braking is controlled through brake control units assimilated with train control management system (TCMS). Service brake application for normal operations having deceleration rate of 1.0 m /sec.

9.15.3 Emergency Brakes

These are mechanical friction brakes applied with maximum force to cater emergency stoppage of train independent of traction system, it has deceleration rate of 1.2 - 1.3 m /sec.

9.15.4 Parking Brakes

These also employ the friction disc brakes and used to park the rolling stock for definite periods. Air braking system as available in conventional trains but same is quite uncommon in monorails train, hydraulic actuation is preferred due to compact design and requirement of less space foe provisioning of high braking force as desired in monorail systems. The monorail train vehicles have rubber tyres with high adhesion; wet beam surfaces can still reduce effective braking force.

9.15.5 Safe braking Distance Calculations

The estimated safe braking distance for the given monorail under the specified conditions is approximately **275 meters**. This distance is calculated considering the combined effect of the regenerative braking system and the friction-based hydraulic brakes, while also accounting for the significant energy added by the 6% downward grade.

9.15.5.1 Key Assumptions

Since exact performance figures for this specific monorail are not available, we must assume industry-standard values for braking systems.

- **Combined Braking Deceleration:** We will assume the regenerative and hydraulic brakes work together seamlessly. A typical maximum service braking rate for modern rail vehicles is around **1.0 m/s²** (often referred to as ~0.1 g). We will use this as our baseline deceleration rate on a flat track.
- **Brake Efficiency:** We assume the braking system is in optimal condition and can deliver this deceleration force consistently.
- **No Reaction Time Delay:** The calculation is for braking distance only, not total stopping distance. It assumes the brakes are applied instantaneously at the 80 km/h point.
- **Adhesion:** We assume sufficient wheel to guide-beam adhesion to utilize the full braking force without skidding.

9.15.5.2 Step-by-Step Calculation

We will calculate the braking distance by considering the energy that needs to be dissipated.

- **Convert Speed to Meters per Second**

Initial Speed U = 80 km/h
U = 80 × 1000 / 3600 =22.22 m/s
Final Speed V = 0 m/s

- **Calculate the Component of Gravity on the Grade**

A 6% grade means a drop of 6 meters for every 100 meters of horizontal travel.
The angle of the slope (θ) is small, so sin (θ) ≈tan (θ) =0.06sin (θ) ≈tan (θ) = 0.06.The acceleration due to gravity component acting along the track is:
$A_{grade} = g \times \sin(\theta)$
$A_{grade} = 9.81\ m/s^2 \times 0.06$
$A_{grade} = 0.589\ m/s^2$

This is a crucial value. On a 6% downhill, gravity is actively accelerating the train at 0.589 m/s², working directly against the brakes.

- **Determine Net Deceleration**

The brakes are trying to decelerate the train at $A_{brake} = 1.0\ m/s^2$
Gravity is trying to accelerate it at $A_{grade} = +0.589\ m/s^2$

The net deceleration a_{net} experienced by the train is:
$A_{net} = A_{brake} - A_{grade}$
$A_{net} = 1.0 - 0.589$
$A_{net} = 0.411\ m/s^2$

This shows the grade reduces the braking effectiveness by over half.

Calculate Braking Distance using Kinematics

We use the equation of motion: $V^2 = U^2 + 2AS$
Where:

V = 0 m/s, U = 22.22 m/s, $A_{net} = -0.411\ m/s^2$ (negative for deceleration), S = distance

$0 = (22.22)^2 + 2 \times (-0.411) \times S$
$0 = 493.8 - 0.822 \times S$
$0.822 \times S = 493.80$
$S = 493.8 / 0.822$
S ≈ 600.7 meters

This result of **601 meters** is very long and reflects a scenario where only the service brakes (1.0 m/s²) are used.

- **Accounting for Regenerative Braking's Potential**

The problem states the train has regenerative braking. On a steep downhill, the regenerative system can work very effectively, not just as a brake but as an energy recovery tool. It can handle a significant portion of the braking effort, especially at higher speeds. Let's assume that under these conditions, the **combined system (regenerative**

+ hydraulic) can achieve a higher deceleration rate. A more realistic combined service deceleration for a modern electric train could be in the range of **1.2 m/s² to 1.3 m/s²**. We will use a conservative estimate of **1.25 m/s²** for the combined braking deceleration on a flat track.

Let's recalculate with this more realistic figure:

$A_{brake\text{-}combined} = 1.25$ m/s
$A_{net} = 1.25 - 0.589 = 0.661$ m/s^2

Now, plug back into the kinematics equation:
$0 = (22.22)^2 + 2 \times (-0.661) \times S$
$0 = 493.8 - 1.322 \times S$
$1.322 \times S = 493.8$
$S = 493.8 / 1.322$
S ≈ 373.5 meters

This is a more reasonable **374 meters** for normal service braking.

- **The Concept of "Safe Braking Distance" and Emergency Brakes**

A "safe braking distance" in rail safety often implies a worst-case scenario or includes a safety margin. However, it can also refer to the performance of the emergency brakes, which are designed to be more powerful than service brakes.

Emergency brakes often have a deceleration rate 15-30% higher than service brakes.

Let's assume the emergency brakes (likely engaging all hydraulic brakes at maximum pressure, possibly with regenerative backup) can achieve **1.4 m/s²**.

Recalculating for emergency braking:
$A_{brake\text{ - }emergency} = 1.4$ m/s^2
$A_{net} = 1.4 - 0.589 = 0.811$ m/s^2

$0 = (22.22)^2 + 2 \times (-0.811) \times S$
$0 = 493.8 - 1.622 \times S$

$1.622 \times S = 493.8$
$S = 493.8 / 1.622$
S ≈ 304.5 meters

- **Final Estimate and Margin of Safety**

Considering the calculations:

- Service Braking (1.0 m/s²): **≈ 601 m** (longer, likely not the "safe" distance)

- Service Braking (Combined 1.25 m/s²): **≈ 374 m**
- Emergency Braking (1.4 m/s²): **≈ 305 m**

A prudent "safe braking distance" for design and signaling purposes would be based on the emergency braking performance, with an additional margin for safety (e.g., variations in load, adhesion, or system performance).

Therefore, a reasonable and safe estimate is approximately **275 to 300 meters**.

9.15.5.3 Conclusion

The safe braking distance for the third-generation monorail, from an initial speed of 80 km/h on a 6% downgrade, is approximately **275 ≈ 300 meters**. This estimate is based on the expected high-performance of its combined regenerative and hydraulic emergency braking systems, which must counteract the very significant accelerating force of the steep downhill grade.

- **Important Note:** For an exact figure, one would need the specific brake performance curves (deceleration vs. speed) for the regenerative, hydraulic, and emergency braking systems from the vehicle manufacturer. This calculation provides a robust engineering estimate.

9.15.6 Tyre Replacement Frequency and life

There are three types of tyres used in monorail train vehicles.

- **Load tyres** are main running tyres which support vehicle weight, provide traction and braking forces. The life expectancy of load tyres is 60000-100000 kms or 1.5 – 3 years, depends on the duty cycle
- **Guide tyres** provide lateral guidance on the straddle beams; their life is longer than load tyres i.e. up to 5-7 years
- **Stabilizer tyres** are used for additional lateral or anti-roll stability in some designs. They have similar or little bit longer life than guide tyres.

There are different factors which affect the life of the tyres. Mainly vehicle load, beam condition, speed, acceleration, deceleration, braking mode / strategy, climate and lastly tyre pressures lead to lesser life and rapid wear.

9.16 Switching and Route Setting in Monorail Straddle Beam Trains

Specialized mechanism is employed for switching and turnouts due to the guide beam infrastructure. The whole guide way beam physically slides or pivot to align the desired route / track. There are two main types.

- **Sliding Beam Switch** in which the guide beam laterally slides on transfer bogies or rails to coincides with the desired track / route.
- **Pivoting Beam switch** in which guide beam rotate around a vertical axis to align with the desired track line.

In order to move the beams hydraulic cylinders, electric motors or combination of electro hydraulic actuators move the beams to align with the desired track / route. Suitable locking arrangement is provided to ensure beam stability under train loads. The time taken for completion of switching operation is 30 - 60 seconds. These movements of switch beams are fully integrated with the signaling and train movement to ensure safety of train operations. It is quite an expensive option for the setting of route but it remains an engineering necessity to opt for beam switching in monorail train system. There is a trade- off for accepting high cost switching in exchange of monorail benefits like narrow corridor requirement, easy train maneuverability in hilly terrain, grade separation, safety and aesthetics.

9.17 Structural Stability of Monorail Train Vehicles

After induction of initial Hitachi-based designs improved models were developed and manufactured locally in China by CRRC Changchun or Bombardier (Innovia Monorail 300 variant) for subsequent extensions and fleet expansion. More robust design vehicles were manufactured to incorporate longer trains (6-8 cars) having higher capacity to operate at max speed of 80km/h with acceptable lateral and vertical oscillation. There is no single global standard body for Monorails train systems, but designs usually conform to ASTM (USA) / ANSI standards for structural materials and vehicle designs. Japanese MLIT Monorail guide-lines are made basis for the Chinese monorail standards. As regards fire and life safety standard NFPA-130 is adopted in monorail train vehicles.

The newer design monorail vehicle has better cross wind load stability and structural survival i.e. (25-30 m/s operational limits) due to incorporation of low-profile design, high friction rubber tyres & beam wrapping by bogie structure to prevent derailments. The design is optimized for high-capacity and high-frequency urban transit as well as higher structural stability was also achieved through

- Use of lightweight aluminum extruded profile for car body structure**.**
- Lower center of gravity
- Improved bogie and guide way tyre design

9.18 Traffic Forecast and Ridership for Glass Train

A study was carried out to assess the existing traffic, ridership, transport demand and commercial viability for introducing a tourist-oriented glass train service from Rawalpindi/Islamabad to Murree. The objective is to quantify that demand and determine whether a rail-based alternative could sustainably absorb a portion of that traffic, reduce pressure on existing infrastructure, and enhance the travel experience for both tourists and residents. Origin- Destination (O-D) surveys and interviews were carried out for traffic and commercial data collection, effort was designed to gather detailed insights into travel behavior, spatial movement patterns, and user requirement & preferences over the Islamabad / Rawalpindi–Murree corridor. The purpose of these roadside interview surveys was to build an evidence-based understanding of why, how and by whom the trips are made as well as to collect a comprehensive set of travel information such as;

- Mode of transport
- Trip origin and destination
- Vehicle occupancy
- Frequency of trip
- Purpose of trip
- Average household income (grouped into income brackets
- Willingness to use the proposed Glass Train (Yes/No)
- Reason for willingness or unwillingness (i.e. comfort, cost, time, convenience)

Travel fare and its acceptable range. The results of the study are shown in the **Tables 9.1, 9.2** below.

Table: 9.1		
MONTH	**TRAFFIC (NHA) 2024**	**FORECAST RIDERSHIP 2025**
January	**268734**	**233162**
February	**3110169**	**269112**
March	**244402**	**212051**
April	**326166**	**282992**
May	**351214**	**304724**
June	**479309**	**415863**
July	**535536**	**464647**
August	**748311**	**414997**
September	**358026**	**310634**
October	**303458**	**263289**
November	**293461**	**254616**
December	**286889**	**248914**
	42356475	**3675000**

TABLE: 9.2			
FORECASTED LOWEST RIDERSHIP MARCH 2025			
	Daily Ridership	**Days**	**Total**
Week days	**6132**	**22**	**134909**
Week ends	**9643**	**8**	**77142**
TOTAL			**212051**
FORECASTED PEAK RIDERSHIP JULY 2025			
Week days	**13437**	**22**	**265613**
Week ends	**21129**	**8**	**169034**
TOTAL			**464647**

9.19 Requirement of Straddle Monorail Train Sets

There are different types of straddle monorail train vehicles having different passenger carrying capacities. The main parameters of different types of straddle monorail vehicles with passenger capacity are shown in the **Table 9.3** below.

Table: 9.3

Comparison of Main Features of Straddle Monorail Vehicles				
Type of Straddle Monorail	**Type A Monorail**	**Type B1 Monorail**	**Type B2 Monorail**	**Airside MRT Monorail**
Speed of train	**80km/h**	**80km/h**	**80km/h**	**80 km/h**
Width of car	**2980 mm**	**3093**	**2980**	**2980**
Length of MC car	**15500 mm**	**13650**	**12180**	**1600**
Length of M car	**14600 mm**	**12700**	**10820**	**Adjustable**
Height of car	**1400 mm**	**1400**	**1400**	**1400**
Axel weight	**11tons**	**9**	**14**	**11**
Number of axels	**4**	**4**	**2**	**4**
MC Passenger capacity seat / total	**32/ 151**	**28 /136**	**21/99**	**43/ 203**
M Passenger capacity seat/ total	**36/165**	**30/ 150**	**22/101**	**43/ 203**
Marshalling (vehicle)	**2/4/6/8**	**2-6**	**2-6**	**1-6**

Keeping in we the details in table (A) above, different options in selection of type of vehicles can be adopted to make a train set. Usually, the tourist traffic requires proper seat arrangement, whereas the daily commuters can utilize this facility for short travel destinations while standing also, hence the train sets can have combination of straddle monorail vehicle having complete seat arrangement to reside 36 – 46 passengers as well as vehicle which has seating arrangement alongside the glass windows with spacious aisle in front having 100 - 150 passenger capacity. Two options of different combination of straddle monorail vehicle of (type B1) are considered & explained in **Table 9.4** as under.

Table: 9.4

Option	Train composition 4 Vehicle		Total passenger capacity
Option A type B1 car	**2 MC cars all seating 28 passenger capacity**	**2M cars mix seating/ standing 150 passenger capacity.**	**356**
Option B type B1 car	**2MC cars all seating 28 passenger each, 1 M car all seating 30 passenger capacity**	**1M car mix seating/ standing 150 passengers**	**236**

Considering the traffic study, daily ridership between Islamabad & Murree and peak Tourism season 12 to 15 round trips of straddle train sets with four vehicles are proposed to satisfy the traffic demand. In case of off-season the trips can be reduced as per demand. After taken into account, train turnaround, availability, maintenance windows and daily ridership fleet of 6-7 train sets of 4 vehicle each are proposed to satisfy the traffic demand.

9.20 Operating Schedule

There can be number of train schedules options depending on the rush hours & demand of the passengers. A typical schedule to run 12 pairs of trains per day between Islamabad and Murree is prepared and attached as Annexure. (A & B)

9.21 Train Operation of Straddle Monorail Train

There are dedicated straddle beam tracks available for Up & Dn trains, hence with suitable signaling system i.e. (Moving Block) one train can run after the other in both directions maintaining safety of train operations. Special working rules and SOPs have to be introduced for the operating staff and Drivers.

9.22 Straddle Monorail Recovery Vehicle (SMRV)

The Straddle Monorail Recovery Vehicle (SMRV) is a self-propelled, straddle Beam guided maintenance and rescue vehicle designed to tow disabled straddle-type monorail trains of up to 200-300 tonnes on gradients up to 6.5% (design margin 8%) having a continuous traction 300-400KW. The SMRV shall provide traction, braking, lifting, evacuation support, diagnostics, and crew transport capabilities. The SMRV shall comply with OEM

rolling stock interface requirements and all applicable safety standards. The overall cost of SMRV complete system ranges from$ 2.5 million to $ 3.5 million.

9.23 Maintenance Regime for Rolling Stock

Usually, the heavy equipment like locomotives and coaches are maintained by railroads of the world as per OEM instructions. There are generally two types of repairs i.e. running maintenance and shop maintenance. These are attended in base sheds and back shops respectively. Similarly, coaches go to washing lines for running maintenance, cleaning & upkeep whereas, for heavy or yearly repairs they are sent to back shops. Some times when the nature of repair is such that it does not fall within any schedule repairs and can't be attended in base / running shed such repair is called nominated repairs and that particular repair is attended in back shop. Usually intermediate and major schedules are carried out in the back shops and rolling stock remains ineffective for longer periods of time ranging from 7-15 days. In order to reduce the ineffective periods due to operational commitments some time the maintenance scope of work is staggered & divided assembly wise for attention in short time ranging from 8-hour day shift to 2 days. In this way all the items of the schedule are attended over a longer period but the rolling stock remains available of service.

9.24 Capital Costs

The capital cost of monorail projects depends on many factors, varies with locations, geography, route layouts of monorail guide ways, station's location & sizes, service and maintenance facilities, switching, electric and signaling controls and lastly the monorail rolling stock. The core system of the monorail represents approx. 85% of the total project and costs.

- **Civil works:** Guide ways, Stations, Switches, Maintenance buildings, Energy Supply.
- **Rolling Stock:** Train sets & special vehicles and Routine Maintenance & Back shop machinery.
- **Signaling & Telecom:** Train control Systems, Communication & Control Centers

The cost estimate guideline of double guide way system is based upon experience of mono rail technology by number of consultant and contractors. The Fixed cost is divided as follows as detailed in **Table 9.5**.

Table: 9.5

Items	Cost percentage
Elevated Guide ways and foundations	**42%**
Stations for loading/unloading and allied facilities	**10%**
Maintenance building, yards and operational control facility.	**7%**
Electrical power, Signals and Block control.	**6%**
Rolling stock	**27%**
Contingencies of all above	**8%**

There are many variants of straddle mono rail vehicles available, which have different technological inputs, varies in sizes, structural layout, interiors and passenger amenities, so the costs. The FOB cost of one mono rail vehicle ranges from 1.2 to 1.8 million US dollars i.e. initial to 4th generation cars. Now if we propose a straddle mono rail vehicle variant of third generation it will cost roughly from 1.5 to 1.6 million US dollar. The cost of one train set comprising of two motorized vehicles and two trailer vehicles will range from 6 to 6.4 million US dollars. Keeping in view the present Tax regime of Custom duty, Sale Tax, and freight (35%) the total landed cost.

9.25 Operational Costs of Straddle Monorail

The cost of energy involved in the running of the six monorail train sets between Islamabad and Murree. The sets where there are two traction cars per set, and each traction car is fitted with four permanent magnet synchronous motors (PMSMs) rated at 105kW, and 2 trailers per set. Trains have to travel around 1200 to 1500 kilometers on a daily basis with four stopovers at stations on a one-minute basis. The route maximum gradient stands at 6 per cent and the axle load on every axle is 11-tons. On this basis, determine the daily energy cost needed to run such monorail train sets.

9.26 Assumptions for Calculation

- Number of trains sets 8 with train formation as under
- 2 traction cars
- Each traction car has 4 PMSMs (Permanent Magnet Synchronous Motors)
- PMSM power rating: 105-130 kW each
- Total motors per train set: 8
- Total installed traction power per train set:

- Motors × 105 kW = 840 kW
- Daily distance travelled by trains: 1200–1500 km
- Stops: 4 stations × 1 minute dwell time each
- Maximum grade: 6%
- Axle load: 11 tons per axle
- Auxiliary loads (HVAC, lighting, control systems) are included in typical monorail consumption factors.

9.27 Computation of daily energy cost

- Average energy consumption per km, which varies with gradient, rolling resistance, aerodynamic drag, acceleration/deceleration, and regenerative braking.
- Typical PMSM monorail energy consumption on gradients (from monorail and light metro benchmarks) ranges between 5–9 kWh/km per train set depending on operational profile.
- Due to high grade 6 % which requires frequent acceleration/deceleration, so, Monorail motor efficiency of ~90%,

We conservatively estimate energy consumption as 8 kWh per km per train set.

9.27.1.1 Daily Energy Consumption per day

For 1200 km/day = 1200 km × 8 kWh/km = 9600 kWh/day

For 1500 km/day= 1500 km × 8 kWh/km = 12,000 kWh/day

9.28 Train Maintenance Costs

Different studies have evaluated the cost of maintaining rolling material both in manpower and material as some percentage of capital cost incurred on equipment like locomotive, carriages etc. Depending on the quality of the repair performed along with the capital cost of the locomotive it costs between 3.6 percent and 4.8 percent per annum to maintain. In case of the carriages, this frequency of maintenance is in the form of 2-2.8 percent per year of the capital cost.

The percentage of the yearly capital cost of the proposed monorail vehicles as maintenance cost is higher compared to the percentage of a capital cost of coaches used in conventional rail systems because of the fact that the proposed monorail vehicles involve the use of new and innovative technology in nearly all their main as well as sub-assemblies and the train consists of about 50 percent of motorized vehicle. Based on this, maintenance cost in straddle monorail vehicle has been assumed to be 3.2 percent of the initial cost of the vehicle per year.

10. Chapter

10.1 Environmental Impact Assessment Study

10.2 Introduction

The Government of Punjab plans a scenic Tourist Glass Train linking Rawalpindi /Islamabad and Murree to enhance accessibility and promote sustainable tourism. The project aims to reduce private vehicular traffic while offering a safe, reliable, and eco-friendly alternative. The Environmental Impact Assessment (EIA) for the project was carried out being an essential deliverable of the feasibility & consultancy agreement & same is also in line with the Punjab Environmental Protection Act, 1997 (amended 2012 & 2017) and the Pakistan EPA (Review of IEE & EIA) Regulations, 2022. This project falls under Category 'D', requiring a full EIA prior to approval. Other relevant laws have also been discussed briefly in Chapter-2 of the (EIA) study already submitted to the client.

During initial phase of the project a conventional rail line of 62.8 km was under consideration, running from Islamabad Sector H-9 to Murree Bus Stand, its alignment involved a number of bridges, tunnels and mixed sections at grade or in cut-and-fill through mountainous terrain. Later on, due to complex geological conditions and insurmountable impediments an alternative Straddle Monorail System with revised alignment of 41 km was opted for the Tourist Glass Train. This (EIA) study relates to the initial alignment pirating to conventional rail.

10.3 Scope and purpose of Study

The scope of this EIA Study aims at collection and scrutinizing of data related to physical, biological and socio-economic environment of the project area and to prepare the baseline environmental profile. It also aims the identification, prediction and evaluation of the possible adverse environmental impacts of the proposed project on its immediate surroundings on both short and long-term bases. Based on the nature and scale of those impacts, appropriate mitigation & remedial measures are proposed in this EIA Report to make the project environmentally friendly and sustainable during the construction and operational stages.

10.3.1 Methodology

The study of EIA was undertaken in a systematic approach to define the baseline conditions and evaluate the impacts and compliance with the legal requirements.

10.3.2 Orientation & Planning

The team meetings were conducted internally to define the scope of the project, determine the information requirements, define the responsibilities, and develop an elaborate data acquisition plan.

10.3.3 Data Collection

The primary or secondary data were collected by literature research, site reconnaissance, map analysis, consultation/testing to the population and environments.

10.3.4 Regulatory Review

Applicable national and international laws, guidelines, and treaties that were related to the project were examined.

10.3.5 Delimitation of Area of Influence (AOI)

AOI includes the area in the surroundings of the proposed alignment receiving direct impact of project activities AOI was considered to be 25 m along the project boundary which included areas that were directly affected by project activities.

10.3.6 Environmental Baseline

In April 2025, environmental, ecological, and social professionals carried out field surveys in order to record the state of local conditions. Data was collected on Physical, Ecological & Socio-Cultural Environment.

The project area falls in Islamabad Capital Territory and District Murree. The alignment traverses' plains, hills, and forested terrain between 471–2,262 m elevation, passing through urban, rural, and ecological zones. As per Building Code of Pakistan (BCP), 2007 (Seismic Provisions), the proposed Project falls in the Zone-B & 3 with Peak Ground Acceleration (PGA) from 0.16g to 0.32g of the seismic zonation. Major sensitive receptors in the area include protected forests, national parks (MHNP, Murree, Kotli Sattian and Kahuta), health and education facilities, and religious sites. These have been recorded based on site survey and by using the GIS tool for the proposed Project.

The ecological setting includes subtropical scrub, Chir Pine, and Himalayan moist temperate forests with diverse wildlife like Golden Jackal, Kashmir Flying Squirrel, Indian Crested Porcupine, Indian Hare, Cobra, Black Partridge, White Wagtail, Rufous-bellied Niltava.

Based on the District Census Report, 2017, a socio-economic profiling was carried out in the month of April 2025. A sample size of 115 (103 Males & 12 Females) was taken by using random sample technique. During the socio- economic survey, respondents were

informed about the Project objectives, its location and basic design features. The respondents highlighted concerns regarding land use, livelihoods, and environmental safety

10.3.7 Stakeholder Consultation

Consultations were held with local communities, project affected person (PAPs) and different Government departments and agencies i.e. Pak-EPA, Punjab-EP&CCD, TMA Murree, Punjab Tourism Development Cooperation of Punjab (TDCP), Forest Department, Wildlife Department, CDA, Islamabad Wildlife Management Board etc. Their key concerns included land acquisition, forest disturbance, and construction-related pollution, health & safety, privacy and implementation of mitigation measures.

10.3.8 Anticipated Impacts & Mitigation Measures

Significant efforts were made to identify the main environmental issues related to the design, construction and operation of the proposed project. The significant adverse impacts and their mitigations during the design, construction and operation phases are here under:

- **Noise & vibration:** Noise and vibration are perceived as one of the most undesirable consequences of construction activities. Controlled through modern equipment, scheduling, and barriers.
- **Water & wastewater:** Wastewater will be generated at the construction camps and from construction activities. Proper treatment and disposal from camps and construction sites. Approximately 6,600 liters/day of waste water is generated for a camp of 200 construction workers which is to be disposed of after proper pre-treatment and processes such as soakage pit.
- **Solid waste:** Collection and disposal through approved solid waste disposal systems (~120 kg/day during construction).
- **Air quality:** Air quality will be affected by fugitive dust emissions from construction machinery working on unpaved surfaces & emissions from batching / asphalt. Dust suppression, vehicle maintenance, and emission control at plants is to be controlled efficiently.
- **Vegetation loss:** The project will involve clearing of vegetation cover on construction areas particularly along proposed track construction. Compensatory plantation in coordination with the Forest Department.
- **Community impacts:** Construction camps may generate waste, dust, and soil or groundwater pollution, while construction activities and vehicle movement could increase the risk of accidents for nearby communities and institutions. Social conflicts may also arise between workers and locals due to cultural, religious, or

resource-related differences. The contractor will be responsible for strict control of construction activities, ensuring community safety, respecting local customs, instructing workers to avoid unethical behavior adhering to cultural norms.

10.4 Environmental Management Plan (EMP)

The EMP includes institutional roles, mitigation, monitoring, and compliance measures with an estimated implementation cost of PKR 26.541 million (excluding afforestation). The EMP will be integrated into contractor obligations.

10.5 Conclusion & Recommendations

The EIA concludes that project impacts are low to moderate on the physical environment but significant on ecological and social systems. These impacts could be reduced by proper and judicious compensation to the affectee and well-planned meticulous design and by implementing an appropriate tree plantation. With strict mitigation, compensatory measures, and adherence to the EMP, the project is environmentally feasible. No critical or unmanageable impacts were identified, and the project can proceed with safeguards in place.

10.6 Policy, Legal & Administrative Frameworks

The policy framework and legislation that applies to control the environmental consequences as a result of the proposed Project implementation and operation. The Project needs to comply with all the applicable environmental policies, laws, guidelines, acts and legislations of Government of Pakistan and Provincial Government (Punjab).

10.6.1 Summary of Key Policies and Strategies

- **National Conservation Strategy (1992):** Emphasizes sustainable development, pollution prevention, biodiversity conservation, and forestry — directly relevant to construction-phase impacts.
- **National Environmental Policy (2005):** Provides a framework for integrating environmental concerns into development planning and mandates enforcement of EIA/IEE provisions.
- **National Climate Change Policy (2012):** Guides adaptation/mitigation measures for climate risks; relevant due to machinery emissions, deforestation, and disaster resilience needs.
- **National Drinking Water Policy (2009) & National Water Policy (2018):** Ensure water quality, wastewater handling, and safe supply during construction and operation.

- **National Forest Policy (2015) & Biodiversity Action Plan (1999):** Applicable as the alignment passes through reserved/protected forests and biodiversity-sensitive areas.
- **Labour Policy (2010):** Protects labor rights and welfare of the workforce engaged in construction.
- **National Disaster Risk Reduction Policy (2013):** Provides guidance for managing natural/man-made disaster risks during construction and operation.
- **Punjab Climate Change Policy (2017):** Complements national climate policy, with province-specific adaptation measures.

10.6.2 Main Legislation/Acts

Following are the Legislations and Acts pertaining to Environment and their Relevance to the Project. Details in **Table 10.1** below

Table: 10.1

Sr. No	Act/ Legislation	Key Requirement	Project Implication	Compliance Action Required
1	Pakistan Environmental Protection Act, 1997	Mandatory IEE/EIA approval before project execution; compliance with NEQS; prohibition of harmful discharges/emissions.	Project must conduct EIA (Sec.12) and obtain Pak-EPA approval before construction;	Comply with NEQS for emissions, noise, and waste.
2	Punjab Environmental Protection Act, 1997 (Amended, 2012 & 2017	Legislative framework for environmental governance i.e. protection, conservation, rehabilitation and improvement of the environment; IEE/EIA approval mandatory; PEQS compliance; prohibits hazardous waste import; penalties for violations.	Project must secure EIA approval from Punjab EP&CCD;	Comply with PEQS for emissions/noise/Waste Water; manage hazardous substances responsibly.
3	Pak-EPA Review of IEE/EIA Regulations, 2000	Classifies projects into Schedule I (IEE) & Schedule II (EIA). Category D (Transport) requires EIA.	Project falls under Schedule II (Transport)	Full EIA required prior to construction.
4	Punjab EPA Review of IEE/EIA Regulations, 2022	Sets out & defines EIA process, screening, roles of EPAs & P&D, filing/approval procedures.	Provisions of regulations require, environmental screening of the Project, which implies that an EIA is required, as same falls under (Category D Transport of Schedule II)	As project relates to Category D (Transport) of Schedule II. PMA to follow the procedure to file an EIA with Punjab EP&CCD and to understand its review

				process along with timelines to be followed
5	National Environmental Quality Standards (NEQS), 2010	National Environmental Quality Standards (NEQS), 201 established with primary objective of safeguarding environmental integrity by setting permissible limits for air, water, land pollutants and noise.	NEQS, 2010 are applicable on proposed Project, due to regulatory limits for air emissions, noise levels, & wastewater discharges can arise in construction and operational phase.	Compliance with NEQS during construction & operation is mandatory for approval
6	Punjab Environmental Quality Standards (PEQS), 2016	These are Standards for drinking water, air, noise, Industrial emissions & effluents, waste. Drinking Water; Motor vehicle exhaust &Treatment of Liquid and Bio-Medical Waste	Applicable to Project, as it fixes regulatory limits for air emissions, noise levels, and wastewater discharge during the construction and operational phases.	Monitoring & compliance of PEQS limits throughout lifecycle.
7	Guidelines for the Preparation and Review of Environmental Reports, 1997.	Guidelines describe the format and content of IEE/EIA reports to be submitted to PEPA for obtaining NOC/approval. Mitigation and impact management & preparation of EPM plan; Review and decision making; Monitoring and auditing; and Project Management.	Applicable to project as it defines format/content of IEE/EIA reports, mitigation, EMP, monitoring & review.	Project's EIA must follow guideline structure to secure approval.
8	Islamabad Capital Territory Building Control Regulations, 2020	Standards for safe building design, accessibility, health and safety.	Applicable to project's design & construction phases.	Compliance of ICT Building Control regulations mandatory.
9	PAK-EPA Ban on Manufacture, Import, sale, purchase, storage & usage of Polythene bags regulations, 2019	Ban on polythene manufacturing, trade & use (except medical/hazardous & municipal waste). Under the Regulations, organizations can use polythene flat bags by paying Fee of Rs 10,000. Fine on supplying polythene bags on manufacturer & wholesalers etc.	Waste management during Construction /operation must exclude banned polythene bags.	Compliance of Polythene bags regulations, 2019 mandatory by contractor.
10	CDA Building Standards for Fire Prevention and Life Safety, 2010	Provides requirements of fire prevention, safety measures & protection systems. Fire prevention cover aspects pertaining to design & construction of buildings on passive fire protection	Stations/buildings must incorporate fire safety features per CDA standards.	Compliance of CDA Building Standards for Fire Prevention and Life Safety, 2010 mandatory

		measures, describing types of material and their fire safety rating. The life safety provision deals with events of fire and similar emergencies, addressing construction and occupancy features that are necessary to minimize danger to life from fire, smoke, fumes or panic. The protection aspect are guidelines for correct selection equipment, installations in buildings as per classifications and type of fire.		
11	Murree Building Bye-Laws, 2021	Regulates height, floor area ratio (FAR), setbacks as well as aesthetic design to maintain the scenic and ecological integrity of Murree district also prevents deforestation & erosion.	The Murree Building Bye-Laws are relevant to the Project, as they establish the regulatory standards for all construction activities.	Strict compliance with these bye-laws is necessary. They are designed to minimize environmental impacts Special sensitive zone.
12	Islamabad Fire Prevention and Life Safety Regulations, 2010	It provides measures to prevent control fires cope with any untoward event fire, control damage & casualties in buildings in Islamabad Capital Territory. Fire safety measures; CDA enforcement & penalties for violations.	These Regulations are applicable to the proposed Project because it involves the construction of building structures.	Project buildings in ICT must comply with fire safety rules.
13	Standard Operating Procedure (SOP) for Management of Sanitation Services in Islamabad, 2008	SOP provides procedure for adequate measures for efficient sanitation and solid waste collection, storage, disposal and management.	These SOP are applicable to the proposed Project for the efficient management of solid waste and sanitation.	Compliance of Solid waste management SOPs during construction & operation.
14	Solid Waste Management Guidelines, 2005	Guidelines for Solid Waste Management have been issued as a draft by the Pakistan. Environmental Protection Agency in coordination with JICA and UNDP in 2005. Handling, transport & disposal of waste.	Applicable, Project's waste management plan must align with these guidelines.	Compliance of Solid Waste Management Guidelines, 2005 is mandatory.

15	Pakistan Trade Control of Wild Fauna and Flora Rules 2018	Permit system for import/export of endangered species; conservation of habitats.	Relevant as project passes through reserved & protected forests; mitigation for wildlife required.	Monitoring & Compliance of Pakistan Trade Control of Wild Fauna and Flora Rules 2018.
16	Pakistan Climate Change Act, 2017	It is a national framework for climate mitigation & adaptation for meeting obligations international conventions relating to climate change	Applicable on project, due to construction and development activities.	Project must adopt emission reduction measures for machinery & construction activities
17	Land Acquisition Act, 1894 (amended)	Land acquisition only for public purposes; fair compensation at market rates	Land for project/camps to be acquired on willing-seller/willing-buyer basis	Market valuation, transparent negotiations, compensation payments
18	Punjab Wildlife Act, 1974 (Amended 2007 & 2021)	Protection of wildlife & habitats in protected areas	Alignment crosses reserved forests	Clearance from Punjab Wildlife Dept., ecological assessment, mitigation
19	Pakistan Antiquities Act, 1975 & Punjab Amendment, 2012	No construction within 61 m of protected sites; chance finds reported	Potential archaeological finds during excavation	Chance Finds Procedure, NOC from Dept. of Archaeology if required
20	Punjab Special Premises Ordinance, 1985	Protection of cultural/historical premises	If alignment near declared premises	Obtain approval; avoid works in notified areas
21	Pakistan Penal Code, 1860	Penalties for noise, pollution, property damage	Applicable during construction/operation	Pollution control, accident prevention, monitoring
22	Labour Laws (Const. 1973, Child Labour Act 1991, Minimum Wages, etc.)	Ban on forced/child labour; fair wages; gender equality	Labour employment during construction	Written contracts, no child labour, compliance audits, fair wages
23	Punjab Water Act, 2019	Regulates sustainable water use/conservation	Water bodies near alignment (Rawal Lake, Korang River, Lai Nullah)	Water protection plan, runoff control, avoid contamination
24	Hazardous Substance Rules, 2003	Safe handling, transport & disposal of hazardous waste	Hazardous waste during construction	Waste Management Plan, training, disposal at licensed sites
25	Punjab EP (Motor Vehicles) Rules, 2013	No excessive vehicular emissions/noise	Construction transport fleet	Vehicle maintenance, emissions checks
26	OSH Acts (Pakistan 2018, Punjab 2019)	Worker health, safety & welfare	Workers at construction sites	OH&S Plan, PPE provision, safety training, monitoring
27	Punjab Restriction on Employment of Children Act, 2016	Prohibits <15 years employment	Labour hiring by contractors	Age verification, strict enforcement
28	Protection of Women against Violence Act, 2016	Workplace safeguards for women	Women employment in project	Anti-harassment policy, grievance redress system
29	Electricity Act, 1910	Compensation for damages from power works	Possible damage to power facilities	Coordination with utility, compensation if affected

30	Cutting of Trees Act, 1975	Restricts tree felling without plantation	Tree cutting unavoidable at alignment	Compensatory plantation, forestry approval
31	Islamabad Nature Conservation & Wildlife Act, 2023	Protection of ICT biodiversity; IWMB approval	Alignment through Margalla Hills NP	NOC from IWMB, ecological study, mitigation measures
32	Islamabad Nature Conservation & Wildlife Act, 2023	Protection of ICT biodiversity; IWMB approval	Alignment through Margalla Hills NP	NOC from IWMB, ecological study, mitigation measures
33	Punjab Forest Act (2010 & 2016 Amendments)	Restricts use of reserved/protected forests	Alignment crosses forested zones	Forest Dept. approval, compensatory afforestation
34	Punjab Protected Areas Act, 2020	Conservation of sensitive habitats	Alignment near protected areas	Approval from Wildlife & Parks Dept., mitigation plan
35	Guzara Forest Rules, 1950	Community forest protection	Alignment through Guzara forests	Community consultation, access safeguards
36	Canal & Drainage Act, 1873	Ban on obstruction/pollution of canals	Project near water bodies	Sediment & pollution control measures
37	Emergency Service Act, 2006 & NDMA Act, 2010	Disaster preparedness & emergency response	Flood/disaster risk in project area	Emergency response plan, coordination with Rescue 1122/NDMA
38	Seismic Building Code of Pakistan, 2007	Minimum seismic design standards	Project structures in seismic zone	Seismic-compliant design & verification
39	Building Code of Pakistan – Fire Safety (2016)	Fire prevention & protection	Stations, depots, facilities	Fire safety design, alarms, extinguishers
40	Building Code of Pakistan (2021)	Structural safety, sanitation, energy efficiency	All project structures	Compliance with building code standards

10.6.3 International Protocol / Conventions

All applicable international conventions for the proposed Project to which Pakistan is signatory are discussed briefly in **Table 10.2** below.

Table: 10.2

SR.No	Act/ Legislation	Key Requirement	Project Implication	Compliance Action Required
1	UNFCCC, 1992 (Amended 2015)	Stabilize GHG concentrations to prevent dangerous climate change.	Project will generate GHG emissions during construction & operation	Compliance of the regulations of UNFCCC are mandatory.
2	Kyoto Protocol, 1997 (Amended 2012)	Binding commitments to reduce GHG emissions.	Same as UNFCCC – GHG emissions expected during construction and operation.	Compliance of the Kyoto Protocol, 1997 (Amended 2012) by all concerning
3	Paris Agreement, 2015	Limit global temperature rise to well below 2°C; promote low-carbon development	Project emissions must be managed with mitigation to align with sustainable pathways	Compliance of Paris Agreement, 2015 by concerning is mandatory
4	UNESCO World Heritage Convention, 1972	Protect cultural/natural heritage sites.	No designated heritage sites in project area; applicable if any cultural property will be found in excavation.	Compliance of UNESCO World Heritage Convention, 1972 by all concerning.
5	Convention on Migratory Species (CMS), 1979	The Convention requires countries to take action to avoid endangering migratory species across borders.	Not triggered as no migratory species recorded in project vicinity.	Compliance of (CMS)is mandatory
6	Basel Convention, 1994	Pakistan signed Basel Convention that restricts trans-boundary movements of "Hazardous Waste and their Disposal''	Project not expected to involve cross-border hazardous waste.	Compliance is required, if applicable
7	International Union for Conservation of Nature and Natural Resources Red List, 2000	This enlists wildlife species experiencing various levels of threats internationally. Some of the species indicated in the IUCN red list are also present in Pakistan.	Several wildlife species found in and around the Project area are subject to varying degrees of threat, as identified in the International Union for Conservation of Nature (IUCN) Red List of threatened species (2000).	Suitable conservation measures for the identified wild life species be taken by all concerning
8	Millennium Development Goals (MDGs), 2000	Gender equality, health, and environmental sustainability.	Applicable on the project regarding Gender equality & empowerment of Women, Combat HIV/AIDS Malaria etc. & ensuring implementation of EMP to mitigate	. Project to ensure women's employment, worker health checks, and EMP implementation for sustainability.

			adverse environmental impacts.	
9	Convention on the International Trade of Endangered Species (CITES), 1975	The Convention requires countries to safeguard the trade in rare or endangered species and it established a permit system to control imports and exports of wild fauna and flora.	Applicable to project due to availability of endangered wild fauna and flora.	Project must comply with CITES safeguards.

10.7 Administrative Framework

The administrative framework for the proposed Project is led by the Punjab Mass Transit Authority (PMA), which serves as the implementing agency and is responsible for ensuring that all mitigation measures are effectively integrated during the design, construction, and operational phases.

Since the project alignment will cross Islamabad and Murree, PMA will need to obtain the required No Objection Certificates (NOCs) and environmental authorization at the Pakistan Environmental Protection Agency (Pak-EPA) and the Environmental Protection and Climate Change Department (EP&CCD), Punjab. Pak-EPA, which is the agency under the act of Pakistani environmental protection 1997, is in the jurisdiction of the section of Islamabad and will examine the Environmental Impact Assessment (EIA), give approval and oversee the compliance. Likewise, EP&CCD Punjab, as part of the Punjab Environmental Protection Act, 2017 (Amended) will review, approve, and oversee compliance with the Murree section hence ensuring that the project is compliant with federal and provincial environmental laws.

10.8 Project Description

The Murree Tourist Glass Train project embodies a visionary initiative to enhance tourism and aims to blend modern infrastructure with the country's natural beauty, offering a unique travel experience while fostering economic growth and environmental sustainability.

10.9 Alternative Assessments

This section presents the different alternatives that have been considered in the project. The analysis has been carried out critically so as to justify the need of the project and the selected options. Besides the economic viability, environmental sustainability and social soundness of the proposed project have also been considered when analyzing various alternatives. The alternatives that have been considered during this study are:

- No Project Option (NPO)
- Route & Technological Alternatives

10.9.1 No Project Option

In case the proposed project is not undertaken, Murree will still be reliant on personal vehicles, which will cause extreme congestion, increased air pollution, and health hazards. The increase of roads and parking spaces would increase the rate of deforestation, habitat destruction and diminished biodiversity. These social and environmental stresses may diminish tourism attractiveness, which will be detrimental to the local economy. The opportunity to create a sustainable, efficient and environmentally-friendly transport system sustaining livelihoods and improving the appeal of Murree would also be lost.

10.9.2 Route and Technological Alternatives

The Train route selection refers to the process of choosing an efficient route to construct a rail track and all attempts were done to ensure that the environment was not harmed or its harm reduced to the least. This optimization of track route can be useful in minimizing the unnecessary number of efforts as well as optimizing the time and resources. The selection of route alignment has been completed with the following features in mind and an attempt has been made to prevent or reduce effects to the environment and social surroundings.

- Game reserves
- Wildlife sanctuaries
- Reserved forest and ecologically important areas
- Settlements
- Topography steep slopes and high altitudes for construction ease
- Water source (large water bodies, major rivers, etc.)
- Major roads and transmission line crossings
- Archaeological historical spots
- Graveyards and culturally important areas

Different route alignments and surveys revealed that the traditional railway method was not able to offer a technically secure, ecologically sustainable as well as economically feasible solution to the Islamabad Murree corridor. The steep gradients, the geology which was delicate, the environmental sensitivities, the security restraints, or high costs of construction, combined to reject all conventional alignments. As a results of this, finally an alternative mass transit system of straddle monorail was adopted having a total length of 41 km, starting from semi-urban outskirts of Islamabad, Lake View Park and

moves into the Margalla and Murree Hills, to Murree Bus Stand. The final route alignment is already shown in **Figure 3.4** above.

As the work on different studies was started in parallel, hence the work on Environmental Impact Assessment Study (EIA) was carried out on an alignment proposed for a conventional rail which has been shown in **Figure 3.3**above.

10.10 Environmental Baseline

Assessment of existing environmental conditions is essential before project planning, design, and execution. Baseline data on physical, ecological, and social aspects provides the foundation for impact evaluation and mitigation planning. For this project, environmental conditions within the defined Area of Influence (AOI) were studied with reference to physical, biological, and socio-economic factors. Data was collected through literature review, official records, field surveys, and consultations with local communities and stakeholders (survey tool used for data collection is attached as Annex-I of already submitted (EIA) study to the client).

The physical baseline covers key parameters of the project area, including **physiography, topography, geology, soil, seismicity, climate and meteorology, ambient air and noise quality, water resources, solid waste, and land use.**

10.10.1 Topography

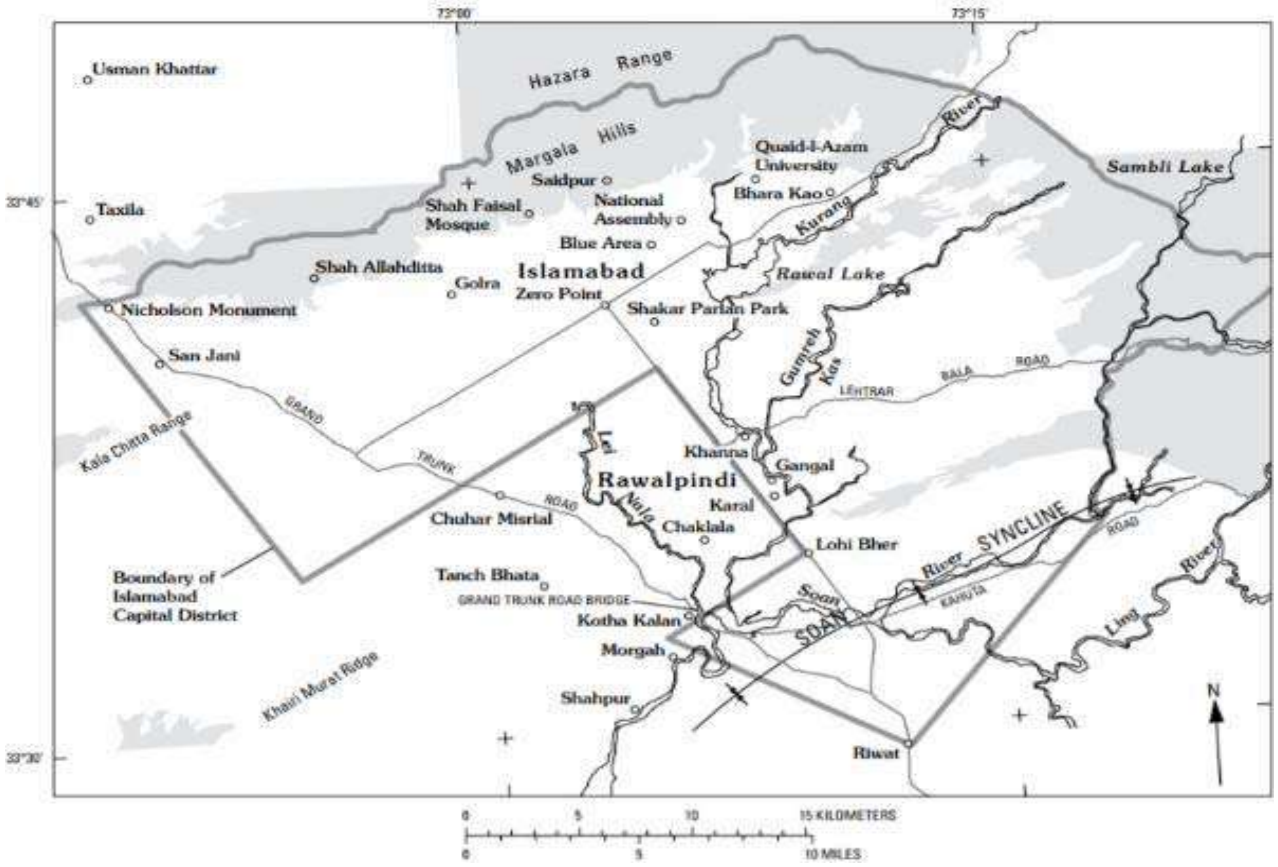
- **Islamabad**

Islamabad lies at the northern edge of the Pothohar Plateau, bordered by Rawalpindi and the Margalla Hills, with an elevation of ~540 m above mean sea level. The terrain consists of plains and mountains with a relief exceeding 1,600 m physio graphically, it is divided into four zones i.e.

- Margalla Hills
- Higher Plain
- Lower Plain
- Valley Area.

The Margalla Hills (up to 1,240 m) are composed mainly of sandstone, shale, and conglomerates, drained by three major tributaries of Lai Nullah namely Saidpur, Tenawali, and Bedarawali Kas & forms a very steep channel bed slope of about 1/10. The Higher Plain covers the urban areas of Islamabad with North–South slopes, while the Lower Plain extends over upper part of Rawalpindi and Valley Area falls down to Soan River tributary of the River Indus forming bowl-shaped and alluvial topography consisting (gravel/boulder and sand/silt). **Figure 10.1** depicts the topography of Islamabad.

Figure: 10.1 Topography of the Islamabad



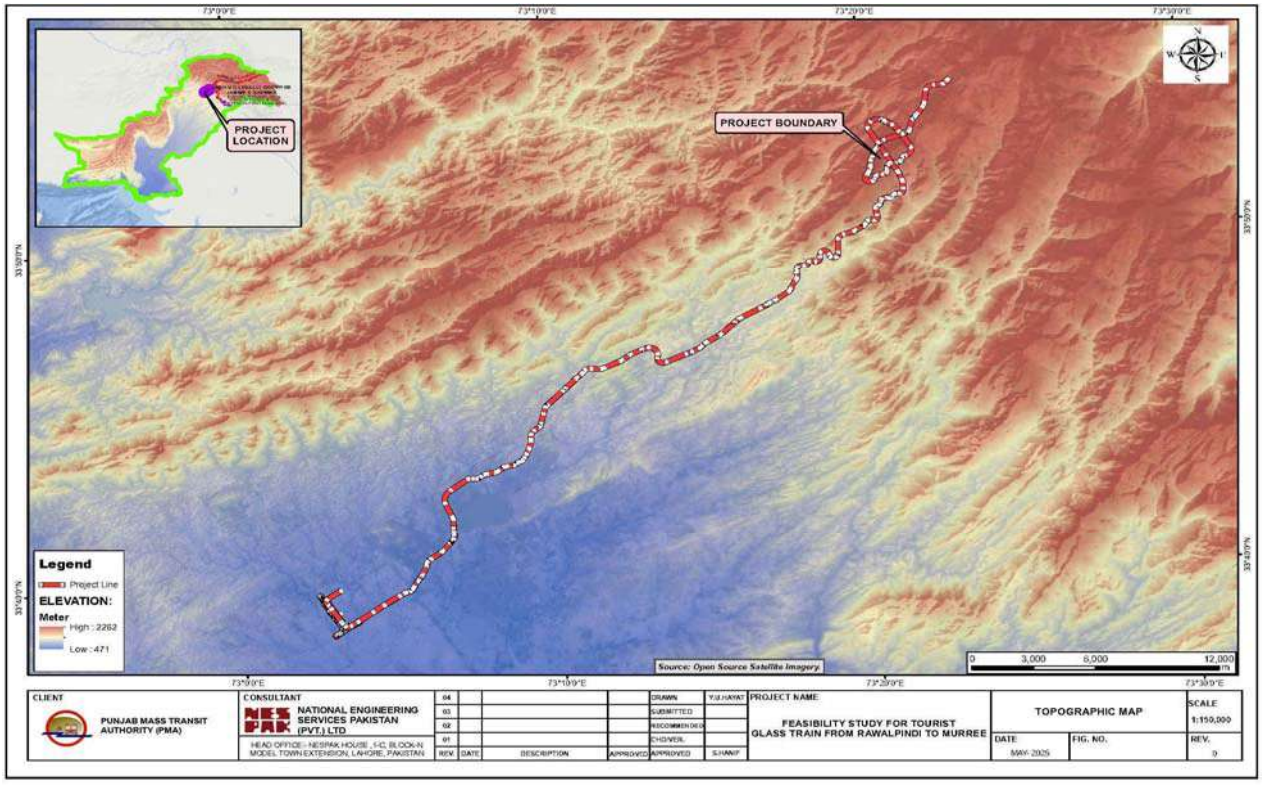
- **Murree**

Murree, situated in the sub-Himalayan Pir-Panjal foothills lies between latitudes 33°48′ and 34°00′ N and longitudes 73°15′ and 73°30′ E. It has rugged ridges, steep slopes (often 30°–50°), and narrow valleys. Elevation ranges from ~1,635 m in valleys to ~2,623 m at ridges, with the town center at ~2,291 m. Physiographic zones include ridges & peaks (e.g., Patriata), terraced slopes (used for agriculture/settlement), narrow valleys and nullahs with steep gradients, and small plateaus/saddles (e.g., Ghora Gali, Jhika Gali). Over 65% of the area has slopes greater than 20%, making it prone to erosion and landslides, particularly during heavy rainfall. Slopes between **10 – 20%** are more stable and have been traditionally used for habitation and agriculture, which includes Ghora Gali & Jhika Gali Plateaus, Bhurban & Surroundings. Dense forests of Chir Pine, Oak, and Blue Pine help stabilize slopes and regulate runoff. The drainage network follows a dendritic pattern, feeding into tributaries of the Soan River and making the area highly susceptible to flash floods.

- **Project Area**

The alignment traverses varied terrain, beginning at Islamabad's plains (~471 m) and rising into Murree's rugged hills (~2,262 m), whereas the topographic features of the project area are shown in **Figure 10.2** below. The corridor passes through forests, agricultural lands, settlements, rivers, nullahs, waterfalls, and built-up infrastructure, reflecting a diverse and sensitive topographic setting.

Figure: 10.2 Topography Map of the Study Area



10.10.2 Geology

- **Islamabad**

The geology of the Islamabad–Rawalpindi region is shaped by the collision of the Indian and Eurasian tectonic plates about 20 million years ago, resulting in complex folding, thrusting, and rapid sediment deposition. Rocks range from Middle Jurassic to Quaternary age, with three main structural zones:

- Mountainous Margalla Hills (North): Jurassic–Eocene limestone and shale, highly folded and thrusted along the Hazara Fault Zone.

- Piedmont Fold Belt (Central): Sandstone and shale of the Rawalpindi Group, truncated and folded, with Pleistocene conglomerates in areas such as Shakar Parian.
- Soan Syncline (South): Asymmetric, faulted fold of regional extent containing fluvial sandstone, claystone, and conglomerates, with maximum width of 11 km, same extending over 100 km southwest. Quaternary are heterogeneous & alluvial deposits (silt, clay, and discontinuous gravel layers) exceed 200–300 m thickness in parts of the subsurface. The lithology comprises four main units:
- Cretaceous sandstone/limestone
- Eocene age Margalla Hill limestone
- Miocene to Lower Pleistocene Nimadrics
- Pleistocene & Quaternary age deposits.

The stratigraphic section of consolidated rocks in the Islamabad-Rawalpindi area is shown in **Figure 10.3** and **Table 10.3,** showing the different formations of the Pleistocene and Holocene in the Study Area and their main lithology characteristics.

Table: 10.3 Lithology of Pleistocene and Holocene Units ***Source: Geological Survey of Pakistan (2007)***

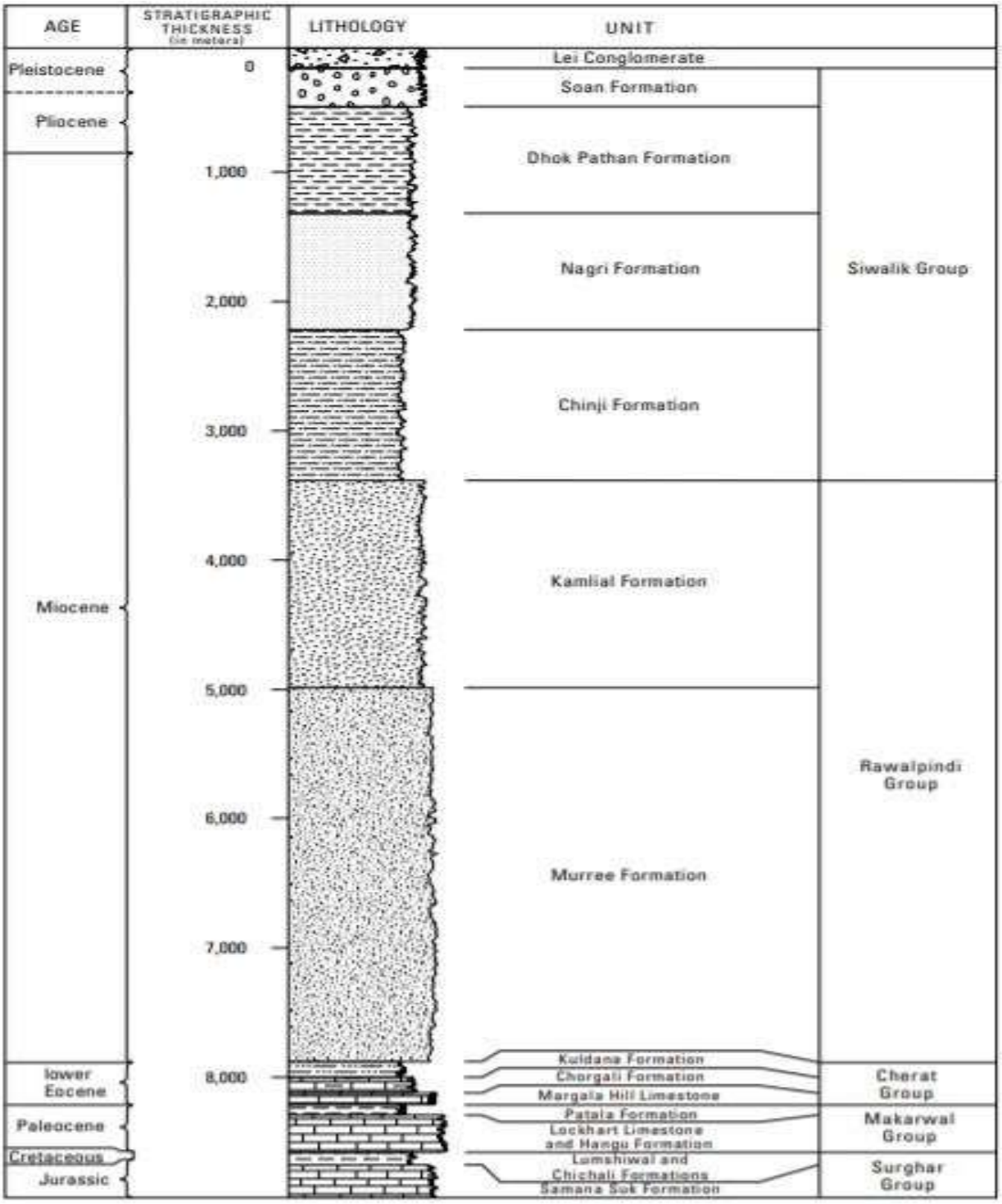
Sr No	Unit Name	Lithology	Thickness (m)
1	Stream-Channel Alluvium	Unconsolidated, cross-bedded, moderately sorted sand & gravel	~3
2	Flood Plain	Sand & gravel with veneer of silt, clay, and organics	~6
3	Fan Alluvium	Poorly sorted sand & gravel with debris-flow deposits; thin soil cover of silt/clay	~20
4	Alluvium & Windblown Silt	Eolian silt with alluvium from channels, terraces & slopes	~10
5	Terrace Alluvium	Sand & gravel overlain by silt, clay & organics	~6
6	Potwar Clay	Compact, calcareous clay/silt with minor gravel	1–35
7	Lei Conglomerate	Sub angular cobbles of Eocene limestone as large as 30 cm. Matrix of reworked Eolian silt. Conglomerate is thickly interbedded with sandy silt beds and gravel beds.	106

- **Murree Formation** the Murree Formation, dominant in the project area, represents Miocene fluvial deposits within the Himalayan Foreland Basin. It comprises reddish to purple **siltstone, claystone, sandstone, and conglomerates**, often calcareous and interbedded with calcrete. Two subunits are distinguished:
- **Lower Murree:** Argillaceous sequence with ripple-marked sandstone, siltstone, conglomerates, and calcrete.
- **Upper Murree:** Arenaceous sequence of thick-bedded, fine-to-medium sandstones and red claystones.

Stratigraphically, it overlies the **Eocene- aged Kuldanna Formation** and is succeeded by the **Siwalik Group**, marking a marine-to-continental transition. Sedimentary features (cross-bedding, ripple marks, fining-upward sequences) indicate deposition in meandering river and floodplain settings, with conglomerates reflecting high-energy floods. Tectonically, the Murree Formation lies within the Hazara-Kashmir Syntaxis, strongly folded and faulted due to Indian–Eurasian plate collision. Thrusting over younger formations, tight anticlines/synclines, and associated weak zones contribute to slope instability, erosion, and landslide susceptibility along the corridor.

- **Project Area Geology** The corridor encompasses stream deposits, Murree Formation, Siwalik Group, Precambrian metamorphic rocks, Miocene, Holocene, and Mesozoic units. At site level, thick sandstone and shale beds dominate, with colluvial slope-wash deposits (silt, clay, and angular rock fragments). Sandstones are moderately hard, fine- to medium-grained, while shales/claystones dominate the Lower Murree sequence. Steep slopes and weak lithologies make the terrain erosion-prone and structurally sensitive. **Figure 10.4 & 10.5** shows the geological conditions in the Study Area & Geological Map of project Area.

Figure: 10.3 Generalized Composite Stratigraphic Section of Consolidated Rocks in Islamabad- Rawalpindi.

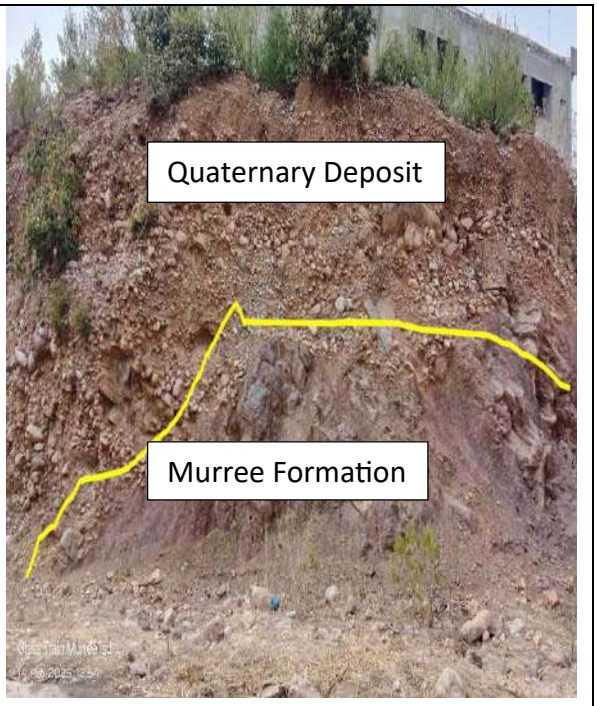


Source: *Geological Survey of Pakistan, under the auspices of the U.S. Agency for International Development, U.S. Department of State, and the Government of Pakistan (2007)*

Figure: 10.4 View of Geological Conditions in the Study Area



Medium to Weak Sandstone exposed near Shahdara Valley



Lithological Setup near Manga

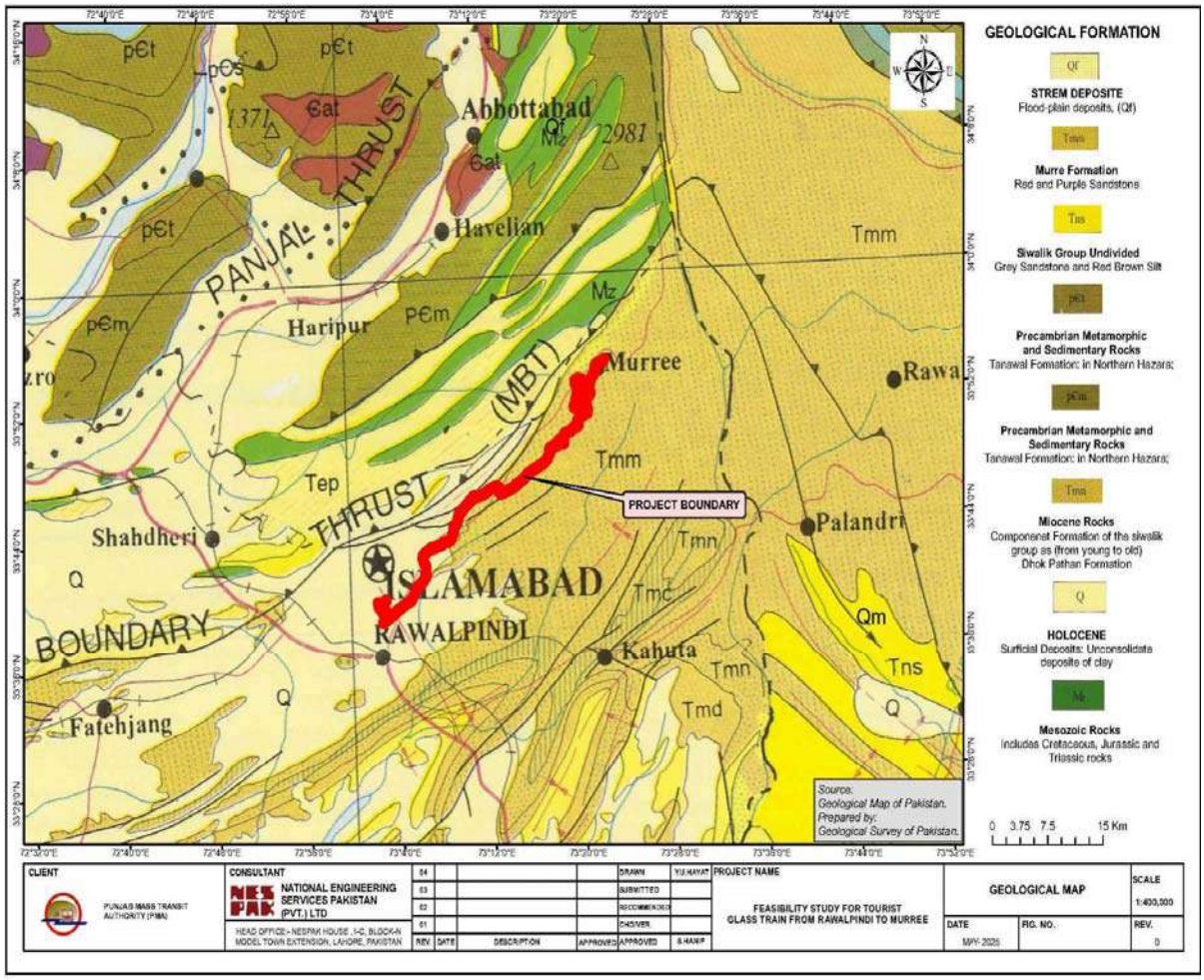


A view of Debris Slide near Nandkot Area



Tunnel Inlet Portal having thick Sandstone beds of Murree Formation

Figure: 10.5 Regional Geological Map of the Study Area



10.10.3 Soil and Seismology

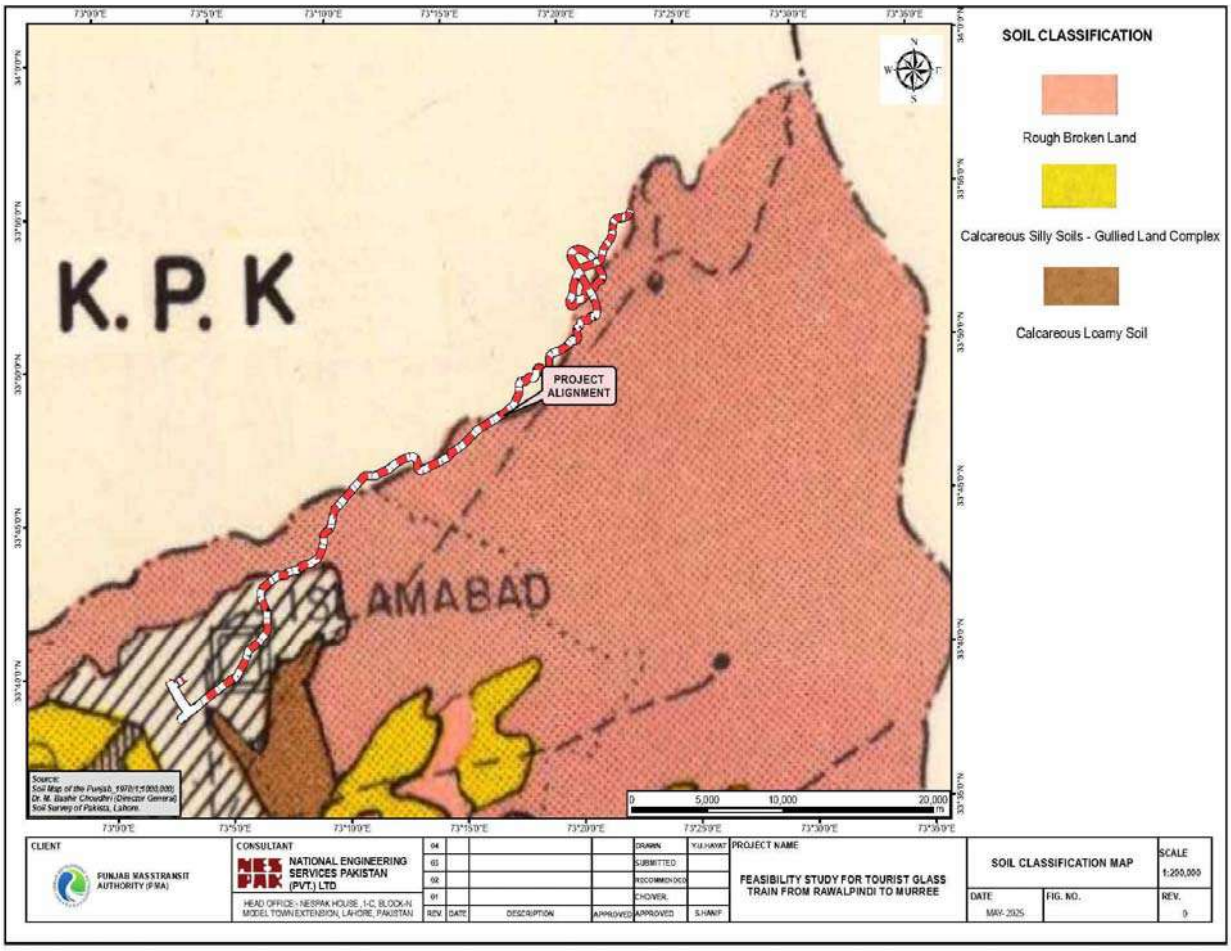
10.10.3.1 Soil

The soil profile within the Islamabad to Murree corridor varies significantly with terrain and geology. The soils in Islamabad are fluvial and alluvial soils, of Soan and Lei formations, with silty clay and sandy loam composition, which has fertile floodplain properties. Erosional regions have thin and sandy soils which are as a result of weathered conglomerates, sandstone & Kamlial formation.

The soils of Murree, which are also mostly Entisols and Inceptisols, on the other hand, consist of weathering products of the molasse formations (sandstone and siltstone of the Murree Formation), sandy loam to silty clay. The acidic soils can be found in higher altitudes whereas the alkaline ones are found in the lower altitudes. Forest cover improves organic soil as well as high frequency wild fires and steep slopes lead to erosion and landslide thereby decreasing soil stability. In general, the soils of the project area are

mainly sandy loam to clay loam, which are of moderate fertility but subject to erosion on steep slopes. Understanding these soil characteristics is crucial for sustainable land management and hazard mitigation in the region. The soil in the Study Area varies from sandy loam to sandy clay loam, silty and loamy. The soil map of the Study Area is shown in **Figure 10.6** below.

Figure: 10.6 Soil Map of the Study Area

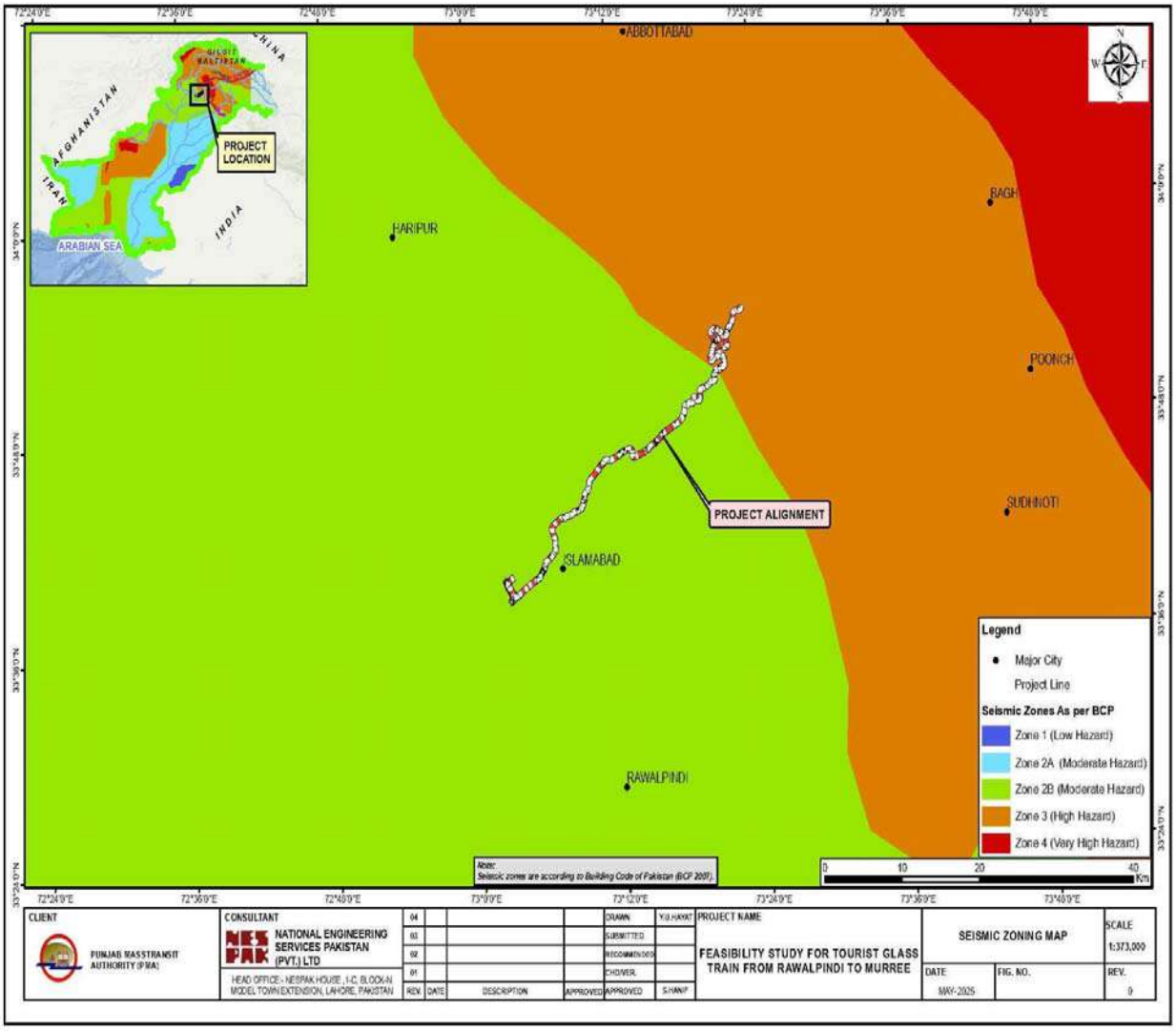


10.10.3.2 Seismology

The Islamabad & Murree are located in a seismically dynamic area that is affected by the Main Boundary Thrust (MBT) and Rawat Fault, where the Indian and Eurasian plates meet. It is vulnerable to earthquakes as demonstrated by its exposure to historical earthquakes, such as the 2005 Muzaffarabad earthquake (Mw 7.6) and the 2015 Murree earthquake (Mw 5.1). In February 2025, a magnitude 4.8 earthquake occurred approximately 17 km from Islamabad, causing noticeable tremors and raising concerns about the proximity of seismic activity to urban areas.

The Building Code of Pakistan (2007) classifies the project area as Seismic Zones 2B to 3 and the ground accelerations of 0.16 up to 0.32g are considered as low up to high levels of ground damages. In Islamabad, soft sediments intensify ground motion whereas the weathered Murree Formation increase risks of landslides caused by earthquakes, and so the strict seismic design and slope stabilization are necessary. **Figure 10.7** shows the seismic zoning map of Project area.

Figure: 10.7 Seismic Zoning Map of the Study Area



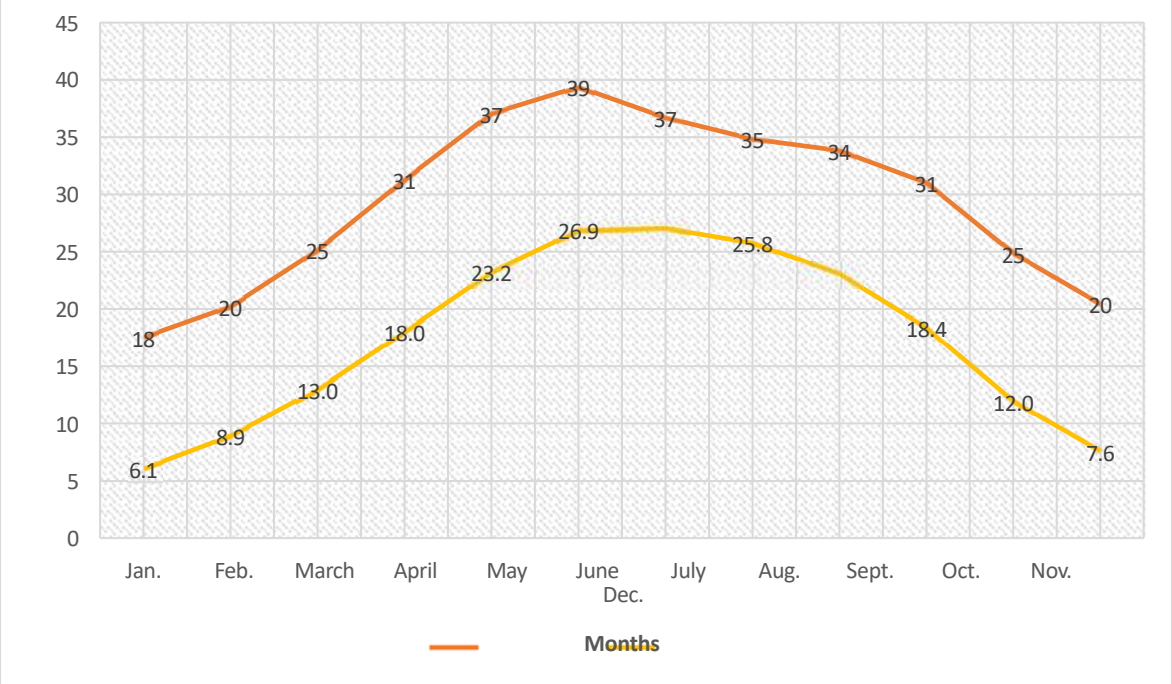
10.10.4 Climate and Meteorology

The Islamabad–Murree corridor exhibits significant climatic variation due to differences in altitude, topography, and exposure to monsoon systems. To determine the overall effect of the climatic stresses on the construction of engineering structures, daily and seasonal temperature changes, site altitude, direct solar radiation, and precipitation

must be considered. These also influence design considerations such as slope stability, drainage, and construction timings.

Islamabad: Islamabad has a humid subtropical climate (Köppen Cwa) characterized by hot summers, a pronounced monsoon season, and mild winters. The average annual temperature is around 21.5°C, with mean maximums of 38–43°C in June and mean minimums of 2–4°C in January. **Figure 10.8** below shows the graphical presentation of average temperatures in the Study Area from the year 2011 to 2022

Figure: 10.8 Average Max. & Min. Temperature in the Study Area (2011- 2022)



The city receives an average annual rainfall of approximately 590–620 mm, about 65% of which occurs between July and September due to the southwest monsoon. Table 9.9 shows the mean monthly precipitation in the study area from 2011 to 2022. The average precipitation remained 129.4 highest in the month of August & 9.9 lowest in the month of November.

Table: 10.9 Mean Monthly Precipitation in the Study Area from 2011- 2022

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2011	7.89	98.57	50.0	63.57	41.83	44.75	76.9	79.39	43.05	33.44	5.09	0.65
2012	15.09	36.96	22.21	61.06	33.63	7.22	29.85	60.66	39.94	10.67	3.25	32.32

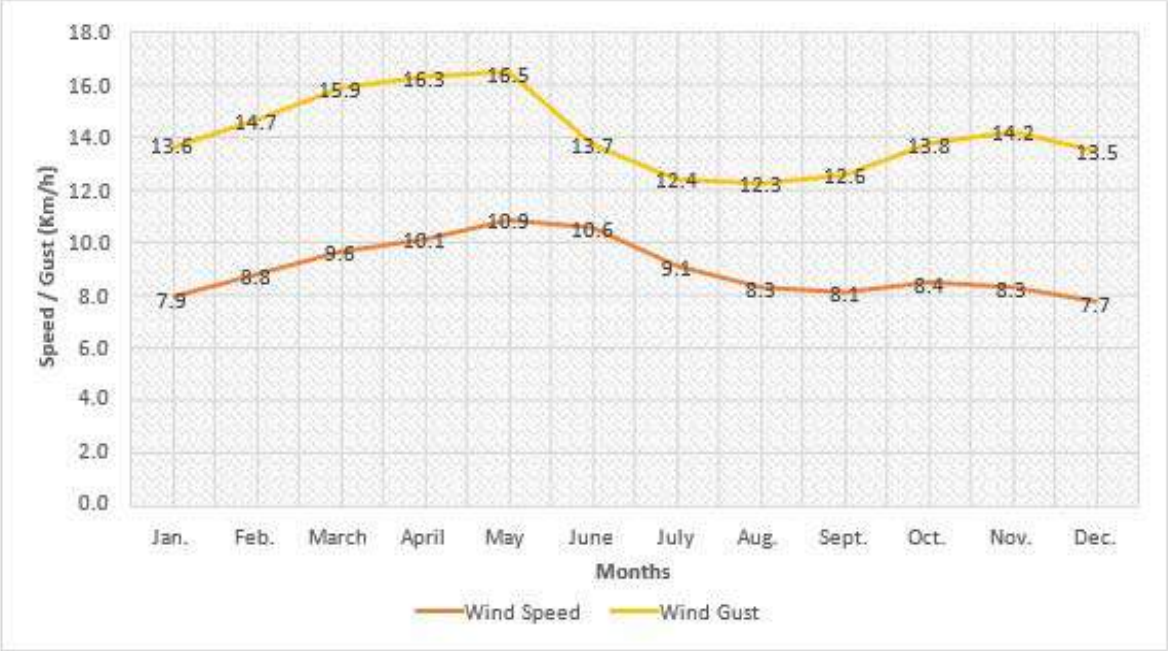
2013	4.94	90	40.72	26.97	10.75	47.35	59.18	85.16	42.13	11.77	3.13	1.12
2014	5.68	26.21	87.93	34.93	28.32	17	60.76	69.04	67.59	17.42	4.84	0.01
2015	7.76	33.36	87.93	45.62	7.96	14.31	72.38	52.24	54.11	16.73	7.03	9.86
2016	7.26	10.95	87.93	23.15	15.1	10.19	72.03	27.82	10	0.83	0.52	0.35
2017	52.35	18.67	22.51	40.04	9.8	26.71	39.55	44.42	11.03	0.12	2.12	16.75
2018	0.65	24.36	11.45	39.66	11.56	26.88	107.13	62.1	27.77	4.1	17.6	2.9
2019	77.8	156.2	110.5	57.9	35.7	28.9	257	323.7	157	52.3	55.2	33.4
2020	187.0	30.0	231.7	78.7	68.5	65.9	118.0	406.8	60.1	0.0	14.0	32.0
2021	71.8	0.9	81.1	58.6	56.6	45.0	477.0	274.7	41.4	15.6	0.0	1.1
2022	37.9	9.2	5.5	0.3	8.3	23.6	110.5	66.7	29.5	0.5	6.6	0.7

Average relative humidity ranges from 30% in May to 65% in August shown in the **Figure 10.10.** Data of wind speed and gust is collected, the wind speeds average 8–11 km/h, occasionally rising to 15–20 km/h during pre-monsoon storms. The **Figure 10.11** shows average wind speed and gust in the Study Area from 2011 to 2022

Figure: 10.10 Average Relative Humidity in the Study Area (2011-2022



Figure: 10.11 Average Wind Speed and Gust in the Study (2011 to 2022)



The city experiences around 70–80 rainy days per year. These conditions imply moderate thermal stress, seasonal heavy precipitation, and low to medium wind loads, all relevant for pavement design, storm water management, and structural safety.

Murree: Murree's subtropical highland climate (Köppen Cwb) is shaped by its elevation (~2,200 m), producing cool summers and cold, snowy winters. The mean annual temperature is 14.8°C, with summer highs of 23–25°C and winter lows frequently below 0°C, reaching –8 to –10°C during winters, **Table 10.10** gives mean temperatures in Murree over the years.

Table: 10.10 Mean Max & Min Temperatures (^{O}C) between 1991 and 2020

Sr. No.	Months	Mean Minimal Temperature	Mean Maximum Temperature
1.	January	- 1.6	8.6
2.	February	- 0.5	9.6
3.	March	4.0	13.9
4.	April	8.7	19.0
5.	May	13.0	23.6
6.	June	15.3	25.6
7.	July	15.7	23.5
8.	August	15.6	22.8
9.	September	13.8	22.3
10.	October	10.5	20.3
11.	November	5.7	16.3
12.	December	1.0	12.4

Annual precipitation averages 1,700–1,900 mm, with major rainfall peaks in July–August (monsoon) and January–February (western disturbances). Mean monthly precipitation in millimeter are shown in **Table 10.11** below. Snowfall occurs from December to March, with accumulations often exceeding 60–90 cm per season. Relative humidity remains high throughout the year (60–85%)

Table: 10.11 Mean Monthly Precipitation (1991 and 2020)

	Month	cipitation (millimeters)
1.	January	119.3
2.	February	167.3
3.	March	170.7
4.	April	139.3
5.	May	82.1
6.	June	153.6
7.	July	315.3
8.	August	272.0
9.	September	148.3
10.	October	56.5
11.	November	39.5
12.	December	49.5
Annual		**1,713.6**

Source: Climate Normal of Pakistan (1991-2020

The wind speeds recorded ranges on an average 1–3 knots (2–6 km/h) in **Table 10.12** below which increases along exposed ridges. Fog and low cloud cover are frequent during the monsoon and winter months, reducing visibility and affecting road safety. Overall, the project corridor experiences humid subtropical to temperate highland conditions, with climatic challenges including intense rainfall, snow accumulation, and freeze & thaw cycles that must be addressed through appropriate engineering, drainage, and slope stabilization measures.

Table: 10.12 Average Wind Speed in Knots (1991 and 2020)

No.	Month	At 00UTC	At 03 UTC	At 12 UTC
1.	January	2.1	2.3	1.8
2.	February	2.4	3.3	2.5
3.	March	2.7	3.3	2.6
4.	April	3.5	3.3	2.5
5.	May	3.3	3.1	2.5
6.	June	2.1	2.2	2.2
7.	July	1.4	1.5	1.7
8.	August	1.3	1.4	1.4
9.	September	1.9	1.7	1.3
10.	October	1.9	1.9	1.2
11.	November	2.0	2.0	1.4
12.	December	1.8	2.2	1.7

Source: Climate Normal of Pakistan (1991-2020)

10.10.5 Groundwater

Islamabad: Islamabad is mainly found in Quaternary alluvial deposits where rainfall and the nearby streams recharge the groundwater. The Capital Development Authority (CDA) has an approximate of 190 tube wells which pump about 127 million cubic meters (MCM) of water per year and are usually supplemented by 129 known municipal wells (63 MGD overall discharge) and a large number of unofficially drilled private wells. Nevertheless, Islamabad has a daily deficit of 52 MGD, which is filled by private water tankers, which are rather expensive. Excessive extraction and urbanization have led to the water reducing by an estimated 23 m to more than 56 m within the last few years. CDA operates 37 small filtration facilities, and a tanker service network, but the long-term sustainability is at stake due to decreasing recharge rates and growing demand.

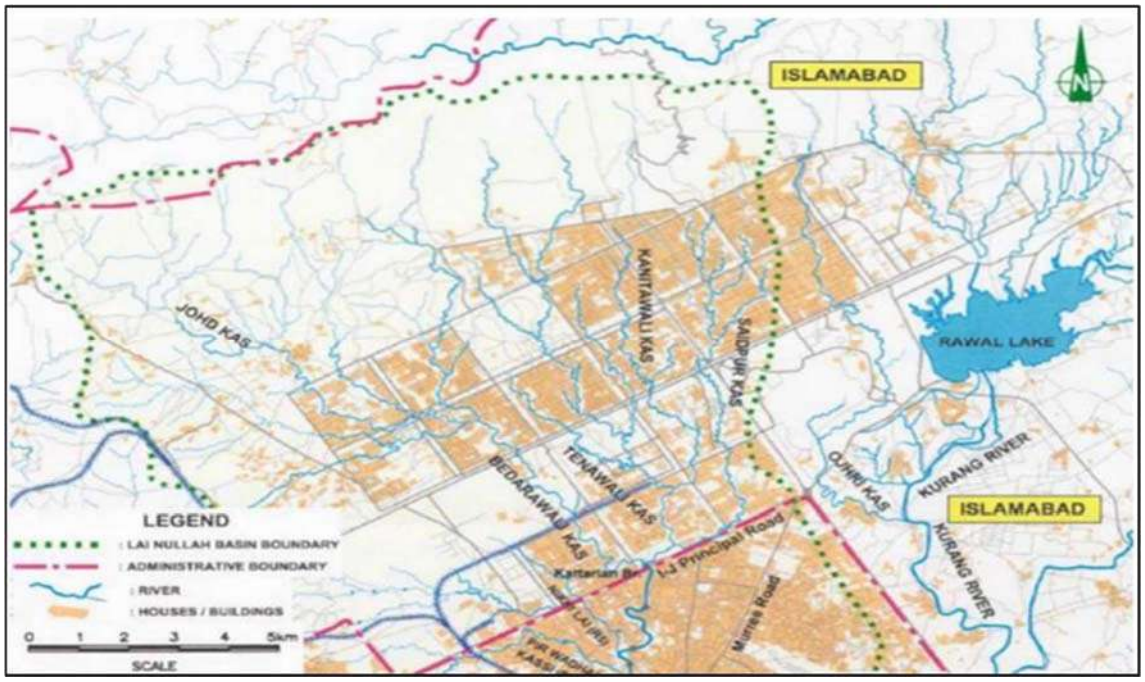
Murree: Murree has an estimated 85 % domestic consumption which rest on ground water and natural springs. Under local consumption, the Water Sufficiency Ratio (WSR) is 1.92 and when national standards are used, the deficit is 0.68. The existing 1.2 MGD supply can hardly satisfy the daily 3 MGD demand by 40 percent. To solve this, Dhar-Jawa Dam and rainwater harvesting plans (with an aim of targeting the 3,000 households) are being developed. Nevertheless, there is the risk of quality and health hazards due to the old and deteriorating infrastructure, insufficient maintenance, and present pollution by sediment and sewage infiltration.

The Project Area has a municipal network and bores well as a source of water supply and stress to Islamabad, and in the Project Area, Murree is mainly dependent on springs and shallow wells as a source of water supply that are stressed by overuse and pollution.

10.10.6 Surface Water Hydrology

Due to the hilly nature and the dense drainage system, Islamabad-Murree corridor is fortunate enough to enjoy the presence of surface water. The hydrology of Islamabad is characterized by the Soan River Basin which receives the inflow of three main tributaries namely, Saidpur Kas (24.7 km^2), Tenawali Kas (39.7 km^2) and Bedarawali Kas (79.9 km 2) draining into the Nullah Lai which is the major drainage system in Islamabad and Rawalpindi. The various streams flow in and around the city of Islamabad as shown in **Figure 10.12** below.

Figure: 10.12 Stream Network in & around Islamabad (Source JICA, 2003)



In addition to these major tributaries, there are other six (06) tributaries or drainage channels/ Sewerage channels, which joint the mainstream between the confluences of Dhok-Ratta Nullah and Soan River. The name and the catchment area of the whole tributaries are given in **Table 10.13**

Table: 10.13 Name and the Catchment Area of the Tributaries

Location of Confluence with Main Stream	No. and Name of Tributary		
	No.	Name	Catchment Area (km^2)
Islamabad	-	Saidpur Kas	24.7
	-	Tenawali Kas (Including Kanitawali Kas as the secondary tributary)	39.7
	-	Bedarawali Kas (Including Johd Kas as the secondary tributary)	79.9
	Total		144.3

The different surface water resources present in and around the study area are discussed below and shown in **Figure 10.13** below**.**

Key surface water features include:

- **Soan River:** It originates near Patriata (Murree), traverses approx. 250 km before joining the Indus at Pirpiyahi & is the key feeder for Simly Dam.
- **Korang River:** Main drainage channel for Islamabad, supplying Rawal Lake.
- **Rawal Lake:** The capacity of Reservoir is 58.6 MCM having a spillway discharge of 2,300 m^3/s. It provides 72 MGD for Islamabad–Rawalpindi & 70% of its catchment area lies in Murree.
- **Simly Dam:** The storage capacity is 35.5 MCM with spillway discharge of 1,275 m^3/s. it is largest drinking water source of Islamabad and supplies 68 MGD.
- **Khanpur Dam:** located on Haro River having capacity of 140 MCM supplies water for domestic, agricultural, and industrial uses. The mean annual water available is 198 MGD.
- **Head-works:** Headwork water is diverted from springs located at Saidpur, Nurpur and Shahdara**.** The capacity of the four headwork's sources i.e. Kurang River: 4 MGD, Saidpur 0.8 MGD, Nurpur 0.7 MGD, and Shahdara 1.6 MGD.
- **Nullah Lai Basin**: It is approx. 30 km long & has a catchment area of 239.8 km^2 out of which 67% lies in Islamabad. The total water supply capacity is 785 MLD, out of which service area of CDA share 507 MLD and WASA Rawalpindi 123 MLD (million liters per day).
- **Natural Springs**: There are a great number of perennial springs i.e. Sandhian, Nara, Chalaar, Changla Gali & Dunga Gali that supply locally, and tourism, which maintain the local ecology of Murree

The combination of these interrelated ground water systems and surface water systems constitutes the main hydrological regime in the Islamabad-Murree area. The management of such sources is imperative to sustainable development capable of sustaining the urban growth, reduce pollution as well as preserve the equilibrium of the environment.

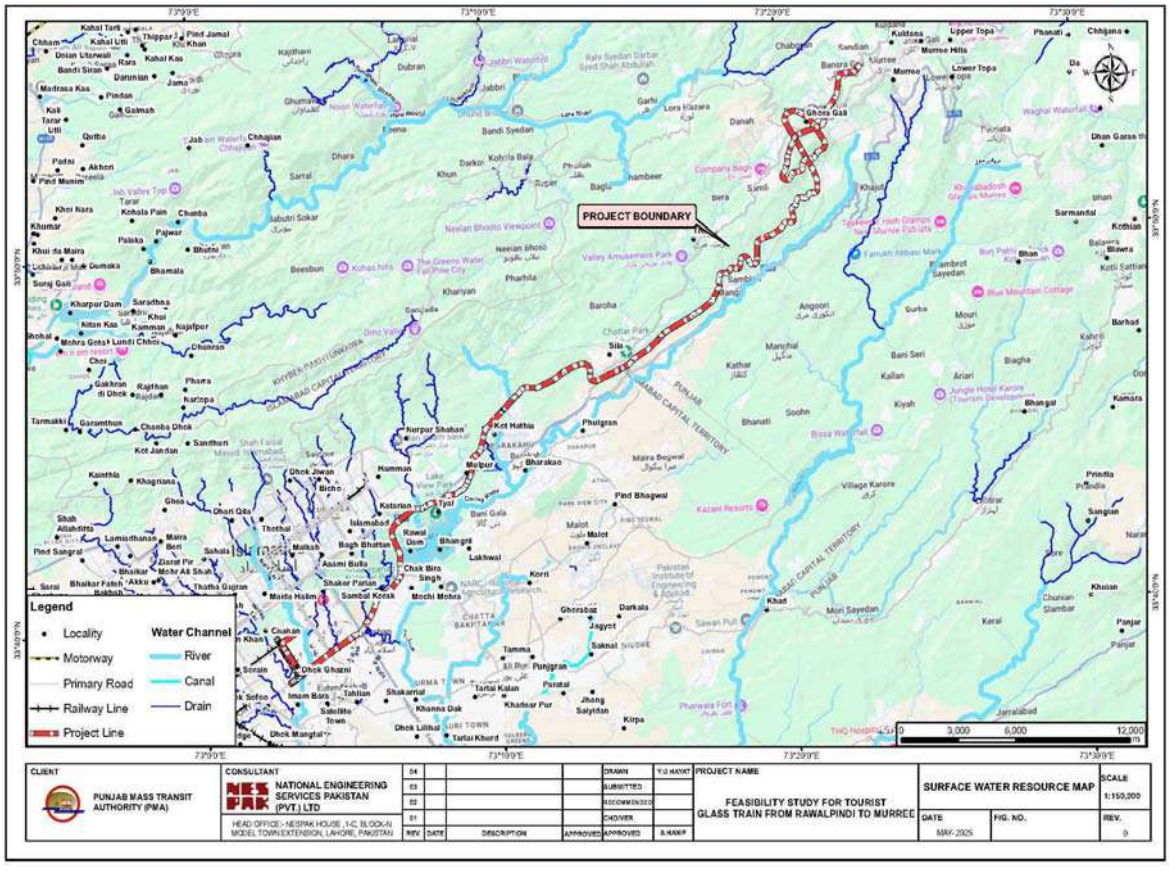
10.10.7 Drainage

Islamabad: Despite being a planned city, Islamabad faces recurring urban flooding due to rapid urbanization, inadequate maintenance, and insufficient storm water infrastructure. The Lai Nullah and its tributaries are the main drainage channels, but they often overflow during intense rainfall events. A record 620 mm rainfall in 10 hours (July

2001) caused severe flooding and 61 fatalities, while a 2021 cloudburst inundated low-lying sectors (E-11, F-10, D-12), exposing the city's limited drainage capacity. It is suspected that city's infrastructure will struggle in future too due to inadequate storm water drainage capacity, particularly in low-lying areas.

Murree: Murree's drainage system is poorly developed, with clogged or absent roadside drains and disrupted natural watercourses due to unplanned construction. The region's steep slopes intensify runoff, accelerating soil erosion and stream bank instability. Heavy monsoon rains frequently cause localized flooding e.g., September 2021 rainfall inundated Judicial Complex Jhika Gali, Neelum Point, and nearby residential areas causing widespread damage. Deforestation, haphazard development, lack of effective drainage infrastructure and poor maintenance continue to increase flash flood susceptibility.

Figure: 10.13 Surface Water Resources Map of the Study Area



The Capital Development Authority (CDA) and Islamabad Metropolitan Corporation (IMC) collect only 60–70%, which is disposed of at a temporary landfill in Sector I-12. The remaining waste is dumped or burned in open areas, contributing to pollution and health risks.

Murree: Waste management in Murree, overseen by the Rawalpindi Waste Management Company (RWMC), faces seasonal stress due to tourism as the town's population swells from approximately 40,000 residents to nearly 1,000,000 visitors. The waste generation rises from 39 tons/day (off-season) to 850 tons/day (peak season), far exceeding the town's 13.8–24 tons/day disposal capacity. This gap leads to open dumping and environmental degradation during tourist influxes

Figure: 10.14 Pictorial View of Waste Management in Study Area



Project Area: Both CDA and RWMC are responsible for waste management across the project corridor; however, field observations revealed inadequate facilities. Open waste piles were commonly observed along roadsides and drains, indicating insufficient collection coverage and lack of designated disposal sites.

10.11 Environmental Monitoring

Comprehensive environmental monitoring was conducted in April 2025 to establish the baseline conditions for air quality, noise, and water resources within the Project Area, the Locations of Environmental Monitoring Points are shown in **Table 10.14** below. The Sampling locations were selected based on proximity to project activities, sensitivity of receptors, and hydrological significance as shown in **Figure 10.15** with results are provided in **Annex-II** of already provided EIA study to the client.

10.11.1 Air Quality

Ambient air monitoring at five representative locations of Islamabad-Murree, pictorial available in **Figure 10.16** below. The key pollutants measured includes CO, NO, NO_2, SO_2, PM_{10}, $PM_{2.5}$, and O_3. Recorded concentrations remained within the National Environmental Quality Standards (NEQS, 2010) and Punjab Environmental Quality Standards (PEQS, 2016) limits, details available in **Table 10.15**. The PM_{10} values ranged from 103–149 µg/m³ and $PM_{2.5}$ from 26–32 µg/m³, both below permissible thresholds (150 µg/m³ and 35 µg/m³, respectively). Overall, the ambient air quality of the project corridor is satisfactory, with traffic emissions being the primary source of pollutants.

Table: 10.14 Locations of Environmental Monitoring Points

Sr. No.	Parameter for Monitoring	Location	Rationale of Selection
1.	Surface Water	Location 1: Waterfall Near Bansra Gali, Murree (31°36'37.0"N 74°23'35.4"E)	Sampling points were selected keeping in view the proximity to the Project site to assess the potential impact on water sources that could be directly or indirectly affected by the Project's activities and the Consultant's experience. Moreover, for the selection of the surface water bodies, consideration was given to the
		Location 2: Korang River Tributary (33°45'37"N 73°10'33"E)	
		Location 3: Rawal Lake (33°42'02"N 73°07'12"E)	
		Location 4: Jinnah Stream (33°44'09"N 73°07'10"E)	
2.	Wastewater	Location 1: Lai Nullah (33°39'54"N 73°03'21"E)	
		Location 1: Near Chitta Mor, Murree (33°54'29"N 73°22'54"E)	

3.	Drinking Water	Location 2: Near Ghora Gali (33°52'57"N 73°21'34"E)	vulnerability of water sources to potential contamination.
		Location 3: Near Malpur (33°43'48"N 73°8'54"E)	
		Location 4: Near Murree Road (33°41'16"N 73°6'38"E)	
		Location 5: 9th Avenue 1-9/3 (33°40'08"N 73°03'32"E)	
4.	Ambient Air Particulate Matter and Gases	Location1: Near Shifa Tree Plantation H Islamabad -8/1 (33°40'03.4"N 73°03'35.0"E)	The monitoring points were selected with reference to the location of receptors and pollution sources. The samples were selected based on the land use of the ROW and COI and sensitive receptors in the proximity of the proposed Project
		Location 2: Near Murree Road (33°41'21.6"N 73°06'34.7"E)	
		Location 3: Near Bara Kahu Bypass (33°44'01.3"N 73°09'10.7"E)	
		Location 4: Near Ghora Gali (33°52'56.7"N 73°21'34.2"E)	
		Location 5: Near Chitta Mor (33°54'31.4"N 73°22'54.8"E)	
5.	Noise	Location1: Near Shifa Tree Plantation H Islamabad -8/1 (33°40'03.4"N 73°03'35.0"E)	The samples were selected based on the land use of the ROW and COI and sensitive receptors in the proximity of the proposed Project
		Location 2: Near Murree Road (33°41'21.6"N 73°06'34.7"E)	
		Location 3: Near Bara Kahu Bypass (33°44'01.3"N 73°09'10.7"E)	
		Location 4: Near Ghora Gali (33°52'56.7"N 73°21'34.2"E)	
		Location 5: Near Chitta Mor (33°54'31.4"N 73°22'54.8"E)	

Figure: 10.16 View of Ambient Air and Noise Level Monitoring at Project Site



Table: 10.15 Average Concentration of Ambient Air Pollutants

Sr. No.	Monitoring Points	Pollutants								
		CO	NO	NO_2	SO_2	Lead	PM_{10}	$PM_{2.5}$	O_3	SPM
Monitoring Duration		8 Hr	24 Hr	24 Hr	24 Hr	24 Hr	24 Hr	24 Hr	1 Hr	24 Hr
NEQS, 2010		5.0 µg/m³	40 µg/m³	80 µg/m³	120 µg/m³	1.5 µg/m³	150 µg/m³	35 µg/m³	130 µg/m³	500 µg/m³
PEQS, 2016		5.0 µg/m³	40 µg/m³	80 µg/m³	120 µg/m³	1.5 µg/m³	150 µg/m³	35 µg/m³	130 µg/m³	500 µg/m³
ISLAMABAD										
1	AA-01	3.87	28.98	61.64	89.27	0.2	148.65	32.12	42.25	248.42
2	AA-02	3.54	25.77	54.82	79.47	0.15	110.51	32.36	38.92	177.87
3	AA-03	3.07	22.68	48.27	69.93	0.16	103.77	31.05	35.38	169.82
MURREE										
4	AA-04	2.52	18.60	39.58	59.66	0.15	107.63	26.51	28.23	169.14
5	AA-05	2.65	19.53	41.56	62.64	0.17	109.96	31.86	29.68	176.82

µg/m³: micrograms per cubic meter
NEQS: National Environmental Quality Standards
PEQS: Punjab Environmental Quality Standards

Table 10.15 above demonstrates that all analyzed environmental parameters at the selected sites of Murree remain within the permissible limits established by the Punjab Environmental Quality Standards (PEQS), 2016 and that of Islamabad conforms to the allowable threshold of National Environmental Quality Standards (NEQS), 2010.

10.11.2 Noise Levels

Major sources of noise observed at the site were traffic / vehicular movement and commercial activities in and around the study area. The detailed results of noise levels have been attached in **Annex-II** of the EIA Study already submitted. The **Table 10.16** shows the noise measurements at five locations indicated that both daytime (72–76 dB (A)) and nighttime (69–73 dB (A)) levels exceeded NEQS/PEQS limits for commercial zones (65 dB (A) day, 55 dB (A) night). Elevated noise levels are primarily attributed to continuous vehicular traffic, tourist inflow in Murree, and ongoing construction and commercial activities in Islamabad

Table: 10.16 Average Concentration of Noise Level

Averaging Time	EQS	PEQS 2010	Unit	Average Concentration of Noise Level in dB (A)				
				Islamabad			Murree	
	Commercial Area			N-1	N-2	N-3	N-4	N-5
Time (06:00 AM to 10:00 PM)	65	65	db (A)	**74.4**	**76.4**	**73.6**	**73.7**	**72.4**
Night-Time PM to 06:00	55	55		**72.4**	**73.1**	**70.7**	**69.1**	**70.3**

10.11.3 Drinking Water Quality

Five groundwater samples were analyzed for physical, chemical, and microbiological parameters, the details are available in **Table 4-17** of the EIA Study already submitted to the client. All parameters complied with NEQS (2010) and PEQS (2016) standards, except for one sample at Chitta-Mor, Murree, where total coliforms (3 MPN/100 mL) indicated minor microbial contamination which is likely from runoff or nearby septic leakage or inadequate protection of water sources from environmental and anthropogenic influences (WHO, 2017; EPA, 2003). Such contamination underscores the need for improved source protection. Overall, drinking water in the Project Area is suitable for consumption after basic disinfection and source protection.

10.11.4 Waste Water Quality

A sample from. Lai Nullah in Islamabad showed all parameters within NEQS (2000) limits for discharge into sewage systems, with BOD = 19 mg/L, COD = 48 mg/L, and TSS = 28 mg/L, indicating moderate organic loading and limited industrial influence. The test results of waste water are shown in Table 10.17 below.

Table: 10.17 Waste Water Quality Monitoring

Sr. No.	Parameters	Unit	Test Results	ischarge into Sewage Treatment NEQS, 2010
1.	Temperature	^{0}C	1.7	≤3
2.	pH	pH unit	7.10	6-9
3.	Total Dissolved Solid (TDS)	mg/l	496.0	3500
4.	Oil and Grease	mg/l	<0.2	10
5.	Biological Oxygen Demand	mg/l	19.0	80
6.	Chemical Oxygen Demand	mg/l	48.0	150
7.	Total Suspended Solid	mg/l	28.0	200

8.	Phenolic Compound	mg/l	<0.01	0.1
9.	Chloride (Cl)	mg/l	68.48	1000
10.	Fluoride (F)	mg/l	0.19	10
11.	Cyanide (CN)	mg/l	<0.01	1.0
12.	Detergent	mg/l	03	20
13.	Sulphate	mg/l	39.51	600
14.	Sulphide	mg/l	<0.4	1.0
15.	Ammonia	mg/l	1.12	40
16.	Silver	mg/l	<0.0032	1.0
17.	Cadmium	mg/l	0.0367	0.1
18.	Chromium	mg/l	0.0914	1.0
19.	Copper	mg/l	0.0057	1.0
20.	Lead	mg/l	<0.013	0.5
21.	Mercury	mg/l	<0.0008	0.01
22.	Nickel	mg/l	0.0424	1.0
23.	Zinc	mg/l	0.1134	5.0
24.	Arsenic	mg/l	<0.01	1.0
25.	Barium	mg/l	<0.031	1.5
26.	Manganese	mg/l	0.1710	1.5
27.	Iron	mg/l	0.7012	8.0
28.	Boron	mg/l	<0.1	6.0
29.	Total Chlorine	mg/l	<0.1	1.0
30.	Selenium	mg/l	ND	0.5
31.	Pesticides	mg/l	ND	0.15
32.	Total Toxic Metals	mg/l	0.1762	2

Mg/l: Milligram per Liter ND: Not Detectable. The above table illustrates that all parameters are well within permissible limits of NEQS, 2000 Standards for Discharge into Sewage Treatment.

10.11.5 Surface Water Quality

Four surface water samples from Rawal Lake, Korang River, Jinnah Stream, and Bansra Gali Waterfall met NEQS (2000) and PEQS (2016) inland water standards. PH values (7.4–7.8) and TDS (261–872 mg/L) were within permissible limits, while heavy metals remained well below threshold levels. The results suggest good surface water quality with no significant contamination observed. The complete surface water quality analysis was carried out and test result are shown in **Table 4-19** of the EIA study already submitted to client.

Figure: 10.15 Pictorial views of the water sampling activity.

	
Ground Water Sampling, Chitta Mor, Murree	Ground Water Sampling Near Ghora Gali
	
Ground Water Sampling Near Malpur	Ground Water Sampling Near Murree Road
	
Ground Water Sampling 9th Avenue I-9/3 ISD.	Surface Water Sampling at Waterfall BansraGali
	
Surface Water Sampling Korang River Tributary	Surface Water Sampling at Rawal Lake

	
Surface Water Sampling at Jinnah Stream	Waste Water Sampling at Lai Nullah

10.11.6 Summary

Baseline monitoring confirms that ambient air, surface water, wastewater, and drinking water within the Study Area are within permissible environmental limits, though localized noise exceeding threshold and minor microbial contamination in one water source highlight the need for continuous monitoring and improved management during project implementation.

10.12 Land Use of the Proposed Project

The alignment of the project passes through diverse terrain which begins in the flat, urbanized zones of Islamabad and extending into the hilly, forested landscape of Murree. Land use along the corridor includes urban settlements, institutional areas, commercial zones, green belts, forest cover, and natural drainage channels (nullahs). Major features include residential neighborhoods, government and private offices, educational and healthcare facilities, religious sites, and transport infrastructure such as roads and the Islamabad Dry Port.

Table: 10.18 Land Use Statistics in the Study Area

Sr. No.	Land Use	Area (Acres)
1.	Forest	1255.64
2.	Built-up	168.97
3.	Graveyard	0.13
4.	Road	119.78
5.	Vacant/Open Spaces/Barren	208.98

(Source: Field Surveys & GIS Analysis, NESPAK 2025)

The Land Use Index Map with detailed maps of the corridor and pictorials illustrating the representative site conditions are provided in Figure 4-13, Annexure-III & Plate 4-5 respectively which have already been provided in the EIA Study to the client.

10.13 Environmental Sensitive Receptors

The sensitive receptors are educational and health institutions, religious sites (mosques, shrines, graveyards), and residential communities, all are located in the Corridor of Influence (COI). Some of the temporary effects on these receptors during the construction phase may include air and noise pollution, vibration, traffic delays as well as limited accessibility caused by construction and site camp. The Index Map of Sensitive Receptors with further mapping details are depicted on **Figure 4-13 & in Annexure-IV** respectively in the EIA study provided to the client.

10.14 Ecological Environment (Quantitative Summation)

The ecological setting in the area of the suggested Islamabad-Murree corridor demonstrates a transition between subtropical scrub and dry deciduous forest in Islamabad toward the moist temperate Himalayan ecosystem in Murree. The gradient provides a lot of ecological diversity in plants, animals and the landscape.

Islamabad Zone

- Elevation: ~500–700 m above sea level
- Climate: Semiarid sub-tropical.
- Rainfall: 800, 1000mm/year (primarily during July September)
- Temperature: 5 ° C (winter) to 42 ° C (summer)
- Humidity: 50–70% average

10.14.1 Floristic Composition

The vegetation is subtropical scrub forests mostly comprising of Phulai (Acacia modesta), Wild Olive (Olea ferruginea), Sanatha (Dodonaea viscosa), Black berries (Monotheca buxifolia) Beri, (Ziziphus nummularia) Royle's Spike Thorn (*Gymnosporia royleana*), Baikarh (*Adhatoda vasica*), Zebrawood (*Pistacia integerrima*), *Tecoma undulate*, and *Capparis decidua* on drier slopes. The Margalla Hills National Park measuring approx. 17,000 hectares has an abundance of more than 300 plant species of which 65 percent are known to have medicinal or economic value.

10.14.2 Fauna/ Wildlife

Islamabad is the only city in the country which has struck a perfect balance between civilized progress and maintaining its wild side too. Different areas in Islamabad are home to various species of wildlife, including monkeys, Golden Jackal, Red Fox, Barking Deer, Porcupine exotic birds and carnivores such as the rare and presently Margalla Common Leopard. Many bird species around 40-50 have been reported in study area which include Black Partridge, Dove, Hoopoe, Spotted Doves and Grey Shrike. Islamabad region

has also reptilian and amphibian species like the Monitor Lizard, Common Krait, Cobra, Bufo bufo and Rana tigrina etc. Deforestation and urban sprawl have also broken up habitats pushing much of the wildlife to the conservation areas.

Murree Zone:

- Elevation: 750–2,300 m above sea level
- Climate: Humid temperate/subalpine.
- Rainfall: 1,700–1,800 mm annually
- Temperature: -2^0 C (winter) to 28^0 C (summer)
- Humidity: 65–85% average

The Murree district has an area of 738 km2 with a population of 372,947 and lies between 33o54'15" N and 73o23'25" E. The elevation of district ranges from 2,500 ft to 7,516 ft. The area has both subtropical and temperate climates and ecological zones. These varying ecological zones support a high degree of plant diversity, including many species adapted to specific altitudes and microclimates. It has a mix of sub-Tropical Broad- Leaved Evergreen Forests, sub- Tropical Chir Pine and Himalayan Moist Temperate Coniferous Forests. In a floral biodiversity survey, a total of 248 species belonging to 56 families were recorded from the area, where Poaceae was the largest family with 48 grass species. This was followed by Papilionaceae with 15, Asteraceae with 10, and Euphorbiaceae with 7 species. The main forest types present in area with their characteristics is as follow.

10.14.3 Subtropical Broad-Leaved Evergreen Forests

The sub-tropical broad-leaved evergreen forests are covering the low ranges of the district in foothills of Himalayas up to 3000-3500 feet. These are immensely important catchment areas of the Rawal and Simli Dams. Dominant tree species of area includes Phulai (Acacia modesta), Wild Olive (Olea ferruginea), and Santha (Dodonea viscosa) — These forest types have been subject to heavy felling and lopping as well as excessive grazing in the past and mostly are in degraded condition.

10.14.4 Sub-Tropical Chir Pine Forests

These are pine (Pinus roxburghii, Quercus incana Oak) forests found at elevation of 900-1700 m in the Western Himalayas within the range of the south-west summer monsoon. These are more or less disintegrated, prone to fire as well, however there is a small overlap with another variant Pinus wallichiana (Kail, Biar) at the upper limit.

10.14.5 Himalayan Moist Temp Temperate Forests

This forest type is characterized by the extensive development of coniferous forests are found over 1,500 m which are rich and dense & forms the ecological backbone of Murree. Dominant trees include Blue Pine (Pinus wallichiana) Silver Fir (Abies pindrow), Spruce (Picea smithiana) Oak (Quercus dilatate, Quercus semicaprifolia) & (Cedrus deodara). These types of forest are located in municipal and cantonment areas of Murree as well as in Patriata area adjacent to Nathiagalli, Dongagalli and Ayubia on the northern and western aspects.

10.14.6 Shrubs & Grasses:

The undergrowth is very scanty and consists of a thin sprinkling of low shrubs like Berberis lyceum (Sumblu), Mysineafricana (Khukhal), Gymnosporearoyaleana (Pataki), Adhatoda vassica (Bhaikar) and Olea cuspidate (Sanatha). Common grasses found in the tract include Cynadon edactylon (Khabbal), Desmostachya bipinnate (Dab) and Chrysopogon echnierlaus.

10.14.7 Fauna

The wildlife consists of different kinds of mammals, reptiles, amphibians and birds. There are approx. 23 species of mammals, include Golden Jackal, Barking Deer, and Rhesus Monkey but a few i.e. Indian Pangolin, common Leopard and Indian flying fox are endangered. As regards birds there are more than 45 species recorded in the list that includes Kalij Pheasant, Great Barbet, Himalayan Bulbul and Griffon Vulture which are in the threatened list. Selective habitat degradation has been caused by livestock and agricultural expansion.

10.14.8 Overall ecological significance:

The corridor propagates a dense bioclimatic gradient of dry subtropical to moist temperate ecosystems, and accommodates more than 400 flora and 100 land-based vertebrate species which include some of endangered ones also.

Nevertheless, human threats of deforestation, change of land use, and automobile pollution continue to mount up, particularly in tear away zones around urban and semi-urban areas. In order to protect and safeguard the biodiversity & ecological protection of this area, reforestation and provisioning wildlife crossings and noise buffers are necessary

Protected Areas:

10.14.9 Margalla Hills National Park (MHNP)

Margalla Hills National Park **(**MHNP) was set up in 1980 and covers approximately 17,386 hectares in the Himalayan foothills of Islamabad containing a variety of subtropical pine and scrub forests. The flora of MHNP is rich and diverse, comprising approximately 600 to 650 plant species, whereas, the faunal diversity of Margalla Hills is equally impressive, with over 600 documented species spanning mammals, birds, reptiles, amphibians, and insects. Mammalian fauna includes approximately 38 species, notable among them being the *Panthera pardus* (common leopard) classified as vulnerable on the IUCN Red List. The park offers very important ecosystem services like watershed management of Rawal Lake and carbon sequestration. Nevertheless, it is subject to city expansion, logging, alien species, and uncontrollable tourism. To maintain the ecological integrity of the conservation of the land, Islamabad Wildlife Management Board IWMB has conservation initiatives such as wildlife monitoring, fire management, reforestation, and awareness programs.

10.14.10 Murree, Kotli Sattian, Kahuta National Parks

The Murree, Kotli Sattian, and Kahuta regions are ecologically significant forest reserves situated in the Himalayan foothills of Punjab, Pakistan, representing vital biodiversity hotspots of pine and oak forest sponsoring leopard, deer, civet and abundant avifauna. Despite its protected status, it faces challenges from poaching, illegal timber extraction, and habitat degradation (WWF Pakistan, 2018). They are ecosystems that are important as they act as watersheds and wildlife corridors but are endangered by deforestation, urbanization and tourism. Their conservation involves strengthening the implementation and enforcement, sustainable land use, and community involvement to sustain conservation.

10.14.11 Nandkot, Salkhetar, Seri-Bari & Murree (Reserved & Guzara Forests)

Guzara Forests are a unique classification of forests found in Pakistan, particularly in the hilly regions such as Murree, Kotli Sattian, and Kahuta. In the context of Murree, Guzara Forests are community-managed forest lands that are owned by the local right-holders but are regulated under the jurisdiction of the Punjab Forest Department. These forests were designated to meet the timber and firewood needs of local communities while ensuring conservation of forest ecosystems, biodiversity, watershed protection and storage of carbon. Nandkot Reserved Forest is situated at an approximate elevation of 1,028 meters near the locality of Phari whereas, Salkhetar Reserved Forest located near Managa Village, at approximately 808 meters elevation. The Seri Bari Reserved Forest is positioned near Kalran in the Murree district of Punjab. These forests dominant flora

species are Chir and Blue Pine, Phulai, Kahu and Oak. Major challenges are overharvesting, encroachment and unregulated tourism, requiring community-based forest management.

10.14.12 Murree Wildlife Park

This Park occupying approximately 240 acres at Bansra Gali sustains a wide range of wildlife and supplements the ecosystem of the Ayubia National Park. It is also an eco-tourism, environmental education and conservation of wildlife in the region.

10.14.13 Crop Pattern

The main agricultural staples are maize, rice (Kharif crops) and wheat (Rabi), in addition to fodder and pulses are also raised in Kharif season.

10.14.14 Crop Yield and Income

Crop yield is usually low due to small land holdings and use of primitive mode of agriculture as shown in **Table 10.19**

Table: 10.19 Crop Yield and Income

Sr. No.	Name of Crop	Yield Per Acre	Income Per Acre
1.	Maize	800 Kg	16,000
2.	Wheat	900 Kg	18,000
3.	Rice	1040 Kg	52,000
4.	Vegetables	-	75,000

***Source**: Agriculture Department, Murree*

10.14.15 Fruit Crops

There are no compact orchards, but there are scanty fruit trees (apple, walnut, apricot, pear, peach) planted on the boundaries of fields and near houses, and some species of these are wild amlok & pear grow along the water streams.

10.14.16 Socio-Economic Environment

The socio-economic environment of the Project Area was assessed in terms of population characteristics, infrastructure, land use, institutions, and quality of life, supported by both primary and secondary data. Field surveys and stakeholder consultations were conducted to gather public opinions and community insights on the proposed Project's implementation.

10.15 Political and Administrative Setup

Islamabad: The Islamabad Capital Territory (ICT), established in 1980, is administered directly by the Federal Government, functioning as both provincial and district authority. It spans 906 km², comprising urban, park, and rural zones with 12 Union Councils and

132 villages. Islamabad Urban area including institutional and industrial area, covering 220 sq.km its Park occupy 220 sq.km and the rural area measures 466 sq.km

Murree: Murree District, formed in 2022 from Rawalpindi, includes two tehsils—Murree and Kotli Sattian and is overseen by a Deputy Commissioner. It is represented through NA-51 (National Assembly) and PP-6 (Provincial Assembly). The district's creation aimed to enhance local governance and disaster management, though several administrative functions remain under Rawalpindi Division.

10.16 Human and Economic Development of Project Area

10.16.1 Population Composition and Demographics

ICT has a population of 2.01 million (2017), growing at 4.91% annually, with a density of 1,165 persons/km². Murree District (2023) has 372,947 people and 66,187 households, with high density (582 persons/km²) and literacy (85.9%).

10.16.2 Religion

Islam dominates both districts 95.5% and 99.61% in Islamabad & Murree respectively. The next higher population percentage is of Christian 4.1% then comes Ahmadis as 3%. The minorities are mostly living in urban settings in both districts.

10.16.3 Ethnic Composition

For the study of ethnography Islamabad can be divided into two parts i.e. urban and rural. Islamabad's rural population mainly comprises Rajputs, Gujjars, Awans, and Syeds, while Murree District is home to a diverse ethnic composition, major tribes include Dhund Abbasi, Dhanyal, Satti, Kethwal, and Jasgam.

10.16.4 Languages / Mother Tongue

The mother tongue refers to the language used for communication between parents and their children in any household. Punjabi (71.6%), Urdu (10%), and Pashto (9.5%) are predominant in Islamabad; Murree primarily speaks Pahari, Hindko, and Urdu.

10.16.5 Migration

Nearly half of ICT's population are in-migrants, mainly from Punjab and Khyber Pakhtunkhwa, indicating strong urban pull factors**.**

10.16.6 Sex Ratio

Proportion of males for every 100 females. According to the census of 2017, the average sex ratio is 111.04 i.e. 108.41 in rural and 113.68 in urban area. In Murree district has a

sex ratio of 101.18 males to 100 females and a literacy rate of 85.90%: 92.13% for males and 79.52% for females

10.16.7 Industrial and Commercial Development

Industrial activity of Islamabad is concentrated in sectors I-9, I-10, and Kahuta Triangle, with 450 industrial plots and supporting markets. Industries include cement, stone crushing, and manufacturing. Murree's economy revolves around tourism and small industries (sawmills, poultry, handicrafts). Ongoing projects such as the PKR 4.5 billion Tourism Development Initiative and real estate ventures like HSQ Tower which aim to modernize infrastructure while preserving heritage, positioning Murree as a key eco-tourism and commercial hub.

10.16.8 Transportation and Communication

The Capital city has a well-planned road network, rail access at Margalla Station, and international connectivity via Islamabad International Airport. Road infrastructure of Murree includes E-75 Expressway and Jinnah Square Underpass, ensuring rapid connectivity with Islamabad. The proposed Kohsar Tourism Expressway will further enhance access. The district enjoys full digital coverage (2G to 5G) and internet services, improving communication and tourism potential.

10.16.9 Educational Facilities

Islamabad is Home to leading universities—NUST, QAU, AIOU, IIUI, Air, and NUML—along with a comprehensive network of colleges and schools comprising of 07 Degree Colleges, 13 Higher Secondary, 79 High Schools, 46 Middle and 216 Primary Schools. There are additional 14 Islamabad Model Colleges. Murree hosts Kohsar University (est. 2020), Lawrence College, PAF College Lower Topa, Cadet College, and historic institutions like the Convent of Jesus & Mary, offering quality education and supporting socio-economic uplift.

10.16.10 Health Facilities

Islamabad: Major hospitals of Islamabad include PIMS, Federal Government Services Hospital, Shifa International, and 35 dispensaries, supported by MCHs and BHUs**.**

Murree: Health services are provided by THQ Hospital, Simly Sanatorium (360 beds), and several BHUs/RHCs. Private facilities such as Farooq Hospital complement public healthcare, ensuring broad medical coverage.

10.16.11 Archaeological and Cultural Heritage

Notable sites of Islamabad include Golra Sharif and Bari Imam Shrines, Faisal Mosque, Lok Virsa Museum, and Shah Allah Ditta Caves reflecting the city's religious and cultural

heritage**.** Murree's heritage includes the prehistoric Riwat Site, colonial landmarks (Holy Trinity Church, Convent of Jesus & Mary), and scenic attractions like Mall Road, Kashmir Point, and Patriata. These sites enhance its cultural identity and tourism value.

10.16.12 Socio-Economics Baseline Survey

A socio-economic survey was conducted in April 2025 using a random sampling technique covering 115 respondents (103 males and 12 females) from communities along the proposed alignment. The objective was to assess the socio-economic profile, perceptions, and anticipated impacts of the Tourist Glass Train Islamabad–Murree Project. Both primary (field interviews, household surveys, consultations) and secondary data (official records and published reports) were utilized to evaluate demographic, economic, and social conditions.

10.17 Survey Findings

Detailed findings of the survey comprising of different parameters are discussed below.

10.17.1 Demographic Characteristics

- **Gender Distribution of the Respondents:** About 115 respondents, comprising 90% male and 10% female population in the Project Area was contacted to carry out socio-economic and impact assessment survey.
- **Gender distribution:** The sample size of 115 person comprises of 90% males and 10% females
- **Population and Family Size:** The surveyed households represent a population of 636 persons out of which 51% were male and 49%were females, with an average household size of 5.6 persons.
- **Age Composition:** About 48% of respondents were of age 46 years or above, 26% were within 36–45 year, 14% were between 26–35 year, and 12% falls in bracket of 15–25 years. These age distributions suggest that the majority of respondents were sufficiently mature to provide informed opinions and express concerns regarding the proposed Project and its potential impacts
- **Education:** Literacy levels are moderate i.e. 86% educated, with 24% matriculate, 14% intermediate, and 16% graduates or above. **Table 10.20** provides clear picture of the education level

Table: 10.20 Educational Level

Sr. No.	Educational Level	Number of Respondent	Percentage (%)
1	Illiterate	16	14
2	Primary	14	12
3	Middle	23	20
4	Matric	28	24
5	Intermediate	16	14
6	Graduation & Above	18	16
Total		115	100

- **Religion & Ethnic Structure:** All respondents identified as Muslim, representing major castes such as Abbasi, Awan, Raja, Chaudhary, Malik, Syed, Qureshi, and Mughal & Lohdi.
- **Languages:** Dominant languages include Hindko (34%), Pothwari (21%), Urdu (18%), and Punjabi (14%), Pashto (8%) & Kashmiri (3%) reflecting cultural diversity of the project area.
- **Family System:** 72% of households follow a nuclear structure, while 28% live in joint families with their Grand patents under same roof.
- **Occupation**

  Livelihoods are diverse: 24% business/shopkeepers, 20% private employees, 17% government workers, 15% laborers, while 9% drivers, 6% mechanics, and 4% hotel operators, farmers 3%. & student 2% form a smaller segment.

Table: 10.21 Occupation of the Respondents

Sr. No.	Profession	Number of Respondent	Percentage (%)
1	Business/Shopkeepers	27	24
2	Private Service	23	20
3	Govt. Employee/ Retired	19	17
4	Labor Workers	18	15
5	Driver	10	9

6	Mechanic	7	6
7	Hotel	5	4
8	Farmers	4	3
9	Students	2	2
Total		115	100

10.17.2 Socio-Economic Characteristics

- **Monthly Income & Expenditure of the Respondents:** the survey shows 24% of respondents belong to the low-income group earning up to PKR 37,000 per month, about 54% of respondents earn between PKR 37,001–67,000/month, while 22% exceed PKR 67,000. On the other hand, expenditure patterns mirror income levels, with 56% spending up to PKR 47,000 monthly, about 25% spend within range of PKR 47,001- 67, while 19% spend over PKR 67,000. **Table 10.22** shows the income and expenditure patterns.

Table: 10.22 Monthly Income & Expenditure of the Respondents

Sr. No.	Average Monthly Income	Average Monthly Expenditures	Nos of Respondent	(%) Income	% Expend
1	Up to 37,000	Up to 37,000	26	24	26
2	37,001 – 47,000	37,001 – 47,000	30	30	30
3	47,001 – 57,000	47,001 – 57,000	14	14	14
4	57,001-67,000	57,001-67,000	11	10	11
5	Above 67,000	Above 67,000	19	22	19
	Total		115	100	100

- **Housing Ownership & Type:** Survey shows that 76% own their homes, 18% live on rent, and 16% occupy land informally. 80% reside in pacca (permanent) houses; the remainder in semi-pacca dwellings.
- **Transport:** 46% respondents use personal vehicles, 22% depend on public transport, and 32% use both.

10.17.3 Civic Amenities

- **Access to Basic Amenities in the Project Area:** Social infrastructure and basic amenities are essential for fostering sustainable communities. Survey results indicate that 97% of households have access to electricity, while only 30% reported access to a water supply. Sui gas was available to 20% of respondents within the Project corridor. Additionally, 63% mentioned having a proper sewerage system
- **Source of Drinking Water and Quality in the Project Area:** Regarding drinking water, 40% rely on boreholes, 34% on springs, 14% on wells, and only 12% on piped supply. 82% are satisfied with water quality & 18 % were dissatisfied with quality due to contamination & brackishness in certain areas.
- **Common Diseases & Health Issues:** Common diseases include respiratory infections, diarrhea, malaria, Influenza, typhoid, and hepatitis. Educational and healthcare services are generally accessible in urban centers, though rural areas remain underserved.

10.18 Awareness and Community Perception

Only 48% of respondents were aware of the Project before consultation. Additionally, the community expressed strong demands for improved access to clean drinking water, Sui gas supply, and enhanced transportation and parking services.

10.19 Perceived Impacts of the Project during & after Construction

- **Perceived Impacts of the Project During and After Construction:** Concerns were raised over land acquisition, tree removal, dust/noise pollution, and traffic congestion. However, respondents acknowledged the potential for temporary job creation and local economic stimulation.
- **Perceived Impacts of the Project during Operational**: The majority anticipate positive outcomes, including enhanced tourism, regional mobility, reduced road congestion, and new business opportunities in hospitality and services. Overall, the Project is viewed as a catalyst for socio-economic uplift of the Islamabad–Murree region.

10.20 Public Consultation and Stakeholder Engagement

Environmental assessment and sustainable development of projects require meaningful stakeholder engagement. Positive consultations lead to improvement of the project design, environmental sustainability and social acceptance, as well as long term collaboration and local ownership.

The project authorities will be made to continuously consult with federal, provincial, and local levels in order to obtain the environmental clearances as well as community support. This chapter defines the nature, goals, and results of consultations that will be undertaken in the course of conducting the IEE study and a guideline of further interaction at the later stages of the project.

10.20.1 Objectives

- The primary goals of stakeholder consultations were to make it open, transparent and inclusive. Key aims included:
- Developing credibility and winning sustained community support in the areas.
- Determining community issues that the project design and mitigation measures need to address.
- Involving stakeholders in the planning and execution. Transparency, conflict reduction & resolution as well as project ownership.

10.20.2 Modes of Consultation

Feedback was collected by means of meetings, interviews and community discussions that improved dialogue and created awareness of project objectives.

10.20.3 Identification of Stakeholders

Stakeholders were identified to ensure effective information sharing, address potential impacts of the project on the physical, ecological and socio- economic conditions and incorporate local concerns.

10.20.4 Primary Stakeholders

Directly affected individuals and groups, including landowners, residents, Project Affected Persons (PAPs), project beneficiaries, and the implementing agency.

10.20.5 Secondary Stakeholders

These are Institutions with regulatory or indirect roles, including Pak-EPA, Punjab EP&CCD, CDA, TMA Murree, Punjab Tourism Development Cooperation of Punjab TDCP, Forest Department, Wild life Department, Islamabad Wildlife Management Board (IWMB) and other line agencies / departments.

Table: 10.23 Roles and Responsibilities of Key Agencies

Stakeholders	Key Role / Responsibility
Pakistan Environmental Protection Agency -EPA	Federal authority for environmental compliance, EIA/IEE approval, enforcing National Environmental Quality Standards (NEQS) and NOC issuance under the PEPA Act 1997.
Punjab Environmental Protection and Climate Control department.	Regulates environmental compliance and NOCs under Punjab Environmental Protection Act 212 amended 2017. EP&CCD is responsible for the compliance of EMP and NOC provision during the construction and operation stages of the Project.
CDA (Environmental Wing)	Ensures environmental management and compliance within ICT; coordinates with Pak-EPA. The Environmental Wing of the Capital Development Authority (CDA) is responsible for ensuring environmentally sustainable urban development within the Islamabad Capital Territory.
Tehsil Municipal Administration (TMA) Murree	Oversees local urban management, sanitation, and compliance with construction bylaws. Its core functions include the provision and maintenance of essential municipal services such as water supply, sanitation, solid waste management, street lighting, and road maintenance. TMA oversees urban planning, public health services, revenue collection, and beautification projects, working to preserve the ecological and scenic character.
Forest Dept. Punjab	Its core roles include enforcing the Punjab Forest Act (amended) and related forestry laws. It manages forest protection, afforestation, and biodiversity conservation. The department also oversees the regulation of timber harvesting, prevention of illegal logging, and control of forest fires. Forest Department supports climate resilience efforts and contributes to national and provincial targets for carbon sequestration and environmental sustainability.
Wildlife Dept. Punjab	Administers wildlife conservation under the Punjab Wildlife Act 1974 Amended. Responsible for the conservation, protection, and management of wildlife and their habitats across the province.

	The department plays a vital role in ensuring compliance with National and International Conservation Agreements, including CITES.
IWMB	It is a statutory body established under the Islamabad Nature Conservation and Wildlife Management Act, 2023, tasked with the conservation, protection, and sustainable management of wildlife and natural habitats within the Islamabad Capital Territory (ICT). Protects and manages Margalla Hills National Park and biodiversity within ICT. Its roles include monitoring wildlife populations, preventing illegal hunting and poaching, conducting ecological research, and engaging communities and stakeholders in nature conservation.
TDCP	Promotes tourism development and sustainable eco-tourism in Punjab. It promotes Punjab's diverse cultural, historical, and natural attractions through various marketing strategies, including participation

10.21 Consultation Process and Approach

Consultations were conducted at both departmental and institutional levels to ensure comprehensive coverage of key concerns. Activities included formal meetings, semi-structured interviews, and field discussions with potential Project Affected Persons (PAPs), local communities and the general public residing in the area. Consultations were conducted at two level i.e. Departments and Institutions Levels.

10.22 Departmental Consultations:

Meetings were held with officials from Pak-EPA, Punjab EP&CCD, CDA, TMA Murree, Forest and Wildlife Departments, IWMB, and TDCP in April 2025.

10.23 Key Issues and Recommendations:

- Obtain NOCs from relevant environmental, forest, and wildlife authorities.
- Minimize tree cutting; implement a Tree Management and Replantation Plan.
- Explore alternative alignments or elevated designs to protect sensitive habitats and their fragmentation and reducing adverse impacts on native flora and fauna.
- Ensure environmental monitoring in National Park areas.
- Control and minimize noise and vibration during construction phase.
- Integrate eco-friendly design compatible with the natural landscape

Figure: 10.16 Pictorial View of the Departmental Consultations



Meeting with Director EIA/Monitoring, Pak- EPA



Meeting with Dy. Dir. Environment- I CDA



Consultation with Director Wildlife, IWMB



leeting the Assistant Director Wildlife Murree



Meeting Astt. Dir. (Field),Murree-Punjab EP&CCD



eeting with Regional Manager, TDCP Murree.



Consultation with DFO Murree



Consultation with TMO Murree

10.24 Institutional Consultations

Consultations were conducted with representatives from educational and industrial institutions (IMSB Malpur, Karlot College, Iqra University, Trimna Model School, and Ittehad Steel Industry).

Figure: 10.17 Pictorials of the Institutional Consultations



eeting with Dir. Karlot Residential- Collage



eeting with Dy. Registrar Iqra University



Representative Ittehad Steel Industry



Meeting IMSB T-V Boy Model School, Malpur.

10.24.1 Key Concerns and Suggestions

- Stations should be strategically located near settlements to ensure accessibility for local communities.
- Avoid construction near educational institutes during school hours.
- Implement dust and noise mitigation measures (e.g., sprinkling, barriers).
- Provide student fare discounts and ensure accessible station locations.
- Maintain access to industrial and residential areas during construction.
- Ensure parking facilities and local employment opportunities

10.24.2 Overview **of Stakeholder Feedback**

In general, the stakeholders were very positive about the Tourist Glass Train Project as it has the ability of encouraging the concept of eco-tourism, improving mobility and the creation of jobs.

10.24.2.1 Major suggestions included

- Investing in the protection of the environment and conservation of forests.
- Maintaining constant liaison with the regulatory bodies.
- Involvement of local communities in the construction and operations.

- Protecting scenic appeals and reducing habitat disturbance.

10.24.3 Community Consultation and Participation

In order to get community perception towards the potential impacts of the Project during and after the construction, meetings were conducted with the local residents, tourists and Project Affected Persons (PAPs) within the Corridor of Impact (COI). The consultations were carried out in a transparent manner, and the participants were free to share their thoughts. The informal group discussion was also conducted to evaluate local expectations, issues, and possible social and environmental.

10.24.4 Methods of Consultation

Public consultations with Project stakeholders is carried out to ascertain their stakes regarding Project.

- Community and public meetings
- Individual interviews with locals and PAPs

People of surrounding communities (males and females) were also consulted along with general public (randomly selected) who were residing or working in the surroundings (COI) of the proposed Project.

10.24.5 Categories of Stakeholders

Stakeholders engaged during consultation which included Tourist, Local residents and communities, Business/shop owners, Government and private employees

10.24.6 Community Consultations

Extensive consultations were conducted across multiple settlements along the proposed alignment. Participants were briefed on Project objectives, design, and implementation stages using design maps and explanatory sessions. Questions and feedback focused on land acquisition, compensation, mobility, safety, and livelihood restoration. Consultation was carried out individually and in groups totaling 153 participants across 14 venues in Islamabad and Murree between January and April 2025.

10.24.7 Key Concerns and Recommendations

- **Livelihood & Land Acquisition:** Ensure fair, market-based compensation before civil works.
- **Mobility & Access:** Provide alternate routes and minimize disruption during construction.
- **Health & Safety**: Implement strict safety, dust, and noise control measures.
- **Public Utilities:** Restore disturbed social amenities before commencing works.

- **Traffic Management**: Develop site-specific diversion and management plans with traffic police.
- **Gender Sensitivity:** Schedule works to minimize movement restrictions, especially for women.
- **Employment: Prioritize** hiring local skilled and unskilled labor.

10.24.8 Community Suggestions

- Maintain affordable fare structures and ensure accessibility for locals.
- Create employment and small business opportunities (e.g., kiosks, refreshment stalls).
- Provide organized parking at stations.
- Enhance passenger comfort and promote eco-tourism.
- Address Murree's existing parking and congestion issues.

10.24.9 Gender Consultations

Recognizing the vital role of women in local society, gender-focused consultations were held in Malpur, Trimna, and Mall Road in April 2025 with 37 female participants. Most women initially lacked awareness of the Project but expressed strong support after being briefed.

10.24.10 Key Gender Concerns and Responses

- Mobility and Access: Construction will be scheduled to avoid disrupting women's daily movement; alternate routes will be provided.
- Privacy: Workers will stay within designated camps; local labor hiring prioritized. Privacy barriers will be installed near schools.
- Health & Safety: Dust and noise will be minimized through regular sprinkling and restricted work hours.
- Employment: Specific job opportunities for women will be included in Project and tender documents.
- Facilities: Separate waiting areas and toilets for women will be incorporated in station designs.

10.24.11 Additional Suggestions:

- Maintain lower fares than existing transport services.
- Provide parking facilities for daily commuters.
- Extend the train route to Muzaffarabad.
- Allocate dedicated female compartments for safety and comfort

10.25 Proposed Consultation Program

Stakeholder engagement will continue throughout construction, operation, and closure phases to ensure transparency, reduce conflicts, and enhance community ownership.

10.25.1 Objectives

- Maintain communication between Project promoters and stakeholders.
- Disseminate key Project information and solicit feedback.
- Address grievances promptly and effectively.
- Incorporate stakeholder inputs to minimize impacts and maximize local benefits.

10.25.2 Key Activities

- Periodic updates on environmental and social management measures.
- Regular community meetings to discuss project progress and issues.
- Maintenance of an active grievance redress mechanism.

10.25.3 Proposed Consultation Framework

A frame work for consultation with different stake holder groups was made which is shown as in **Table 10.24** below.

Table: 10.24

Stakeholder Group	**Project Phase**	**Frequency**
Government Institutions / Departments	Pre-implementation, Construction, Operation, Closure	Once before implementation, biannually during operation, and once at closure
Local Communities/ Key Persons	All phases	Pre-construction and periodic meetings during construction and at completion
NGOs / CBOs	All phases	needed, depending on Project requirements

A During the operational phase of the Project, consultations with stakeholders are important to assess the benefits of the Project and impacts on the local community's comprehensive stakeholder engagement plan will be prepared by the contractor to ensure continued dialogue, timely resolution of issues, and sustained community support throughout the Project lifecycle.

10.26 Environmental Impacts and Mitigation Measures

This section offers identification of the key environmental and social impacts, both beneficial and adverse expected during the design/pre-construction, construction, and operation phases of the proposed project. It also provides mitigation and remedial actions to reduce the negative impacts in physical, ecological and socio-economic spheres. The evaluation determines the possible effects on air, water, soil and flora, fauna and the local communities. These impacts have been systematically assessed and rated with the formulation of a Project Impact Evaluation Matrix.

10.26.1 Notion of Significance

The impacts are classified according to direction (positive/negative), duration (short/long-term), area (local/wide) and impact (direct/indirect). Significance is dependent on the amount of impact and also on the sensitivity of the receptor which is very low, low, moderate, high and very high. All impacts of moderate or greater importance are suggested to be mitigated, although there may remain some residual effects even after the mitigation.

10.26.2 Impact evaluation methodology.

Two types of tools are used for impact assessment.

10.26.2.1 Impact Evaluation Matrix

Impact Evaluation Matrix is created by aligning the project activities in one axis (i.e. Y-axis) and on the other axis (i.e. X-axis) the various environmental parameters that will be impacted by the proposed group of project actions categorized into various groups i.e. physical, ecological and socio-economic environment. **Table (6.1)** of the EIA study already submitted to client provides Project Impact Evaluation Matrix.

10.26.2.2 Overlays

GIS-based mapping of land use, infrastructure and vegetation and other features based on spatial analysis to determine areas that may be impacted.

10.26.3 Study Area / AOI Delineation

The Area of Influence (AOI) is the area that is about 25 meters in the outside of the project boundary, which registers areas where project effects, both direct and indirect, can be experienced. **Figure (1.2)** of the EIA study already submitted shows AOI.

10.27 Potential Environmental Impacts and Mitigation Measures

The proposed Project may cause notable adverse environmental impacts during its three key phases are Pre-Construction, Construction, and Operation & Maintenance (O&M).

The Pre-Construction Phase involves site investigations (topographical, geotechnical, and seismic studies) and design activities, Construction Phase covers all activities from contractor mobilization to project completion, whereas, Operation & Maintenance Phase includes routine inspection, maintenance, and repair works. Potential impacts and corresponding mitigation measures have been identified for each phase to minimize effects on the local environment and ensure compliance with environmental standards.

10.27.1 Potential Environmental Impacts; Pre-Construction / Design Phase

This phase includes all activities prior to construction, such as design finalization, route alignment, site selection, investigations, and establishment of preliminary facilities. Though physical works are limited, this stage determines the magnitude of many future environmental and social impacts. Proper environmental integration in design is therefore critical. A matrix has been constructed which explains potential environmental impact as under in **Table 10.25.**

Table: 10.25 Potential Impacts and Mitigation Measures (Pre-Const. / Design Phase)

Aspect Component	Potential Environmental Impact	Significance	Proposed Mitigation / Management Measures
Topography & Terrain	Hill cutting, valley filling, and tunneling may alter natural topography, induce slope instability, erosion, and drainage disruption.	High	• Adopt minimal-cut alignment using tunnels and viaducts. • Stabilize slopes with retaining structures and vegetation. • Restore contours and landscape aesthetics post-construction.
Route Optimization	Inappropriate alignment may disturb ecosystems or require community displacement.	High	• Select alignment through multi-criteria analysis considering

Aspect Component	Potential Environmental Impact	Significance	Proposed Mitigation / Management Measures
			environmental, social, and technical constraints. • Avoid forests, settlements, mosques, graveyards, and water bodies.
Design Responsiveness	Poor design may cause operational inefficiencies, safety issues, and public dissatisfaction.	Moderate	• Integrate environmental design principles, ensure safety and accessibility. • Optimize material use and minimize natural system interference.
Infrastructure Design (Stations, Buildings)	Inadequate drainage, sanitation, or waste management may create hygiene issues and nuisance.	Moderate	• Incorporate proper sewerage, storm-water, and solid-waste systems. • Ensure compliance with municipal building and environmental by-laws.
Level Crossings Safety	Poorly designed crossings may cause accidents and electrocution risks.	High	• Provide automatic or manned barriers, warning lights, alarms, and pedestrian gates. • Ensure visibility

Aspect Component	Potential Environmental Impact	Significance	Proposed Mitigation / Management Measures
			and signage at crossings.
Hydrology & Drainage	Disruption of natural flow paths may lead to flooding, erosion, or foundation failure.	High	• Design culverts and drainage based on hydrological data. • Avoid blocking natural drains; provide lined channels and sediment traps.
Seismic Risk	Project area lies in Seismic Zone 2B–3; inadequate design could endanger structures.	High	• Design all structures as per *Seismic Building Code of Pakistan (SBC-07)*. • Conduct site-specific seismic studies.
Construction Camps (Planning Stage)	Poor siting may cause vegetation loss, sanitation issues, and community conflicts.	Moderate	• Select sites away from settlements, water bodies, and reserved forests. • Provide waste disposal, drainage, and sanitation systems. • Avoid involuntary resettlement.
Material Transport Planning	Haulage routes may increase dust, noise, and traffic congestion.	Low–Moderate	• Designate approved haul routes; enforce transport safety and

Aspect Component	Potential Environmental Impact	Significance	Proposed Mitigation / Management Measures
			dust suppression measures. • Schedule transport to minimize disturbance.
Noise & Vibration (Design Basis)	Improper design may result in excessive operational noise and vibration levels.	Moderate	• Use composite/disc brakes, noise barriers, and acoustic grinding for track maintenance. • Maintain buffer distances near sensitive receptors.
Public Utilities	Relocation of utilities may disrupt power, water, and communication services.	Moderate	• Coordinate with utility departments early. • Prepare relocation plans prior to construction.
Emergency Management	Lack of preparedness for fire, earthquakes, or other disasters.	High	• Integrate fire stations, emergency exits, and escape routes. • Develop and implement an *Emergency Response Plan (ERP).*
Flora / Vegetation	Site clearance may cause tree loss and habitat disturbance.	High	• Obtain NOCs from Forest Department. • Jointly mark trees for removal; avoid

Aspect Component	Potential Environmental Impact	Significance	Proposed Mitigation / Management Measures
			vegetated areas. • Implement compensatory afforestation (at least 3:1).
Fauna / Wildlife	Noise and movement may disturb local fauna and migratory species.	Moderate	• Avoid critical wildlife areas and routes. • Fence camps and properly dispose of waste. • Restrict night-time vehicular activity.
Biodiversity & Conservation	Potential habitat fragmentation and loss of ecological integrity.	High	• Implement Biodiversity Management Plan. • Provide wildlife crossings and green buffers. • Prevent introduction of invasive species.
Traffic & Safety	At-grade crossings may lead to congestion and accidents.	Moderate	• Construct grade separations, warning systems, and signage. • Enforce penalties for safety violations.
Land Acquisition & Resettlement	Permanent land take and displacement of structures.	High	• Minimize acquisition through design optimization. • Ensure fair

Aspect Component	Potential Environmental Impact	Significance	Proposed Mitigation / Management Measures
			compensation as per *Land Acquisition Act 1894.*
Temporary Land Use	Use of private/barren land for camps and borrow areas.	Low	• Obtain short-term lease agreements. • Restore land to original condition after use.
Agriculture	ROW clearance may affect crops and livelihoods.	Moderate	• Compensate for crop losses at market rates. • Restrict activity to defined ROW.
Structures & Community Assets	Possible impact on residential/commercial units or religious sites.	High	• Provide full replacement cost for affected structures. • Consult communities before relocation of sensitive structures.

The Pre-Construction / Design Phase has moderate to high-level potential effects on the topography, drainage, biodiversity and socio-economic conditions. Nevertheless, these impacts can be mitigated to reasonable levels through eco-friendly design, seismic resistant construction, best route alignment and proper stakeholder consultation. It is essential to incorporate the environmental aspect in the design phase to reduce the residual effects, as well as make sure that the project is implemented sustainably.

10.27.2 Potential Environmental Impacts during Construction Phase

The construction phase of the project may cause short- to medium-term adverse impacts on the physical, ecological, and social environment. These effects are mostly localized and temporary but require proper management to avoid long-term degradation. The

matrix depicting the aspect, environmental impact and mitigation action is shown below in **Table 10.26**

Table: 10.26 Environmental Impacts and Mitigation Measures during (Const. Phase)

Aspect/ Competent	**Potential environmental Impacts**	**Significance**	**Proposed Mitigation / Management Measures**
Air Quality Deterioration	Dust emissions, vehicle exhaust, and asphalt fumes affecting air quality.	High	Regular water sprinkling, vehicle maintenance, covering of materials, enforcing speed limits, and siting plants away from communities.
Noise and Vibration	Noise from machinery, piling, and vehicular movement disturbing public and fauna.	High	Use noise barriers, restrict night work, maintain machinery, provide PPE, and monitor noise levels.
Soil Erosion / Contamination	Excavation and spills leading to soil degradation.	Moderate	Proper drainage, avoid stockpiling on slopes, and ensure spill containment and cleanup plans.
Water Pollution	Runoff and waste discharge polluting surface/ground water.	High	Install sedimentation pits, manage wastewater, avoid direct discharge, and store fuels in band areas.
Solid Waste Generation	Improper disposal causing site pollution.	Moderate	Segregate, recycle, and dispose waste at approved sites; maintain cleanliness at camps.
Construction Camp Sanitation	Poor hygiene, wastewater and waste causing health issues.	Moderate	Provide toilets, safe drinking water, proper drainage, and regular disinfection.

Aspect/ Competent	Potential environmental Impacts	Significance	Proposed Mitigation / Management Measures
Traffic and Access Disruption	Construction activities hindering public movement.	Low	Prepare traffic management plan, provide signage, and coordinate with local authorities.
Utilities Interference	Damage to underground or overhead utilities.	Moderate	Identify existing utilities before work, coordinate with departments, and ensure timely restoration.
Material Handling / Storage	Spillage, dust, and safety hazards.	Low	Cover materials, provide impermeable flooring, and ensure safe lifting practices.
Borrow Areas and Quarries	Land degradation and dust nuisance.	Moderate	Use approved sources, rehabilitate borrow areas, and control dust and noise.
Spoil Disposal	Unplanned dumping affecting landscape.	Moderate	Select approved disposal sites and stabilize slopes.
Drainage Blockage / Flooding	Blockage by debris leading to localized flooding.	Moderate	Maintain drainage paths and regular clearance of channels.
Natural / Manmade Disasters	Earthquakes, fires, or site accidents causing injury and loss.	Moderate	Develop ERP, conduct safety drills, display emergency numbers, and train workers.
Occupational Health & Safety (OHS)	Injuries, exposure to dust, noise, welding hazards, and fatigue.	High	Enforce PPE use, safety training, first aid, emergency plan, and

Aspect/ Competent	Potential environmental Impacts	Significance	Proposed Mitigation / Management Measures
			compliance with ILO standards.
Community Health & Safety	Accidents, pollution, and disease transmission affecting locals.	High	Restrict access, control dust/noise, provide diversions, manage spills, and conduct awareness programs.
Communicable Diseases	Spread of COVID-19, HIV/AIDS, and other infections.	High	Implement SOPs, maintain hygiene, conduct awareness campaigns, and coordinate with health units.
Gender-Based Violence (GBV)	Harassment and exploitation due to labor influx.	Moderate	Enforce GBV policy, conduct gender awareness training, provide separate facilities, and monitor compliance.
Child Labor	Use of underage labor in construction.	Low	Verify worker age, raise awareness, enforce ILO Convention 138, and penalize violations.
Resource Conservation	Overuse of nonrenewable materials and fuels.	Moderate	Use low-Sulphur fuels, maintain machinery, minimize waste, and install solar power at camps.
Discovery of Heritage Sites	Damage to archaeological or cultural artifacts.	Moderate	Stop work, notify DG Archaeology, and follow Chance Find Procedure.

Aspect/ Competent	Potential environmental Impacts	Significance	Proposed Mitigation / Management Measures
Flora	Vegetation loss, tree cutting, and dust impacts.	High	Avoid tree removal, replant 10:1 ratio, prepare afforestation plan, and ban open fires.
Fauna	Disturbance and displacement of wildlife.	High	Ban hunting, avoid night works, inform Wildlife Dept., manage waste, and minimize noise.
Loss of Habitat	Destruction of wildlife habitats and biodiversity.	High	Restrict clearing, avoid blasting in breeding season, implement reforestation, and engage ecologist.
Social / Cultural Conflicts	Tensions between workers and locals.	Moderate	Prefer local hiring, cultural sensitivity training, and regular public communication.
Economic Activity	Employment and commercial opportunities.	Moderate	Maximize local labor and procurement to enhance economic benefits.

10.27.3 Potential Environmental Impacts & Mitigation Measures (Operational Phase)

During operation, the project's environmental impacts are generally moderate to low and manageable through standard O&M practices, **Table 10.27** below explains. Proper wastewater and waste management, ecological restoration, and a robust emergency response system will ensure environmental protection. Positive socio-economic and air quality benefits will outweigh the residual adverse impacts.

Table: 10.27 Potential Environmental Impacts & Mitigation Measure (Operational Phase)

Aspect	Potential Impact	Significance	Mitigation / Management Measures
Surface Water	Risk of pollution from untreated sewage, accidental spills, or leakage along the track.	Moderate & manageable	Implement spill contingency plan and maintain rolling stock and tracks. Ensure all wastewater is treated to NEQS/PEQS standards through septic tanks, oil separators, or municipal treatment systems.
Drinking / Internal Water System	Contamination from unclean storage tanks or corroded pipelines causing health issues among employees.	Moderate & manageable	Install adequate filtration units. Clean storage tanks quarterly and monitor water quality per PEQS/NEQS standards.
Solid & Hazardous Waste	Generation of litter, food waste, plastics, metals, and possible hazardous wastes from maintenance activities leading to drainage blockage, pollution, and health hazards.	Low and manageable	Develop a comprehensive waste management plan. Place color-coded bins, segregate waste at source, and ensure daily housekeeping. Compost biodegradable waste and dispose residual

Aspect	Potential Impact	Significance	Mitigation / Management Measures
			waste via certified contractors. Conduct regular track inspections to remove hazardous materials.
Emergency Preparedness / Disaster Management	Fire, derailment, oil spills, brake failures, floods, or terrorism posing risks to life and property.	Low and manageable	Formulate ERP in line with NDRP in coordination with NDMA. Train staff in emergency response and conduct regular fire and evacuation drills. Maintain firefighting equipment and display emergency contacts at stations.
Air Quality	Overall improvement in ambient air due to modal shift from road to rail; reduced GHG emissions (CO, NO_x, SO_x).	Moderate & manageable	Promote public transport integration to sustain modal shift benefits. Maintain efficient train operations and energy use to minimize emissions.
Ecology and Biodiversity	No major adverse impacts anticipated; reduced vehicular emissions will improve ambient environment.	Low and manageable	Implement compensatory afforestation for removed trees and maintain for five years. Coordinate with Forest/Wildlife

Aspect	Potential Impact	Significance	Mitigation / Management Measures
			Departments for habitat enhancement programs. Restrict access to protected or ecologically sensitive zones. Prohibit hunting or disturbance of wildlife.
Socio-Economic Conditions	Improved connectivity, job creation, and business opportunities; enhanced tourism potential and road safety.	Moderate & manageable	Maximize local employment and business participation. Promote tourism support facilities and community engagement programs.

During operation, the project's environmental impacts are generally moderate to low and manageable through standard O&M practices. Proper wastewater and waste management, ecological restoration, and a robust emergency response system will ensure environmental protection. Positive socio-economic and air quality benefits will outweigh the residual adverse impacts. In essence, the consultation process has provided valuable insights into community expectations and environmental sensitivities. These have been integrated into project planning to enhance social acceptance, minimize environmental impacts, and ensure sustainable and inclusive implementation of the Glass Train Project.

10.28 Environmental Management Plan (EMP)

Essentially, EMP is a practical instrument that does not leave behind any environmental protection measures when planning, constructing and running a project. It also lays down definite responsibility, monitoring and capacity building facilities to ensure

adherence to the national environmental policies and the sustainability development goals.

The Environmental Management Plan (EMP) is used to establish a methodical approach of taking and observing the mitigation measures to facilitate environmental sustainability of the project. It provides measures of how to control physical, ecological and socio-economic effects through design and construction and operation, institutional roles, monitoring and budget requirements.

10.28.1 Environmental Management Plan Components

The EMP incorporates the objectives, scope, legislation & framework, institutional framework, mitigation and monitoring matrices, implementation planning, training & capacity building, documentation, management plans (e.g., chance find, emergency, waste), public disclosure and EPM cost estimations.

10.28.2 Objectives of the Environmental Management Plan (EMP)

- Identify project impacts, propose mitigation measures, and define related implementation activities.
- Ensure timely corrective actions through systematic environmental monitoring.
- Establish procedures for responding to unforeseen environmental issues.
- Clarify roles and responsibilities of PMA, Contractors, and Consultants for effective environmental and social management.
- Define monitoring mechanisms, parameters, and reporting schedules to verify implementation of mitigation measures.
- Develop training and capacity-building programs for project stakeholders.
- Specify resource needs and financial arrangements for EMP execution.
- Outline documentation and reporting requirements to ensure regulatory compliance**.**

10.29 Institutional Framework

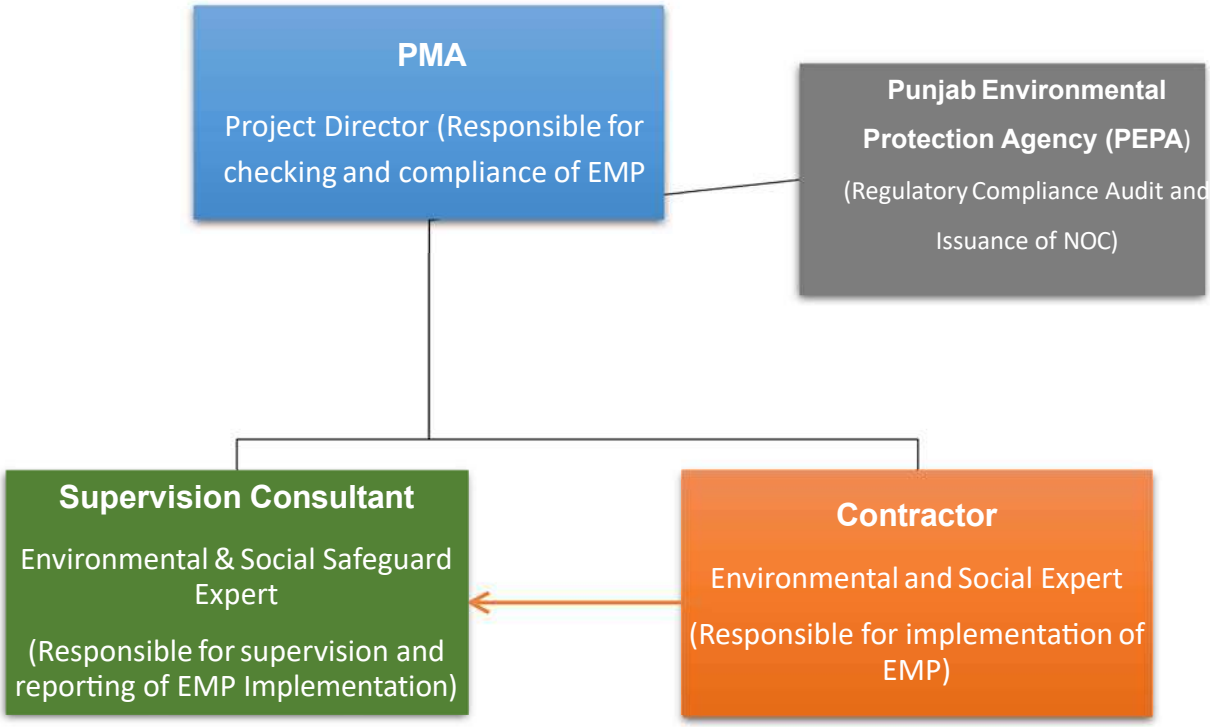
The institutional requirements for the Construction and Operation & Maintenance (O&M) phases are detailed as under.

10.29.1 Institutional Setup for Implementation and Management of EMP

The key players involved during construction phase of the proposed Project are, PMA as employer/proponent, PEPA, the Supervisory Consultant (SC) and the Contractor/ its environmental representative. The employer/ proponent (PMA) will make Contractor bond through contract documents to implement the EIA including EMP and other terms and conditions of the Environmental Permit. The EMP will be included as a clause of the

contract documents. The organizational setup for implementation of EMP during construction phase is provided in **Figure 10.18**

Figure: 10.18 Organizational Setup for the Implementation of EMP at Construction Stage



10.29.2 Roles and Responsibilities for EMP Implementation (Const. Phase)

10.29.2.1 PMA (Proponent)

Setting up systems for environmental management & general responsibility for EMP implementation, coordination, training and compliance reporting to EPA. Assessment of the crops, trees, valuation of property (if any), public utilities and negotiation with the affected for fixation of compensation to be paid for temporary as well as permanent acquisition of the land

10.29.2.2 Supervision Consultant (SC)

Monitors and supervises compliance & performance of the contractor, provides environmental and social monitoring, capacity building and reporting. Inspect, supervise and monitor all the construction and allied activities related to the EMP for the project and oversee the performance of the Contractor to make sure that the Contractor is complying with EMP & suggest any additional mitigation measures (if required)

10.29.2.3 Contractor/ Environmental Manager

Responsible to take mitigation actions at the site with the help of a qualified Environmental and Social Expert (ESE), prepares Site-Specific EMPs, provides worker safety, and adheres to a Code of Conduct covering EHS, community relations, waste management and anti-harassment policies**.**

10.29.2.4 Punjab EPA

PEPA is the regulatory authority for issuance of NOC for the proposed Project. As part of its mandate, protection of environment is their responsibility. Therefore, the agency will undertake an environmental audit (as and when required) of the activities of the Project (both phases i.e. Construction and Operation) with respect to the protocols as defined in EMP and in NOC

10.29.3 Institutional Arrangement for Implementation of EMP (O&M Phase)

The implementation and compliance of EMP will be controlled by PMA through its District Support and Monitoring Department. Plantation programs will be tracked by an Environment and Social Expert who will also deal with the unexpected effects and coordinate with the EPA and other departments where necessary.

10.30 Environmental Mitigation and Management Matrix

Environmental Mitigation and Management Matrix (EMMM) are considered as one of the main elements of EMP. The EMM establishes particular effects, mitigation activities, monitoring metrics, agencies to be accountable and the schedules of implementation of all project stages. In order to have effective management of the environment, contractors will prepare localized EMPs in accordance with this framework. The design-phase EMP emphasizes preventive measures through eco-sensitive design, hazard resilience, safety integration, and social safeguards. Early-stage planning, engineering refinement, and institutional coordination, especially between the design consultant, PMA and regulatory bodies are critical to ensuring long-term environmental and social sustainability. **Table 10.28** below provides the EMM plan

Table: 10.28 Environmental Mitigation and Management Plan – Design / Pre-Construction Phase

Sr. No.	Environmental Impact	Key Mitigation / Management Measures	Performance/ Monitoring Indicators	Responsibility
1	Topography & Landscape Alteration	Use of special machinery to minimize cutting Retain natural contours through slope stabilization Retaining walls, gabions, and erosion control provision of drainage system Integrate landscaping and tree plantation.	Design incorporation audits Site inspections.	Design Consultant (Impl.) Proponent (Monit.)
2	Route/ Alignment Optimization	Route selected to avoid settlements, ecological and cultural sites; minimize displacement and ecological disturbance through GIS-based route planning.	Design verification; environmental audits.	Design Consultant / Proponent
3	Environmental Responsive Design	Optimize layout to reduce natural resource use; avoid forests and watercourses; comply with national/international engineering codes.	Design conformance checks.	Design Consultant / Proponent
4	Station & Building Infrastructure	Integrate proper drainage, sewerage, and solid waste systems; ensure storm-water management and culvert provision.	Design reviews; audit records.	Design Consultant / Proponent

Sr. No.	Environmental Impact	Key Mitigation / Management Measures	Performance/ Monitoring Indicators	Responsibility
5	Level Crossings & Safety	Include barriers, signals, signage, alarms, and communication systems at crossings; consider automated or manned controls.	Design compliance verification.	Design Consultant / Proponent
6	Hydrology & Drainage Pattern	Maintain natural drainage; properly grade and align culverts; design per local flood history; prevent erosion and waterlogging.	Design audit; hydraulic checks.	Design Consultant / Proponent
7	Seismic Risk	Apply Seismic Building Code of Pakistan (SBC-07); conduct geotechnical and seismic hazard studies; design for Zone 2B–3 conditions.	Design certification; audit review.	Design Consultant / Proponent
8	Site Selection of Construction Camp	Select non-residential, non-flood-prone, environmentally neutral sites; ensure adequate sanitation and waste disposal; avoid sensitive habitats.	Site selection approvals; design audit.	Design Consultant / Proponent
9	Noise & Vibration	Incorporate low-noise braking systems (disc/composite); apply acoustic barriers and rail dampeners; plan buffer vegetation.	Design incorporation confirmation.	Design Consultant / Proponent
10	Public Utilities Relocation	Identify affected utilities early; include relocation costs and coordination with departments in design.	Utility relocation plan approval.	Design Consultant / Proponent

Sr. No.	Environmental Impact	Key Mitigation / Management Measures	Performance/ Monitoring Indicators	Responsibility
11	Emergency Management	Provide firefighting and emergency response facilities; include Emergency Response Plan in design.	ERP inclusion verification.	Design Consultant / Proponent
12	Flora & Vegetation Loss	Avoid vegetated areas for camps or access roads; compensate tree removal with replantation; coordinate with Forest Dept.	Site audits; vegetation records.	Design Consultant / Proponent
13	Fauna & Habitat Disturbance	Avoid wildlife routes and sensitive habitats; obtain NOCs for works in national parks; implement waste controls to deter animals.	Wildlife and NOC compliance reports.	Design Consultant / Proponent
14	Traffic & Safety Management	Introduce grade separations, signals, barriers, and pedestrian overpasses; enforce fines; plant noise barriers near sensitive receptors.	Safety design verification; audit records.	Design Consultant / Proponent
15	Land Acquisition & Resettlement	Minimize acquisition through alignment refinement; follow Land Acquisition Act 1894; ensure compensation and grievance redress.	RAP approval; audit and consultation records.	Design Consultant / Proponent
16	Structures (Private / Public)	Conduct inventory and valuation; compensate at replacement cost; ensure consultation and timely resettlement.	Verified compensation and consultation documentation.	Design Consultant / Proponent
17	Community & Religious Sites	Modify alignment to avoid mosques and graveyards; if unavoidable, relocate in	Design verification; consultation records.	Design Consultant / Proponent

Sr. No.	Environmental Impact	Key Mitigation / Management Measures	Performance/ Monitoring Indicators	Responsibility
		consultation with affected communities.		

Environmental Management and Monitoring Plan (EMMP) — Construction Phase

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
19	Topography	Reuse excavated material in backfilling or aggregate production. Prepare and implement a Borrow Area Management Plan prior to extraction. Dispose of surplus spoil at designated, approved sites. Restore disturbed sites post-construction.	Visual inspection and photographic record. Approved borrow area and disposal plan. Site restoration report.	Implementation: Contractor Monitoring: PMA / SC
20	Soil Erosion & Contamination	Strip, store, and reuse topsoil separately Protect stockpiles from wind/rain and keep ≥50 m from water bodies. Restrict heavy	Visual inspection. Maintenance and leakage records. Waste disposal logs. Site rehabilitation verification.	Implementation: Contractor Monitoring: PMA / SC

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
		machinery to work zones. Regularly inspect equipment for oil/fuel leaks and repair immediately. Dispose of spoils at LWMC-approved sites. Avoid wash water discharge into soil; pave washing yards. Stabilize exposed areas through grass/shrub planting post-works.		
21	Geo-Hazards (Landslides / Slope Instability)	Conduct geotechnical investigations to assess slope stability and hazard-prone areas. Adopt slope protection (retaining walls, drainage, bio-engineering) where needed. Avoid excessive cutting/filling at tunnel portals. Stabilize spoil tips and cut slopes promptly.	Slope monitoring reports. Visual inspection and photographic record. Geo-hazard mitigation plan compliance.	Implementation: Contractor Monitoring: PMA / SC
22	Water Quality Degradation	Dispose effluents and wastewater as	Water quality testing reports.	Implementation: Contractor

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
		per PEQS. Locate camps with natural drainage; prevent runoff contamination. Provide sedimentation and oil traps for wastewater. Avoid discharge of debris and waste into drains or streams. Conduct regular surface and groundwater quality monitoring. Maintain storm water flow through proper drainage.	Effluent treatment records. Visual inspection of drains.	Monitoring: PMA / SC
23	Air Quality Deterioration	Maintain all vehicles and machinery; enforce PEQS for emissions. Cover material trucks and avoid overloading. Sprinkle water on exposed surfaces. Ban open burning of waste. Install filters/scrubbers on batching and asphalt plants. Prohibit unnecessary idling of engines.	Air quality monitoring reports. Vehicle maintenance logs. Water sprinkling records. Visual checks.	Implementation: Contractor Monitoring: PMA / SC

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
		Provide masks to workers.		
24	Noise & Vibration	Maintain equipment and restrict noisy activities to daytime (0600–2200 hrs). Use noise barriers near sensitive receptors (schools, hospitals, mosques). Inform communities prior to blasting or high-noise work. Comply with NEQS noise limits. Schedule construction to minimize disturbance.	Noise level monitoring results. Equipment maintenance logs. Grievance or complaint records.	Implementation: Contractor Monitoring: PMA / SC
25	Borrow Areas / Open Pits	Obtain permits and follow approved Quarry/Borrow Area Management Plan. Limit excavation depth ≤1.5 m (≈5 ft) with slope ≤1:4. Prevent erosion and restore site post-use. Avoid mosquito breeding in stagnant water. Ensure rehabilitation per Annex-IV guideline.	Permit and NOC records. Visual inspection. post-restoration report.	Implementation: Contractor Monitoring: PMA / SC

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
26	Construction Camps Operation	Select sites away from communities and ecologically sensitive areas. Employ local labor to minimize conflict. Prepare and enforce Camp Management & Waste Plans. Provide safe water, sanitation, and solid waste facilities. Conduct cultural awareness and safety training. Restore site post-demobilization.	Camp audit checklists. Waste management compliance. Training attendance records. Visual inspection.	Implementation: Contractor Monitoring: PMA / SC
27	Wastewater Generation (Camps)	Install septic tanks and soakage pits for domestic wastewater. Monitor effluent quality for PEQS compliance. Prevent discharge into drains or surface water. Submit site-specific wastewater management plan.	Effluent quality test results. Visual inspection. Plan implementation record.	Implementation: Contractor Monitoring: PMA / SC
28	Solid Waste Generation at Construction Camps	Segregate, reuse, and recycle solid waste. Dispose of non-recyclable waste at approved landfill	Waste volume & disposal logs. Oil recovery records. Visual inspection.	Implementation: Contractor Monitoring: PMA / SC

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
		sites. Store used oil in secure containers and hand over to licensed recyclers. Train staff in waste handling and emergency spill response. Implement Construction Waste Management Plan.	Spill response records.	
29	Traffic Congestion & Safety	Restrict heavy vehicle movement during peak hours. Prepare and implement Traffic Management Plan (Annex-VI). Provide signage, diversions, and flagmen. Park vehicles at designated sites. Repair damaged roads promptly.	TMP compliance reports. Traffic incident records. Visual inspection.	Implementation: Contractor Monitoring: PMA / SC
30	Greenhouse Gas (GHG) Emissions	Maintain machinery to improve fuel efficiency. Prohibit engine idling and train drivers on fuel conservation. Use low-Sulphur fuels. Encourage	Vehicle inspection & maintenance logs. Fuel consumption records. Plantation records. Air quality reports.	Implementation: Contractor Monitoring: PMA / SC

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
		renewable energy sources where feasible. Implement tree plantation (1:10 ratio). Enforce PEQS for gaseous emissions.		
31	Natural & Man-made Disasters	Prepare and implement Emergency Response Plan (ERP). Conduct safety drills and training for staff. Display emergency contact numbers. Record and analyze near-miss incidents.	ERP document & training, records Emergency drill reports Visual inspections	Implementation: Contractor Monitoring: PMA / SC
32	Occupational Health & Safety (OHS)	Provide PPEs and ensure compliance. Conduct OHS and HSE trainings Maintain first aid kits, ambulance, and safety signage. Implement emergency management plan.	PPE usage logs Training attendance Incident & injury records	Implementation: Contractor Monitoring: PMA / SC

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
33	Community Health & Safety	Restrict public entry near active sites. Maintain vehicle speed limits and signage. Control spillage and dust. Conduct awareness on road safety and communicable diseases. Manage labor influx and community interaction.	Community complaint logs Medical & accident records HSE inspection reports	Implementation: Contractor Monitoring: PMA / SC
34	Communicable Diseases (COVID-19, HIV/AIDS)	Run awareness and health campaigns. Implement COVID-19 SOPs. Maintain hygienic labor camps with proper waste management. Strengthen local health facilities.	Health screening reports Hygiene inspection records	Implementation: Contractor Monitoring: PMA / SC
35	Resource Conservation	Use efficient machinery and low-sulfur fuel. Turn off idle equipment. Promote water and material reuse. Implement solar	Fuel/water consump. logs Audit and inspection reports	Implementation: Contractor Monitoring: SC / PMA

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
		energy and waste minimization measures.		
36	Gender-Based Violence (GBV)	Enforce Gender Protection SOPs. Conduct GBV awareness sessions. Provide gender-segregated sanitation facilities. Prevent harassment and intimidation at worksites.	GBV training & awareness records Complaints redressal logs	Implementation: Contractor Monitoring: PMA / SC
37	Child Labor	Strictly prohibit underage labor. Verify CNICs of all workers. Conduct community awareness sessions. Include labor clauses in contracts.	Worker verification logs Site inspection records	Implementation: Contractor Monitoring: PMA / SC
38	Chance Finds / Cultural Heritage in Excavation	Follow Chance Find Procedure (Annex-X). Immediately notify Directorate of Archaeology upon discovery.	Chance finds records Official notifications	Implementation: Contractor Monitoring: PMA / SC
39	Flora (Tree Cutting & Loss of Vegetation)	Avoid unnecessary tree cutting. Implement compensatory	Tree cutting & plantation records Visual inspections	Implementation: Contractor Monitoring: PMA / SC

Sr. No.	Environmental Social Impact	Mitigation Measures	Performance / Monitoring Indicators	Responsibility
		plantation (1:10 ratio). Obtain tree-cutting NOC. Use gas for cooking, prohibit open fires.		
40	Fauna (Wildlife Disturbance)	Prohibit hunting and trapping. Limit noisy works, especially at night. Properly dispose waste to avoid attracting wildlife.	Visual observations Wildlife incident reports	Implementation: Contractor Monitoring: PMA / SC
41	Loss of Habitat	Avoid vegetation clearance in sensitive areas. Implement afforestation and habitat restoration. Avoid construction during bird breeding season.	Tree plantation plan Ecologist's inspection reports	Implementation: Contractor Monitoring: PMA / SC
42	Social / Cultural Conflicts	Prefer local hiring. Conduct public awareness and notification campaigns. Train workforce on local cultural sensitivity.	Community feedback Site inspection reports	Implementation: Contractor Monitoring: PMA / SC

Environmental Mitigation and Management Plan – Operational Phase

Sr. No.	Aspect / Impact	Mitigation Measures	Performance/ Monitoring Indicators	Responsibility
43	Surface Water Pollution	Treat all wastewater before discharge; install oil separators and septic tanks; implement spill contingency and emergency response plans.	Water quality monitoring; spill response readiness.	PMA / O&M Contractor → EPA
44	Drinking Water Contamination	Install filtration units; regularly clean overhead tanks; conduct quarterly water quality testing.	Water test results meeting PEQS/NEQS standards.	PMA → EPA
45	Waste Generation (Solid & Hazardous)	Implement waste segregation and color-coded bins; compost biodegradable waste; dispose residuals through certified vendors; conduct regular housekeeping.	Waste management records; site cleanliness; inspection reports.	PMA / Sanitation Contractor → EPA
46	Air Quality Improvement	Promote modal shift to rail; maintain rolling stock and equipment; monitor emissions annually.	Air quality data showing reduced CO, NOx, SOx; maintenance logs.	PMA / Transport Dept → EPA
47	Noise & Vibration	Use low-noise braking systems; maintain rail track; install noise barriers near sensitive receptors.	Noise monitoring results ≤ NEQS limits.	PMA / O&M Contractor → EPA

Sr. No.	Aspect / Impact	Mitigation Measures	Performance/ Monitoring Indicators	Responsibility
48	Ecological Impacts	Implement compensatory plantation plan; maintain vegetation for at least 5 years; collaborate with Forest/Wildlife Depts on habitat restoration.	Plantation survival rate; ecological monitoring reports.	PMA / Forest Dept → EPA
49	Emergency Preparedness & Disaster Management	Develop and implement ERP as per NDRP; train staff; conduct regular fire and evacuation drills; maintain emergency contacts.	Drill records; updated ERP; incident response logs.	PMA / NDMA → Local Authorities
50	Energy Use & Efficiency	Adopt energy-efficient lighting and systems; promote renewable energy for station operations.	Energy audit results; reduced consumption trend.	PMA → Energy Dept
51	Socio-economic Benefits	Maximize local employment; encourage small business development near stations; enhance tourism through improved mobility.	Employment statistics; socio-economic survey outcomes.	PMA / Local Govt
52	Traffic & Safety	Maintain functional signaling and communication systems; ensure trained operators; enforce safety protocols.	Safety audits; incident records; compliance reports.	PMA / Traffic Police

Sr. No.	Aspect / Impact	Mitigation Measures	Performance/ Monitoring Indicators	Responsibility
53	Public Health & Safety	Maintain cleanliness at stations; ensure proper lighting, sanitation, and crowd control.	Station inspection reports; complaint records.	PMA / O&M Contractor
54	Institutional Strengthening	Conduct regular staff training in OHS, environmental compliance, and emergency response; establish environmental monitoring unit.	Training attendance; compliance audit results.	PMA / EPA

KEY: DC--- Design Consultant, CC--- Construction Contractor, SC—Supervision Consultant.

10.31 Environmental Monitoring

Environmental monitoring will be systematically conducted during construction and operation to ensure compliance with Punjab Environmental Quality Standards (PEQS, 2016). PMA will lead implementation with support from contractors and supervision consultants. Mitigation and monitoring actions will be reinforced by training, documentation, and stakeholder engagement. The EMP cost, estimated at PKR 26.54 million, covers environmental testing, audits, safety measures, and capacity building, ensuring sustainable and compliant project execution.

10.31.1 Objectives of Construction Phase

- Assess actual environmental impacts on physical, biological, and socio-economic receptors.
- Recommend corrective measures for unanticipated or excessive impacts.
- Ensure legal and safety compliance at construction sites.
- Monitor rehabilitation of borrow areas, restoration of camps, and safe waste disposal**.**

10.31.2 Objective of Operation Phase

- Evaluate the adequacy of EIA predictions and long-term impacts.
- Assess effectiveness of mitigation measures and propose improvements.
- Compile periodic environmental monitoring reports.

10.31.3 Monitoring Strategy

The Punjab Mass Transit Authority (PMA) will oversee all monitoring activities and share periodic reports with Punjab EPA. Monitoring will focus on water, air, soil, noise, and ecological parameters at sensitive locations. The detailed monitoring schedule and parameters are summarized in **Table 10.29** below.

Table: 10.29 Summarize Environmental Monitoring Schedule

Receptor	**Monitoring Parameters**	**Monitoring Mechanism & location**	**Frequency**	**Responsible**
Water Quality	Physical, chemical, biological parameters (PEQS 2016)	Visual checks & sampling. Drains, distributaries & other effluent points	Quarterly (Const.), Biannually (Ops.)	PMA / Contractor
Soil Contamination	Heavy metals, effluents, solid waste residues	Visual checks & sampling. Project Area, washing yard & construction camp	Quarterly (Const.), Biannually (Ops.)	PMA / Contractor
Dust & Air Quality	PM_{10}, $PM_{2.5}$, CO, NO_x, SO_x, Lead	Visual checks& monitoring. Residential, education & health and religious places.	Quarterly	PMA / Contractor
Noise Levels	Day and night levels (dB(A))	Visual checks& monitoring. Residential, education & health and religious places.	Quarterly	PMA / Contractor

Receptor	Monitoring Parameters	Monitoring Mechanism & location	Frequency	Responsible
Ecology	Habitat disturbance, tree cutting, wildlife interference	Visual checks& monitoring. Natural habitat in project area	Continuous visual checks	PMA / Contractor
Worker Safety	PPE use, accident logs, health checks	Accident misses records, medical surveillance at construction site.	Quarterly	Contractor
Site Restoration	Waste removal and reinstatement	Visual inspection. Construction site and camp sites	Post-construction	Contractor

10.31.4 Responsibilities and Reporting

- **Construction Phase:** Contractor conducts monitoring under supervision of the **Supervision Consultant (SC)** and submits quarterly and final reports to PMA and Punjab EPA.
- **Operation Phase:** Concessionaire conducts biannual monitoring through **EPA-certified labs**; results compared to PEQS and reported annually to EPA.

10.32 Estimate for Environmental Monitoring & Compliance

Total estimated cost for environmental monitoring and compliance is PKR 2.88 million (Const. & Ops. Phases). Annual monitoring cost will escalate by 10% per year during operation.

Refer to Table 7.3 for parameter-wise breakdown of the EIA Study already provided to client.

10.32.1 Tree Plantation

To offset vegetation loss, PMA will implement a Compensatory Plantation Plan in coordination with the Forest Department/CDA, maintaining a 1:10 replacement ratio for all felled trees. The detailed plan will be finalized after assessing the total number and species affected.

10.32.2 Training and Capacity Building

A targeted Environmental and Social Training Program will strengthen institutional capacity for EMP implementation. PMA will engage a Technical Assistance (TA) Consultant to train project staff, contractors, and supervision consultants.

10.32.3 Objectives

- Establish effective environmental and social management systems.
- Build staff capacity in pollution control, monitoring, and health & safety.
- Conduct specialized training on air, water, and noise monitoring.

A three-day training session before and during construction is to be carried out for capacity building & technical assistance of PMA and Environmental staff and workers. The Cost Estimates is PKR 0.9 million.

10.32.4 Communication and Documentation

A planned communication system will ensure transparency, accountability & decision-making.

- **Data Recording:** Standardized forms for all monitoring and compliance data.
- **Database:** Include information of training, staffing, non-compliances, and corrective actions, environmental data i.e. soil, land, air and water pollution Disposal of waste water, water resources, fuel oil and chemical spills, vegetation record etc.
- **Meetings & Reporting:** Monthly and quarterly review meetings with formal reporting.
- **Complaint Register:** For documenting and addressing public grievances.
- **Photographic Records:** Visual evidence of site conditions and mitigation activities.
- **Non-Compliance Management:** Deductions in contractor payments for EMP violations.

10.32.5 Periodic Review

10.32.5.1 Social Complaint Register

The Contractor will maintain a register of complaints record from local communities and measures taken to mitigate these concerns

10.32.5.2 Photographic Records

Contractors will maintain photographic records during the implementation of the proposed Project. As a minimum, the photographic records will include the site photographs, all the roads, camp sites and monitoring activities, etc.

10.32.5.3 Non-Compliance of the EMP

The implementation of the proposed EMP involves inputs from various functionaries. The Contractor will be primarily responsible for ensuring implementation of the mitigation measures proposed in the EMP, which will be part of the contract documents. The provision of the environmental mitigation cost will be made in the total cost of Project, for which the Contractor will be paid on the basis of monthly compliance reports. However, if the Contractor fails to comply with the implementation of EMP and submission of the monthly compliance reports, deductions will be made from the payments to the Contractor claimed under the heads of environmental component

10.32.6 Management Plans

The Contractor will prepare detailed site-specific management plans, to be approved PMA before mobilization.
These include:

- Tree Plantation / Reforestation Plan
- Health, Safety & Environment (HSE) Plan
- Emergency Preparedness Response Plan
- Waste & Resource Management Plans
- Site Restoration & Rehabilitation Plan
- Drinking Water & Sanitation Plan
- Traffic & Quarry Management Plans
- Change Management Plan

10.32.7 Public Disclosure

PMA will disclose the EIA and Executive Summary (Urdu version) to all stakeholders before construction. Copies will be available at PMA offices, construction sites, and on the PMA website to ensure community awareness and transparency.

10.32.8 Conclusion and recommendations.

This Environmental Impact Assessment (EIA) has been developed based on the following requirements: Pakistan Environmental Protection Act, 1997; Punjab Environmental Protection Act, 2017 (Amended); and the Review of IEE/EIA Regulations, 2022. The

research is in accordance with national environmental assessment procedures and guidelines to be able to be regulatory and environmentally sustainable.

10.32.8.1 Conclusion

The EIA assessed in detail the physical, ecological and socio-economic environment that was likely to be impacted by the proposed Project. It was evaluated through field research, consultation with the stakeholders and primary and secondary data, which were analyzed. The major possible effects during the pre-construction, construction, and operation stages are

- Border loss and disturbance of wildlife habitat
- Slope instability and other geo-hazard risks
- Construction activities and road traffic Air and noise pollution
- Accidental spills, surface runoffs, and disposal of waste on the soil and water
- Temporary impediment to community access, movement and local actions
- Occupational health and safety hazards of the workers and their neighbors

The results show that the proposed Project will not be a threat to the environment in critical and irreversible ways. But there can also be moderate and local effects, which need suitable mitigation. The Project will allow reaching environmental sustainability and long-term socio-economic advantages with the strict observance of the Environmental Management Plan (EMP), compliance with the best practices in the design, and the effective afforestation program.

10.32.8.2 Recommendations

As a measure to ensure that the environmental, health, and safety issues are properly addressed, the following are some of the measures that can be suggested

- **EMP Implementation:** Implement the mitigation and monitoring provisions contained in the EMP in all phases of the Project in a strict manner.
- **Design Standards:** Make sure that you use the compliance with Seismic Building Code of Pakistan (2007) and all the special standards of construction.
- **Construction Camps:** Set up camps and laydown areas in the environmentally acceptable points, accepted by PMA and the concerned authorities.
- **Health and Safety:** Design and adopt an extensive Health, Safety and Environment (HSE) Management Plan, which encompasses the mandatory use of Personal Protective Equipment (PPE), emergency preparedness and training.
- **Waste Management:** Develop and implement a Solid Waste Management Plan on how waste is to be collected, segregated, recycled and safely disposed of both during construction and operation.

- **Local Employment:** Create as many jobs as possible to the locals to improve the acceptance of the community and socio-economic welfare.
- **Afforestation and Landscape:** Provide adequate funds to compensatory tree plantation in liaison with Forest Department and CDA, where 10 trees should be planted in every one lost.
- **Pollution Control:** Avoid water and soil pollution by making sure that fuel and chemicals are well stored and wastewater collected in septic tanks and soakage pits. Reduce dust-emission by sprinkling the construction machinery with water and by performing frequent maintenance on the equipment. Regulate noise and vibration through planning of high noise activities and proper maintenance of equipment.
- **Monitoring and Reporting**: Carry out frequent environmental observations in accordance with the EMP and provide compliance reports to PMA and EPA Punjab. The Bidding Documents are to be integrated. It is necessary to incorporate the price of environmental mitigation and monitoring, as well as training into the bidding documents of the contractor to guarantee the responsibility and distribution of resources.

10.33 Final Statement

To sum it up, the proposed Project could be applied without leaving significant or irreparable environmental damage under the condition of strict implementation of all the mitigation and monitoring measures. Through the successful application of the EMP, the Project will improve the diaspora of the region, ensure sustainable transport, and add as a positive factor to the environmental and socio-economic development goals.

11. Electric Power Study

11.1 Introduction

The Government of Punjab has introduced a transformative scheme to establish a scenic rail link between Rawalpindi/Islamabad and Murree, designed to enhance accessibility for both the public and tourists. This initiative aims to provide an alternative and sustainable transportation mode for tourists, many of whom currently rely on private vehicles to reach Murree. By reducing vehicular traffic, the Glass Train project is envisioned as a step towards sustainable tourism and improved accessibility. Previous work by Pakistan Railways on a rail linkage between Rawalpindi/Islamabad and Murree forms a foundational basis for this project, which will address gaps in earlier studies and propose a viable connection to the Murree hilltop at an elevation of approximately 2,000 meters.

11.2 Scope of Services for Electric Power Study

- Methodology for Electric Distribution
- Approach and Methodology
- Review/Preparation of Feasibility Study
- Design Works
- MV (11kV)/LV Networks
- Station Electrification
- Lighting Design
- Preparation of Design Criteria, Specifications, Bill of Quantities and Cost Estimate
- Preparation of Final Feasibility Level Design Documentation.

11.2.1 TOR for the Electric Power Study

The Electrical Power Study includes, according to the TOR, the evaluation of electricity requirements for official and residential buildings at various stations along the proposed alignment, identification of source of supply and purchase of electricity, description of the distribution network for the supply of electricity to stations, yards, residential buildings, tunnels and signaling equipment and examine the electric power generation for proposed Islamabad – Murree Monorail Link.

- Electricity requirements for the official and residential buildings.
- Identification of source of supply and purchase of electricity.
- Distribution network for the supply to stations, yards, residential/office

buildings, colonies and signaling equipment etc.

- Electric power generation, if required.

11.2.2 Environmental Conditions

The electrical design will be based on the following environmental conditions as given in **Table 11.1**

Table: 11.1

Extreme maximum air temperature	50ºC
Extreme minimum air temperature	-10ºC
Maximum rainfall	350 mm
Minimum rainfall	20 mm
High relative humidity	85 - 95%
Low relative humidity	35 - 40%
Elevation above sea level	1500 meters

Design ambient temperature for cable ratings will be 30ºC, when buried directly and 50ºC when installed in air.

11.2.3 Categories of Electrical Loads

The schedules of load during detailed designing phase will be subdivided into various categories of load for each category. The connected loads will be categorized as

- Essential
- Non-essential, and
- Standby loads.

All load calculations and distribution system will be designed according to the load requirements.

11.2.4 Essential Loads

Equipment running without interruption will be connected with power supply system having backup power supply, like train operation system, signaling system and partial lighting system.

11.2.5 Non-Essential

Non-Essential loads are switched on and off automatically or manually in response to process requirements, like plate form lighting, yard lighting, station building lighting and other railway offices etc.

11.2.6 Standby loads

Standby loads are loads that are not normally running. For instance, in a system if two parallel pumps have been installed, one will act as stand pump and will be required to run when other has stopped working.

11.3 Electrical System for Buildings

Primary power for each building facility shall be properly designed to supply adequate power with sufficient capacity for expansion. If the building is in close proximity to an electrified railroad track, specific care should be taken to bond exterior metal in order to minimize the potential for electric shock and stray current.

11.4 Cables and cable routes

Within the buildings cables and wires with enhanced fire-resistant properties are to be used. The insulating and cladding mixtures must be:

- Halogen-free,
- Low-smoke, and
- Non-toxic as far as possible.

The trays for cables and wires are to be jointly determined by the expert planners for building equipment and appliances and the architect. The particular problem of the thermal load in emergency routes should be noted. High voltage cables and cables for information technology that use the same cable routing systems, building inlets or similar facilities must be laid according to the specifications. They are to be laid in an electromagnetically separated and bundled manner. The metal cable receptacles and installation channels are to be equipped with a separating steel plate strip. When the laying takes place in multi-cable supports, for example in the ceiling cavity above suspended ceilings, the minimum electrical spacing between the cables and wires are to be adhered to as well. Furthermore, fire protection measures must be observed and applied to the cable trays.

Cable systems for emergency lighting and fire-protection appliances are to be constructed in such a way that they can ensure functional integrity of at least 30 minutes in case of fire.

11.5 Electric circuits

For switches and sockets the standard models are to be used. Lights and sockets are principally to be connected to separate circuits. For the sockets located in corridors and used for cleaning appliances, separate circuits are to be planned. These electric circuits are also intended to incorporate the water heaters / boilers of the cleaning rooms - except if these water heaters should be controlled separately for energy-related reasons. For each workspace two sockets 240V for general appliances and two-three sockets 240V information & communications technology (ICT) appliances should be planned. For the sake of circuit segmentation and cross-section assessment it must be observed that the maximum permissible voltage drop is not exceed the permissible limit. Furthermore, a maximum of 12 sockets for general appliances or a maximum of 10 sockets for ICT should be connected to a 240 V electric circuit.

11.6 Fire safety

The installation of the electrical facilities depends on the constructional fire safety of the building. Should fire safety concepts be available, then these also serve as a mandatory requirement for the electrical installation. The following aspects are to be noted in particular:

- Cables and wires are not allowed to abet or contribute towards a spreading of a fire into other fire sections
- In case of fire, electrical installations belonging to essential safety systems have to re-main functional for a specified time
- In escape and rescue routes the development of smoke, burning and fire must be prevented by means of building measures

11.7 Main Components of Electrical Power Supply System

- Electrical power system and its main components comprise the following:
- Low Voltage Power Distribution
- Electrical Protection System
- Lighting Protection and Overvoltage Protection
- Low Voltage Switch Gear
- Lighting System
- Cables
- Tunnel Lighting if required
- Ventilation, Firefighting and De-watering arrangements in tunnels
- Standby Diesel Generators

11.8 Low Voltage Power Distribution

The objective of the electrical system design is to satisfy the electric supply requirements and to maximize the availability and reliability of the equipment, besides personnel safety, keeping in view the following requirement.

11.9 System Voltage / Frequency

The system voltage levels will be 415 Volts for 3 phase and 230 Volts for single phase requirement on 50 Hz frequency.

11.10 Electrical Protection System

11.10.1 Protection against inadmissible contact voltage

For the electrical systems and operating resources, protective measures against undue contact voltage are to be met. Insulation class II operating resources should be used.

11.10.2 Overvoltage protection

Protective measures against overvoltage are to be planned and intended to protect the facilities and devices.

11.10.3 Electromagnetic compatibility

The facilities are to be installed, dimensioned and arranged in such a way that the regulations relating to transient emissions and immunity to interference in electric and magnetic fields are adhered to.

11.10.4 Electromagnetic fields

The facilities are to be installed, dimensioned and arranged in such a way that the regulations relating to the electric and magnetic fields in respect to their impact/influence on humans are adhered to. This is valid for energy-related facilities as well as for telecommunication facilities (e.g., mobile phone antennas). The electrical protection system would also take into account the following measures:

- Motor Starting
- Electrical System Operating Conditions
- System Fault Levels
- System Overloads

The following protection measure would also be provided for major installations:

- For Feeders and Interconnectors
    - Over Current
    - Earth Fault
- For Motors

- Short circuit
- Overload
- Single Phasing
- Earth Fault

11.11 Lighting Protection and Overvoltage Protection

11.11.1 Brief Description

In order to avoid damage caused by overvoltage, measures for exterior and interior lightning protection according to IEC 62305 -1 to IEC 62305 - 4 are required. Particularly, if electronic components are installed (building automation systems, computers, alarm/security systems) the necessary requirements (potential equalization, screening, overvoltage protection) are to be determined. An exterior lightning protection consisting of arrester, conductor and earthing system according to EN 62305-3 is to be installed.
In the buildings overvoltage protection devices (SPDs = Surge Protective Device) serving to incorporate the energy- and ICT-relevant cables and wires into the potential equalization are to be hierarchized with respect to their protection level and surge arresting capacity. Within the building installation area, type 1, 2 and 3 SPDs are used according to the requirements and overloads.

11.11.2 Earthing

The objective of earthing is to eliminate danger to personnel and to minimize disturbance and damage to equipment arising from:

- Faults between live conductors, equipment and steel structure
- Lightning

Single core stranded copper conductors with a green or green and yellow sheath, will be used for making all earthing and bonding connections. Where a copper bar is installed, it will be made clearly recognizable by means of identification markers colored green and yellow. Earth conductors will be design according to IEC standard, for the prospective fault current available at their point of installation.

11.11.3 Electrical System Earthing

For safety of personnel, all major electrical equipment such as motors, cable armoring, cable trays, motor starters, switch gears and transformers etc., will be earthed to clear fault in the least possible time. The earthing system will consist of main earthing ring with multiple earth electrodes. From the earth ring, connections will be established to earth rods. The earthing system will provide minimum earth resistance.

11.11.4 Lightning Protection

The protection of structures against lightning will be carried out in accordance with above mentioned IEC standards. Columns and other structures will be earthed against lightning by two separate connections to earthing system.

11.11.5 Bonding

All metallic equipment, whether electrical or not, will be effectively bonded by provision of earth continuity bonds. Armor of multi-core power cables will be bonded to earth at both ends of the cable.

11.11.6 Low Voltage Switchgear

Low voltage switchgear, Motor control centers and distribution boards are generally factory-built assemblies, which are designed and tested to perform to local standards. Main incoming supplies, bus sections, bus bars and bus riders will be rated to carry full load current capacity. All switchboards/distribution boards and MCCs will use ACBs, MCCBs or MCBs of suitable ratings and short circuit capacity for both incoming and outgoing circuits.

Motors starters in motor control center will comprise MCCB, Magnetic Contactor and thermal overload relay with phase failure protection.

11.12 Lighting Systems

11.12.1 Lighting Intensity

The lighting system will be designed to provide the following illuminations levels both for Interior and Exterior Lighting.

- Stairways 150 lux
- Control Room 400 lux
- Offices 400 lux
- Meeting Room 400 lux
- Reception Area 200 lux
- Washroom 150 lux
- Station Hall 200 lux
- Parking Area 50 lux
- Street lighting 50 lux

11.12.2 Indoor Lighting

Fluorescent lamps with electronic starters, metallic halide lamps, compact fluorescent lamps and LED lamps will be installed in the buildings. The planned alignment of lights can be taken from the layout plans of the buildings. In the subsequent planning phase,

the lighting planning should be adapted on the basis of a binding setup plan, as only this approach enables optimal solutions. The alignment of lights conforms to the purpose of the respective room. Hereby it has to be considered that when designing a workplace disrupting dazzling effects, reflections or mirroring is avoided. The lights shall be aligned parallel to the main line of sight and therefore parallel to the main window front. Generally, no lamps are to be located directly above the workplaces in order to avoid glare by reflection on the screens.

Plan and guidelines for indoor lighting system are given below:

- Wiring for light fixtures, will be carried out with PCV cables of 600-volt grade in PVC pipes concealed in walls and concrete roof slabs. Possibilities of running cable trays in railway stations and tunnels will be ascertained and carried out, if required.
- In all rooms, switches, switch-socket outlets etc. will be installed on bake painted M.S steel embedded junction boxes.
- The switches and sockets will be of flush type and will be rated at 5/13/15/20A single phase 230V and 32/63A, 1 or 3 Phase wall mounted industrial sockets.
- All indoor lighting, in general, will be of fluorescent, LED or PLCE type in low ceiling areas. High bay lighting will be provided on ceiling above 5.5m.
- "Emergency" lighting will be installed to illuminate critical areas, to function as exit lighting. Emergency lights will be of LED type, with battery backup.

11.12.3 Outdoor Lighting

For the outdoor lighting of track areas, sodium vapor high-pressure lamps with low-loss ballast [LLB], metallic halide lamps and LED lamps are to be used. Lighting systems on platforms, approach routes and rail yards must fulfill the requirements outlined below:

- Lamp castings and switch cabinets in safety class II
- Lamp fittings with an optimal degree of efficiency in relation to the application (light distribution curve) for the photometric requirements
- UV-resistant
- Inherent stabile
- Lamps must open from the bottom without use of tools
- Arrester devices for detachable parts, no losable small parts
- Stain-resistant and easy to clean
- Manufacture/finish; no edges and burrs, clean cable feeding systems, no ragged surfaces for pigeons and dirt.
- External lighting cables will be multi-core, 1000 Volt, PVC/PVC/Cu laid underground. The cables will be laid in UPVC pipes were crossing the roads. Multi-core cables will be terminated by using proper sizes cable lugs. The cable

will be terminated in a junction box provided with the lighting poles.

- Station lighting circuits, street, fence and area lighting will be designed for automatic switching by an intelligent lighting system such as C-Bus will be provided with manual override.
- Electric supply for the relevant external lighting distribution board will be made from the Main Lighting Circuits and will be individually protected by circuit breakers.
- Weather proof light fixtures with LED lights, will be used for area, street and fence lighting. For Floodlights, a pole with a height of 10 – 12 m will be used. Floodlights will be mounted on top of the pole by means of suitable brackets.

11.12.4 Emergency Lighting in the Buildings

The emergency lighting is a part of the general lighting system. Correspondent lights are equipped with an emergency light device in order to ensure continuous operations in case of a power cut. The escape route and important work places are illuminated with a compulsory minimal illumination level. Emergency facilities can therefore be clearly recognized. The safe exiting of the rooms or facilities is thereby ensured for all the time periods in which persons are present in the building. A minimum illumination level of 1 lx and a service life of 1 hour are to be maintained.

11.12.5 Platform lighting

- Platform lighting is essential to safety and security at station facilities. When platforms are properly illuminated, it will enhance station safety as well as its security. Passengers will perceive greater security when platforms are properly illuminated and such illumination will provide for increased safety of the passengers as they board and de-board trains.
- Fixtures used for platform lighting should be waterproof and vandal resistant. Fixtures should preferably be canopy mounted, with captive fasteners on lenses and refractors. The lighting of possible access stairs and barrier-free ramps is to be considered. The color rendering properties are to be chosen in such a manner that the safety colors are discernible. For the use of fluorescent lamps, the luminous color 840 is to be selected. If LED lights are used, then the luminous color must be 4000 K. A deviation of 200 K is admissible.
- Lighting systems are to be distributed onto the individual phases and electric circuits in such a manner, that a preferably even illumination of the platforms and access paths is maintained, should individual circuits break down.
- In placing lighting standards, consideration should be given to a safe method of revamping and servicing the fixtures without having to remove adjacent tracks

from service. Platform lighting should standardize the type and wattage of lamps to minimize maintenance cost. Use of longer than 48 inch (1.2 m) fluorescent lamps on platforms should be avoided. If train schedules result in lengthy periods with no public use of the platform, consideration should be given to reducing the lighting to a "security" mode by switching off 40-60% of fixtures during these periods of inactivity.

- Platform lighting should be situated in a manner to illuminate station identification signage to enable passenger to identify their stops from inside the train.

11.12.6 Rail yard lighting

The track and signal areas are illuminated in darkness and in periods of poor visibility caused by the weather. To illuminate the rail yard, lights are used. For track fields an illumination level of Em~10 lx with a uniformity of U0 = 0.25 is to be complied with. This ratio of luminance is reached by means of single conic steel masts with two installation doors at mounting heights ranging between 12 to 14 m, equipped with two 150 W HPS-lamps. Illumination sources with a particularly and demonstrably high standard of glare control are applied. This guarantees a high degree of security for the operating staff. In the rail yards a majority of information for the train operation is controlled via light-signal systems. Inappropriate illumination can lead to incorrect information or misinterpretations.

11.13 Cabling

11.13.1 General Requirements

All cables will have stranded cooper conductor and single wire metallic armoring where required. Sub-circuit cabling within building will be unarmored and run-in cable tray/conduit systems.

11.13.2 Types of Cables

All cables for fixed installations will be of PVC insulated; PVC sheathed and galvanized steel wire armor (if required). The power cable current ratings will generally be based on a design temperature of 30ºC, for buried cables. Conductor sizes will be selected on the basis of full load current and equipment supply voltage requirements.

11.13.3 Core Identifications

- Power and multi core control cables will be identified as follows:
- 2 Core: Red – Black
- 3 Core: RED – YELLOW – BLUE
- 4 Core: RED – YELLOW – BLUE – BLACK

- Another multi-core will be numbered accordingly

11.13.4 Segregation

Power cables and power control cables will be routed separately from control, instrumentation and communications cables. The separation distance between these groups will be a minimum of 500 mm apart for parallel runs. Cables runs crossing will be kept to a minimum, but where this is unavoidable, they will cross at right angles, maintaining the 500 mm spacing.

11.13.5 Installation

Cables will be installed both above and below ground. The most appropriate installation method selected will ensure lowest risk of failure/damage, longest life expectancy and most economic installation.

Cables installed below ground in un-paved areas will be buried directly and in paved areas will be run in pre-formed concrete or brick-sided trenches or duct banks. Cables installed outdoor, above ground will be run on galvanized steel heavy duty cables tray or heavy-duty cable ladder track. Cable trenches and cable trays/ladder racks will be designed to allow for 25% spare capacity, for future installation. Cable support steelwork will be constructed from standard channel and angle iron sections. All major cable routes will utilize cable ladder with rungs at a maximum of 300mm spacing. Cable ladder rack covers will be provided outdoors to protect cables from direct sunlight.

Cables will be laid on Electrostatic painted cable ladder or covered cable trays of 1.5 mm thick Hot dipped galvanized steel sheet. Control cables may be layered or laid in bundles as may some power cables. Bundles will not exceed 100 mm in diameter. Dressing of the installation to achieve a neat appearance and to ensure effective utilization of racking space will be completed with cables straps.

Cables installed in pre-formed trenches or buried directly will be laid with spaces between each cable embedded and covered with soft sand, warning tape with bricks/tile covers.

11.13.6 Termination of Cables

Cables will be crimped into enclosures using mechanical or hydraulic type compression tool. All glands made of brass and fiber type washers, will be used to maintain the integrity of the enclosure.

11.14 Tunnel Requirements (If required)

11.14.1 Tunnel Lighting

Lighting system of the tunnels will be provided to maintain sufficient illumination level throughout the tunnel with minimum lighting level of 25 lux. All wires and cables will be

fire resistant.

When train enters in a tunnel, the driver is unable to see anything due to Black Hole Effect. HPIT Sodium Flood Lights will be used at the tunnel(s) entrance, to clear the visibility of the driver. These will be provided at both ends of the tunnel(s). Tunnel Lights with Fluorescent Lamps, with battery backup of 90 minutes, will be provided in the remaining part of the tunnel(s). Further elaboration shall be under taken during the detailed design of the tunnels and necessary electric installation therein.

11.14.2 Tunnel Ventilation

Tunnel Ventilation will be provided for tunnels longer than 188.67 m (600 ft). The tunnel ventilation will consist of one or more of the following configurations:

- Jet fans in the tunnels
- Axial fans located at tunnels portals
- Axial fans located at ventilation shafts or ventilation tunnels

Tunnel ventilation configurations will be defined for each tunnel by consideration of the following factors:

- Efficiency
- Maintenance
- Redundancy
- Reliability
- Economics

11.14.3 Tunnel Fire Fighting

A water supply for tunnel firefighting purposes will be provided. House reel cabinets, connected to adequate water supply system of 60,000 gallons (minimum), will be provided. The water supply system will be capable of providing a minimum 500 gallons per minute at a residual pressure of 100 psi, for a period of at least 2 hours.

A standby booster pump for firefighting purposes will be provided, besides provision of a jockey pump to maintain constant water pressure. A standby diesel engine operated pump will also be provided to work as standby to work in case of failure of electric supply. The diesel pump will be auto-start, fitted with AMF/ ATS panels.

11.14.4 Tunnel De-watering

Adequate drainage will be provided to ensure the stability of slopes at the portal. Water sumps, fitted with de-watering/submersible pumps, will collect seepage and condensate water and other flows in tunnel(s). Tunnel drainage reservoirs will be provided at both ends of the tunnel(s) to collect water from the sumps.

11.14.5 Backup Power Supply System

11.14.5.1 Standby Diesel Generators

One Standby Diesel Generator set of appropriate capacity has already been proposed in the Signaling and Telecommunication Study Report by the Consultants at each station, in addition to the regular electric supply from IESCO. This standby Diesel Generator will also serve as standby arrangement for the electric supply for the electric appliances other than signaling and telecommunication equipment at that station

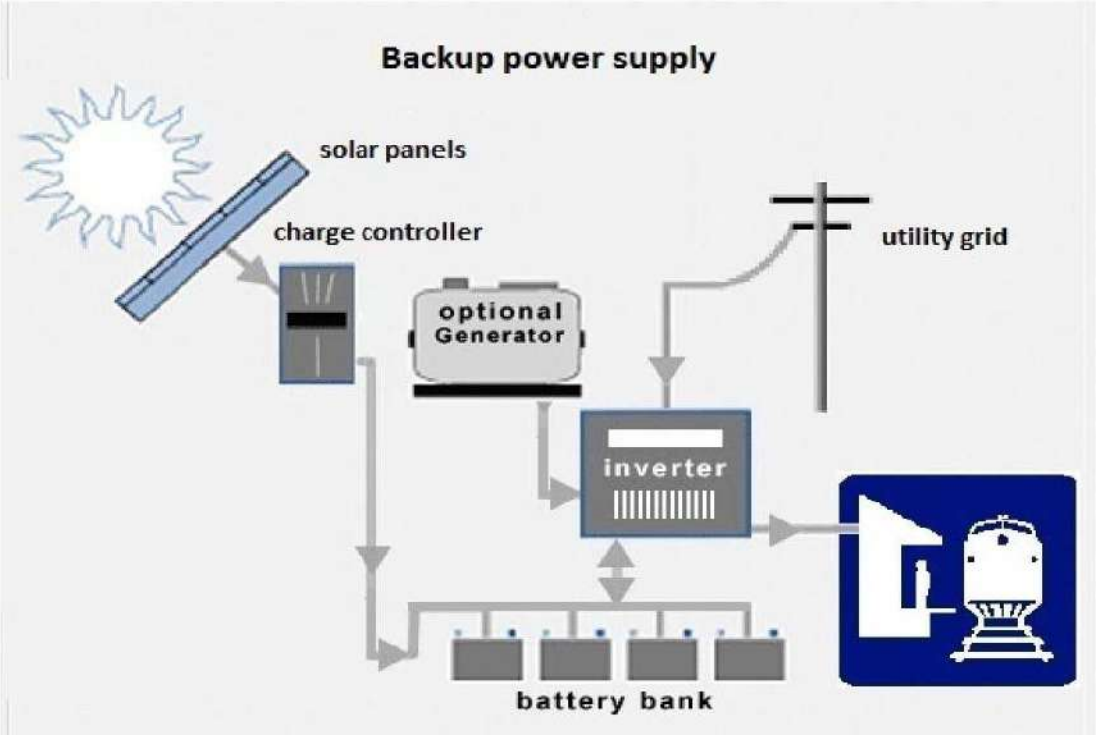
No standby arrangement has been proposed in addition to IESCO supply which will be provided for the residential buildings at the stations. Diesel fuel storage facility for two weeks will also be provided for the standby Diesel Generator set at every station.

11.14.6 Standby Solar Power System

For the backup power supply, a solar system with batteries may also be considered at the detailed design stage. This will serve to secure power supply and feed the systems in case of the breakdown of the main power supply. At the large complexes generator units are necessary as stated under sub-section 10.17.5 above.

The solar system basically consists of the inverter, a PV system, and a storage battery. During normal operation, one or more solar inverters will feed electricity from the PV system into the public grid. The backup system will only activate in the event of a grid failure / load shedding. The switching mechanism will then disconnect both PV system and power consumers from the public grid in accordance with the applicable standards, while supply to the in-house grid continues from the battery. In the role of system manager, the backup device coordinates all switching operations. Thus, it provides reliable backup for every grid failure / load shedding. By integrating a fuel generator, an energy source which is readily available at short notice will be used. As a result, the size of the solar plant required will be reduced disproportionately. The backup power supply is shown in **Figure 11.1** below.

Figure: 11.1 Standby Solar Power System



11.15 Estimation of Power Requirement

11.15.1 Electrical Load Calculations for Various Installations

11.15.1.1 Station Buildings

The estimated connected load of a typical station building has been determined by means of a specific electrical energy per unit area at an estimated medium power factor

- For buildings with low levels of technical equipment it amounts to 20 W/m^2
- Power factor is 0.7
- Specific electrical energy per unit area 20x0.7 =14 W/m^2
- For escalators consumption of energy is approximately 5.0 kilowatts/hr.
- For elevators consumption of energy is approximately 11.0 kilowatts/hr.

11.15.2 Residential Accommodation for Staff at Station

It is an optional requirement, if it is required the estimated connected load of residential accommodation for staff can be determined by means of a specific electrical energy per unit area at an estimated medium power factor

- For buildings with low levels of technical equipment it amounts to 20 W/m
- Power factor is 0.7
- Specific electrical energy per unit area 20x0.7 =14 W/m^2

11.15.3 Station Platforms

The estimated connected load of a typical platform has been determined by the installed facilities:

Table: 11.1 Estimated Load of a Typical Station

Type of facility	Power Consumption [kW]
Lighting (fluorescent luminaires)	3.6
Information system	0.5
Total	**4.1**

11.15.4 Typical Rail Yard Lighting

The estimated connected load of the rail yard lighting can be determined by the quantity of lighting masts with two 150 W high pressure sodium vapor lamps (HPS-lamps), mounted at 30 m, every second rail track. For the largest rail area, like Islamabad and Murree with such a lighting system it will be about 2 kW.

11.15.5 Typical Telecommunication System

The estimated connected load of the telecommunication system at one location (platform, etc.) included the acoustic irradiation and transmission technology amounts to 3 kW.

11.15.6 Signaling System

The estimated power consumption of the signaling system depends on the type of

facility

Table: 11.2 Estimated Power Consumption of Signaling System

Type of Facility	Power Consumption [kW]
Large Stations	158
Other Stations	70
Electronic command and control center (ECCS)	60

11.15.7 Pumping Installations at the Stations (If required)

Pumping installations may have to be provided at some of the stations where water supply from the local Municipal Authorities is not available. The load of the pumping installation may be taken as 5kW.

11.15.8 Calculation of Electrical Loads at Different Stations

There will be 4 Stations from Islamabad to Murree as given in **Table 10.4** below. Islamabad, Chattar Park, Ghora Gali and Murree will be the stations and there will be 4-way side stations as listed below. The calculations of requirement of electrical load at these stations has been calculated in given below annexures A1 to A4

11.15.9 Names of the Corresponding Electric Supply Companies

The names of the corresponding Electric Supply Companies have also been indicated in the table.

Table: 11.3 Name of Stations and Corresponding Electric Supply Companies

Sr. No	Name of Stations	Remarks
1	Islamabad	Islamabad Electric Supply Company (IESCO)
2	Chattar Park	Islamabad Electric Supply Company (IESCO)
3	Ghora Gali	Islamabad Electric Supply Company (IESCO)
4	Murree Bus stop	Islamabad Electric Supply Company (IESCO)

11.15.10 Summary of Estimated Electrical Load at Stations

A summary of the load requirement of all the Stations is given below:

Table: 11.4 Summary of Estimated Electrical Load Requirements at Stations

Sr. No	Description	Estimated Load kW	Transformer
1	Islamabad (Park View)	158.00	**200 KVA**
2	Chattar Park	60.50	**100 KVA**
3	Ghora Gali	60.50	**100KVA**
4	Murree Bus Stop	70.00	**100KVA**

11.16 Estimation of Electrical Load for Stations

The estimation of load of the stations and requirement of electrical staff is detailed in tables below in **Tables 11.6, 11.7, 11.8, 11.9, 11.10, 11.11, 11.12, 11.13,** and **11.14** respectively.

Table: 11.6 Estimation of Electrical Load (Islamabad (Park-view) Station)

Sr. No	Description	Unit (Sq. m)	Load Estimation (w)	Total Estimated load (kw)
1	Passengers Platforms	2 No.	3500	**3.50**
2	Station Building (Sq. m)	300	2000	**2.00**
3	Offices of the field staff	500	2500	**2.50**
4	Rolling Stock Shed	Lump Sum	30000	**30.00**
5	Washing Lines/Sick Lines	Lump Sum	20000	**20.00**
6	Mech. & Elect. Equipment	Lump Sum	10000	**10.00**
7	External Lighting	Lump Sum	10000	**10.00**
8	Signaling & Telecom Load	Lump Sum	50000	**50.0**

9	Escalator & elevator	Lump Sum	30000	**30.00**
Sub Total				**158.00**
Total Connected Load (KW)				**158.00**
Total Connected Load (KVA)				**197.5**
Proposed Transformers 1 Nos.				**200KVA**

Table: 11.7 Estimation of Electrical Load (Chattar Park Station)

Sr. No	Description	Unit (Sq. m)	Load Estimation(w)	Total Estimated load (kw)
1	Passengers Platforms	2 no's	2000	**2.00**
2	Station Building (Sq. m)	200	1500	**1.50**
3	External Lighting	Lump Sum	2000	**2.00**
4	Signaling &Telecommunication Load	Lump Sum	25000	**25.00**
5	Escalator & elevator	Lump Sum	30000	**30.00**
Sub Total				**60.50**
Total Connected Load (KW)			**60.50**	
Total Connected Load (KVA)			**75.625**	
Proposed Transformers 1 No			**(one 100 KVA)**	

Table: 11.8 Estimation of Electrical Load Requirement (Ghora Gali Station)

Sr. No	Description	Unit (Sq.m)	Load Estimation(w)	Total Estimated load (kw)
1	Passengers Platforms	02 No's	2000	**2.00**
2	Station Building (Sq.m)	200	1500	**1.50**

3	External Lighting	Lump Sum	2000	**2.00**
4	Signaling &Telecommunication Load	Lump Sum	25000	**25.00**
5	Escalator & elevator	Lump Sum	30000	**30.00**
Sub Total				
Total Connected Load (KW)				**60.50**
Total Connected Load (KVA)				**75.625**
Proposed Transformers 1 Nos.				**100KVA**

Table: 11.9 Estimation of Electrical Load (Murree Bus Stop Station)

Sr.	Description	Unit (Sq.m)	Load Estimation (w)	Total Estimated load (kw)
1	Passengers Platforms	2 No.	3500	**3.50**
2	Station Building (Sq.m)	300	2000	**2.00**
3	Offices of the field staff	500	2500	**2.50**
4	Rest House	200	1500	**1.50**
5	Residential Colony	Lump Sum	3000	**3.00**
6	External Lighting	Lump Sum	2500	**2.50**
7	Signaling and Telecommunication Load	Lump Sum	25000	**25.00**
8	Escalator & elevator	Lump Sum	30000	**30.00**
Sub Total				**70.00**
Total Connected Load (KW)				**70.00**
Total Connected Load (KVA)				**87.50**
Proposed Transformers 1Nos				**100KVA**

12. Chapter

12.1 Electric Traction Study

12.1.1 Scope of Services for Electric Traction Study Report

The scope of services for the Electric Traction Study is as under:

- Propose the type, design and characteristics of overhead electric traction equipment
- Requirement and availability of electricity
- Requirement of sub stations and locations thereof
- Remote control facilities for the operation and control of electric traction equipment particularly in the sub-stations
- Communication and control facilities required for the maintenance of electric traction equipment.

12.2 Requirements of Electric Traction on Railways

Steam was the first power generation medium used for traction. It was used for railway traction in 1830's and thereafter for more than 120 years the steam engine remained the principal means of railway traction.

Diesel traction was developed systematically after the Second World War. The diesel traction locomotives are driven by a diesel internal combustion engine. In comparison to steam traction, the diesel traction offers far higher efficiency, a lower operating cost (by almost 50%), much better performance in respect of speed and power, cleaner operation and improved passenger comfort, convenience and less strenuous work for the drivers.

The electric traction was first introduced on conventional railways in 1900, when it was adopted in the London and Paris metro lines and in the mountain lines of Switzerland. It has been extensively used since 1920, especially after 1950. Its operating cost is 35% lower than the diesel traction (in European countries), but it necessitates higher initial costs due to permanent plant required. Electric traction is accordingly used only on high-traffic lines.

12.2.1 Electric Traction

In contrast to diesel traction, where the energy required for train operation is generated within the diesel locomotive itself, the energy needed for electric traction is transmitted to the electric locomotive by an external sub-system, the power supply sub-system.

12.2.2 Principles of Electric Traction

Electric traction systems utilize electric motors powered by overhead lines, third rails, or onboard energy storage systems (like batteries). Key concepts include:

- **Traction Motors**: Convert electrical energy into mechanical energy.
- **Power Supply Systems**: Include AC or DC power, typically 25kV AC or 750V DC.
- **Control Systems**: Involve advanced electronics for acceleration, braking, and speed control

12.2.2.1 Components of Electric Traction

- **Overhead Equipment (OHE)**: Wires and infrastructure for power delivery.
- **Pantograph**: Connects moving trains to overhead wires.
- **Substations**: Step down and convert electric supply.
- **Traction Transformers and Converters**: Modify voltage and type (AC/DC).
- **Third Rail:** A method to provide electricity into the vehicles through a rail alongside the tracks.
- **Electric Motors:** These are devices that convert the electrical energy into mechanical energy to propel the vehicles.
- **Regenerative Braking:** When electric traction systems have the feature whereby their motors act as generators during braking, consequently converting kinetic energy back into electrical energy that can be used or stored.
- **Catenary:** The system of overhead wires used for supplying electricity to electric trains. The above terms become cardinal in uunderstanding how electric traction systems work.

12.2.3 Power Supply Sub-System

The power supply sub-system includes:

- Substations, where the voltage is stepped down and (in certain electric traction systems) the alternating current (AC) frequency is converted or AC is rectified into direct current (DC). The electric substation may obtain electric power, either from the national high-voltage power network at a frequency of 50 Hz or from a separate high-voltage distribution network, at a frequency considerably lower than that of the national network. Transmission lines or conductor rails, to convey the electric energy from the substations to the electric locomotive. The transmission line from substations to vehicles is, as a rule, in single phase configuration.
- The electric traction engines obtain electric power from a conductor which may be either an overhead line, as used in railways and (sometimes) in metros or a conductor rail (one or two), used in metros and some suburban railways.

When only one transmission line or conductor rail is provided, current return is affected through the rails. In the case of an overhead transmission line, electric power is transferred from the line to the locomotive through a pantograph. In the locomotive this electric power is converted into mechanical energy, which is used to operate the train.

12.2.4 Electric Traction Systems

- **Direct Current (DC) Systems**: Common in urban metros (e.g., 750V or 1500V DC).
- **Alternating Current (AC) Systems**: Used in long-distance railways (e.g., 25kV, 50 Hz).
- **Diesel-Electric Systems**: Combines diesel engine with electric drive.
- **Battery Electric Vehicles (BEVs)**: Fully electric with onboard battery packs.
- **Hybrid Systems**: Combine multiple energy sources.

This electric transmission system is operated at the same voltage as that of traction motors. The main voltages employed are:

- 750 V, mainly for transmission on third and fourth rail systems
- 1,500 V, more widespread than other voltages
- 3,000 V.

The above voltages are far lower than those employed on public power networks and too low for efficient power transmission. DC railway traction therefore necessitates large cross-sections of the transmission line (400 to 900 mm ^{2}) and closely-spaced substations. Sub- station spacing is 15 to 20 km in the case of 1,500 V and 35 to 40 km in the case of 3,000 V.

Direct Current railway traction, though superior as regards the traction sub-system, proves inferior when it comes to the power supply sub-system. The DC traction is presently used in about 50% of electric railway lines worldwide and has mainly been used in France, Spain, Italy, Russia and Japan and in certain parts of U.K.

12.3 Third Rail Traction

Third rail system is the system in which with power for the traction system is provided by a parallel rail next to the consecutive rails of transportation it is also called as conductor rail. This is the conventional method.

On most third rail systems, the conductor rail is placed outside of the running rails and the electricity is transmitted to the train by means of a sliding shoe, which is held in contact with the rail. A third rail system offers a number of benefits, including:

Eradicating the impact of electromagnetic interference on electrical components

Reducing maintenance costs because power supply equipment is virtually maintenance-free with only regular inspections and cleaning required.

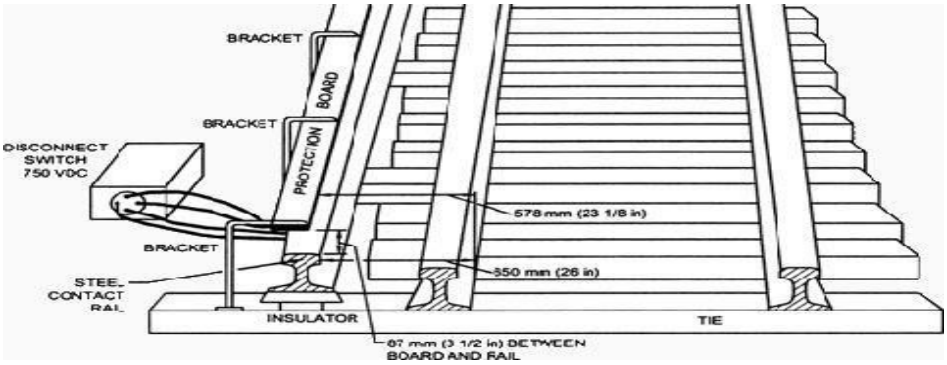
Offering high efficiency, 750 V DC system offers a power supply transmission efficiency average of 92-94%.

As a solid composite rail running along the track, a third rail is more rugged than an overhead contact wire and has a longer life expectancy.

The system similarly benefits from high reliability because it is fed on both sides by rectifiers from adjacent substations, and it can offer lower comparative initial costs than an AC system. Rolling stock used on these systems also tends to be cheaper because no transformers are installed on board which also reduces the weight of the vehicles and increases capacity for passengers.

The Layout of the third rail system is shown below:

Figure: 12.1 Typical Layout of the third rail system



Six of the most commonly used voltages have been selected for European and international standardization. These are independent of the contact system used, so that, for example, 750 V DC may be used with either third rail or overhead lines (the latter normally by trams). There are many other voltage systems used for railway electrification systems around the world, and the list of current systems for electric rail traction covers both standard voltage and non- standard voltage systems.

The permissible range of voltages allowed for the standardized voltages is as stated in standards BS EN 50163 and IEC 60850. These take into account the number of trains drawing current and their distance from the substation.

Early electric systems used low-voltage DC. Electric motors were fed directly from the traction supply and were controlled using a combination of resistors and relays that connected the motors in parallel or series also called as the third rail method which is seen in many metros and trams like Bangalore metro.

12.3.1 Drawbacks of DC Supply

DC systems (especially third rail systems) are limited to relatively low voltages and this can limit the size and speed of trains and cannot use low-level platform and also limit the amount of air- conditioning that the trains can provide. This may be a factor favoring overhead wires and high voltage AC, even for urban usage. In practice, the top speed of trains on third-rail systems is limited to 100 mph (160 km/h) because, above that speed, reliable contact between the shoe and the rail cannot be maintained.

The DC system is quite simple but it requires thick cables and short distances between feeder stations because of the high currents required. There are also significant resistive losses.

The DC electrification is usually done in short distances such as between two suburban stations because there is a power loss (DC loads don't have maximum power transfer) but in the express or intercity trains AC OHE is preferred

12.3.2 Alternating Current (AC) Traction

Alternating Current (AC) is superior to Direct Current (DC) as regards the power supply sub-system, but encounters problems in the traction sub-system. AC motors meeting the requirements of traction engines are series-excited AC motors with collector, which, however, face problems proportional to the AC frequency. The need therefore initially arose to use AC at a frequency lower than the 50 Hz, used on public power mains.

12.3.3 Alternating Current Traction at 15,000 V 16 2/3 Hz

In this system, electric substations may obtain power from either of two sources:

- From the national power network (at a frequency of 50 Hz), in which case there is voltage reduction in the sub-stations and a frequency conversion.
- A separate network carrying low-frequency AC, in which case there is only a voltage reduction in the sub-station.

AC traction at 15,000 V, 16 2/3 Hz is currently used in Central Europe where sub- stations are supplied from special low frequency AC power plants, and in Northern Europe where sub-stations are supplied from the 50 Hz national power network. This AC traction system corresponds to 20% of electric railway lines worldwide.

12.3.4 Alternating Current Traction at 25,000 V 50 Hz

In this system, substations are supplied from the national network and simply step the voltage down to 25,000 V, 50 Hz, which is transmitted to the locomotive through the transmission line. In the locomotive the voltage is again stepped down, rectified, and applied to the series-excited DC traction motors.

The 25,000 V, 50 Hz system represents 30% of electric railway lines worldwide and is almost exclusively used in new electric railway traction facilities. It may be added here

that Pakistan Railways had also adopted this, when electric traction was introduced here in i969.

Sub-Stations are 60 to 100 km apart and transmission conductors have cross sections 3 to 5 times smaller than in DC systems. This system moreover enables the use of series DC motors, which are superior for driving trains.

A comparison of the construction cost for traction systems using 1,500 V DC and systems using 25,000 V, 50 Hz AC, yields figure lower by 30% for the latter than for the former.

12.4 Transmission Lines

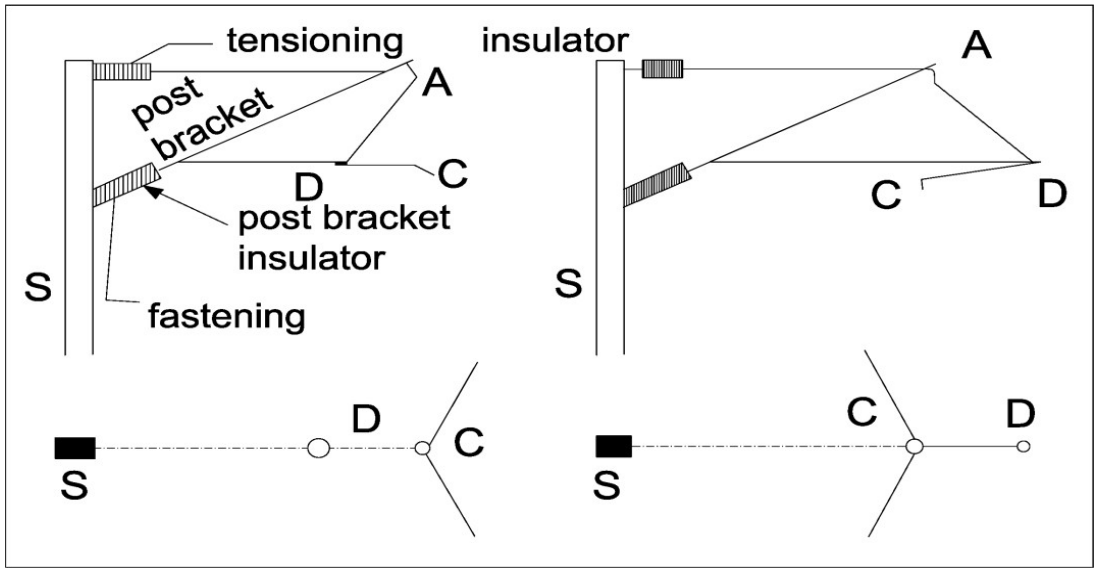
Parts and components of the transmission line the transmission line concept includes**:**

- Feeder conductors, contact conductors (touching the pantograph), suspension wire rope, guy wires.
- Conductor supported structures, which may consist of poles or frames.

Insulators, post brackets, tensioning devices (usually every 1,200 m), counterweights, various mounting hardware, wires connecting the poles to the transmission line and to the ground, conductors for connection to the substations.

- Proposal for the type, design, and characteristics of overhead electric traction equipment.
- Analysis of electricity requirements and availability.
- Determination of substation requirements and optimal locations.
- Specification of remote-control facilities for substation operation.
- Outline of communication and control systems for equipment maintenance

Figure: 12.2 Insulators and post bracket



As illustrated in **Figure 12.2** above, the overhead transmission line is suspended from the post brackets, which in turn are mounted by insulators on supporting poles, erected 2.20-3.00 m from the track axis. The post brackets are usually zinc-plated steel pipes.

12.5 Calculation of the Transmission Line Cross-Section

Calculation of the cross-section and other characteristics of the transmission line is performed on the basis of the permissible voltage drop from the sub-stations to the locomotive switchboards, allowing a fluctuation of no more than 10% from nominal value.

Theoretical calculation of the voltage drop is based on the assumption that the passing load is constant, which, however, is not the case, since the number of the operating trains, their positions, etc. are variable. Calculation of the transmission line is accordingly carried out with the help of a small-scale physical model where:

- Substations are simulated by constant-voltage sources, complemented by suitable resistors simulating the internal circuits of the stations
- Current feeder and return lines are simulated by suitable resistors.
- Trains are simulated by variable resistors, which can be connected to various points of the line.
- Suitable measuring instruments give a direct reading (as a function of substation distance and transmission line cross-section) of substation output Voltage, total current at each substation, voltage at traction engine switch-boards.

This physical model enables the testing and verification of various combinations of

transmission conductors, substation distances, etc. and the selection of the optimum solution.

In any case, according to UIC regulations, in the case of 25,000 V, 50 Hz traction, the transmission line voltage, in order to ensure a normal traction engine power supply, should have a maximum value of 27,500 V, a normal value of 25,000 V, a minimum value of 19,000 V, and only a momentary fall to 17,000 V. Transmission line suspension. Various transmission line suspension methods are being used depending mainly on train speed, but also on climatic conditions (wind speed and direction) and on pole spacing. With low speeds (up to 120 km/h), simple suspension is adequate, whereas with medium and high speeds catenary-type suspension is mandatory.

12.6 Overhead Line Supporting Poles

- **Pole material**

The poles supporting the overhead line may consist of:

i. Cast steel
ii. Zinc plated steel
iii. Pre-stressed concrete
iv. Reinforced concrete.

- **Pole Spacing**

Spacing between supporting poles ranges between 50 to 75 m depending on the following factors:

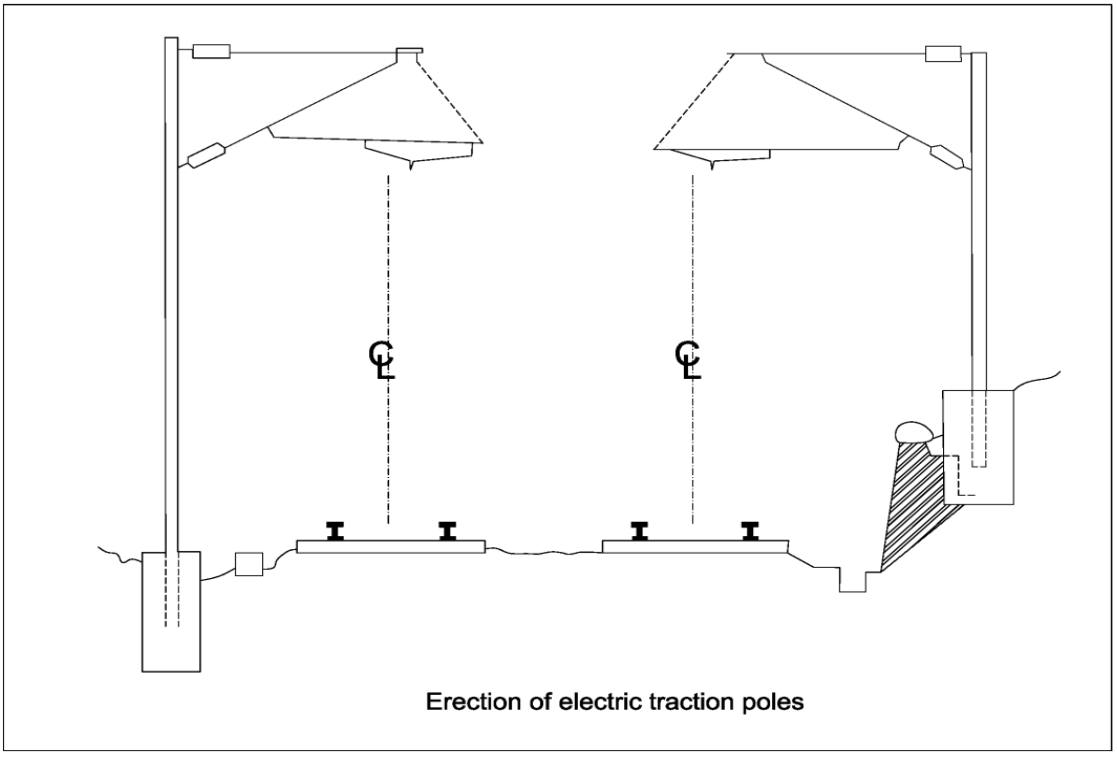
- Pantograph Oscillations
- Locomotive Transverse Motions
- Climatic Conditions

Both longitudinal and transverse pantograph motion have to be calculated in detail. It should be stressed that the primary constraint on maximum train speed is the maximum permissible pantograph oscillations, and to a lesser degree the metal-to-metal (wheel-rail) contact.

- **Pole Foundation**

When erecting poles for electric traction, special care is required both at the excavation and at the filling-up stages, so as to minimize eventual settlement of the ground.
Figure 12.3 below show the erection of electric traction poles.

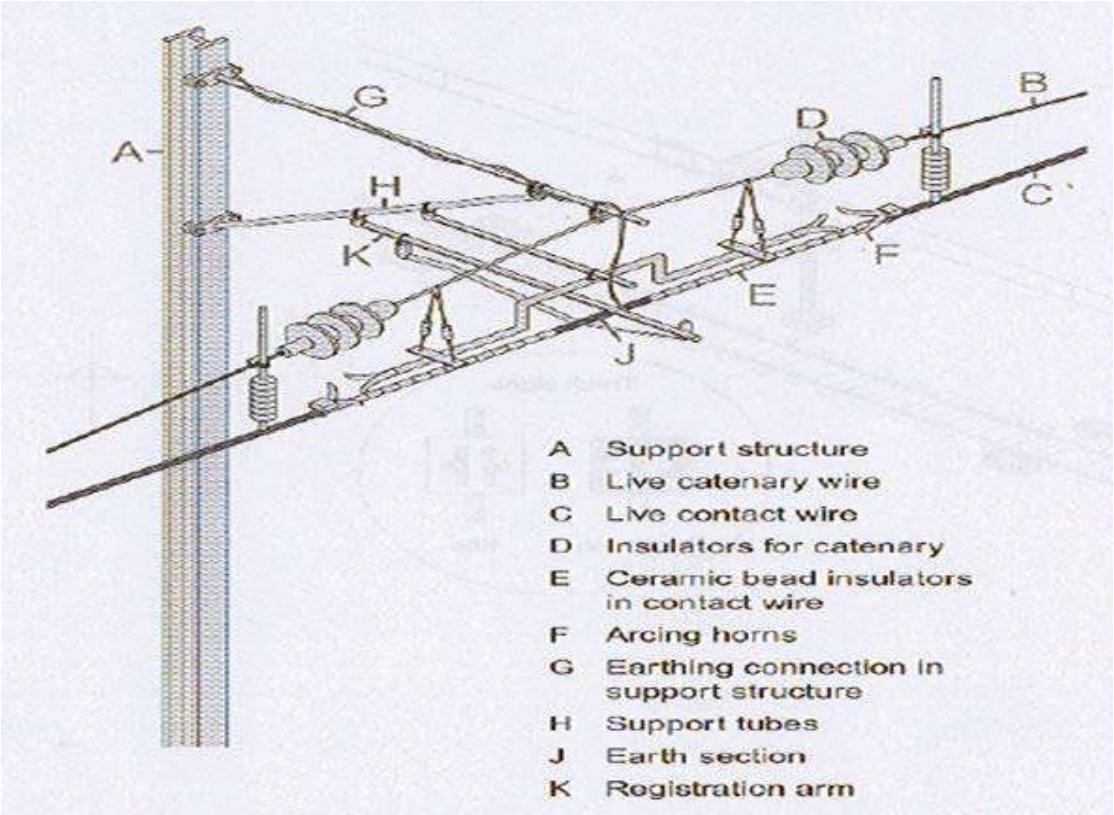
Figure: 12.3 Erection of Electric Traction Poles.



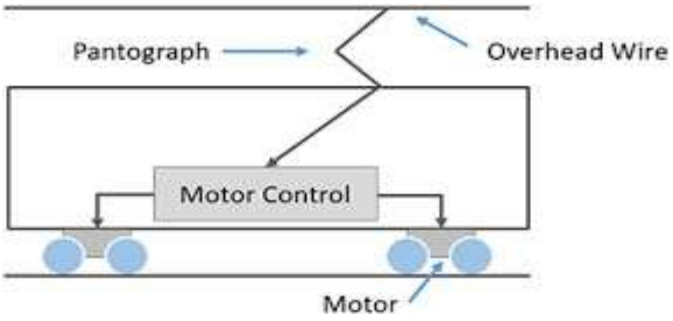
12.6.1 OHE (Overhead Equipment) or Catenary System

The most widely used mode of transmission is OHE because it provides easier transmission of power to large distances it has 3 conductors that are supported by poles or power line structure. Towers for support of the lines are made of wood either grown or laminated, steel or aluminum (either lattice structures or tubular poles), concrete, and occasionally reinforced plastics. A major goal of overhead power line design is to maintain adequate clearance between energized conductors and the ground so as to prevent dangerous contact with the line, and to provide reliable support for the conductors, resilience to storms, ice loads, earthquakes and other potential damage causes. So, to get the essence the OHE conductors can collide with each other that can cause a short condition which at such a high frequency and voltage can burn the entire substation supply, so the wires have insulators and wire non contactors (the structure that separates 2 wires). The different components of OHE are shown below in **Figure 12.4.**

Figure: 12.4 OHE (Overhead Equipment) or Catenary System



The Direct AC voltage coming from the OHE is taken through the pantograph and fed to the traction system of the train. The AC to DC conversion and power reduction is done in the traction system a simple layout of the process is shown below in **Figure 12.5**



The main process of Conversion of phase and power is based on the principle of power electronics and multiple power electronics components such as transformers, rectifiers, Inverters & switching circuits.

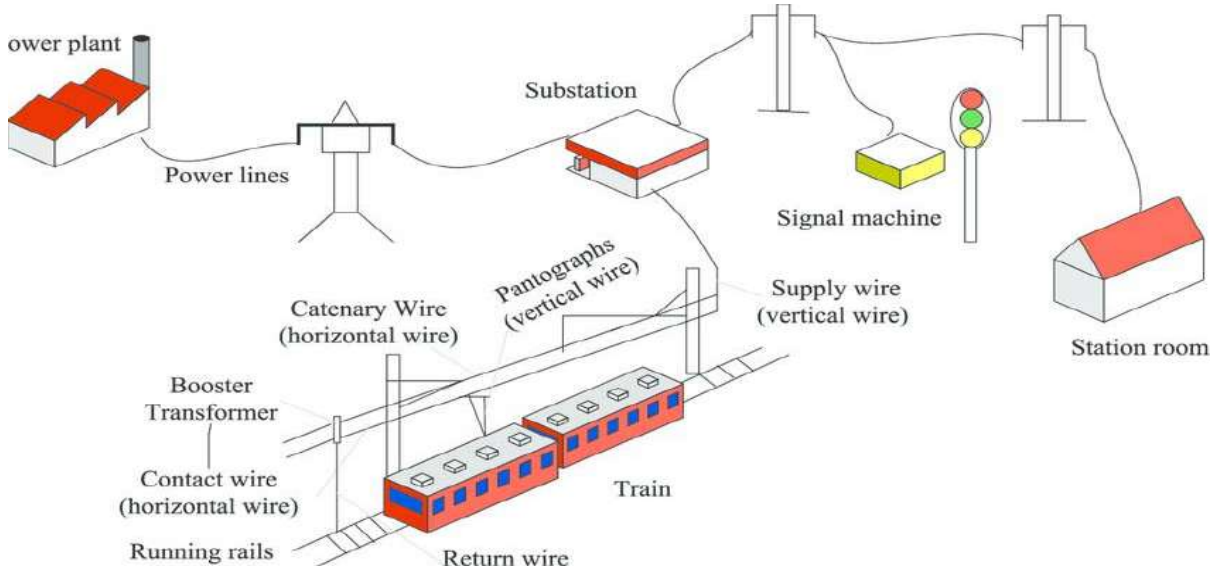
12.6.2 Drawbacks of the OHE AC Transmission

OHE is the most widely used electrification method but it also has some drawbacks like:

- A lot of infrastructure and investment is required like sub-stations, support structures, Transmission units etc. The overhead contact line system is more prone to failure so regular maintenance is necessary and requires a plan that is supported by a 24-hour maintenance team.
- The potential for electromagnetic interference and the impact of magnetic fields on properties and activities close to the line must also be considered, although special design features such as return conductors or booster transformers that minimize magnetic fields are now commonly used.
- The efficiency of transmission is very less in OHE as compared DC third rail system which is above 90%.

12.7 Generation and Transfer of Power

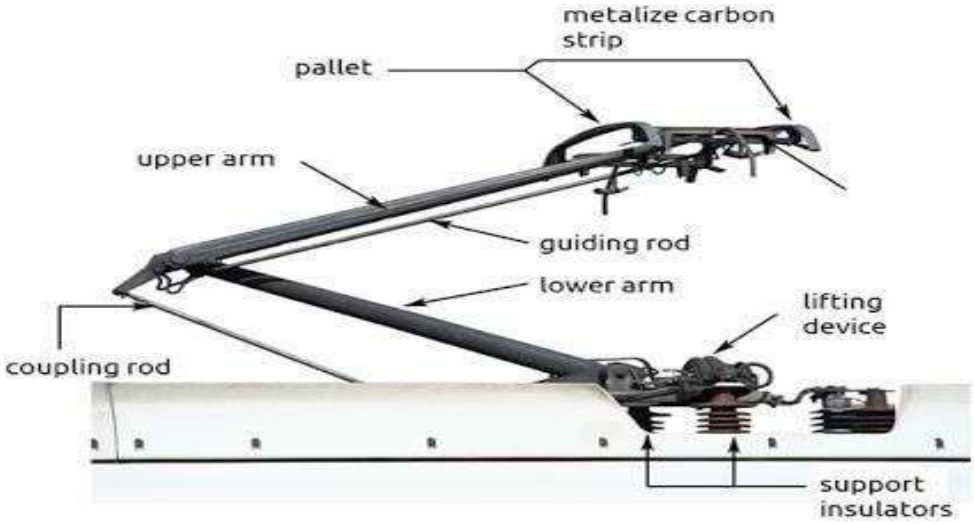
Figure 12.6 Generation & Transfer of Power



The power that is fed to the Traction of the train is taken from OHE as discussed in the earlier sections but that power travels through a long path to reach the OHE. The power made in power plant is transferred to substation via power lines every railway track line has a substation at a distance of approx. 80km. Substation is important after some distance as even the AC voltage will face diffusion resistance after travelling some distance. For example, in Lahore – Khanewal section there were five substations which were located at, Kotlakhpat, Habib Abad, Sahiwal, Mian-Channu and Khanewal stations. The substation distributes the power for majorly 2 purposes firstly for the OHE and secondly for use in railway stations like lights and other domestic uses, signaling and yard

works. The electricity from OHE is taken by the train through a device called as pantograph which is shown in **Figure 12.7** below.

Figure: 12.7 Pantograph Arrangement



Pantograph is a set of articulated arms fixed to the roof of the engine. It unfolds and extends along a vertical axis. The horizontal end piece of the pantograph is called head. This head is fitted with carbon strip. Their number and types depend on the nature and intensity of the current to be transmitted that is AC or DC. These carbon strips along the catenary contact wire thus capturing the electricity required to power the engine's traction motors. The cable of the overhead line is so heavy that suspended between two points they do not form straight line but sink (form a curve) due to their weight. For higher speed and in order to get a continuous contact between the catenary and the head of the pantograph, thus avoiding excessive power loss the catenary contact wire must maintained in a horizontal position. It must also be rigid enough to interact in a dynamic way with the pantograph.

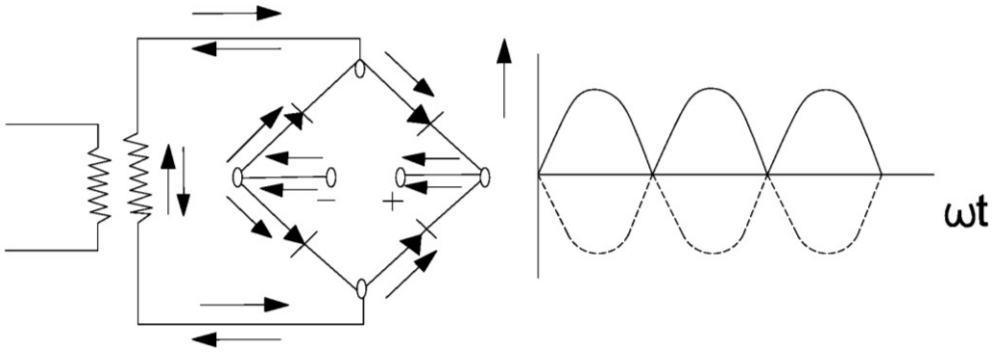
12.8 Sub-Stations

12.8.1 Substation for Feeding Direct Current Systems

Substations supplying DC systems, in addition to stepping the three-phase voltage down, also rectify the AC into DC. Rectification was initially performed by AC motor - DC generator couples, later superseded by mercury-pool rectifiers and more recently by

silicon rectifiers. A modem substation includes a high-medium voltage transformer with one or two output voltages, and a rectifier assembly **Figure 12.8** below. Silicon diodes or thyristors have been used as rectifiers, but since the mid-1980s, they have been replaced by GTO technology.

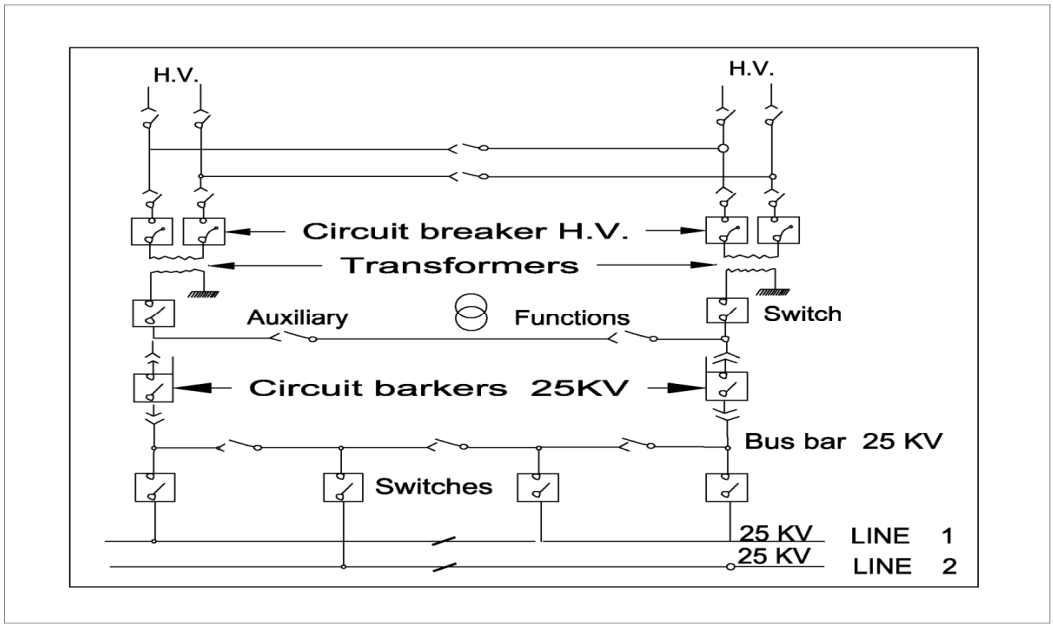
Figure: 12.8 Simplified Schematic of a DC Substation



12.8.2 Substation for Feeding Alternating Current Systems

In AC substations **Figure 12.9**, only the voltage is being stepped down and therefore substations in this class are simpler than DC substations. AC substation design should take into particular consideration the risk of short-circuiting. This can be prevented by the addition of preventive configurations and devices that limit the risk of short circuiting.

Figure: 12.9 Substation Feeding Alternating Current



12.8.3 From Thyristor to GTO Technology

Thyristors were extensively used until the mid-1980s. The introduction at that time of

the Gate Turn off (GTO) Technology (Figure 7) permitted omission of the commutating circuits, thus enabling distinct reduction of load losses shown in Figure **12.10**.

Figure: 12.10 Thyristor and GTO Techniques

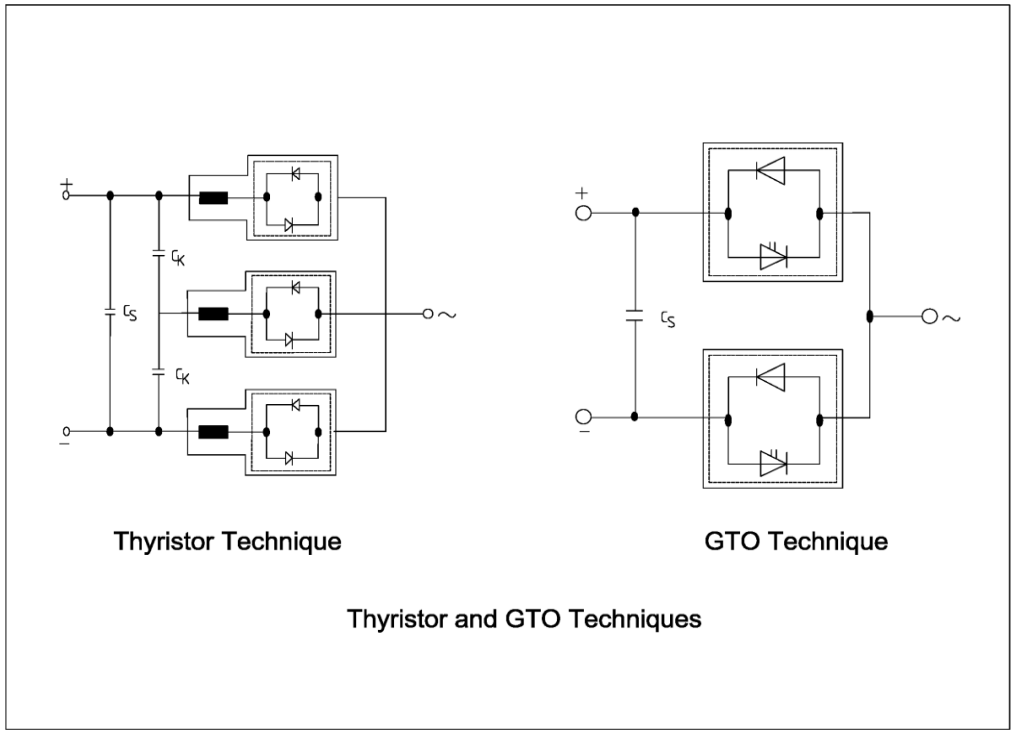
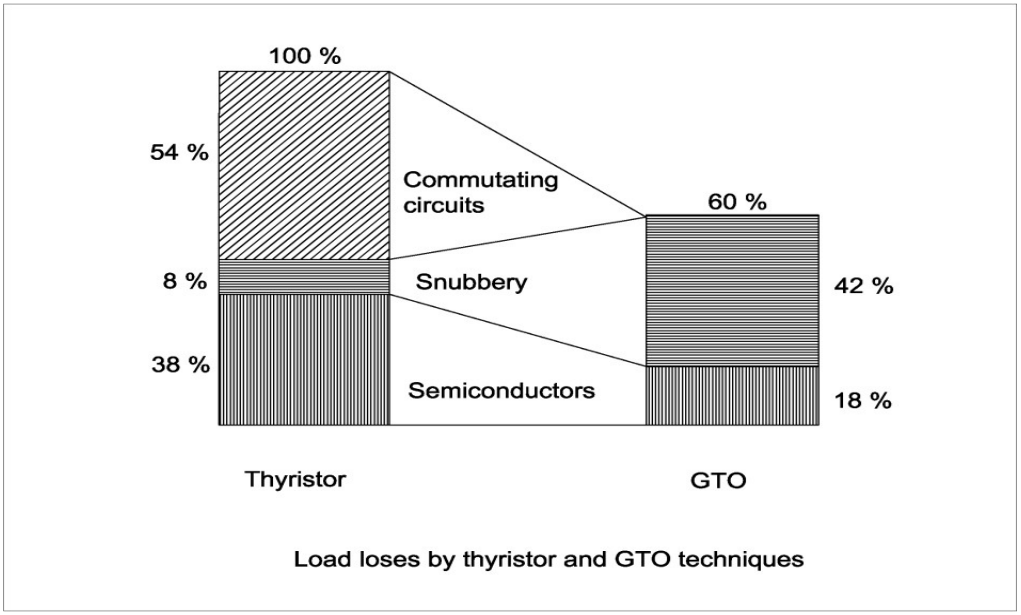


Figure: 12.11 Load Losses by Thyristor and GTO techniques



12.8.4 Central Remote Control

Today, substations and the systems supplied by them, are remote-controlled and

monitored from a central control station, provided with a visual panel showing the lines, substations, and the sections supplied (and therefore controlled) by each substation. Remote control is achieved using a signal code composed of different frequencies. Electronic control circuits in recent years have made possible execution times in the order of 0.3 sec.

12.8.5 Interference of Electrical Traction on Telecommunication Systems

In addition to power transmission lines (in the case of electric traction), railway telecommunication cables are also running (usually underground) alongside railway tracks. In order to prevent interference between power and telecommunication cables, voltages induced in the telecommunications network should precisely be calculated.
Problems may also arise where traction power cables intersect with lines of the public power network.

12.9 Regenerating Braking

To understand the phenomenon of regenerative braking we should first know how a traction motor functions. The traction motor gets three phase power from the traction system which helps in moving the rotor which finally makes the wheel move so in other words the motor converts electrical energy into mechanical energy. But if the opposite starts to happen i.e. the motor rotates and creates electrical energy then the traction motor becomes a generator this phenomenon is called as regenerative braking.
Train when takes a halt the kinetic energy is fed back to the traction motor which produces electricity that is fed back to the OHE and back to substation supply this saves a lot of energy as the train takes multiple stops with regenerative braking, we save approximately 17% energy in a trip.

In earlier times locomotives used vacuum or pneumatic brakes but nowadays the railway design and specification organization has made regenerative brakes compulsory for all electric locomotives manufactured because of the following advantages:

- A part of energy is returned to the supply system, so energy consumption for the run is considerably (about 20 to 30 per cent) reduced thereby affecting a considerable saving in the operating cost.
- The wear of the brake shoes and wheel tires is reduced to considerable extent; therefore, their life is increased and replacement cost is reduced.
- Higher value of braking retardation is obtained so that the vehicle can be brought to rest quickly and running time is considerably reduced.
- Very Small amount of brake dust is produced when the mechanical brakes are applied.
- Higher speeds are possible while going down the gradients because the high

braking retardation can be obtained with regenerative braking.

- Propulsion of heavier trains on gradients is possible without dividing them into sections with speed and safety.

12.10 FEASIBILITY ANALYSIS OF ELECTRIC TRACTION

12.11 Advantages and Disadvantages of Electric Traction Compared to Diesel

Advantages of Electric Traction

- Energy Efficiency: Lower energy consumption per unit distance.
- Eco-Friendly: Zero emissions at point of use.
- High Performance: Faster acceleration and deceleration.
- Low Maintenance: Fewer moving parts than internal combustion engines.
- A basic advantage of the electric locomotive is its specific power (50 to 55 kW/t), more than double the specific power of the diesel locomotive (20 to 25 kW/t)).
- Electric engines can sustain momentary overloads (when starting and on steep gradients, etc.).
- Along lines traversing high-altitude regions, no power drop is observed with electric traction engines. This is not the case with diesel engines, as the air entering the engine is significantly reduced.
- In the case of long tunnels, electric traction is advantageous due to the limited air supply.
- Finally, electric engines cause little, if any, atmospheric pollution, while maintenance is far simpler and easier than with diesel locomotives. Nevertheless, it should be noted that even diesel trains pollute much less than automobiles (at the ratio of 1: 14 per passenger-km).

Disadvantages of Electric Traction

- **High Initial Cost**: Infrastructure setup is expensive.
- **Dependency on Grid**: Susceptible to power failures.
- **Limited Flexibility**: Requires electrified tracks.

12.12 Feasibility Analysis- Parameters and Procedure

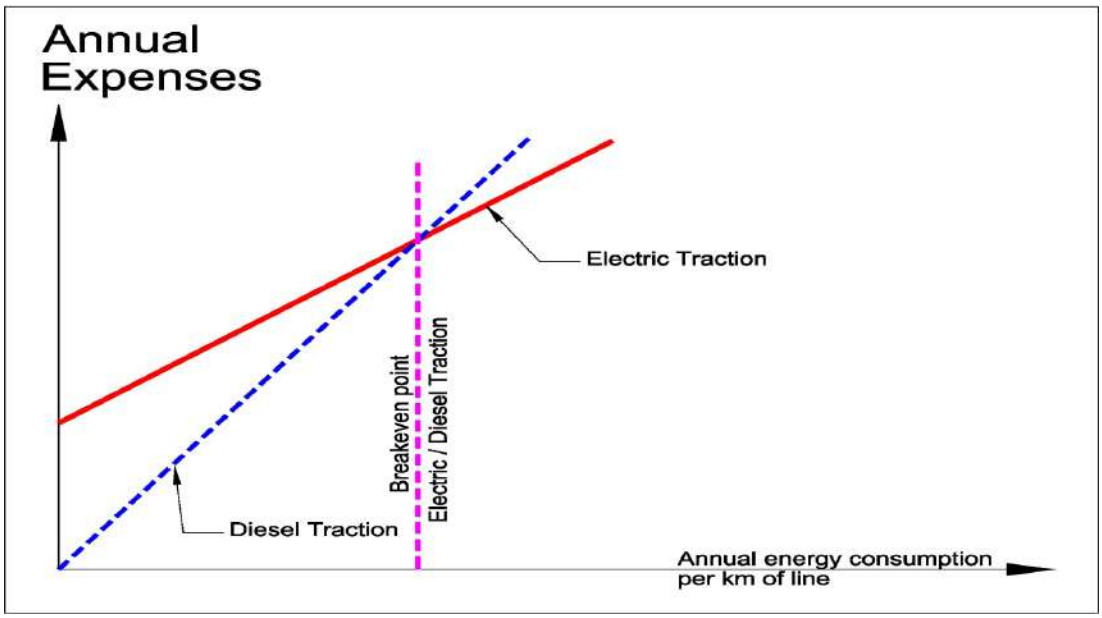
Cost factors taken into consideration:

i. Construction expenses, including transmission lines and substations, which do not depend on traffic,

ii. Operating and maintenance expenses, which increase with traffic.

The quantity commonly studied is the total annual expense as a function of line's traffic, an index of the latter being the energy expended annually per kilometer of line. **Figure 12.12** illustrates a comparative presentation of the annual expenses of diesel and electric traction.

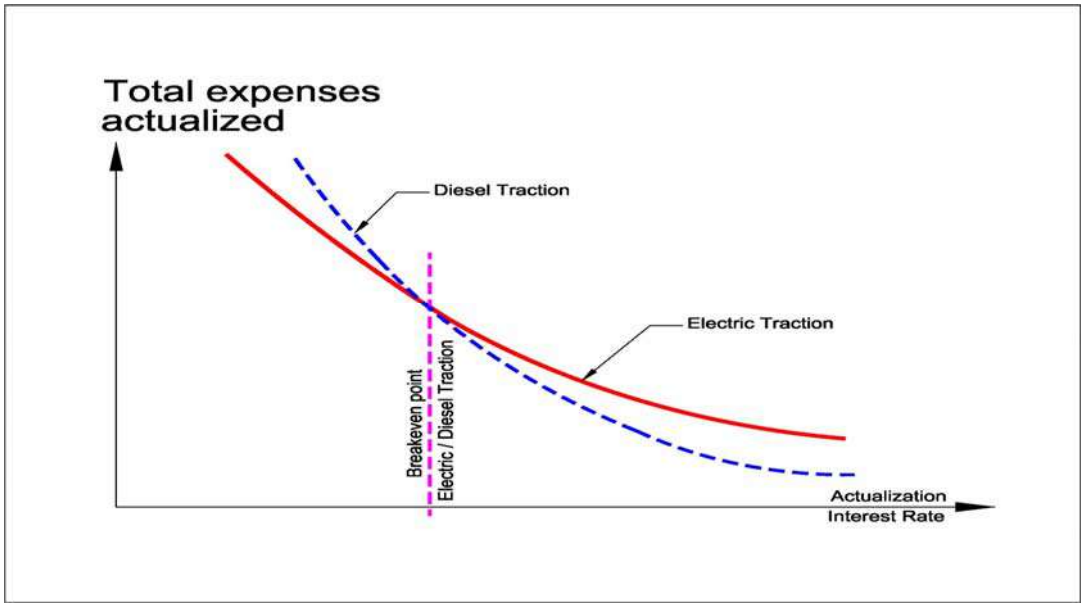
Figure: 12.12 Annual expenses as a function of energy consumption per kilometer of line for diesel and electric traction.



We see that at low traffic; electric traction is not cost effective. However, as the point beyond which electric traction becomes cost-effective is approached, a more detailed investigation of the problem is required.

The period of analysis is usually the following 20 to 25 years, and expenses as a whole (initial construction expense and annual operating expense) are converted for each traction system to constant prices by the present value method. **Figure 12.13** illustrates the form of the curves referring to each traction system, enabling an accurate determination of the traffic load beyond which electric traction becomes cost-effective.

Figure: 12.13 Feasibility analysis for determination of critical traffic load on a line beyond which electric traction becomes cost effective



A feasibility analysis of electric traction involves many uncertainties, particularly with respect to the price of liquid fuel in the next 20 to 25 years, the actualization interest rate whereby the various expenses are converted to constant prices, the length of the feasibility analysis period, etc. It is accordingly advisable to also perform a sensitivity analysis (which aims to examine the impact of the variation of one parameter to the result of the feasibility analysis).

12.13 Criterion for Selection of the Lines to be Electrified

The foregoing analysis is not applicable in every case and moreover in most cases the need arises to reach a conclusion easily and quickly as to whether or not electrification of a particular line is advisable. The various railway networks have accordingly adopted simple criteria to this effect, the most widely used being the number of trains on a line or (more precisely) the energy consumption per km of line. The criteria in question vary from one network to the other, since particularities of each country as regards cost of labor, cost of energy, financial investment cost, etc. are involved.

A criterion, which, however, can only be used to make a first approximative estimate, is the number of trains running on the line. For example, until 1973 (when the cost of energy was low), a line had to be run daily by at least 30 trains per direction to qualify for consideration of electrification cost-effectiveness. After the energy crises of 1973 and 1979, this criterion becomes around 15 trains per direction daily.

However, given that a train may consist of a small or a large number of vehicles, a criterion was sought which would take into account the number of vehicles. Such a criterion is the energy consumption per km of line. For instance, French Railways consider in principle an annual consumption of 70,000 kW/km of line as the electrification cost-effectiveness threshold, while the German Railways estimate this limit at 150,000 kW/km. Criteria, therefore, from one network to the other may differ significantly.

12.14 Criterion Used by Railways for Selection of the Lines to be Electrified

Railways also take into consideration for the calculation of operational expenses both with diesel electric locomotives and electric locomotives, as a function of the traffic density on that line, expressed in terms of Gross Million Tonnes (GMT) carried per route km/annum. The following costs are considered for the comparison:

i. Fixed costs: which include, Interest and depreciation, on the cost of transmission lines and substations for electric traction and are not dependent on traffic,

ii. Variable costs: which include fuel/energy cost, (Interest+ depreciation) on cost of

locomotives+ operating and maintenance cost of locomotives and Overhead Equipment (OHE) and will increase with the rail traffic.

The breakeven point in the comparative presentation of the annual operating expenses of diesel and electric traction determines the GMT per km/annum at which the electric traction will be justified on any particular section of the railway.

A Committee of Executive Directors of Railway Board carried out a study in 1996, which was based on the then prevalent unit prices of diesel and electric energy, wherein the breakeven point for the adoption of electric traction on any of their railway line was assessed as 49.72 GMT per route km/year. This Committee had also carried in 1989 a similar study, wherein the same breakeven point had been determined as 34.9 GMT.

12.15 Estimated Gross Million Tonnes (GMT) to be Carried per route km/year on the New Railway Line

Based on the projected passenger traffic on the new line from Islamabad to Murree, we have proposed running of eight pairs of passenger trains daily, with a trailing load of 400 tonnes, keeping in view the ruling gradient of 1 in 40. This traffic will amount to about 4.00 GMT per km per year, which is far less than the above-mentioned breakeven value of 49.72 GMT for any section proposed to be electrified. In face of above position discuss above in subheading 4.3, and 4.4, it is considered that provision of conventional electric traction on proposed new railway link between Islamabad/Rawalpindi and Murree is not justified economically and operationally.

12.16 Non-Feasibility of Conventional Electric Traction

Initial evaluations focused on conventional railway electrification using overhead equipment (OHE) with 25 kV AC traction. However, the following critical challenges render such a system impractical for this specific project:

Topographical Limitations: The corridor involves steep gradients exceeding 5–6%, which are beyond the capabilities of standard electric rolling stock operating on broad gauge with conventional adhesion-based traction.

Geological Hazards: Extensive geological surveys revealed areas with unstable slopes and crushed rock formations, particularly near tunnel portals. These conditions pose high risks of landslides and structural instability, especially during the construction of heavy OHE support infrastructure.

Alignment Constraints: The available corridor space and environmental sensitivity near Murree restrict the implementation of wide rail footprints, extensive cuttings, and tall traction poles required for traditional electrified rail.

High Capital and Maintenance Costs: The construction of conventional electric rail systems—requiring multiple substations, extensive OHE infrastructure, and reinforced civil works—would not be cost-effective, especially given the relatively low anticipated Gross Million Tones (GMT) of traffic on this tourist-oriented line.

12.17 RECOMMENDATIONS

Based on the detailed analysis and field investigations conducted during the feasibility study, the adoption of straddle monorail technology was considered and is strongly recommended over conventional electric traction systems. This recommendation is grounded in both technical feasibility and operational sustainability, considering the unique geographic, geological, and topographical constraints of the Islamabad–Murree corridor.

12.18 Technical and Economic Justification for Straddle Monorail

In contrast, the straddle monorail system presents a highly suitable alternative for the following reasons:

Superior Gradient Handling: Monorail systems are capable of operating efficiently on gradients up to 6%, eliminating the need for rack rail systems or additional traction modifications.

Compact Footprint: The monorail requires minimal right-of-way, both horizontally and vertically, which reduces land acquisition costs and minimizes disruption to the surrounding terrain and communities.

Integrated Electric Traction: Powered by electric motors, the straddle monorail draws power through side-mounted conductor rails embedded in the guide beam. This eliminates the need for complex and high-maintenance OHE infrastructure, making the system more resilient and easier to maintain in harsh mountain conditions.

Shorter Construction Timeline: The modular and elevated nature of the monorail infrastructure allows for faster deployment, particularly important in areas where traditional excavation or heavy earthworks would be geotechnically challenging or environmentally disruptive.

Environmental Compatibility: The monorail is an energy-efficient, low-emission system, well-aligned with the project's goal of promoting sustainable tourism in an ecologically sensitive region.

Passenger Experience: Elevated guideways and panoramic window designs provide passengers with uninterrupted scenic views, enhancing the tourism value of the Glass Train concept.

12.19 Electrical Traction Design for Straddle Monorail

12.19.1 Route Characteristics

- Length: 40 km (approx.)
- Terrain: Mountainous and hilly
- Elevation Gain: ~1,500 meters (from ~540 m to ~2250 m)
- Stations: 4 Nos
- Train Sets: 8 train sets
- Each Train Set: 4 cars per train, 8 traction/induction motors per train
- Motor Power: 125 kW per motor
- Total Traction Power per Train Set: 8 × 125 kW = 1,000 kW = 1 MW

12.19.2 Power Demand Estimation

- Eight Number of train sets will be in operation simultaneously
- Traction Power Demand: 8 MW

- Add 20% for gradient compensation, acceleration peaks, and losses: 1.6 MW

Total Peak Load Estimate: 8 to 10 MW.

12.19.3 Power Source and Grid Connection

- Nearest Grid Stations (NTDC/IESCO):
- IESCO Grid Station (Zero Point), Islamabad - 132 kV (~10 km)
- Murree Grid Station, Murree - 132 kV (Near terminal point ~ 3km)
- Primary Feeder: 132 kV double-circuit from Zero Point Grid Station
- Secondary/Redundant Feeder: 132 kV connection from Murree Grid Station

12.19.4 Power Transmission Design

- 132 kV Transmission Lines
- Type: Double-circuit Steel Tower Line / Under-ground
- Right of Way (ROW): 3m wide
- Total Length: Approx. 10-12 km
- Switching Stations: as per design

12.19.4.1 Power Grid Stations (PGS)

- Number of PGS: 2 (Strategically at each terminal)
- PGS-1: Near Islamabad Terminal -132 kV input, 33 kV
- PGS-2: Murree Terminal -132 kV input, 33 kV
- 132/33 kV Power Transformers (40–50 MVA, 2 per PGS)
- Circuit Breakers, Isolators, SCADA & Fire Systems
- Distribution through Dual 33 kV ring main with N–1 redundancy

12.19.5 System Layout

132/33 kV Grid Station (Islamabad) → TPSS1 (~0 km) → TPSS2 (~10 km) → TPSS3 (~30 km) → TPSS4 (~40 km) ← 132/33 kV Grid Station (Murree)
Dual-fed 33 kV loop ensures continuous supply and fault isolation

12.19.5.1 Traction Power Substations

- 4 to 6 Nos TPSS, every 8-10 km distance
- 33 to (0.75- 1.5) kV Step down Traction Transformers
- Rectifier Units (750 - 1500 V DC output)

12.19.6 Traction Power Supply

- Traction Voltage: 750- 1500 V DC (third rail)
- Power Distribution: Underground conduits or elevated third rail
- Power per Train Set: 1 MW
- Total Traction Power for 8 trains: 8 MW

12.19.7 Monitoring & Control (SCADA)

- Central SCADA system in Lake View Park Control Center
- Remote access to TPSS, energy metering, voltage tracking, outage detection
- Integration with fire alarm, CCTV, and PA system
- Fire-resistant TPSS building
- Cable Trenches, Raceways, Surge Arrestors
- Lightning Protection Systems and Security Fencing
- Functions
    - Real-time voltage, current, and breaker monitoring
    - Remote control of isolators, DGs, and HVAC
    - Event alarms, data archiving, and trend analysis

Table: 12.1 Power Zones

Section	Source	Coverage
0–20 km (Islamabad Zone)	Islamabad Grid → TPSS1, TPSS2	Depot + 2 stations
20–40 km (Murree Zone)	Murree Grid → TPSS3, TPSS4	Murree terminal + 1 intermediate
Mid-Section	Dual-fed	Ensures redundancy, stable voltage

12.19.8 Working Plan for Power Supply & Distribution

A dual-grid, ring-fed 33 kV system is proposed to ensure uninterrupted traction and auxiliary power for the 40 km Islamabad–Murree monorail. The system provides full redundancy, remote monitoring via SCADA, and adaptation for hilly terrain operation.

Table: 12.2 Key Highlights

Component	Description
Grid Stations	2 (Islamabad & Murree, 132/33 kV) – each feeding ~20 km
Distribution Voltage	33 kV AC ring main for TPSS and auxiliaries
Traction Supply	1.5 kV DC from 4–6 TPSS (spaced 8–10 km apart)
Auxiliary Supply	33/0.4 kV for lighting, HVAC, lifts, signaling, etc.
Backup Power	UPS (2–4 hr) + DG sets at depots, terminals, and OCC
Control System	SCADA with fiber optic backbone, master at Islamabad Depot
Reliability	N+1 redundancy in transformers, rectifiers, DGs, and UPS
Depot Supply	Dedicated 33 kV feeder + local TPSS for train operations
Special Features	Regenerative braking, high-torque traction motors, weatherproof design

12.19.9 Protection Devices in Electrical Power System

A multi-layered protection system ensures the safety, reliability, and continuity of power supply across traction, auxiliary, and control systems of the 40 km monorail. Protection is provided at 132 kV, 33 kV, 1.5 kV DC, and 400 V levels through coordinated relays, breakers, surge arresters, and earthing systems, all integrated via SCADA-based monitoring.

12.19.9.1 Protection & Earthing Overview

- Purpose: Prevent equipment damage, isolate faults quickly, and ensure personnel safety
- Multi-voltage protection (132 kV to 0.4 kV)
- Dedicated earthing grids at all substations and depots
- Surge protection and lightning arrestors at all voltage interfaces
- Redundant feeds and automatic transfer via ATS/UPS systems

Table: 12.3 Key Protection Devices by Voltage Level

Voltage Level	Main Protection Devices	Purpose
132 kV (Grid Stations)	SF_6 circuit breakers, distance & differential relays, CTs/VTs, surge arresters, NGR	Protect incoming lines, transformers, and feeders from major faults
33 kV (Feeder & TPSS Input)	Vacuum circuit breakers (VCB), OC/EF relays, differential relays, surge arresters, sectionalizes	Isolate faulty feeders and protect transformers & distribution circuits
1.5 kV DC (Traction)	DC breakers, rectifier protection, overcurrent & earth fault relays, surge arresters	Protect traction circuits, rectifiers, and third-rail distribution
0.4 kV (LV Systems)	MCCBs, MCBs, RCCBs/RCDs, fuses, SPDs, motor protection relays	Localized protection for lighting, HVAC, escalators, signalling, and control loads

12.19.9.2 Earthing & Lightning Protection

- Earth Mats at all substations and depots (resistance ≤ 5 Ω).
- Dedicated Signal Reference Grid (SRG) for telecom and control equipment.
- Lightning Arresters at 132 kV, 33 kV, and 1.5 kV DC levels.

12.19.9.3 SCADA Integration

- All relays and breakers are numerical and IEC 61850 compatible.
- Continuous monitoring of current, voltage, breaker status, alarms, and faults.
- Remote operation and trip logging from the command center (Islamabad Depot).

Table: 12.4 Summary of Major Equipment

Substation Type	Typical Rating	Key Protection
132/33 kV Grid Station	Transformers 40–50 MVA, CB 40 kA	Distance/differential relays, surge arresters, CT/VT, earthing, SCADA RTU
33/1.5 kV TPSS	Transformers 5–8 MVA, Rectifiers 3–4 kA	DC breakers, rectifier & feeder protection, surge arresters, earthing
33/0.4 kV Aux. Substation	500–1000 kVA Tx, DG 250–500 kVA	MCCBs, UPS, ATS, SPDs, RCDs, earthing

12.19.10 Power Consumption & Rolling Stock

A comprehensive estimation of traction and auxiliary energy demand ensures proper sizing of substations, rectifiers, feeders, and billing forecasts

Table: 12.5 Traction Energy (Train Operation)

Parameter	Value
Train type	**Straddle monorail 2 trailers & 2 traction cars**
Motor load	**1 MW per train (peak)**
Energy use	**8 kWh/km/train**
Trains Sets in service	**6 Nos normal 8 Nos peak hours**
Daily trips/train	**12 - routine 15 - peak hours**
Total daily Traction energy to run 12 trips (1200 km)	**≈ 9600 Kwh/day**
Regenerative energy in downhill braking	**50 – 65 % recovery**

12.20 Conclusion

In view of the significant challenges encountered with the conventional rail electrification approach especially related to terrain, safety, feasibility, and considering the clear technical and economic advantages offered by the straddle monorail, it is recommended that the project proceed with the monorail system as the preferred electric traction solution for the Islamabad–Murree scenic rail corridor. This approach ensures a safe, sustainable, and cost-effective implementation aligned with both engineering best practices and the strategic tourism development objectives of the Government of Punjab.

13. Chapter

13.1 Signaling and Telecommunication Study

13.2 Introduction

The Government of Punjab has launched an initiative to develop a scenic railway link between Islamabad and Murree to improve accessibility for both tourists and the public while promoting sustainable transport. The centerpiece of this effort is the proposed Glass Train a modern concept featuring panoramic windows and glass ceilings to provide passengers uninterrupted views of Murree's Mountain landscape. Similar systems in Switzerland, Norway, Japan, and Canada have proven highly successful in combining mobility with tourism.

The project aims to reduce road congestion, emissions, and environmental impact by offering a cleaner alternative to private vehicles. It aligns with the Government's broader goals of sustainable tourism, inclusive mobility, and regional development.

Building on earlier studies by Pakistan Railways, this initiative seeks to develop a technically and economically viable rail link to Murree, situated around 2,000 meters above sea level. The Punjab Mass Transit Authority (PMA), with technical support from the Transport Planning Unit, is conducting a comprehensive feasibility study covering:

- Passenger and seasonal tourism demand assessment.
- Optimal route alignment considering terrain and environmental constraints.
- Evaluation of suitable rail technologies (conventional, rack, or funicular).
- Integration with the existing Pakistan Railways network.
- Financing and delivery options, including PPP and EPC models.
- Preliminary engineering designs for stations, rolling stock, and systems.
- Legal and institutional frameworks for implementation and maintenance.

Through this study, the Government aims to establish a safe, modern, and environmentally responsible scenic railway system that enhances regional connectivity while preserving Murree's natural beauty.

13.3 Scope of Services for the Signaling and Telecommunication Study

The Signaling and Telecommunication report will cover the following areas:

- Definition of signaling and telecommunication systems based on traffic forecasts and density for each section.

- Compliance with relevant rules, regulations, and operational requirements.
- Adoption of appropriate technical design standards.
- Evaluation of modern signaling and telecommunication technologies, including key design features, equipment specifications, and power supply systems.
- Preparation of yard layouts.
- Development of signaling and telecommunication plans for selected routes.
- Cost estimation, including equipment, recurring expenses, training, and spare parts.
- Proposal for maintenance facilities, organizational structure, and maintenance systems.

13.3.1 Design Standards and Technology Options

This section will define the technical design standards applicable to the proposed systems and evaluate modern signaling and telecommunication technologies suitable for the project's alignment and terrain. Options to be reviewed include Computer-Based Interlocking (CBI), axle counter-based block systems, Communication-Based Train Control (CBTC), token less block working, GSM-R, LTE, and optical fiber networks. Key design features, equipment specifications, and power supply with redundancy arrangements will also be outlined.

13.3.2 Plans, Layouts, and Integration

This section includes the preparation of preliminary yard layouts, station interlocking and block sectioning plans, signaling and telecommunication layouts with equipment locations, and an integration plan to ensure seamless connectivity and compliance with Pakistan Railways standards.

13.3.3 Costing and Maintenance

This section covers preliminary cost estimates for signaling and telecommunication equipment, civil works, power, and installation. It also includes recurring costs for operations, maintenance, spares, and training, along with proposals for maintenance facilities, tools, and organizational setup.

13.3.4 Cyber security, Reliability, and Risk

This section identifies cyber security measures to protect signaling and telecom systems and includes a preliminary risk assessment addressing reliability, redundancy, and environmental resilience in mountainous conditions.

13.4 RAMS (Reliability, Availability, Maintainability, and Safety) and Lifecycle Planning

This section defines RAMS requirements in line with the project's operational and safety goals. It includes a preliminary analysis of reliability, availability, maintainability, and safety targets, along with lifecycle support recommendations covering spares, documentation, training, and tools to ensure long-term system performance.

13.4.1 Basic Definitions and Principles

This section explains the fundamental concepts and operating principles of signaling and telecommunication systems, including train separation, block working, interlocking, and communication needs for safe and efficient operations. It also outlines relevant national and international standards, safety integrity levels (SIL), and core design philosophies such as fail-safe operation, redundancy, and cyber security.

Following are fundamental principle of Railway Signaling and Telecommunication

- **Safe Train Separation:** Maintain adequate distance between trains to prevent collisions.
- **Fail-Safe Design:** Systems must default to a safe state during failures or power loss.
- **Interoperability:** Ensure seamless integration with existing and future Pakistan Railways systems.
- **Redundancy:** Provide backup for critical equipment and communication links to maintain continuity.
- **Cyber security:** Incorporate protection against unauthorized access and cyber threats.
- **Environmental Compatibility:** Design systems to perform reliably in mountainous and variable climatic conditions.

Following are Salient points for Station, Yard and Facility Operations

- **Yard Operations:** Control of train movements for stabling, marshalling, and maintenance (e.g., small yard at Murree or Islamabad for overnight parking).
- **Maintenance Depot:** Facility for inspection and upkeep of rolling stock with dedicated signaling and telecom systems (e.g., depot at Islamabad).
- **Third Rail:** Electrification method using an additional rail for power supply; generally used in metro systems and unlikely for the Murree Glass Railway unless electric traction is adopted.

13.4.2 Operational and Capacity Metrics

- **Headway:** Minimum safe time interval between consecutive trains (e.g., 10–15 minutes with axle counters, 3–5 minutes with CBTC).
- **Train Density:** Number of trains operating on a section within a set period (e.g., 8 tourist trains per day during peak season).

13.5 Safety Integrity Levels (SIL) in Railway Signaling and Telecom

13.5.1 Safety Integrity Level (SIL)

SIL defines the level of risk reduction achieved by a safety-related system and its ability to perform safety functions reliably. In railway signaling and telecom, SIL applies to systems like interlocking, train detection, and automatic train protection. As per CENELEC standards (EN 50126, EN 50128, EN 50129), SIL ranges from 1 (lowest) to 4 (highest), with higher levels ensuring greater safety and lower failure probabilities.

13.5.2 SIL Matrix for Railway Applications

Table: 13.1 SIL Matrix for Railway Applications

SIL Level	Typical Use in Railways	Probability of Dangerous Failure per Hour (PFH)	Risk Reduction Factor (RRF)
SIL 1	Non-critical systems; e.g. auxiliary monitoring	$\geq 10^{-6}$ to $<10^{-5}$	10 to 100
SIL 2	Systems where failure causes limited safety impact; e.g. depot protection systems	$\geq 10^{-7}$ to $<10^{-6}$	100 to 1,000
SIL 3	Systems where failure could result in significant hazard; e.g. automatic warning systems, block section controls	$\geq 10^{-8}$ to $<10^{-7}$	1,000 to 10,000
SIL 4	Systems where failure may cause catastrophic consequences; e.g. interlocking, ATP, train detection	$\geq 10^{-9}$ to $<10^{-8}$	10,000 to 100,000

13.5.3 Fundamental Functions of Signaling

- **Train Separation**: Prevent collisions by ensuring safe headway.
- **Route Setting:** Guide trains over correct, conflict-free paths.
- **Speed Regulation:** Inform drivers of permitted speed and hazards.

- **Fail-Safe Operation:** Ensure systems default to the safest condition during faults.

13.6 Conclusion

Interlocking is vital for rail safety across all systems. Pakistan Railways is moving from mechanical and relay-based controls to modern CBI and ATP-integrated interlocking. For the Murree Glass Train, adopting CBI compliant with CENELEC SIL-4 standards, along with ATP/Cab Signaling where needed, will ensure safe and efficient operations.

13.6.1 Need and Importance of Block Working

Block working ensures train safety and efficient traffic flow by:

- Preventing collisions through controlled entry into track sections.
- Maintaining safe spacing in high-density corridors.
- Maximizing capacity by allowing more trains with safe separation.
- Providing fail-safe operation during system failures.

It remains the foundation of safe railway operations, supporting higher speeds and closer intervals across tourist, metro, and intercity systems.

13.6.2 Moving Block System

Principles:

- Dynamic block length based on speed, braking distance, and position.
- Continuous position reporting via radio or data link.
- Safe “virtual block” maintained behind each train.

Advantages:

- Higher line capacity.
- Shorter headways.
- Ideal for high-density or automated systems.

Limitations:

- Requires reliable real-time communication.
- High cost and system complexity.
- Unsuitable for rural or mountainous routes like the Murree Glass Train.

Global Use:
Adopted in urban metros and select high-speed lines; not yet used by Pakistan Railways.

13.6.3 Conclusion

Block working remains fundamental to railway safety. Pakistan Railways' shift from Absolute to Automatic Block, with future potential for Moving Block, marks a balanced modernization approach. For routes like the Murree Glass Train, combining Absolute Block with modern detection systems (e.g., coded track circuits or axle counters) ensures safety, cost efficiency, and operational flexibility without added complexity.

13.6.4 CBTC vs. CBTC Lite

Comparison is detailed in the **Table 13.2** below

Aspect	**CBTC (Full CBTC)**	**CBTC Lite / CBTC Overlay**
Definition	A full moving block signaling system where train location, speed, and separation are continuously controlled via continuous communication (typically radio). No reliance on fixed blocks.	A hybrid or overlay system that provides selected CBTC functions (e.g. enhanced train detection, automatic train protection) on top of existing fixed block signaling without full moving block capability.
Train Separation	Moving block safe distance dynamically calculated in real time.	Fixed block or fixed virtual block — follows existing block sections, but with improved train detection and control.
Capacity	Maximum capacity headways as low as 60–90 seconds on metro systems.	Moderate capacity increase compared to traditional ABS; headways typically reduced by 10–30% depending on design.
Infrastructure Change	Requires comprehensive infrastructure change — wayside equipment, onboard units, control center integration.	Minimal disruption uses existing signals, blocks, and infrastructure possible, adds CBTC elements on top.
Application	High-capacity urban metros, new build lines, highly automated or driverless lines (GoA 3/4).	Existing lines needing capacity improvement without full replacement of signaling; light metro or suburban corridors.
Cost and Complexity	High initial cost, complex deployment, major system change.	Lower cost than full CBTC; incremental upgrade.

Aspect	CBTC (Full CBTC)	CBTC Lite / CBTC Overlay
Example	Dubai Metro, Hong Kong MTR, Delhi Metro (GoA 4 sections)	CBTC overlays on parts of Indian suburban rail, Paris suburban network (as interim step).

13.6.5 Emerging Detection Technologies

New detection methods under exploration include:

GNSS-based Location: Uses GPS/GNSS for positioning; less accurate near tunnels or dense structures.

Balise /Beacon Detection: Fixed transponders (as in ETCS) update train positions.

Fiber Optic Monitoring: DAS technology detects vibrations and movement; tested in European networks.

13.6.6 Control Panels and Interfaces for Railway Signaling Evolution, Types, and Comparative Assessment

At the core of any signaling system is the control panel, enabling operators to monitor and manage train movements. Control panels have evolved from mechanical frames to hardwired panels and now to digital LED or VDU-based interfaces (e.g., EBI Screen, Siemens VDU). Each represents its technological era with specific advantages and limitations.

This chapter outlines the types, features, and constraints of control panels used in Pakistan Railways and compares them with modern systems.

13.6.7 Hardwired Control and Indication Panels (Mimic Panels)

These panels display a yard schematic with LEDs showing track occupancy, point positions, and signal aspects. Routes are set using push buttons or switches.

Advantages: Reliable, easy to use, and independent of IT systems.
Limitations: Bulky, complex wiring, hard to modify, limited diagnostics, and high maintenance.
Current Use: Still common in older ARI stations and early CBI setups within Pakistan Railways.

13.6.8 Graphical Display Panels (LED Monitors / VDU Systems)

Modern systems like EBI Screen, Siemens West cad, and Ansaldo Microlok use dynamic, computer-based displays for real-time control and monitoring of train movements.

Advantages: Flexible, scalable, easy to update, integrates with CBI/ATP, and offers full data logging and diagnostics.
Limitations: Dependent on stable power and IT support, requires cyber security measures, and operator retraining.

13.6.9 Worldwide Signaling Standards and Systems for Metro Railways

Metro railways, typically high-density urban transit systems place unique demands on signaling: they must safely manage short headways, frequent stops, high passenger loads, and often fully automated operation.
Unlike mainline railways, where long block sections and mixed traffic (passenger + freight) are common, metros prioritize:

- Maximum throughput (trains per hour);
- Minimal headways (as low as 90–120 seconds);
- High reliability in start/stop cycles;
- Integration with platform screen doors, automatic train operation (ATO), and even driverless modes (GoA 4).

To achieve this, metros around the world have moved beyond traditional “fixed block” signaling to Communication-Based Train Control (CBTC) where trains continuously report their position, allowing moving block operation.

Standards applied:

- **IEEE 1474** - US & global CBTC systems standard;
- **IEC 62290** -European and Asian urban rail CBTC standard;
- **CENELEC EN 50126/8/9** - lifecycle safety (RAMS);
- **SIL-4** required for CBTC and ATO systems controlling movement authority.

Table: 13.3 International Foot Print of Metro & Signalling System

Region / City	Typical Metro Signaling System	Notes
Paris Metro	CBTC (Siemens/Alstom)+ legacy	Migrating all lines to CBTC
London Underground	Moving block CBTC (Thales Seltrac)	Full ATO on some lines
New York Subway	CBTC (Siemens, Thales) on new sections; legacy elsewhere	Very complex retrofit program
Delhi Metro	CBTC (Siemens, Alstom)	SIL-4 certified
Dubai Metro	CBTC + full GoA 4 (driverless)	One of the most advanced
Singapore MRT	CBTC (Thales, Siemens)	GoA 4 driverless
Hong Kong MTR	CBTC + legacy hybrid	One of world's densest metro operations
Shanghai Metro	CBTC / ETCS-L2 hybrid	Largest urban metro globally
Tokyo Metro	CBTC + ATC/ATS hybrid	Very high reliability, dense timetable

13.6.10 Metro CBTC vs. Mainline CBI

The comparison of Metro CBTC with CBI system is detailed in **Table 13.4 below.**

Table: 13.4

Feature	Metro CBTC	Mainline CBI
Block principle	Moving Block	Fixed Block (with ATP overlay)
Headway	90–120 sec	Typically, 5–10 min
Automation Level	GoA 2–4 (driverless possible)	GoA 1 (driver present)
Trackside signals	Often eliminated	Required

Feature	Metro CBTC	Mainline CBI
Speed range	Up to 80–120 km/h	Up to 160–200 km/h (PR)
Traffic type	Dedicated metro, no freight	Mixed traffic (passenger, freight)
ATP	Built-in CBTC	ETCS/ATP separate
System complexity	High (full integration)	Modular (CBI + ATP + CTC)
Supplier examples	Siemens CBTC, Alstom Urbalis, Hitachi, Thales Seltrac	Siemens Track guard, Alstom Smart lock, Bombardier EBI Lock 950
Standards	IEEE 1474, IEC 62290, CENELEC SIL-4	CENELEC EN 50126/8/9, EN 50129, SIL-4

13.6.10.1 Conclusion:

- For urban metro or tourist mountain lines (e.g. Murree Glass Train), CBTC LITE offers advantages: fewer wayside signals, moving block, smoother ride, and low-maintenance.
- For mainline corridors with mixed traffic, CBI + ATP/ETCS remains the appropriate choice.

13.6.11 CBTC Functional Levels GoA 1 to GoA 4

CBTC systems are classified by Grade of Automation (GoA) defining the extent of driver involvement in train operation is detailed in **Table 13.5**

Table: 13.5

GoA Level	Description	Driver's Role
GoA 1	Manual driving with CBTC supervision (ATP/ATC).	Full driving and door operation; CBTC enforces safety.
GoA 2	Semi-automatic operation (ATO) under driver supervision.	Driver starts train and monitors; CBTC handles movement, speed.
GoA 3	Driverless operation with onboard attendant.	Onboard staff only for emergencies; CBTC drives train.

GoA Level	Description	Driver's Role
GoA 4	Fully unattended train operation (UTO).	No staff onboard; CBTC fully controls train and doors.

13.6.12 Advantages of CBTC for Tourist / Light Mountain Lines

For routes like the Murree Glass Train, simplified or CBTC Lite systems offer key benefits:

- **Moving Block:** Efficient use of single-track sections.
- **Flexible Headways:** Adjusts to seasonal or event-based demand.
- **Less Wayside Equipment:** Minimal signals and interlocking.
- **Gradient Handling:** Automatic speed control on slopes.
- **Energy Efficiency:** Smooth operation reduces fuel use.
- **Enhanced Experience:** Supports coordinated tourist features.
- **Low Maintenance:** Fewer mechanical failures in mountain conditions.

GoA 2 or GoA 3 automation levels best balance safety and passenger experience.

13.6.13 ETCS vs CBTC

Both ETCS and CBTC offer advanced train control but serve different needs:

- **ETCS:** Suited for mainline and high-speed rail with mixed traffic, long distances, and interoperability across networks (e.g., Europe, China).
- **CBTC:** Designed for metro and light rail with short headways, frequent stops, and higher automation (GoA 2–4).

Application:

- Urban or tourist lines like the Murree Glass Train → CBTC Lite.
- Mainline mixed-traffic routes → ETCS Level 1 or 2.

13.6.14 Cyber security for CBTC and CBI Systems

CBTC and CBI systems depend on IP networks, radio links, and COTS hardware, making cyber security essential. Threats like unauthorized access, spoofing, or DoS attacks can disrupt operations or safety.

Key Measures:

- Separate safety-critical and IT networks.
- Use firewalls, secure communication protocols, and intrusion detection.
- Enforce strict access control and regular software updates.
- Conduct cyber security audits throughout the project.

For systems like the Murree Glass Train, a Cyber security Management Plan must be in place from the start to ensure safety and reliability.

13.7 Communication Requirements for Signaling and Operations

Modern railway systems, including tourist and metro lines, depend on highly reliable and secure communication infrastructure to support signaling, train control, and operational safety. This chapter outlines the data and voice communication requirements for systems such as CBTC, CBI with Auto Block, and Token less Block, with reference to international best practices and standards (CENELEC, SIL-4 & ERTMS).

13.7.1 Overview of Communication Functions

Railway communication systems serve two main roles:

- **Data communication:** Supports signaling, interlocking, train protection, and control.
- **Voice communication:** Enables coordination, emergency response, and fallback operations.
  Both are vital for safe and efficient train movement.

13.7.2 Data Communication Requirements

- **Functions:** Continuous exchange of safety-critical data and coordination between train, wayside, and control systems.
- **Key Requirements:**
  - Availability ≥ 99.999% (SIL-4)
  - Latency < 100 m (CBTC), a few seconds for CBI
  - Dual wired/wireless redundancy
  - Encrypted, authenticated links
  - Network segregation for safety-critical data
  - Fail-safe response to link loss
  - Time synchronization (NTP/PTP)
  - Continuous link monitoring

- **Typical Systems:**
    - CBTC: Fiber backbone + LTE-R / Wi-Fi 6
    - CBI/Auto Block: Fiber or copper between interlocking, stations, and posts

13.7.3 Voice Communication Requirements

Functions: Real-time coordination, fallback control, and emergency response.

Key Requirements:

- Availability ≥ 99.99%
- Latency ≤ 300 ms
- Redundant voice paths (LTE-R + VoIP)
- Emergency phones at critical points
- Encrypted, priority-based routing

Typical Voice Links:
Drivers, stations, control centers, depots, and yard staff.

Typical Systems:

- LTE-R (new systems)
- VoIP over fiber (fixed sites)
- GSM-R (legacy)
- VHF/UHF (yards and depots)

13.7.4 Comparative Summary Data Communication vs. Voice Communication

Table: 13.6

Aspect	**Data Communication**	**Voice Communication**
Purpose	Safety-critical train control, signaling	Operational coordination, fallback
Latency	< 100 ms (CBTC); seconds (CBI)	~300 ms max
Availability	≥ 99.999%	≥ 99.99%
Redundancy	Dual radio + dual wired	Primary + fallback path
Fail-safe default	Train stop / block occupied	Use emergency comms
Cyber security	Encryption, authentication	Encrypted voice, secure routing
Technology	LTE-R data, Wi-Fi 6, fiber	LTE-R voice, VoIP, radios

13.8 Murree Glass Train Communication Concept

For the Murree Glass Train, communication systems should:

- Implement a fiber optic ring backbone to support SIL-4 signaling.
- Use LTE-R radio for both data and voice (preferred), or Wi-Fi 6 for tunnels/stations as a supplement.
- Include VoIP systems at stations, depots, and control centers.
- Provide VHF/UHF radios for yard operations and maintenance.
- Install emergency telephones at strategic locations (tunnels, sidings, stations).

13.9 Public Address and Synchronized Clock Systems

Modern railway infrastructure includes not only signaling and train control but also essential passenger amenities and operational tools that enhance safety, service quality, and efficiency. Among these, the Public Address (PA) system and Synchronized Clock System play vital roles in delivering timely information, ensuring operational precision, and maintaining passenger confidence.

13.9.1 Public Address (PA) System

The PA system is used to broadcast audio announcements for passengers and staff, ensuring clear and timely communication of train schedules, service updates, and safety instructions.

13.9.1.1 Key Features

- Clear audio across platforms, stations, and depots.
- Linked with signaling/control systems (CBTC, CBI, ATS) for automated messages.
- Zoned announcements for specific areas or full-station broadcasts.
- Emergency override for priority alerts.
- Operator consoles at stations and control centers.
- VoIP-based network over fiber backbone for high reliability.

13.9.2 Communication Integration

- Linked with train control systems (CBI / CBTC / ATS) for automatic train arrival, departure, and delay announcements.
- Tied into control center for manual or automated broadcast of operational and emergency messages.

- Synchronized with Passenger Information Display Systems (PIDS) for visual/audio consistency.

13.9.3 Synchronized Clock System

The system provides uniform, accurate time across stations, depots, and control centers to ensure coordinated operations and schedule adherence.

13.9.3.1 Key Features

- GPS or NTP/PTP-based master clock with synchronized slave clocks.
- Integrated with signaling, PA, PIDS, and ATS systems.
- Automatic time adjustments and fault monitoring for reliability.

13.9.4 System Architecture and Requirements

Table13.7

Component	Function	Typical Technology
PA Central Controller	Manages audio content, zoning, priority control	VoIP PA server, integrated with ATS/CBI
PA Amplifiers / Speakers	Delivers announcements in zones	IP / analog speakers, digital amplifiers
PA Console	Allows manual announcements	Touchscreen workstation, mic console
Clock Master	Provides standard time source	GPS master clock / NTP server
Slave Clocks	Displays uniform time	Digital/analog platform & concourse clocks
Integration Links	Interfaces PA & clock with signaling & PIDS	Fiber LAN/VLAN, NTP/PTP time sync

13.9.5 Murree Glass Train Recommendations

13.9.5.1 Public Announcement System:

- VoIP-based, fiber-connected public address system with zoned control for each station and terminal.
- Automatic link to train forecast (ATS/CBI) for dynamic announcements.
- Emergency override capability and integration with CCTV for incident

management.

13.9.5.2 Synchronized Clock System:

- GPS master clock with NTP/PTP sync, feeding slave clocks at platforms, stations, control center, and depot.
- Time sync extended to signaling (CBI), ATS, and PIDS for precise operations.

13.10 Operation Control Room (OCR)

The OCR is the central command center for safe and efficient management of the Murree Glass Railway. It integrates signaling, train supervision, communication, passenger information, and security systems for real-time control of the 64 km corridor.

13.10.1.1 Key Functions:

- **Train Operations:** Monitors train movement, headways, and timetable compliance.
- **Signaling Control:** Remotely operates signals, points, and block sections via CBI.
- **ATS:** Tracks trains, manages schedules, and enables automated regulation.
- **Passenger Information:** Controls PA and PIDS for real-time updates and announcements.
- **Security:** Oversees CCTV for surveillance and incident response.
- **Telecom Management:** Manages LTE-R, VoIP, emergency, and radio communications.

13.10.2 Core Systems Integrated within the OCR

Table 13.8 Core Signalling System & Functionality

System	Functionality
Computer-Based Interlocking (CBI) Console	Controls points, signals, block sections, level crossings, ensuring fail-safe routing of trains.
Automatic Train Supervision (ATS) Console	Monitors and regulates train movements in real time, manages timetable adherence, generates alerts.
Public Address (PA) System	Delivers automated and manual audio announcements across stations, platforms, and depots.
Passenger Information Display System (PIDS)	Provides real-time visual information to passengers on platforms and concourses.

System	Functionality
Telecom and Voice Communication Management	Manages LTE-R / VoIP calls, emergency telephones, and Radio systems for drivers, shunters, and station staff.
CCTV System Integration	Provides continuous visual monitoring of stations, platforms, depot areas, and critical track sections.

13.11 Safety, Security, Surveillance, Fire Protection, and Hazardous Material Detection Systems

13.11.1 Safety and Security Overview

The Murree Glass Railway ensures passenger, staff, and infrastructure safety through advanced surveillance, screening, and hazard detection systems beyond conventional measures.

13.11.2 System Components

13.11.2.1 CCTV Surveillance

Artificial intelligence enabled cameras with analytics to detect suspicious activity and potential hazardous incidents.

13.11.2.2 Access and Entry Screening

- **Explosive Detection Systems (EDS):** Integrated with baggage scanners to identify explosives.
- **Trace Detection Portals:** Detect explosive residues on luggage or clothing.
- **Radiation Detection Portals:** Monitor gamma or neutron emissions at entry points and cargo zones.
- **Biohazard Sniffers (Optional):** Air sampling for biological threats in enclosed areas.

13.11.3 Hazardous Material Detection Integration

13.11.3.1 Deployment Areas

- Terminal entrances, parking, and cargo docks
- Platform access points
- Baggage handling zones
- Depot entry gates

13.11.3.2 System Features

- Real-time alarms linked to security control and law enforcement
- Automatic lockdown and isolation on confirmed threats
- Event logging for forensic review

13.11.3.3 Operator Support

- Trained security staff for containment and evacuation
- Integrated PA system for hazard-specific announcements

13.11.4 Fire Detection and Suppression

As detailed earlier, now supplemented by:

- Gas leak detectors (if any hazardous gases are stored or used in maintenance areas).
- Integration with hazardous detection alerts to trigger appropriate fire suppression modes.

13.11.5 Security Control Room Enhancements

- Additional monitoring consoles for hazardous material alarms.
- Direct link to national CBRN (Chemical, Biological, Radiological, Nuclear) response teams.
- Automated reporting templates for hazardous incident alerts.

13.11.6 Standards and Compliance

The system will align with:

- IAEA Safety Standards: Radiation monitoring at transport hubs.
- NFPA 472: Standard for Competence of Responders to Hazardous Materials.
- IEC 62676 / EN 50133: CCTV surveillance in security applications.
- ISO 22320: Emergency management for public incident response.
- National counter-terrorism security protocols applicable in Pakistan.

13.11.7 Recommendations

- Install explosives, radiation, and biohazard detection at key terminals and depots.
- Link detection alarms with control room and emergency systems.

- Train staff in CBRN response, evacuation, and containment.
- Conduct regular testing and drills for hazard detection and response.

13.12 General Maintenance Hierarchy

13.12.1 First-Level Maintenance

Routine and corrective maintenance using diagnostics and module replacement for minor faults or potential failures.

13.12.2 Second-Level Maintenance

Detailed fault investigation and repair using specialized test equipment when first-level actions are insufficient

13.12.3 Third-Level Maintenance

Off-site diagnosis and repair of modules replaced during earlier maintenance levels. All systems will be modular and use plug-in components to speed up repairs and reduce downtime. A dedicated CBI design workstation will support layout modifications, testing, and software updates for future signaling changes.

13.12.4 Maintenance Spares

Spares for a minimum of two years will be procured with the original order. The contractor must ensure spare part availability throughout the equipment's service life and provide advance notice before discontinuing or replacing any component. Alternatively, long-term maintenance contracts may be awarded to the supplier to ensure continued support beyond the warranty period.

13.12.5 Training of Technical Staff

Comprehensive training will be provided to technical staff responsible for system upkeep. Selected Pakistan Railways engineers will receive factory training abroad to gain expertise in system software, maintenance, and future upgrades. In addition, local training sessions will cover all operational and maintenance aspects to ensure staff can perform routine servicing and troubleshooting effectively.

13.12.6 Proposed Maintenance Structure and Organization

It is recommended to depute the following maintenance staff at stations/depot:

- Signal and Telecommunication Engineers.
- Inspector/Foreman signal and telecommunication.
- Sub-Engineers signal and telecommunication.

- Technician signal and telecommunication.
- Technician for Track circuits, batteries.
- Mua wans signal and telecommunication.

14.

15.

16. PARKING STUDY

16.1 Project Background

The Government of Punjab is coming up with a visionary project to have a beautiful rail connection between Rawalpindi/Islamabad and Murree to increase the accessibility of people and tourists.

The project will enhance sustainability of tourism by offering an attractive alternative to the use of the road by the private vehicles, hence minimizing road congestion and impact on the environment. It is a continuation of the earlier Pakistan Railways attempts to connect Rawalpindi/Islamabad with Murree filling the technical gaps and suggesting a viable alignment to the top of the Murree hill in an altitude of approximately 2,000 meters.

A Feasibility Study was initiated by NESPAK on the instructions of Punjab Mass Transit Authority (PMA) in consultation with the Transport Planning Unit of the Transport and Mass Transit Department for the Tourist Glass Train. In order to assess every facet of the project & to complete this study, a Parking Study was undertaken to evaluate currently available parking facilities on the proposed route and to decide on future demand of efficient park-and-ride facilities. Parking facilities will be integrated strategically to facilitate access, modal shift as well as ensure an unhindered connection between the commuters and the tourists. This particular Parking Study was carried out for (Route No. 3 Blue line) which was one of the three conventional railway alignments proposed from Islamabad to Murree as shown in Figure 3.2 chapter 3 above. The route originated at H-9 Margalla Station in Islamabad and terminated at the Murree Bus Stand, covering a total length of 44.6 km. Later on, due to significant obstacles: excessive gradients (up to 6.1%), unstable slopes, crushed limestone, and geo-hazard red zones along proposed tunneling sections the traditional railway solutions became technically and economically unfeasible due to high tunneling costs, slope instability, and unacceptable safety risks. As a result, the study shifted focus to alternative transport technologies more compatible with topography of Murree and option of Straddle Monorail was adopted starting from Lake View Park. A station is planned with a large maintenance Depot at Lake View which also

reside a large Parking area of more than 300 vehicles in addition to Lake View Parking area.

16.2 Objectives of the Parking Study

The Parking Study aims to:

- Assess existing parking facilities along the proposed rail alignment.
- Evaluate opportunities to integrate them into an efficient park-and-ride system.
- Forecast future parking demand based on expected ridership and travel patterns.
- Identify suitable sites for new parking infrastructure considering land, access, and connectivity.
- Recommend design features consistent with international standards and user needs.
- Contribute to the overall feasibility and success of the Glass Train project through a well-planned parking strategy.

16.3 Study Area Description

The Parking Study deals with the two principal clusters, Murree Town and its environs tourism belt, and the Rawalpindi/Islamabad feeder zones connected with the proposed Glass Train alignment.

At Murree, the target locations are major places of traffic like Mall Road, GPO Chowk, Kashmir point, Pindi point and Bhurban approach locations and areas that experience extreme parking demand and particularly during high tourist seasons. Lower Topa, Kuldana Chowk, Musyari Link Road, and other entry points are notorious spillover entry points as their capacity within the town is low. Most hotels and guesthouses do not have off-street parking and thus result in outdoor parking and traffic jams.

The potential of Faizabad Interchange, Pirwadhai Bus Terminal, Murree Road Corridor (Zero Point to Bhara Kahu), and Margalla Railway Station as park-and-ride hubs in Rawalpindi/Islamabad was studied. These can also be used as the transfer at which the tourists may change their vehicles and use the Glass Train to ease traffic congestion at Murree.

The evaluation was conducted in stages, based on data and beginning with a desk review of the current state of affairs and the existing literature and proceeding to the field survey of the shortlisted parking sites along or close to the suggested alignment.

Table: 16.1 Selected Parking sites for Data Collection

S/No.	Location	Parking Capacity	Remarks
1	Valley Park	150	
2	Lake View Parking	300	
3	Abpara Market	80	Marked =20 Open = 60
4	Abpara Market-2	70	Shop owners Parking
5	Jasmine Garden	200	
6	Shaker Parian	550	Monument = 250+TKR 300
7	Railway Parking Area	45	
8	Parking Stand Adjacent to dry Port	60	
9	GPO Car parking	30	
10	Paid Car parking Club Road	25	
11	TMA Car parking	20	

The sites were then surveyed using full day field survey (weekdays and weekends) in order to obtain real time measures of vehicle entrances and exits, which could give strong indicators of accumulation rate and occupancy rate. The results were also evaluated to find suitability of the current facilities to be integrated into the park and ride system of the train.

The next set of images obtained through Google Maps presents the current parking locations in the research territories, which gives us an idea of their location and structure.

Figure: 16.1 Valley Amusement Pa



Figure: 16.2 Lake View Parking

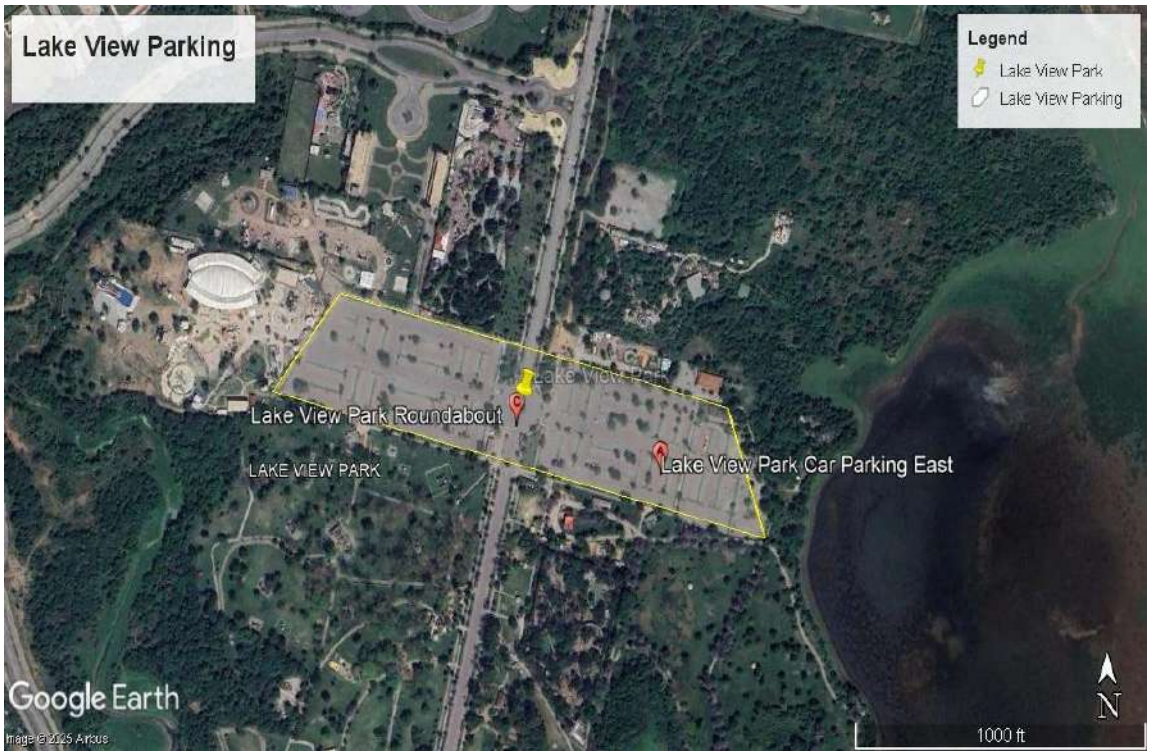


Figure:16.3 Aab Para Market Parking

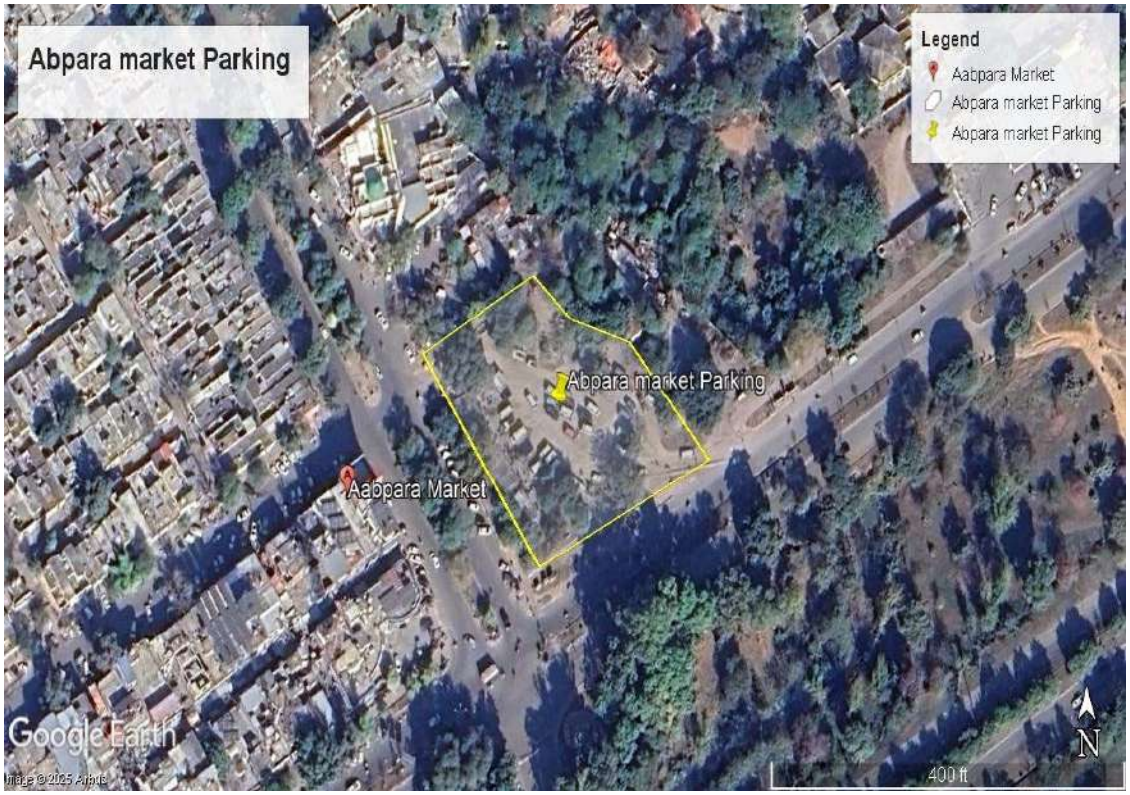


Figure: 16.4 Jasmine Garden Parking


Jasmine Garden Parking
Legend
Jasmine Garden
Jasmine Garden
Jasmine Villa Murree
Google Earth
Image © 2025 Airbus
400 ft
N

Figure:16.5 Shakar Parian Parking



Figure:16.6 Railway Parking Area



Figure:16.7 Parking Stand Adjacent to Dry Port

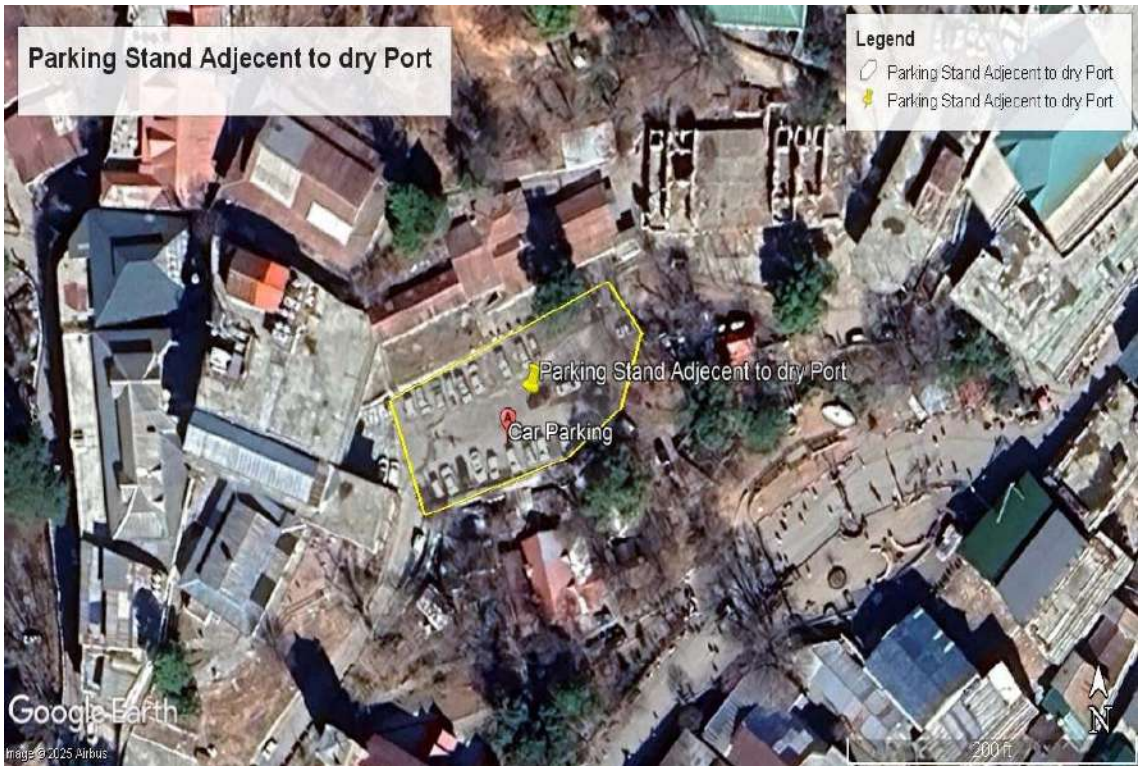


Figure: 16.8 GPO Car Parking



Figure:16.9 Paid Car Parking Club Road



Figure: 16.10 TMA Parking



Future demand projections were generated using ridership estimates derived from the main feasibility study. These projections were cross-referenced with current parking supply data to identify gaps and propose future solutions. Design principles and recommendations were framed based on global best practices to ensure modern, efficient, and user-friendly parking systems.

16.4 Integration with Main Alignment Planning and Ridership Projections

The Parking Study is closely linked to the overall feasibility study, particularly in alignment planning and ridership forecasting. Parking site selection and future location planning are based on proximity to proposed stations and projected passenger flows. Integrating parking with mainline infrastructure ensures a unified, multimodal system that improves accessibility while reducing congestion and environmental impact.

16.5 Methodology

16.5.1 Analysis of Existing Parking Facilities

As a first step, existing parking facilities along the proposed Murree–Islamabad Glass Train alignment were assessed to evaluate their potential for future park-and-ride integration.

The analysis covered capacity, utilization, operations, location, and accessibility. Day-long manual surveys were conducted at shortlisted sites to record hourly vehicle entries and exits. From this data, parking accumulation and occupancy rates were calculated to determine usage patterns and efficiency.

This assessment provided a clear understanding of current conditions, highlighting overcrowded or underutilized areas and identifying sites suitable for integration or requiring improvement to support the Glass Train system.

16.5.2 Demand and Supply Studies

A demand and supply analysis has been conducted to evaluate the usage of parking at present and predict future use in association with Murree Islamabad Glass Train. The objective of the study was to know the current parking trends and how this is expected to change due to the expected movement to rail travel.

The survey was carried out manually between 8:00 AM and 7:00 PM on selected locations in order to record the number of vehicle entries and exits per hour. The major indicators were the trends of hourly demand, peak occupancy and the turnover rates. The comparison between actual use and the available capacity assisted in identifying

where there was high demand, but lacked capacity or areas with low demand had excessive capacity or other access issues.

16.5.3 Prediction of the future parking requirement.

The ridership projections, the modal shift assumptions and the increased factor in growth that included the increasing ownership of vehicles and increased tourism growth were used to estimate future parking demand. These were used to predict the number of train users who would be coming by themselves and need to park.

The findings were applied to estimate the parking demand of major stations and park and ride locations, compare it with current supply and would determine locations that require new facilities or capacity enhancement.

16.5.4 Data Collection

A Number Plate Survey was also carried out at major points along the corridor to determine the travel patterns along the corridor. The surveys were conducted between 7:00 AM and 10:00 PM in 2 shifts that included the peak and off-peak hours on weekdays and weekends.

The number plate of the vehicles, type of vehicle, direction of movement, and time of entry/exit were done manually by enumerators using standardized data sheets so that consistency is ensured. These vehicles consisted of motorcycles, cars, vans, buses and trucks.

It is a methodical process that has resulted in a dependable sample of data to be used in the analysis of traffic volumes, trip purposes, and vehicle movements necessary in the planning and feasibility of the project.

16.5.5 Results

The collected data for each site was being analyzed at each site for the whole day and the Accumulation (%) per hour and occupancy (%) has been calculated for both weekdays and weekends. The data has been attached below in **Table 16.2.**

Table:16.2

From	To	Total Entrances	Total Exits	Net	Accumulation	Occupancy (%)
8:00	9:00	25	6	19	19	6%
9:01	10:00	57	26	31	50	17%

10:01	11:00	102	52	50	100	33%
11:01	12:00	39	50	-11	89	30%
12:01	13:00	30	40	-10	79	26%
13:01	14:00	31	30	1	80	27%
14:01	15:00	28	22	6	86	29%
15:01	16:00	30	21	9	95	32%
16:01	17:00	22	18	4	99	33%
17:01	18:00	58	25	33	132	44%
18:01	19:00	58	28	30	162	54%
19:01	20:00	8	0	8	170	57%
20:01	21:00	0	0	0	170	57%
21:01	22:00	0	0	0	170	57%
22:01	23:00	0	0	0	170	57%
23:01	0:00	19	19	0	170	57%
		507	337			

Mode Share		
1	Motorcycle	138
2	Cars	347
3	Rickshaw / Qingqi	0
4	Wagon/Suzuki/Mini-Bus	4
5	Mazda / Coaster	19
6	Trucks	0

16.6 Analysis

In accordance with the Parking Study of the Murree Islamabad Tourist Glass Train Project, a study was conducted to estimate the parking flux of the potential nodes within the route. The purpose of the study was to evaluate the hourly and daily parking demand based on the anticipated ridership, and to design a useful park-and-ride plan to facilitate the modal shift.

A preliminary sizing recommendation was given in each of the proposed sites and the capacity of each site was evaluated based on the capacity to carry peak-hour parking demand. The paper also assessed the necessity of having multi-level parking in high demand places and recommended appropriate design characteristics.

17. Preliminary Structural Designs

17.1 Preliminary Design for Selected Rail Track

17.2 Straddle Monorail System (Rawalpindi–Murree Corridor)

17.2.1 Background and Selection Rationale

Initially, a conventional railway system was examined for the Rawalpindi–Murree corridor. However, detailed assessment of alignment constraints, steep gradients, complex geology, limited right of way, sharp curves, and environmental sensitivity of the hilly terrain indicated that a traditional rail system would require extensive earthworks, tunneling, land acquisition, and slope stabilization. Considering these factors, a Straddle Monorail system has been selected as the most technically feasible and environmentally suitable option for this corridor.

17.2.2 Track Configuration and Guideway

The selected system is an elevated straddle-type monorail consisting of a single reinforced or prestressed concrete guide beam. The monorail vehicle straddles the guideway and runs on rubber-tired bogies, providing better traction and ride comfort on steep gradients. The guide beam typically has a width of approximately 0.8–1.0 meters and functions as the running surface as well as the primary structural element of the track.

The guideway is supported on reinforced concrete piers, generally spaced 20–30 meters apart. Span length may vary depending on topography, curvature, and structural requirements. Elevated construction minimizes ground disturbance and allows the alignment to cross valleys, streams, and unstable slopes with limited environmental impact.

17.2.3 Alignment Characteristics

The preliminary alignment is designed to generally follow existing road corridors, particularly the Murree Expressway and adjoining hill roads, to reduce land acquisition and resettlement issues. The Straddle Monorail system permits steeper longitudinal gradients, typically up to 6–10 percent, which is well suited to the mountainous terrain of Murree. This flexibility significantly reduces the need for deep cuttings, heavy embankments, or long tunnels.

The system also accommodates tighter horizontal curves compared to conventional rail, enabling smoother alignment adjustment within constrained hilly sections and forested areas.

17.2.4 Foundations and Geotechnical Considerations

Pier foundations will be designed based on detailed geological and geotechnical investigations. Depending on soil and rock conditions, open foundations or pile foundations will be adopted. Special attention will be given to slope stability, drainage, seismic considerations, and erosion control to ensure long-term safety and durability of the structure.

17.2.5 Switches, Power Supply, and Interfaces

Track switches are designed as beam-switch systems, allowing safe and smooth diversion of monorail vehicles at stations and depot access points. Power supply rails, signaling interfaces, communication cables, drainage channels, and expansion joints are integrated within or along the guideway to ensure compact design and ease of maintenance.

17.2.6 Stations and Track Integration

Stations are proposed as elevated structures integrated with the guideway, with side or island platforms depending on passenger demand and site constraints. The track design ensures seamless interface with stations, maintenance depot, evacuation walkways, and emergency access provisions. Terminal and intermediate stations will be connected with feeder transport, parking, and pedestrian facilities, particularly at Rawalpindi and Murree.

17.2.7 Design Outcome

The preliminary design of the selected Straddle Monorail track provides a terrain-responsive, safe, and sustainable solution for the Rawalpindi–Murree corridor. It minimizes environmental impact, reduces construction risks, and ensures reliable year-round operation while supporting tourism and commuter mobility objectives of the project.

17.2.8 Design Parameters at a Glance

Design Parameter	Preliminary Value / Range	Remarks
System Type	Straddle Monorail	Elevated, rubber-tired system suitable for hilly terrain
Guide Beam Width	0.8 – 1.0 m	Prestressed / reinforced concrete beam
Typical Pier Spacing	20 – 30 m	Varies with terrain, curvature, and span requirements

Design Parameter	Preliminary Value / Range	Remarks
Maximum Longitudinal Gradient	6% – 10%	Significantly higher than conventional rail, ideal for Murree terrain
Minimum Horizontal Curve Radius	50 – 100 m (approx.)	Allows alignment flexibility in constrained areas
Track Elevation	Elevated on piers	Minimizes land acquisition and environmental impact
Foundation Type	Open / Pile Foundations	Subject to geotechnical and geological conditions
Switching System	Beam Switch	Integrated within guideway at stations and depot
Design Speed	40 – 70 km/h (section dependent)	Reduced in sharp curves and station approaches
Seismic Consideration	As per relevant seismic codes	Special detailing for hilly and seismic-prone areas
Drainage Provision	Integrated with guideway	Suitable for heavy rainfall and hill runoff

Note: Final design parameters shall be confirmed during detailed engineering design based on topographical survey, geotechnical investigations, and system supplier specifications.

17.2.9 Suitability of Design Parameters for Murree Terrain

Straddle Monorail system design parameters chosen are specifically adapted to the Murree corridor and obviously better than the parameters of a conventional railway in a hilly terrain. Operation over steeper longitudinal gradients to around 6-10 percent does not need extensive cuttings, tunnels and long detours, which would otherwise be inherent with the conventional rail systems whose practice is generally restricted to far milder gradients.

A reduced distance between the pier and a higher guide way will minimize the disturbance of the ground in regions that are environmentally sensitive and susceptible to landslides as well as limiting the amount of land required in the narrow hill roads. The ability to negotiate smaller horizontal curves radius enables the alignment to follow closely existing road corridors, eliminating the need to excavate significant slopes and clear forests.

A concrete guide beam is operated on rubber tires, which offers better traction, braking ability and operation reliability even in wet, foggy and icy weather often experienced in

Murree. This is much safer and more advantageous to service continuity during negative weather conditions than in the case of traditional steel wheel rail systems.

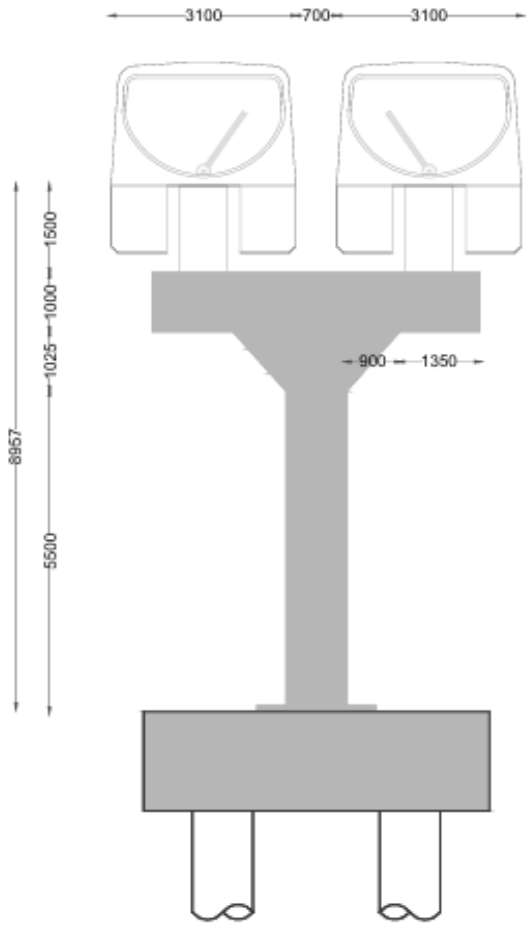
In general, these parameters provide a safer, more flexible, and cheaper system to operate in mountainous areas, and Straddle Monorail can be used as a more appropriate and sustainable solution than the traditional rail in the Rawalpindi-Murree corridor.

17.3 Typical Pier and Beam Design (Monorail)

Straddle monorail vehicles ***ride on and wrap around*** a single guide beam. Stations must support this beam, allow safe boarding, and be accessible for all users.

Typical vehicle width for modern straddle monorails: ~2.7m to 3.0m Typical car length: ~12m to 18m (often 4-car sets for metro/regional service). A typical Pier drawing is shown as under.

17.4 Guide Beam / Track



17.4.1 Elevated Structure

- Center guide beam flanked by platform edges.
- One platform per direction (island) or two separate side platforms, depending on space.

17.5 Types of Stations

For Rawalpindi to Murree, expect these station types:

- Urban/Suburban Stations
    - In Rawalpindi / Islamabad periphery
    - Higher ridership
    - Elevated structures preferred (to avoid land acquisition issues)
- Intermediate Rural Stations
    - Smaller towns/villages
    - Lower volumes, simpler design
- Terminal Stations
    - Major hubs at both ends (Rawalpindi city and Murree)
    - Larger yards, additional facilities

17.6 Platform Design

17.6.1 Platform Geometry

- Height: Match vehicle floor for level boarding — typically 1000 mm to 1100 mm (about 1.0–1.1 m) above rail top.
- Width:
    - Urban station: 3.0 m to 4.0 m minimum clear width.
    - High-capacity: 4.5 m to 6.0 m (to allow peak crowds).
- Length:
    - Standard: ~60 m to 72 m (for ~4 car trains).
    - Future proofing: ~90 m (for 6 car trains if needed).

17.6.2 Canopy and Shelter

- Full-length roof canopy to protect from sun and rain.
- Drainage designed for heavy monsoon rain.

17.6.3 Edge Protection

- Safety lines (painted markings).
- Optional platform screen doors or half-height barriers (recommended for safety and climate control).

17.6.4 Station Structural Components

17.6.5 Track and Beam

- Elevated concrete guide beam, typically 300 mm to 500 mm wide.
- Designed for low vibration and minimal deflection under load.

17.6.6 Columns and Foundations

- Spaced approximately 20 m to 30 m center-to-center (depending on structural requirements and terrain).
- Foundations sized per soil conditions (hilly area near Murree requires geo-tech input for piles or spread footings).

17.6.7 Platform Slab

- Reinforced concrete deck slab.
- Integrated conduits for electrical and communication systems.

17.6.8 Access and Circulation

- Vertical circulation: stairs, ramps, elevators — enough to handle peak crowding.
- Horizontal circulation: clear flows, no pinch points.

17.7 Passenger Flow and Amenities

17.7.1 Ticketing and Entry

- Ticket gates at entry concourse.
- Space for fare vending machines.

17.7.2 Waiting Areas

- Seating distributed along platform.
- Clear signage and real-time displays.

17.7.3 Accessibility

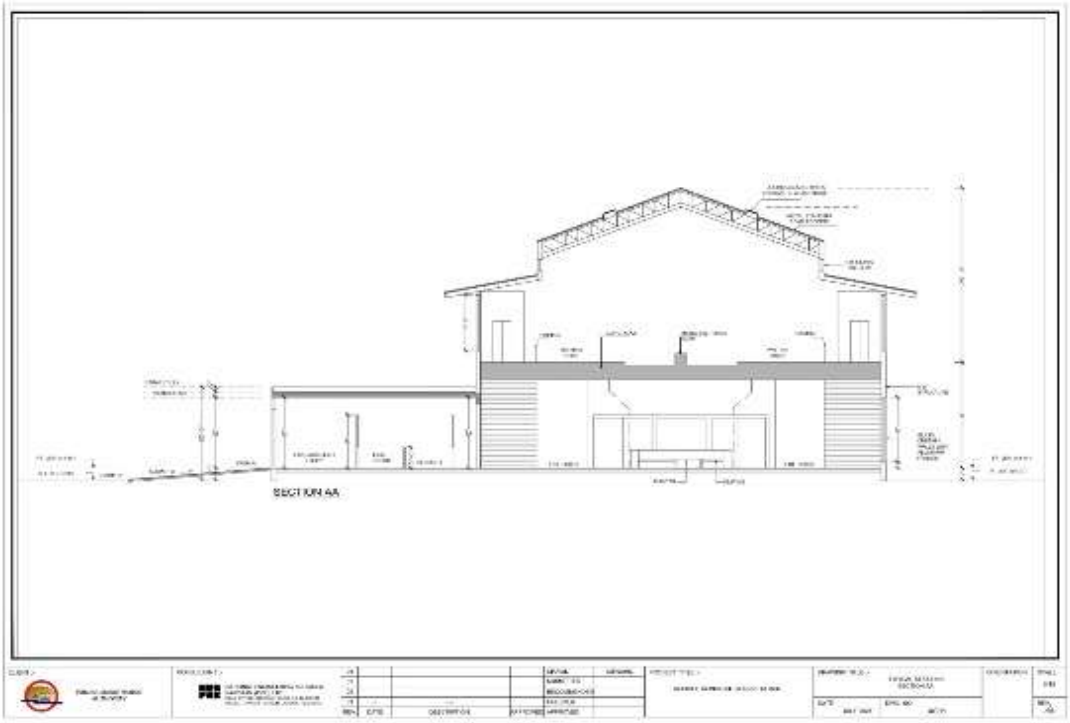
- Ramps or elevators to every level.
- Tactile guidance paths.

17.7.4 Safety

- CCTV coverage.
- PA system.
- Emergency exits clearly signed.

17.8 Typical Cross-Section (Elevated Station)

Typical Cross-section with Roof Canopy is shown in the drawing below.



17.9 Terminal Station Considerations

Rawalpindi / Islamabad Terminal

- Larger concourse.
- Bus/taxi integration.

- Parking and drop-off zone.
- Train stabling yard adjacent or below.

Murree Terminal

- Tourist luggage handling.
- Weather-resilient waiting area.
- Emergency holding/wait area.

17.10 Design Criteria Summary

Item	Typical Value / Note
Platform Height	1000–1100 mm
Platform Width	3.0–6.0 m (depending on demand)
Platform Length	60–90 m
Guide Beam Width	300–500 mm
Column Spacing	20–30 m
Accessibility	Full ADA/UN standards
Roof	Full canopy, local climate rated
Safety Barriers	Recommended (doors or half doors)

17.11 Next Steps

To move from this preliminary concept to detailed design you'll need:

1. Passenger demand forecasts (peak hour loads).
2. Topographical and geotechnical surveys along the corridor.
3. Vehicle specification (length, width, door placement).
4. Local codes and standards (seismic, wind, snow load near Murree).
5. Integration with other modes (bus, pedestrian, park & ride).

17.12 Summary Table

Preliminary Design – Stations & Platforms (Straddle Monorail)

Item	Design Parameter	Preliminary Provision (PC-1 Level)
System Type	Rail System	Elevated Straddle Monorail
Station Typology	Station Categories	Urban (Rawalpindi), Intermediate, Terminal (Murree)
Station Configuration	Platform Arrangement	Elevated Island Platform (preferred) or Side Platforms (where ROW constrained)
Platform Height	From Top of Guide Beam	1000 – 1100 mm (Level Boarding)
Platform Width	Clear Width	3.0 m (minimum) to 6.0 m (high-demand stations)
Platform Length	Train Accommodation	60 – 72 m (4-car trains), provision for future extension up to 90 m
Guide Beam	Beam Type	Precast / Cast-in-situ Concrete
Guide Beam Width	Typical	300 – 500 mm
Column Spacing	Typical Span	20 – 30 m (subject to terrain and structural design)
Station Structure	Structural System	Reinforced Concrete Columns and Platform Slab
Roof / Canopy	Passenger Shelter	Full-length weather-resistant canopy
Vertical Access	Passenger Circulation	Stairs, Ramps, and Elevators (Barrier-Free Access)
Concourse Level	Fare Control & Services	Paid and Unpaid Areas with AFC Gates
Ticketing System	Fare Collection	Cashless AFC (QR / Smart Card compatible)
Passenger Facilities	Platform Amenities	Seating, Signage, Passenger Information Displays
Safety Systems	Platform Safety	Platform Edge Markings; Half-Height Platform Screen Doors (recommended)

Item	Design Parameter	Preliminary Provision (PC-1 Level)
Security	Surveillance	CCTV and Public Address System
Accessibility	Universal Access	Compliance with accessibility standards (ramps, tactile paths)
Utilities Integration	MEP Services	Power, Lighting, Drainage, ICT, Fire Protection
Environmental Considerations	Climate & Terrain	Designed for monsoon rain, temperature variation, hilly terrain
Terminal Station Features	Rawalpindi	Multimodal Integration, Bus/Taxi Interface, Parking
Terminal Station Features	Murree	Tourist-oriented facilities, weather-protected waiting areas
Future Provision	Expandability	Platform length and system capacity expandable
Design Stage	Level of Detail	Preliminary / Feasibility Level (PC-1)

Suggested Note:

The station and platform design has been developed at feasibility level, based on standard straddle monorail practices, projected passenger demand, terrain constraints, and environmental conditions along the Rawalpindi–Murree corridor. Detailed architectural, structural, and systems design shall be finalized at the detailed engineering stage.

18.

Annexure And Appendices

Annexure: A

O/D	Murree	Nathiagalli	Towards Kashmir	Abottabad and beyond in KPK	Rawalpindi	Islamabad	Other cities towards south(Lahore, Gujranwala, etc)
Murree	964	174	72	538	2727	4286	1282
Nathiagalli	100	0	0	18	161	46	160
Towards Kashmir	155	0	37	0	376	186	423
Abottabad and beyond in KPK	489	23	69	160	485	328	777
Rawalpindi	1537	114	213	483	60	228	40
Islamabad	5456	249	170	644	895	3024	367
Other cities towards south (Lahore, Gujranwala, etc)	1489	160	330	820	192	179	149

Annexure A1

O/D	Murree	Nathiagalli	Towards Kashmir	Abottabad and beyond in KPK	Rawalpindi	Islamabad	Other cities towards south(Lahore, Gujranwala, etc)
Murree	6.22%	1.18%	0.48%	3.11%	6.76%	9.90%	2.91%
Nathiagalli	0.67%	0.00%	0.00%	0.12%	0.51%	0.09%	0.33%
Towards Kashmir	0.71%	0.00%	0.14%	0.00%	1.76%	0.71%	1.14%
Abottabad and beyond in KPK	2.67%	0.05%	0.14%	1.09%	2.43%	1.69%	1.61%
Rawalpindi	5.74%	0.77%	1.09%	2.31%	0.19%	0.49%	0.09%
Islamabad	18.15%	0.81%	0.81%	3.61%	2.31%	6.98%	1.07%
Other cities towards south (Lahore, Gujranwala, etc)	4.19%	0.33%	1.14%	1.90%	0.55%	0.63%	0.40%

Annexure B

O/D	Murree	Nathiagalli	Towards Kashmir	Abottabad and beyond in KPK	Rawalpindi	Islamabad	Other cities towards south(Lahore, Gujranwala, etc)
Murree	2055	116	22	665	3056	5955	1112
Nathiagalli	29	0	0	29	126	123	304
Towards Kashmir	330	0	44	25	359	316	619
Abottabad and beyond in KPK	440	0	25	239	304	442	784
Rawalpindi	2398	356	614	524	174	897	0
Islamabad	5294	311	536	784	725	2506	67
Other cities towards south (Lahore, Gujranwala, etc)	4041	413	825	1150	191	113	0

Annexure B1

O/D	Murree	Nathiagalli	Towards Kashmir	Abottabad and beyond in KPK	Rawalpindi	Islamabad	Other cities towards south (Lahore, Gujranwala, etc)
Murree	8.59%	0.49%	0.11%	2.75%	7.56%	12.07%	2.08%
Nathiagalli	0.12%	0.00%	0.00%	0.12%	0.21%	0.28%	0.51%
Towards Kashmir	1.61%	0.00%	0.21%	0.04%	1.59%	1.24%	1.31%
Abottabad and beyond in KPK	0.95%	0.00%	0.04%	0.62%	0.51%	1.02%	1.30%
Rawalpindi	7.01%	1.08%	2.51%	1.57%	0.36%	2.07%	0.00%
Islamabad	14.49%	0.99%	2.26%	2.52%	1.67%	5.03%	0.19%
Other cities towards south (Lahore, Gujranwala, etc)	7.81%	0.76%	1.58%	2.00%	0.47%	0.28%	0.00%

APPENDICES

- APPENDIX-A: LOCATION PLAN GEOTECHNICAL INVESTIGATION PLAN SUBSURFACE

  SOIL/ROCK PROFILE

- APPENDIX-B: BOREHOLE LOGS

- APPENDIX-C:

  VARIATION OF SPT BLOWS WITH DEPTH VARIATION OF CORE RECOVERY WITH DEPTH VARIATION OF RQD WITH DEPTH

- APPENDIX-D:

  SUMMARY OF LABORATORY TEST RESULTS DETAILED TEST RESULT SHEETS

- APPENDIX-E:

  FOUNDATION DESIGN RECOMMENDATIONS

- APPENDIX-F:

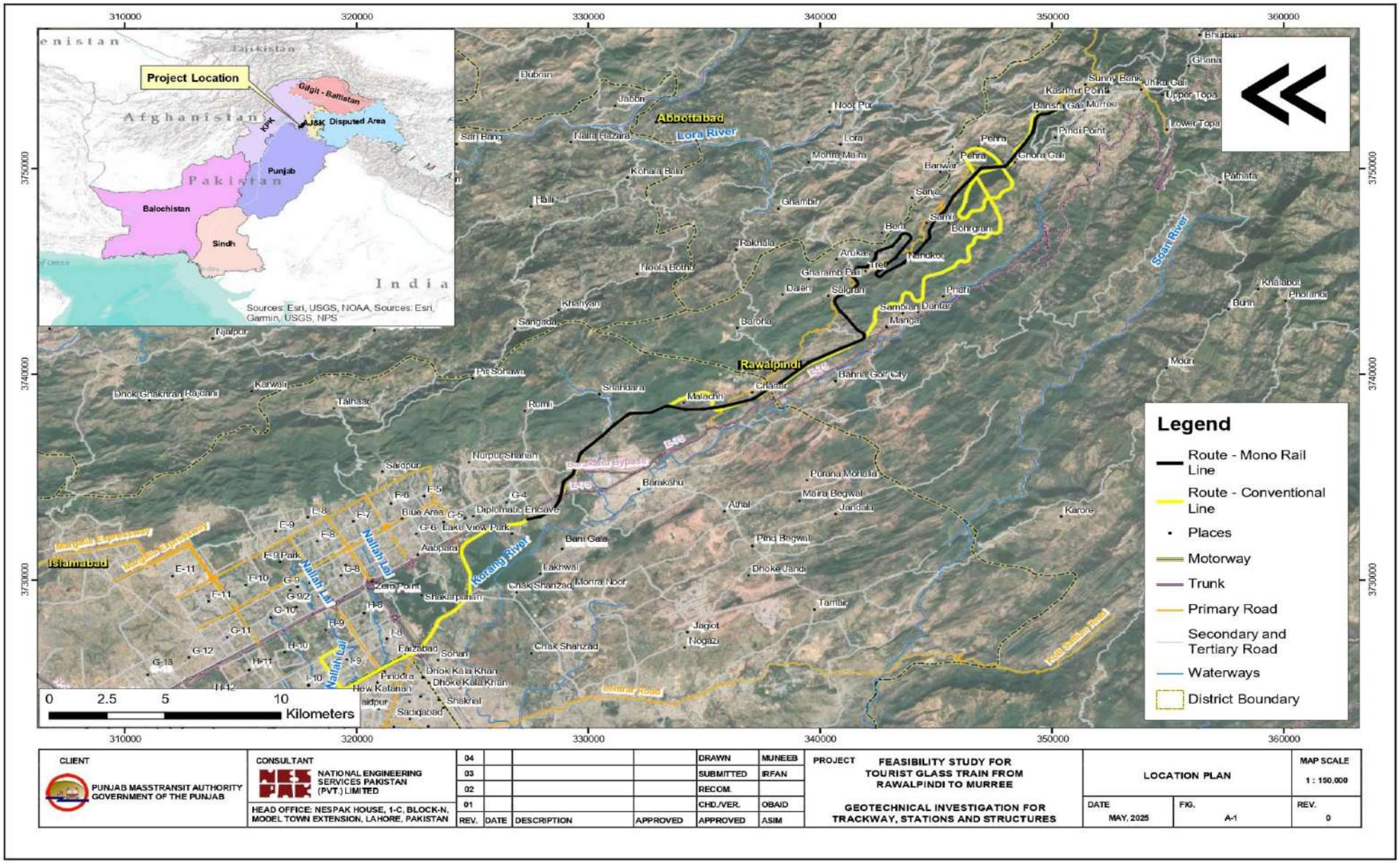
  SITE PHOTOGRAPHS

APPENDIX-A

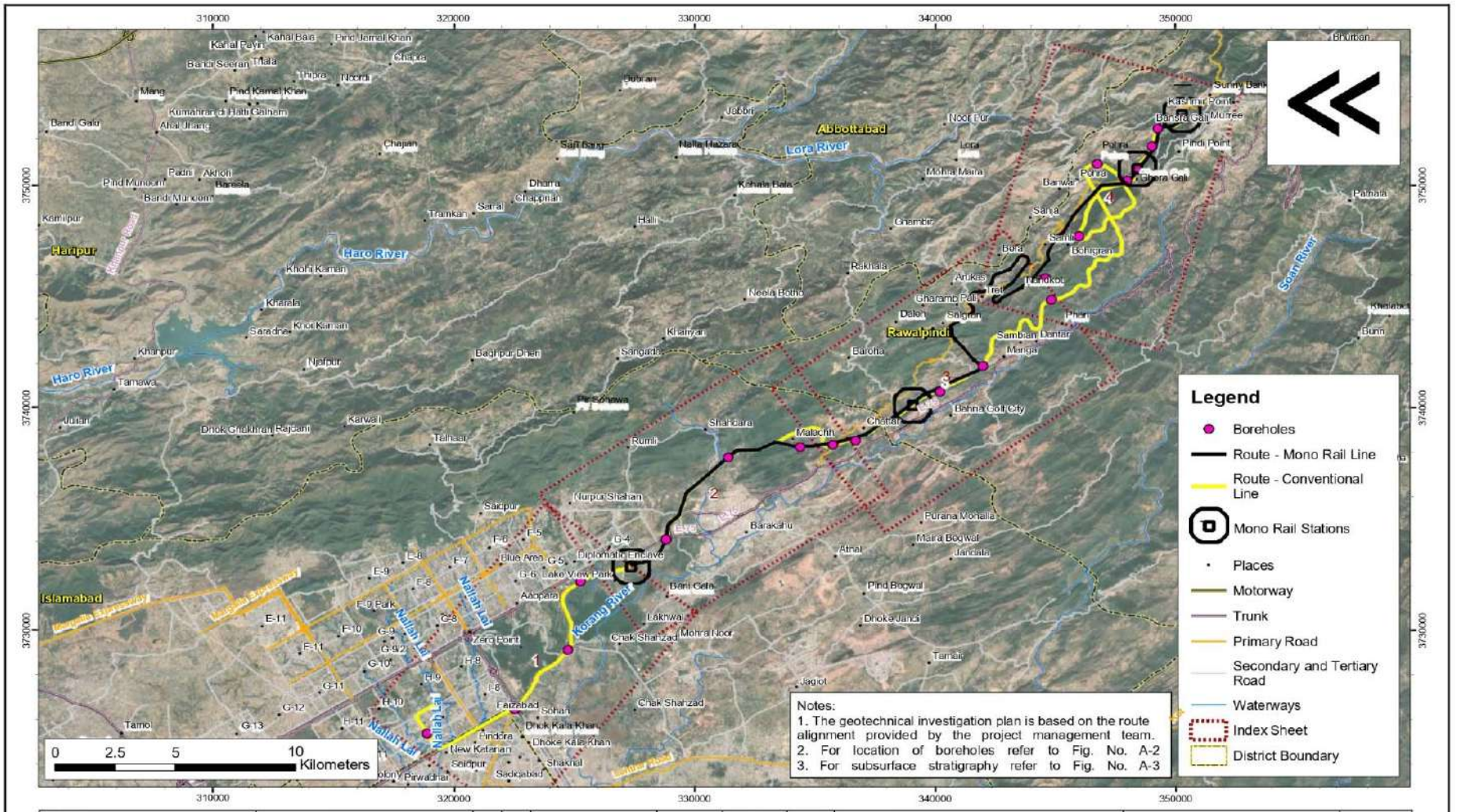
FIG. A-1: LOCATION PLAN

FIG. A-2: GEOTECHNICAL INVESTIGATION PLAN

FIG. A-3: SUBSURFACE SOIL/ROCK P

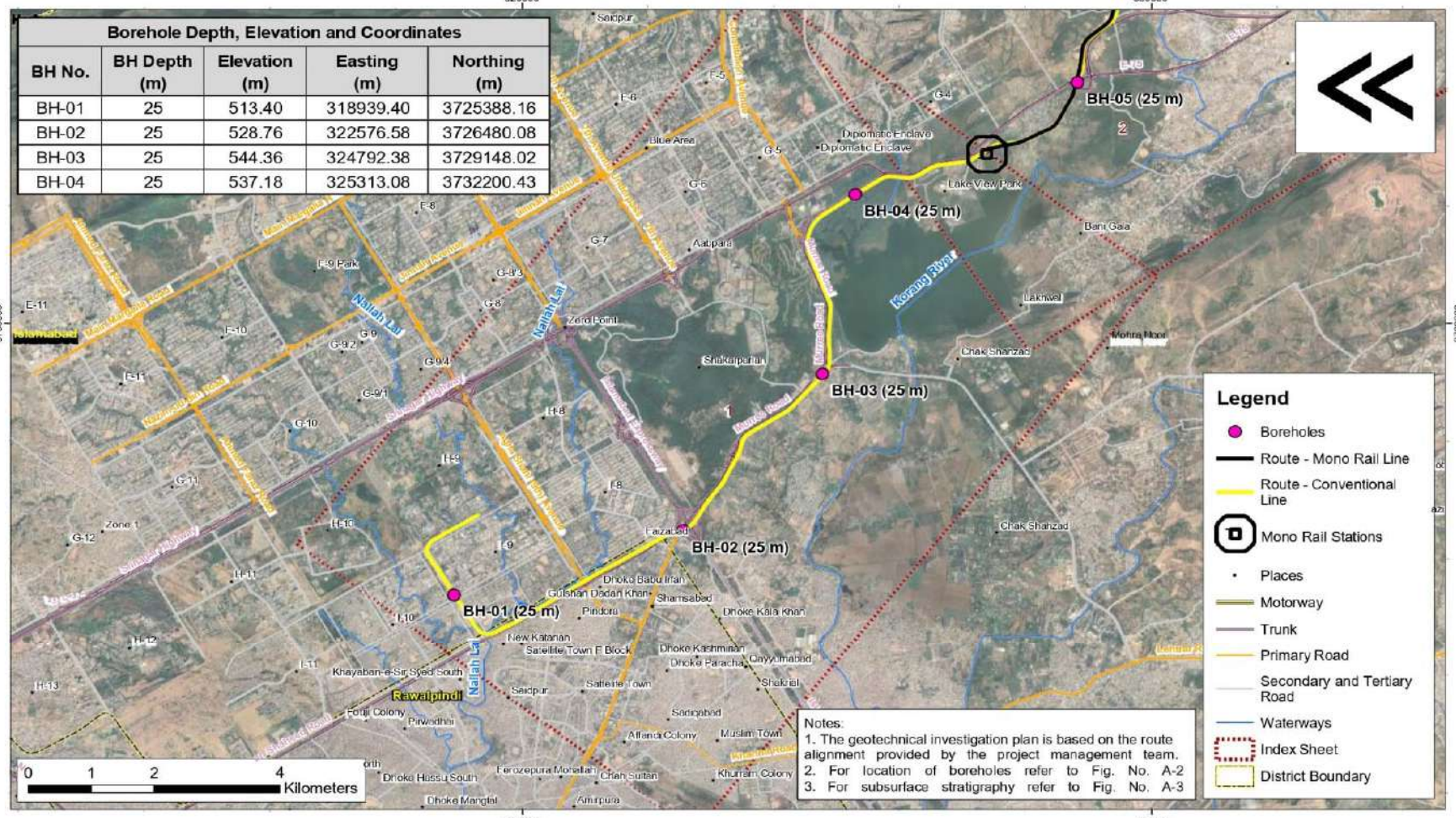


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		03				SUBMITTED	IRFAN			
		02				RECOM.				
		01				CHD./VER.	OBAID	GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	DATE: MAY, 2025	FIG.: A-1
	HEAD OFFICE: NESPAK HOUSE, 1-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN	REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM			REV.: 0

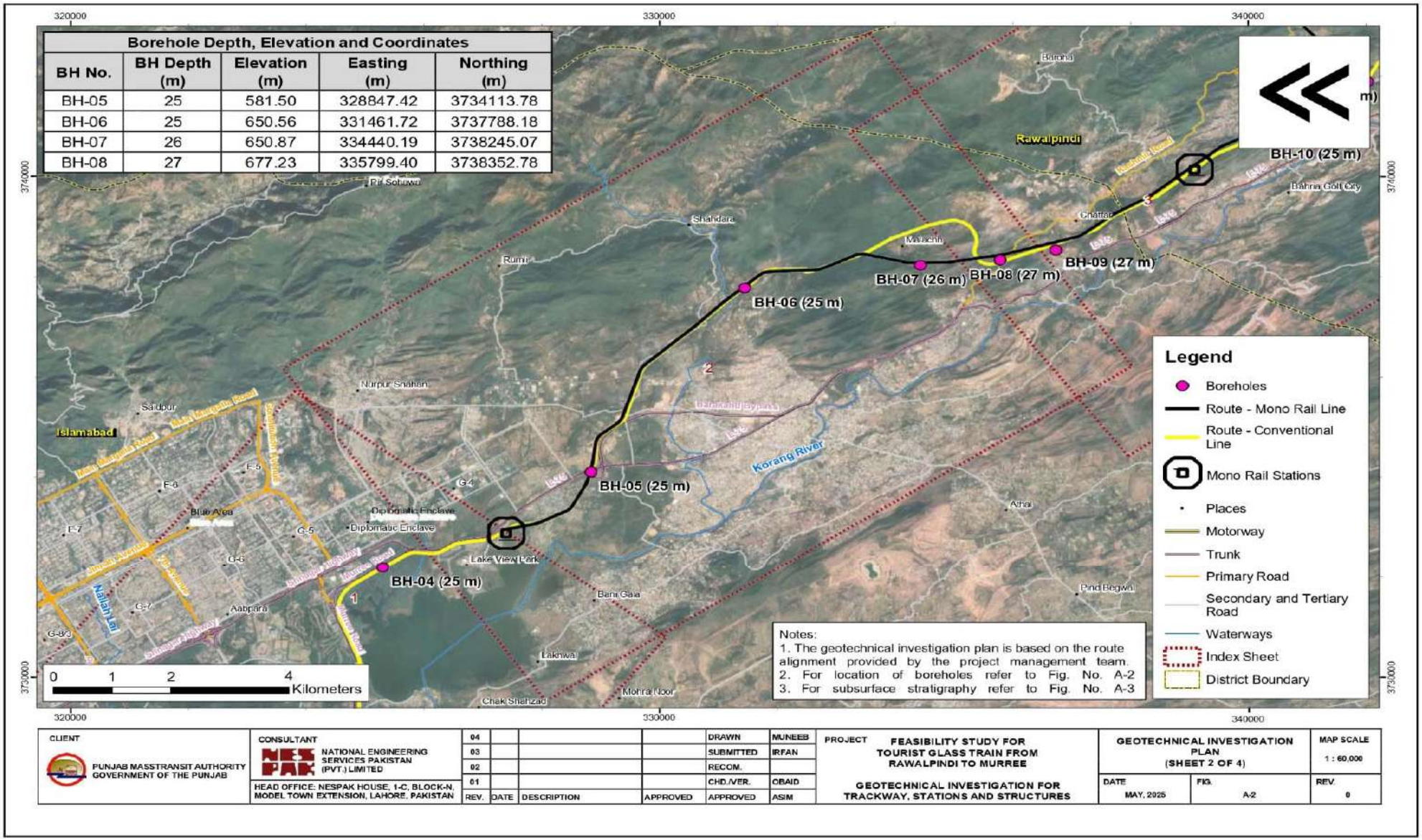


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		03				SUBMITTED	IRFAN				
		02				RECOM.					
	HEAD OFFICE: NESPAK HOUSE, 1-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN	01				CHD./VER.	OBAID	GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	DATE: MAY, 2025	FIG.: A-2	REV.: 0
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM				

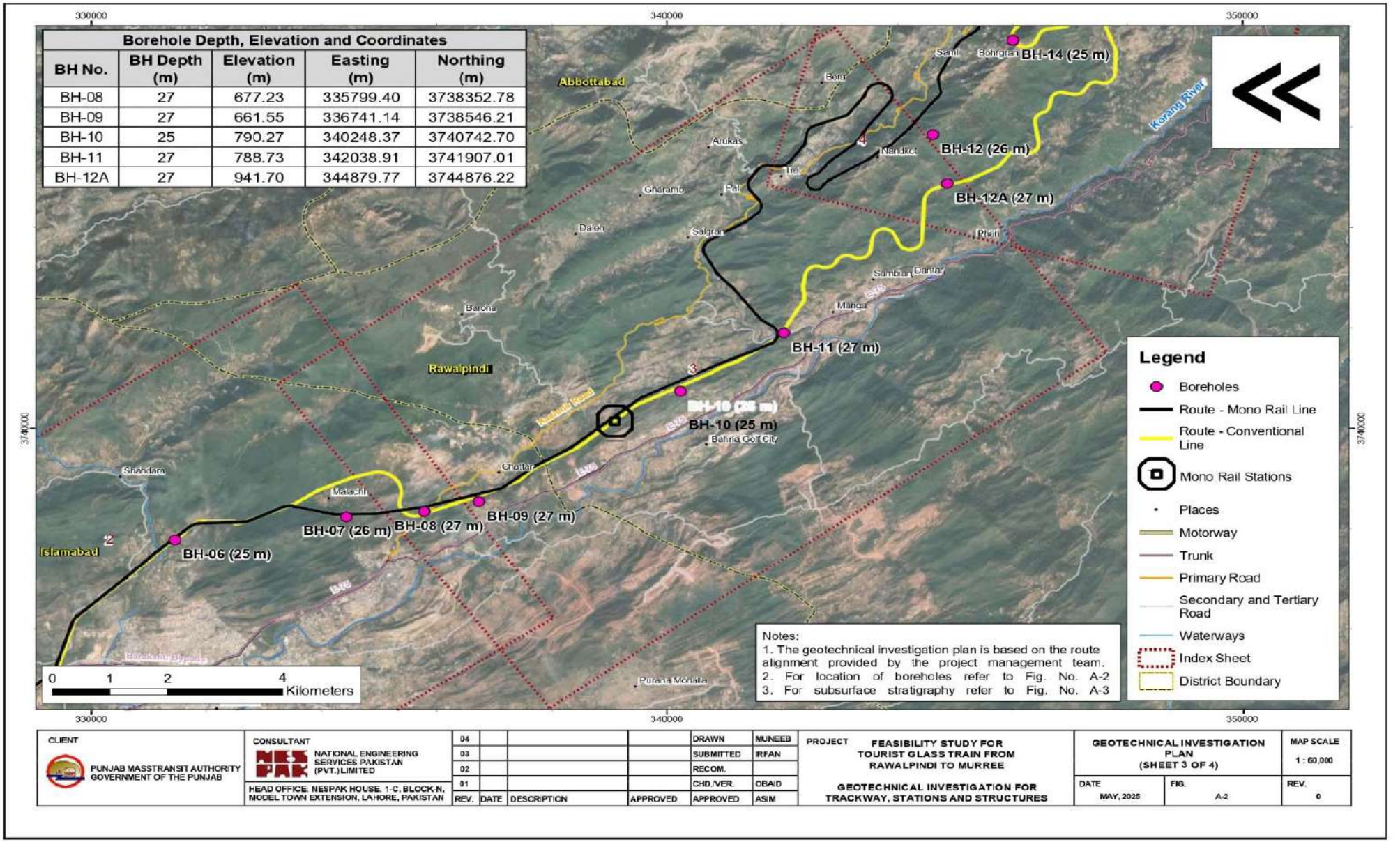
Borehole Depth, Elevation and Coordinates				
BH No.	BH Depth (m)	Elevation (m)	Easting (m)	Northing (m)
BH-01	25	513.40	318939.40	3725388.16
BH-02	25	528.76	322576.58	3726480.08
BH-03	25	544.36	324792.38	3729148.02
BH-04	25	537.18	325313.08	3732200.43



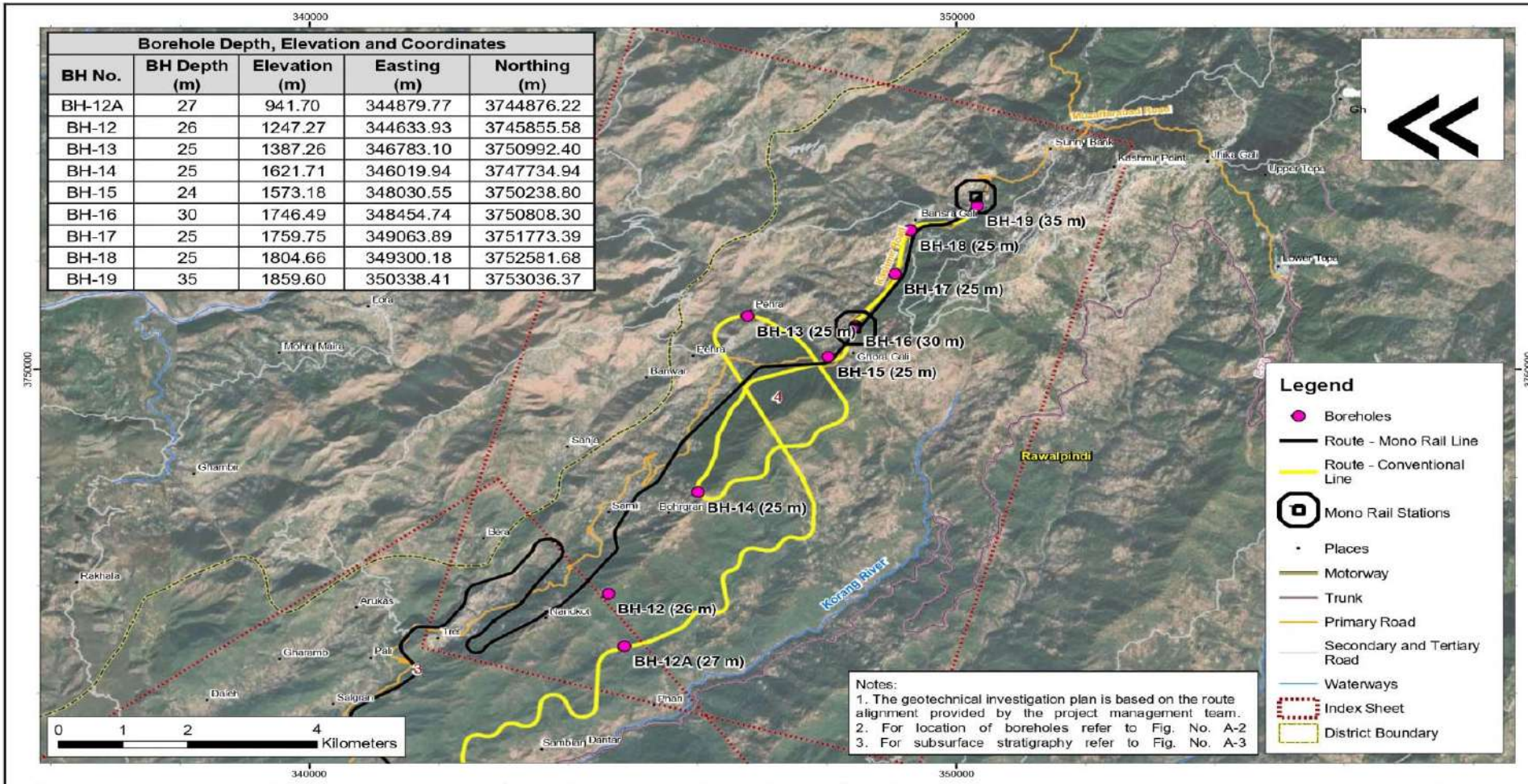
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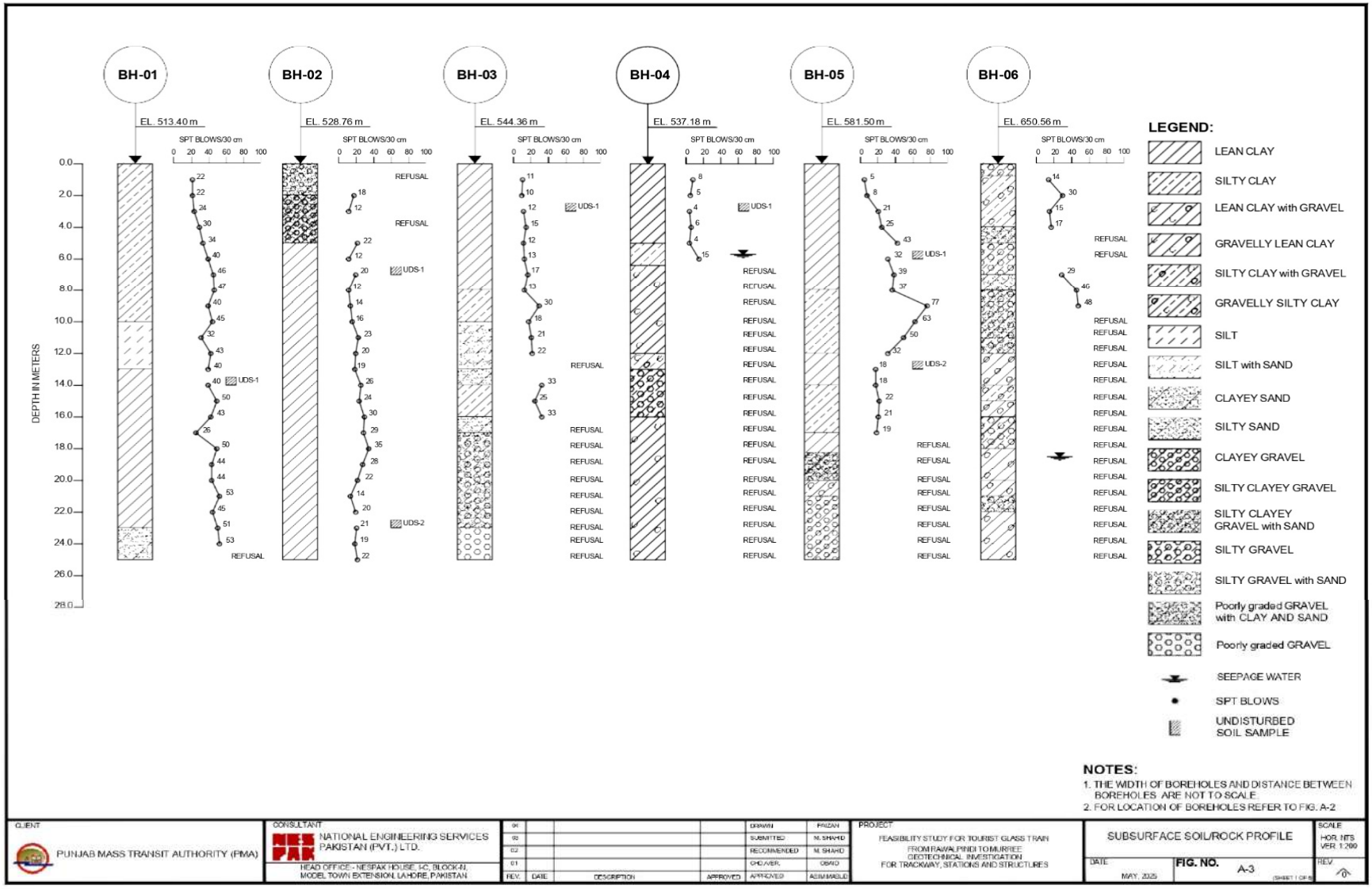
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		03				SUBMITTED	IRFAN			
		02				RECOM.				
		01				CHD./VER.	OBAID		DATE: MAY, 2025	FIG.: A-2
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM			REV.: 0

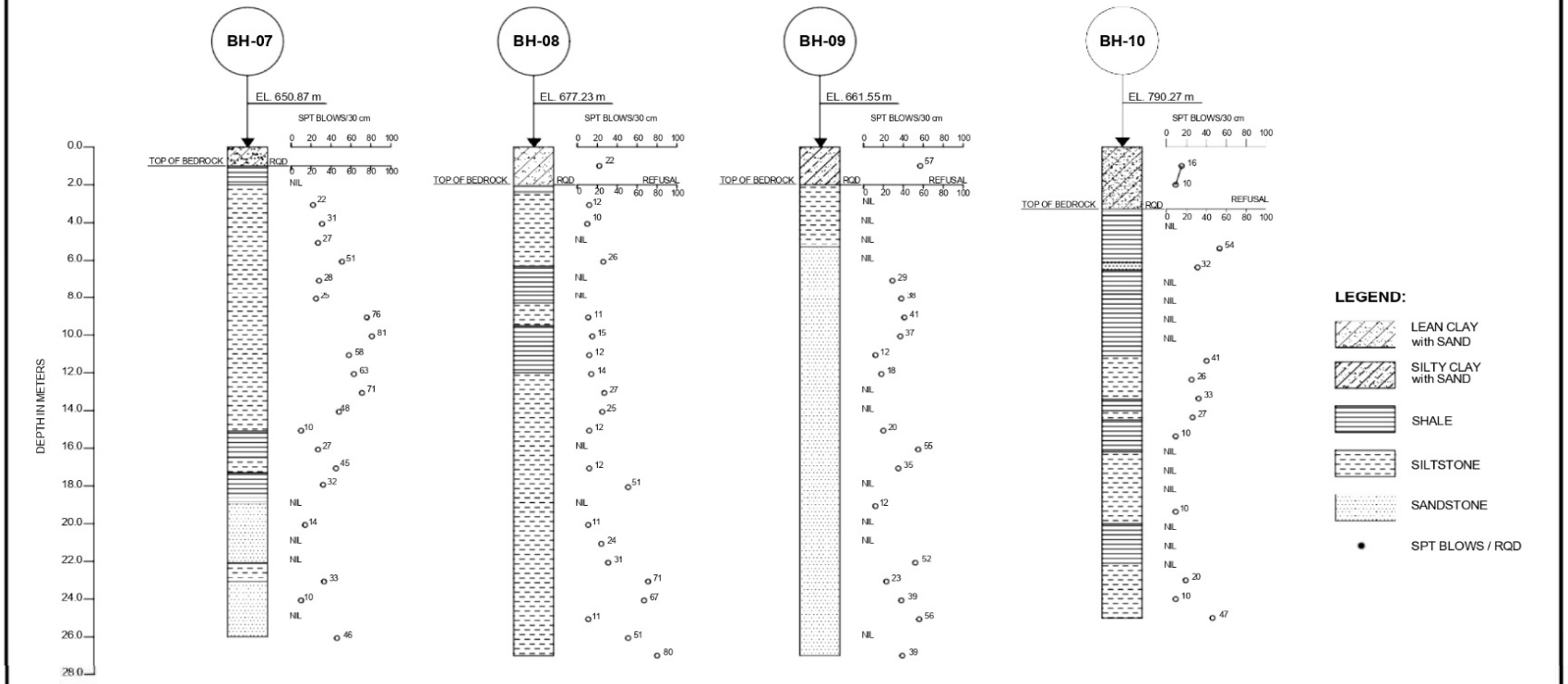


CLIENT: PUNJAB MASSTRANSIT AUTHORITY GOVERNMENT OF THE PUNJAB	CONSULTANT: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED. HEAD OFFICE: NESPAK HOUSE, 1-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN	04				DRAWN	MUNEEB	PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE. GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	GEOTECHNICAL INVESTIGATION PLAN (SHEET 3 OF 4)	MAP SCALE 1 : 60,000
		03				SUBMITTED	IRFAN			
		02				RECOM.			DATE: MAY, 2025	FIG.: A-2
		01				CHD./VER.	OBAID			REV.: 0
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM			



CLIENT: PUNJAB MASSTRANSIT AUTHORITY GOVERNMENT OF THE PUNJAB	CONSULTANT: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED	04				DRAWN	MUNEEB	PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	GEOTECHNICAL INVESTIGATION PLAN (SHEET 4 OF 4)	MAP SCALE: 1 : 60,000
		03				SUBMITTED	IRFAN			
		02				RECOM.				
	HEAD OFFICE: NESPAK HOUSE, 1-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN	01				CHD./VER.	OBAID	GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	DATE: MAY, 2025 / FIG.: A-2	REV.: 0
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM			

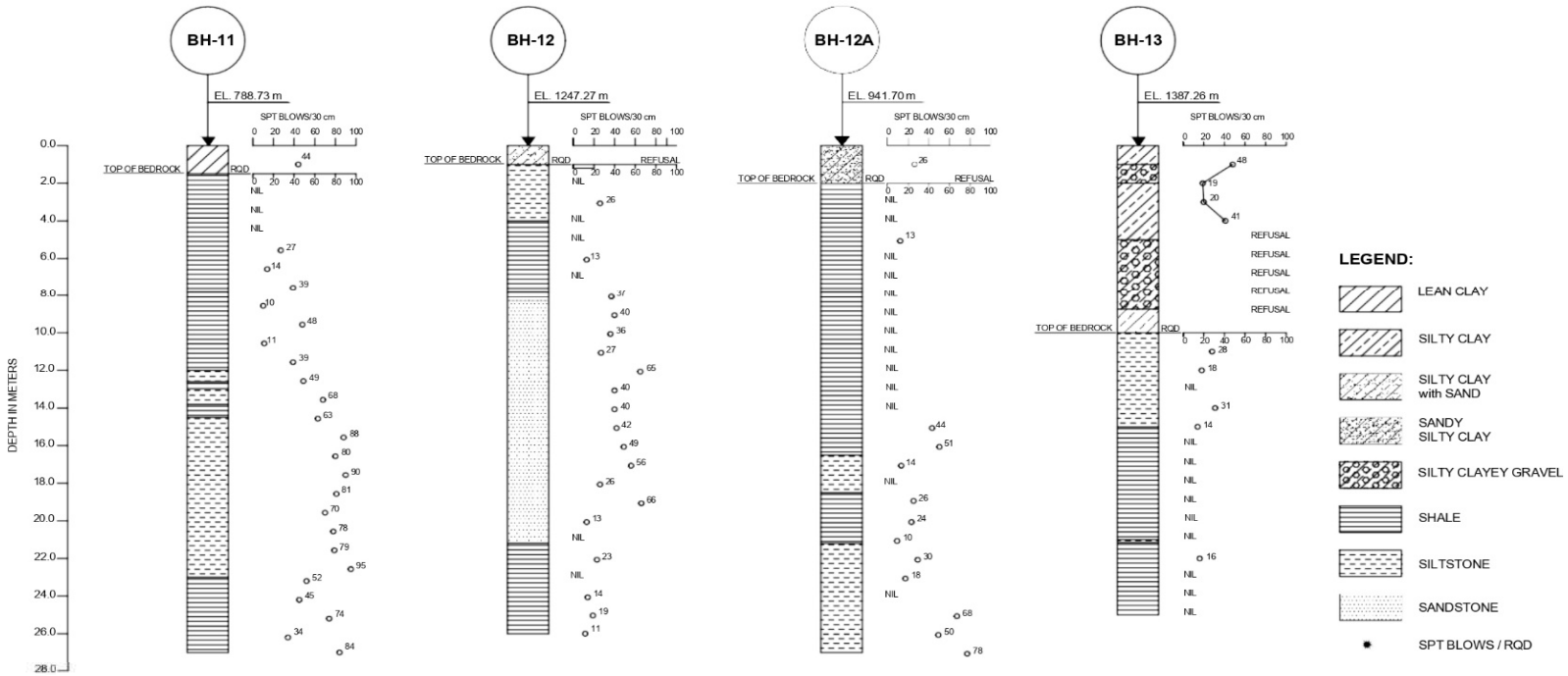

BH-01
BH-02
BH-03
BH-04
BH-05
BH-06
EL. 513.40 m
EL. 528.76 m
EL. 544.36 m
EL. 537.18 m
EL. 581.50 m
EL. 650.56 m
SPT BLOWS/30 cm
0 20 40 60 80 100
DEPTH IN METERS
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
REFUSAL
UDS-1
UDS-2
LEGEND:
LEAN CLAY
SILTY CLAY
LEAN CLAY with GRAVEL
GRAVELLY LEAN CLAY
SILTY CLAY with GRAVEL
GRAVELLY SILTY CLAY
SILT
SILT with SAND
CLAYEY SAND
SILTY SAND
CLAYEY GRAVEL
SILTY CLAYEY GRAVEL
SILTY CLAYEY GRAVEL with SAND
SILTY GRAVEL
SILTY GRAVEL with SAND
Poorly graded GRAVEL with CLAY AND SAND
Poorly graded GRAVEL
SEEPAGE WATER
SPT BLOWS
UNDISTURBED SOIL SAMPLE
NOTES:
1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2
CLIENT
PUNJAB MASS TRANSIT AUTHORITY (PMA)
CONSULTANT
NESPAK
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD.
HEAD OFFICE:- NESPAK HOUSE, 1-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN
REV. DATE DESCRIPTION APPROVED
DRAWN FAIZAN
SUBMITTED M. SHAHID
RECOMMENDED M. SHAHID
CHECKED OSAID
APPROVED ASSUMABLE
PROJECT
FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES
SUBSURFACE SOIL/ROCK PROFILE
SCALE
HOR. NTS
VER. 1:200
DATE
MAY, 2025
FIG. NO.
A-3
(SHEET 1 OF 8)
REV.
0



NOTES:

1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2

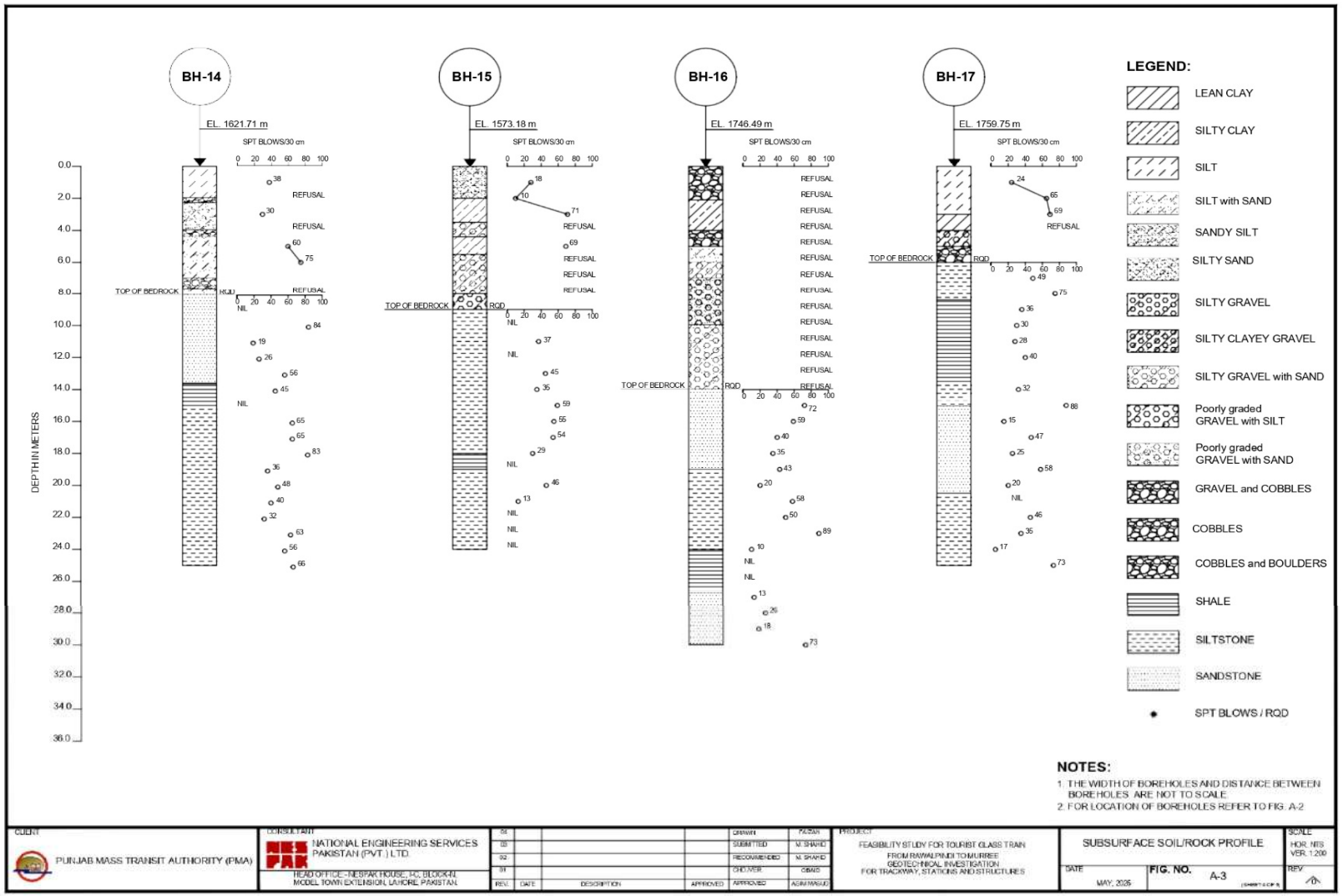
CLIENT: PUNJAB MASS TRANSIT AUTHORITY (PMA)	CONSULTANT: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. HEAD OFFICE: NESPAK HOUSE, I-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN.	04			DRAWN	FAIZAN	PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	SUBSURFACE SOIL/ROCK PROFILE	SCALE: HOR. NTS VER. 1:200
		03			SUBMITTED	M. SHAHID			
		02			RECOMMENDED	M. SHAHID			
		01			CHECKED	OBAID		DATE: MAY, 2025	FIG. NO. A-3 (SHEET 2 OF 3)
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM NASUD		REV. 0

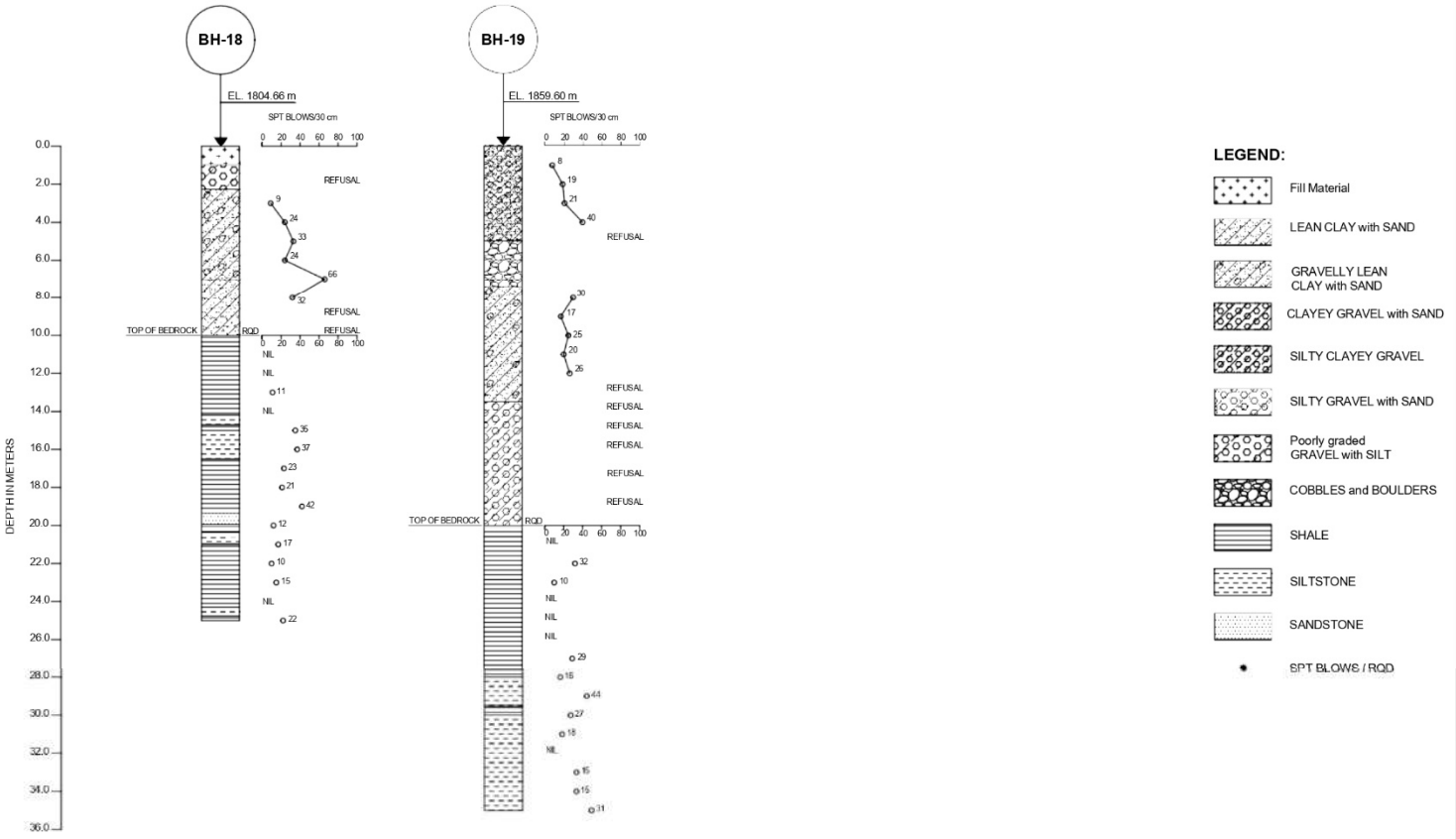


NOTES:

1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2

CLIENT: PUNJAB MASS TRANSIT AUTHORITY (PMA)	CONSULTANT: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. HEAD OFFICE:- NESPAK HOUSE, 1-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN.	04 / 03 / 02 / 01 / REV. DATE DESCRIPTION APPROVED	DRAWN: FAIZAN; SUBMITTED: M. SHAHID; RECOMMENDED: M. SHAHID; CHECKED: OSAID; APPROVED: ASIM WASJID	PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES	SUBSURFACE SOIL/ROCK PROFILE; DATE: MAY, 2025; FIG. NO. A-3 (SHEET 3 OF 5); SCALE: HOR. NTS VER. 1:200; REV. 0


BH-14
EL. 1621.71 m
BH-15
EL. 1573.18 m
BH-16
EL. 1746.49 m
BH-17
EL. 1759.75 m
SPT BLOWS/30 cm
TOP OF BEDROCK
RQD
DEPTH IN METERS
LEGEND:
LEAN CLAY
SILTY CLAY
SILT
SILT with SAND
SANDY SILT
SILTY SAND
SILTY GRAVEL
SILTY CLAYEY GRAVEL
SILTY GRAVEL with SAND
Poorly graded GRAVEL with SILT
Poorly graded GRAVEL with SAND
GRAVEL and COBBLES
COBBLES
COBBLES and BOULDERS
SHALE
SILTSTONE
SANDSTONE
SPT BLOWS / RQD
NOTES:
1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2
CLIENT
PUNJAB MASS TRANSIT AUTHORITY (PMA)
CONSULTANT
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD.
HEAD OFFICE - NESPAK HOUSE, 1-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN.
DRAWN
SUBMITTED
RECOMMENDED
CHECKED
APPROVED
PROJECT
FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES
SUBSURFACE SOIL/ROCK PROFILE
SCALE
HOR. NIS
VER. 1:200
DATE
MAY, 2025
FIG. NO.
A-3
REV.
0



NOTES:

1. THE WIDTH OF BOREHOLES AND DISTANCE BETWEEN BOREHOLES ARE NOT TO SCALE.
2. FOR LOCATION OF BOREHOLES REFER TO FIG. A-2

CLIENT: PUNJAB MASS TRANSIT AUTHORITY (PMA)	CONSULTANT: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. HEAD OFFICE - NESPAK HOUSE, I-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN	04				DRAWN	FAIZAN	PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES		SCALE: HOR. NTS VER. 1:200
		03				SUBMITTED	M. SHAHID			
		02				RECOMMENDED	M. SHAHID			
		01				CHECKED	OBAID		DATE: MAY, 2025	FIG. NO. A-3 (SHEET 3 OF 5)
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	ASIM MASUD			REV.

APPENDIX-B

BOREHOLE LOGS

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01
SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR SNGPL OFFICE-I9

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3725388.16 m E: 318939.40 m Ground Elevation 513.40 m Drafted By FAIZAN Date 22-04-2025 To 24-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0				Brown, very stiff to hard, SILTY CLAY, low plastic, medium dry strength, moist.	125 mm		
1.0	SPT-1		CL-ML			22	
2.0	SPT-2					22	
3.0	SPT-3					24	
4.0	SPT-4					30	
5.0	SPT-5					34	
6.0	SPT-6					40	
7.0	SPT-7					46	
8.0	SPT-8					47	
9.0	SPT-9					40	
10.0	SPT-10					45	

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01
SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR SNGPL OFFICE-I9

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3725388.16 m E: 318939.40 m Ground Elevation 513.40 m Drafted By FAIZAN Date 22-04-2025 To 24-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0	SPT-10		ML	Brown, hard, SILT, low plastic, low dry strength, trace concretion, moist.	125 mm	45	
11.0	SPT-11					32	
12.0	SPT-12					43	
13.0	SPT-13					40	
	UDS-1		CL	Dark brown, very stiff to hard, LEAN CLAY, low plastic, medium dry strength, moist.			(Denison) UDS-1 13.50-14.0 m depth.
14.0	SPT-14					40	
15.0	SPT-15					50	
16.0	SPT-16					43	
17.0	SPT-17					26	
18.0	SPT-18					50	
19.0	SPT-19					44	
20.0	SPT-20					44	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01

SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR SNGPL OFFICE-I9

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3725388.16 m E: 318939.40 m Ground Elevation 513.40 m Drafted By FAIZAN Date 22-04-2025 To 24-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20		CL	Dark brown, hard, LEAN CLAY, low plastic, low to medium strong, moist.	125 mm	44	
21.0	SPT-21					53	
22.0	SPT-22					45	
23.0	SPT-23					51	
			SM	Brownish grey, very dense, SILTY SAND, trace mica, moist.			
24.0	SPT-24					53	
25.0	SPT-25					REFUSAL	

BOTTOM OF BOREHOLE

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02
SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR FAIZABAD INTERCHANGE

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3726480.08 m E: 322576.58 m Ground Elevation 528.76 m Drafted By FAIZAN Date 18-04-2025 To 21-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0							
1.0	SPT-1(c) / DS-1		GP-GC	Reddish brown, very dense, Poorly graded GRAVEL with CLAY AND SAND, of size 4.75 to 44 mm, rounded to sub rounded, moist.			REFUSAL
2.0	SPT-2					18	
3.0	SPT-3		GC-GM	Reddish brown, medium dense to very dense, SILTY CLAYEY GRAVEL with SAND, of size 4.75 to 21mm, sub rounded, moist.		12	
4.0	SPT-4						REFUSAL
5.0	SPT-5				125 mm	22	
6.0	SPT-6			Reddish brown, stiff to very stiff, LEAN CLAY, low plastic, medium dry strength, moist.		12	
	UDS-1						(Shelby) UDS-1 6.5-7.00 m depth.
7.0	SPT-7		CL			20	
8.0	SPT-8					12	
9.0	SPT-9					14	
10.0	SPT-10					16	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02
SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR FAIZABAD INTERCHANGE

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3726480.08 m E: 322576.58 m Ground Elevation 528.76 m Drafted By FAIZAN Date 18-04-2025 To 21-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0	SPT-10		CL	Brown, very stiff to hard, LEAN CLAY, low plastic, medium dry strength, moist.	125 mm	16	
11.0	SPT-11					23	
12.0	SPT-12					20	
13.0	SPT-13					19	
14.0	SPT-14					26	
15.0	SPT-15					24	
16.0	SPT-16					30	
17.0	SPT-17					29	
18.0	SPT-18					35	
19.0	SPT-19					28	
20.0	SPT-20					22	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02
SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR FAIZABAD INTERCHANGE

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3726480.08 m E: 322576.58 m Ground Elevation 528.76 m Drafted By FAIZAN Date 18-04-2025 To 21-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20		CL	Greyish brown, stiff to very stiff, LEAN CLAY, low plastic, low dry strength, moist.	125 mm	22	
21.0	SPT-21					14	
22.0	SPT-22					20	
	UDS-3						(Denison) UDS-3 22.5-22.90 m depth.
23.0	SPT-23					21	
24.0	SPT-24					19	
25.0	SPT-25					22	
				BOTTOM OF BOREHOLE			

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-03
SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR MARGALLA TOWN

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3729148.02 m E: 324792.38 m Ground Elevation 544.36 m Drafted By FAIZAN Date 25-04-2025 To 28-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0				Brown, stiff to very stiff, LEAN CLAY, low plastic, medium dry strength, dry.	125 mm		
1.0	SPT-1		CL			11	
2.0	SPT-2					10	
	UDS-1						(Shelby) UDS-1 2.5-3.00 m depth.
3.0	SPT-3					12	
4.0	SPT-4					15	
5.0	SPT-5					12	
6.0	SPT-6					13	
7.0	SPT-7					17	
8.0	SPT-8					13	
				Reddish brownish, stiff to very stiff, SILTY CLAY, low plastic, medium dry strength, moist.			
9.0	SPT-9		CL-ML			30	
10.0	SPT-10					18	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-03
SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR MARGALLA TOWN

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3729148.02 m E: 324792.38 m Ground Elevation 544.36 m Drafted By FAIZAN Date 25-04-2025 To 28-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0	SPT-10		ML	Brown, medium dense, SILT with SAND, trace concretion, moist.	125 mm	18	
11.0	SPT-11					21	
12.0	SPT-12					22	
13.0	SPT-13		SM	Brownish grey, very dense, fine to medium grained, SILTY SAND, trace mica, moist.			REFUSAL
14.0	SPT-14		CL-ML	Brown, very stiff to hard, SILTY CLAY, low plastic, medium dry strength, moist.		33	
15.0	SPT-15					25	
16.0	SPT-16		SM	Brownish grey, dense, fine grained, SILTY SAND, trace mica, moist.		33	
17.0	SPT-17(c) DS-1		GM	Grey, very dense, SILTY GRAVEL with SAND, of size 5 to 40 mm, sub-rounded to sub angular, moist.			REFUSAL
18.0	SPT-18(c) DS-2						REFUSAL
19.0	SPT-19(c) DS-3						REFUSAL
20.0	SPT-20(c) DS-4						REFUSAL

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-03
SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR MARGALLA TOWN

Site Incharge M. RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3729148.02 m E: 324792.38 m Ground Elevation 544.36 m Drafted By FAIZAN Date 25-04-2025 To 28-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20						
	DS-4(c)		GM	Grey, very dense, SILTY GRAVEL with SAND, size 18 to 54mm, sub rounded to sub-angular, moist.	125 mm	REFUSAL	
21.0	SPT-21						
	DS-5(c)					REFUSAL	
22.0	SPT-22						
	DS-6(c)					REFUSAL	
23.0	SPT-23						
	DS-7(c)		GP	Grey, very dense, Poorly graded GRAVEL, size 15 to 50mm, sub rounded to sub-angular, moist.		REFUSAL	
24.0	SPT-24						
	DS-8(c)					REFUSAL	
25.0	SPT-25					REFUSAL	
				BOTTOM OF BOREHOLE			

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-04
SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR JINNAH SQUARE INTER CHANGE

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY/ PERCUSSION Drilling Fluid BENTONITE SLURRY/PLAIN WATER Ground Water Depth 5.7 m (SEEPAGE WATER)

Coordinates N: 3732200.43 m E: 325313.08 m Ground Elevation 537.18 m Drafted By FAIZAN Date 06-05-2025 To 22-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0				Brown, soft to medium stiff, LEAN CLAY, low plastic, medium dry strength, moist.	125 mm		0-6 m DRILLED WITH STRAIGHT ROTARY AND 6-25 m WITH PERCUSSION
1.0	SPT-1		CL			8	
2.0	SPT-2					5	
	UDS-1						(Shelby) UDS-1 2.5-3.00 m depth.
3.0	SPT-3					4	
4.0	SPT-4					6	
5.0	SPT-5					4	
			CL-ML	Brown, soft to stiff, SILTY CLAY, low plastic, medium dry strength, moist.			
6.0	SPT-6 DS-1					15	SEEPAGE WATER ENCOUNTERED AT 5.7 m
				Reddish brown, hard, GRAVELLY LEAN CLAY, low pastic, medium dry strength, wet.	200 mm		
7.0	SPT-7(c) DS-2					REFUSAL	
8.0	SPT-8(c) DS-3		CL			REFUSAL	
9.0	SPT-9(c) DS-4					REFUSAL	
10.0	SPT-10(c) DS-5					REFUSAL	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-04
SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR JINNAH SQUARE INTER CHANGE

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth 5.7 m (SEEPAGE WATER)

Coordinates N: 3732200.43 m E: 325313.08 m Ground Elevation 537.18 m Drafted By FAIZAN Date 06-05-2025 To 22-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0	SPT-10(c)						
			CL	Reddish brown, hard, GRAVELLY LEAN CLAY, low pastic, medium dry strength, wet.	200 mm	REFUSAL	
11.0	SPT-11(c) DS-6					REFUSAL	
12.0	SPT-12(c)					REFUSAL	
	DS-7		CL-ML	Reddish brown, hard, SILTY CLAY with GRAVEL, low plastic, medium dry strength, wet.			
13.0	SPT-13(c)					REFUSAL	
	DS-8		GC-GM	Reddish brown, very dense, SILTY CLAYEY GRAVEL, gravel of size 4.75-70 mm, trace cobble, wet.			
14.0	SPT-14(c) DS-9					REFUSAL	
15.0	SPT-15(c) DS-10					REFUSAL	
16.0	SPT-16(c)					REFUSAL	
	DS-11		CL	Reddish brown, hard, GRAVELLY LEAN CLAY, low pastic, medium dry strength, wet.			
17.0	SPT-17(c) DS-12					REFUSAL	
18.0	SPT-18(c) DS-13					REFUSAL	
19.0	SPT-19(c) DS-14					REFUSAL	
20.0	SPT-20(c) DS-15					REFUSAL	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-04
SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR JINNAH SQUARE INTER CHANGE

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth 5.7 m (SEEPAGE WATER)

Coordinates N: 3732200.43 m E: 325313.08 m Ground Elevation 537.18 m Drafted By FAIZAN Date 06-05-2025 To 22-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20(c)						
	DS-15		CL	Reddish brown, hard, GRAVELLY LEAN CLAY, low pastic, medium dry strength, wet.	200 mm	REFUSAL	
21.0	SPT-21(c)					REFUSAL	
	DS-16						
22.0	SPT-22(c)					REFUSAL	
	DS-17						
23.0	SPT-23(c)					REFUSAL	
	DS-18						
24.0	SPT-24(c)					REFUSAL	
	DS-19						
25.0	SPT-25(c)					REFUSAL	
				BOTTOM OF BOREHOLE			

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-05
SHEET 1 OF 3

BOREHOLE LOG

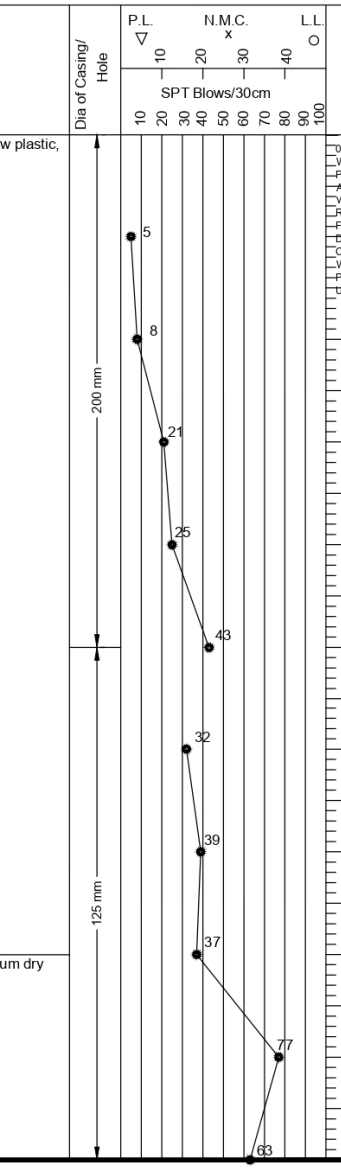
Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location STARTING POINT BHARA KAHU BYPASS

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY/ PERCUSSION Drilling Fluid BENTONITE SLURRY/PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3734113.78 m E: 328847.42 m Ground Elevation 581.50 m Drafted By FAIZAN Date 03-05-2025 To 10-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	Remarks
0.0				Brown, medium stiff to hard, LEAN CLAY, low plastic, low dry strength, trace concretion, moist.	200 mm	0-5 m DRILLED WITH PERCUSSION AND 5-20 m WITH STRAIGHT ROTARY THEN FURTHER DRILLING CARRIED OUT WITH PERCUSSION UPTO 25 m
1.0	SPT-1					
2.0	SPT-2					
3.0	SPT-3					
4.0	SPT-4		CL			
5.0	SPT-5				125 mm	
	DUS-1					(Denison) UDS-1 5.5-6.00 m depth.
6.0	SPT-6					
7.0	SPT-7					
8.0	SPT-8			Brown, hard, SILTY CLAY, low plastic, medium dry strength, trace few fine gravel, moist.		
9.0	SPT-9		CL-ML			
10.0	SPT-10					



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-05
SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location STARTING POINT BHARA KAHU BYPASS

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY/ PERCUSSION Drilling Fluid BENTONITE SLURRY/PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3734113.78 m E: 328847.42 m Ground Elevation 581.50 m Drafted By FAIZAN Date 03-05-2025 To 10-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm	Remarks
10.0	SPT-10		CL-ML	Brown, hard, SILTY CLAY, low plastic, medium dry strength, trace fine gravel, moist.	125 mm	63	
11.0	SPT-11					50	
12.0	SPT-12		CL	Brown, very stiff to hard, LEAN CLAY, low to medium plastic, medium dry strength, moist.		32	
	UDS-2						(Denison) UDS-2 12.50-13.0 m depth.
13.0	SPT-13					18	
14.0	SPT-14		CL-ML	Brown, very stiff, SILTY CLAY, low plastic, medium dry strength, moist.		18	
15.0	SPT-15					22	
16.0	SPT-16					21	
17.0	SPT-17		CL	Brown, very stiff to hard, LEAN CLAY, medium plastic, medium dry strength, moist.		19	
18.0	SPT-18					REFUSAL	
	DS-1		GC-GM	Brown, very dense, fine to coarse, SILTY CLAYEY GRAVEL, sub angular to sub rounded, gravel sedimentary origin of size 4-75mm, moist.			
19.0	SPT-19(c)					REFUSAL	
	DS-2						
20.0	SPT-20(c)					REFUSAL	
	DS-3						

P.L. ▽ N.M.C. x L.L. ○

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-05
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BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location STARTING POINT BHARA KAHU BYPASS

Site Incharge M.RASHID SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3734113.78 m E: 328847.42 m Ground Elevation 581.50 m Drafted By FAIZAN Date 03-05-2025 To 10-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20(c)						
	DS-3		CL-ML	Brown, hard, SILTY CLAY with GRAVEL, low plastic, moist.	200 mm	REFUSAL	
	SPT-21(c)					REFUSAL	
21.0	DS-4		GC	Brown, very dense, fine to coarse, CLAYEY GRAVEL, sub angular to sub rounded, gravel sedimentary origin of size 4-75.5mm, moist.			
22.0	SPT-22(c)					REFUSAL	
	DS-5						
23.0	SPT-23(c)					REFUSAL	
	DS-6						
24.0	SPT-24(c)					REFUSAL	
	DS-7						
25.0	SPT-25(c)					REFUSAL	
				BOTTOM OF BOREHOLE			

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-06
SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location SUBBAN SYEDIAN VILLEGE

Site Incharge M.ARIF/M. R SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring STRAIGHT ROTARY/ PERCUSSION Drilling Fluid BENTONITE SLURRY/PLAIN WATER Ground Water Depth 18.5 m (SEEPAGE WATER)

Coordinates N: 3737788.18 m E: 331461.72 m Ground Elevation 650.56 m Drafted By FAIZAN Date 09-05-2025 To 17-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0			GC-GM	Brown to grey, fine to coarse, SILTY CLAYEY GRAVEL, sub angular sub rounded, gravel of sedimentary origin of size 4.75-5 mm, moist.	125 mm		0-4 m DRILLED WITH STRAIGHT ROTARY AND 4-25 m WITH PERCUSSION
1.0	SPT-1		CL-ML	Brown, stiff, SILTY CLAY with GRAVEL, low plastic, size 4.75-10 mm, moist.		14	
2.0	SPT-2					30	
3.0	SPT-3					15	
4.0	SPT-4					17	
			SC-SM	Brownish grey, medium dense, SILTY CLAYEY SAND, trace mica, moist.			
5.0	SPT-5(c)						REFUSAL
	DS-1		GC-GM	Brown to grey, very dense, SILTY CLAYEY GRAVEL, sub angular sub rounded, gravel of sedimentary origin size 4.75-71 mm, moist.	200 mm		
6.0	SPT-6(c)						REFUSAL
	DS-2						
7.0	SPT-7(c)					29	
	DS-3		SC-SM	Brown to grey, medium dense, fine to coarse grained, SILTY CLAYEY SAND with GRAVEL, gravel are fine to course of size 5-70 mm, moist.			
8.0	SPT-8(c)					46	
	DS-4		GC-GM	Brown to grey, dense to very dense, fine to coarse, SILTY CLAYEY GRAVEL with SAND, sub angular sub rounded, gravel of sedimentary origin of size 5-60 mm, moist.			
9.0	SPT-9(c)					48	
	DS-5						
10.0	SPT-10(c)						REFUSAL
	DS-6						

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-06
SHEET 2 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location SUBBAN SYEDIAN VILLEGE

Site Incharge M.ARIF/M. R SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth 18.5 m (SEEPAGE WATER)

Coordinates N: 3737788.18 m E: 331461.72 m Ground Elevation 650.56 m Drafted By FAIZAN Date 09-05-2025 To 17-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0	SPT-10(c)						
	DS-6		GC-GM	Brown to grey, very dense, SILTY CLAYEY GRAVEL, sub angular to sub rounded, sedimentary origin of size 4.75-6.5 mm, few cobble of size 150 mm, moist.	125 mm	REFUSAL	
11.0	SPT-11(c)					REFUSAL	
	DS-7						
12.0	SPT-12(c)					REFUSAL	
	DS-8		CL	Brown to grey, hard, LEAN CLAY with GRAVEL, low plastic, sub angular to sub rounded, gravel of size 4.75-70 mm, moist.			
13.0	SPT-13(c)					REFUSAL	
	DS-9						
14.0	SPT-14(c)					REFUSAL	
	DS-10		CL-ML	Reddish brown, hard, SILTY CLAY with GRAVEL, low plastic, sub angular to sub rounded, gravel of sedimentary origin of size 5 mm 3.5 mm, moist.			
15.0	SPT-15(c)					REFUSAL	
	DS-11		CL	Brown to grey, hard, LEAN CLAY with GRAVEL and cobble, sub angular to sub rounded gravel of sedimentary of size 15 mm -75 mm, cobble of size 100 mm, moist.			
16.0	SPT-16(c)					REFUSAL	
	DS-12		GC-GM	Reddish brown to grey, very dense, SILTY CLAYEY GRAVEL and COBBLES, sub angular to sub rounded, gravel of sedimentary origin of size 15-75 mm, cobble of size 110 mm, moist.			
17.0	SPT-17(c)					REFUSAL	
	DS-13						
18.0	SPT-18(c)					REFUSAL	
	DS-14		CL	Reddish brown, hard, GRAVELLY LEAN CLAY, low to medium plastic, sub angular to sub rounded, gravel of sedimentary origin of size 4.75-55 mm, wet.			
19.0	SPT-19(c)					REFUSAL	SEEPAGE WATER ENCOUNTERED AT THE DEPTH OF 18.5 m
	DS-15						
20.0	SPT-20(c)					REFUSAL	
	DS-16						

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-06
SHEET 3 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location SUBBAN SYEDIAN VILLEGE

Site Incharge M.ARIF/M. R SUBHANI Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S SAFE SERVICES

Type of boring PERCUSSION Drilling Fluid PLAIN WATER Ground Water Depth 18.5 m (SEEPAGE WATER)

Coordinates N: 3737788.18 m E: 331461.72 m Ground Elevation 650.56 m Drafted By FAIZAN Date 09-05-2025 To 17-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
20.0	SPT-20(c)						
	DS-16		CL	Reddish brown, hard, LEAN CLAY with GRAVEL, few sand, sub angular to sub rounded, gravel of sedimentary origin of size 4.75-50 mm, wet.	200 mm		REFUSAL
21.0	SPT-21(c)						REFUSAL
	DS-17		GC-GM	Reddish brown, very dense, SILTY CLAYEY GRAVEL with SAND, sub angular to sub rounded, gravel of sedimentary origin of size 4.75-65 mm, wet.			
22.0	SPT-22(c)						REFUSAL
	DS-18		CL	Reddish brown, hard, LEAN CLAY with GRAVEL, few sand, sub angular to sub rounded, gravel of sedimentary origin of size 4.75-50 mm, wet.			
23.0	SPT-23(c)						REFUSAL
	DS-19						
24.0	SPT-24(c)						REFUSAL
	DS-20						
25.0	SPT-25(c)						REFUSAL
				BOTTOM OF BOREHOLE			

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-07
SHEET 1 OF 4

BOREHOLE LOG

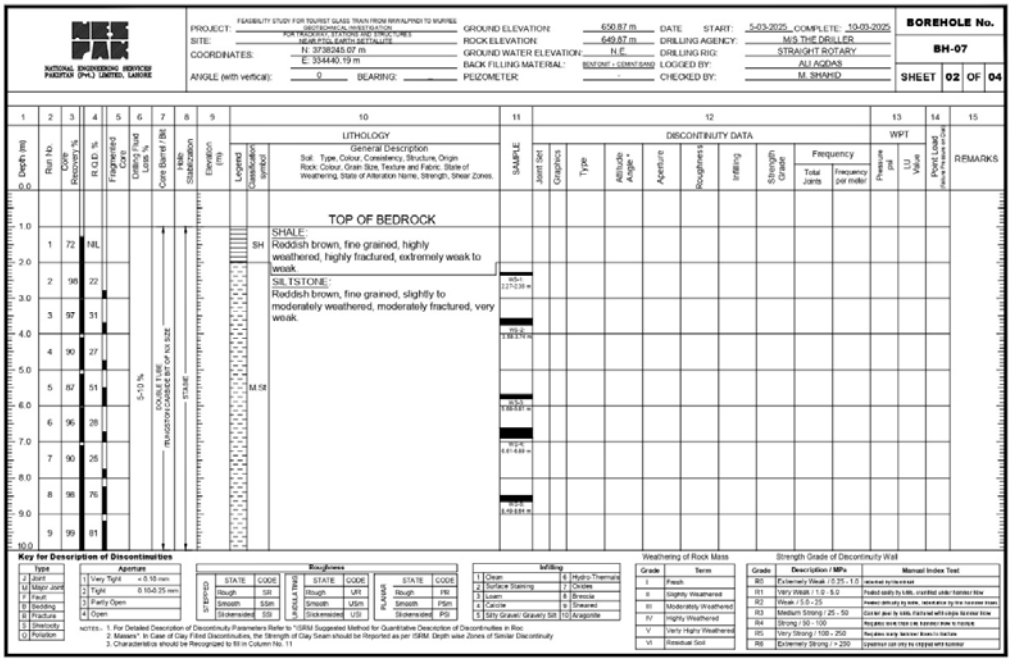
Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR PTCL EARTH SETTALLITE

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3738245.07 m E: 334440.19 m Ground Elevation 650.87 m Date 5-03-2025 To 10-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm (10 20 30 40 50 60 70 80 90 100)	Remarks
0.0							
	SPT-1		CL-ML	Dark brown, SILTY CLAY with SAND, low plastic, low dry strength, trace gravels, trace grass roots, etc.	75 mm		
1.0				TOP OF BEDROCK ENCOUNTERED AT 1.0 M DEPTH			



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKS, STATIONS AND STRUCTURES NEAR PTDC EARTH SETTLAITE
COORDINATES: N: 3738245.07 m, E: 334440.19 m
ANGLE (with vertical): 0 BEARING: —

GROUND ELEVATION: 650.87 m
ROCK ELEVATION: 649.87 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMENT SAND
PEIZOMETER: -

DATE START: 5-03-2025 COMPLETE: 10-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-07

SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUITY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Mud Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: per meter	Pressure psf	U.I. Value	Point Load (Is50) MPa	REMARKS
0.0																										
											TOP OF BEDROCK															
1.0	1	72	NIL							SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak to weak.															
2.0	2	98	22								SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, very weak.	BS-1 2.27-2.39 m														
3.0	3	97	31																							
4.0	4	90	27									BS-2 3.96-3.74 m														
5.0	5	87	51		5-10 %	DOUBLE TUBE TRANSITION CARBIDE BIT OF NX SIZE	STABLE			M.St																
6.0	6	96	28									BS-3 5.68-5.81 m														
7.0	7	90	25									BS-4 6.61-6.69 m														
8.0	8	98	76																							
9.0	9	99	81									BS-5 8.93-9.01 m														
10.0																										

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
O	Pyroklon

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness								
	STATE	CODE		STATE	CODE		STATE	CODE
STEPPED	Rough	SR	UNDULATING	Rough	UR	PLANAR	Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro Thermale
2	Surface Staining	7	Oxides
3	Loam	8	Brecsia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravelly Silt	10	Aragonite

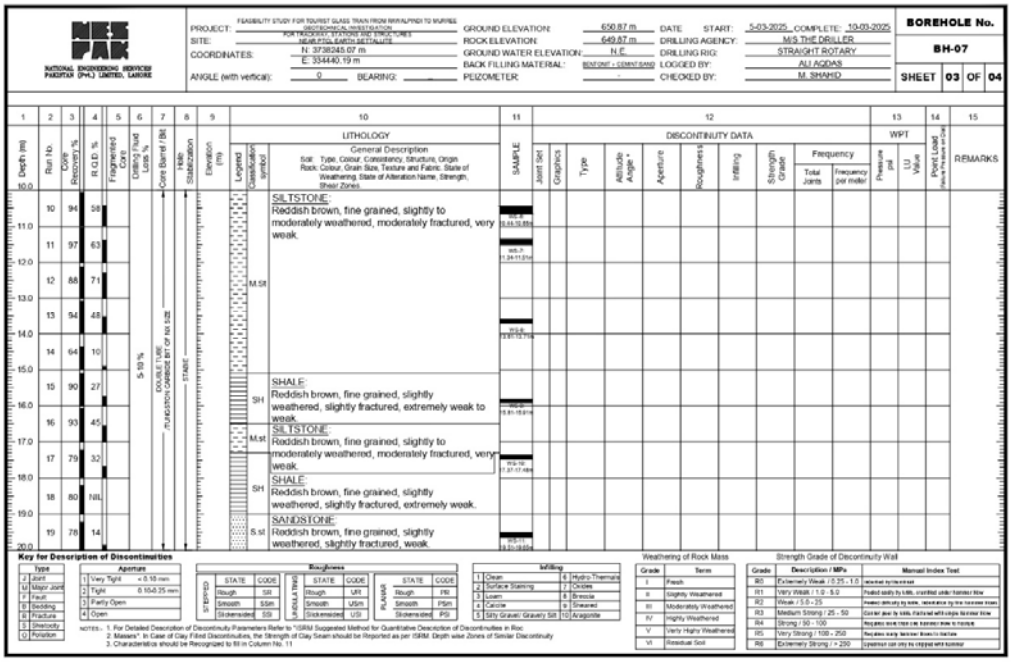
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented easily by knife, crumbled under hammer blow
R1	Very Weak / 1.0 - 5.0	Fractured easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Fractured difficulty by knife, indentations by fine hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR PROPOSED STATIONS AND STRUCTURES NEAR PTCL EARTH SETTALITE
COORDINATES: N: 3738245.07 m, E: 334440.19 m
ANGLE (with vertical): 0 BEARING: ____

GROUND ELEVATION: 650.87 m
ROCK ELEVATION: 649.67 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMENT SAND
PEIZOMETER: -

DATE START: 5-03-2025 COMPLETE: 10-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-07
SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Diam. of Hole Less %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY: Legend, Classification symbol, General Description (Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones)	SAMPLE	DISCONTINUITY DATA: Joint Set, Graphics, Type, Altitude Angle*, Aperture, Roughness, Infilling, Strength Grade, Frequency (Total Joints, Frequency per meter)	WPT: Pressure psf, UU Value, Point Load (Field Test)		REMARKS
10.0														
11.0	10	94	58						SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, very weak.	WS-6 10.65-10.85m				
12.0	11	97	63							WS-7 11.24-11.51m				
13.0	12	88	71						M.St					
14.0	13	94	48							WS-8 13.81-13.91m				
15.0	14	64	10											
16.0	15	90	27		5-10 %	DOUBLE TUBE / TUNGSTEN CARBIDE BIT OF NX SIZE	STABLE							
17.0	16	93	45						SH: SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, extremely weak to weak.	WS-9 15.91-16.01m				
18.0	17	79	32						M.St: SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, very weak.	WS-10 17.37-17.48m				
19.0	18	80	NIL						SH: SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, extremely weak.					
20.0	19	78	14						S.St: SANDSTONE: Reddish brown, fine grained, slightly weathered, slightly fractured, weak.	WS-11 18.91-19.02m				

Key for Description of Discontinuities

Type	
J	Joint
U	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
O	Pyrolation

Aperture	
1	Very Tight < 0.10 mm
2	Tight 0.10-0.25 mm
3	Partly Open
4	Open

Roughness								
	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
STEPPED	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SS		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Brecsia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravelly Silt	10	Aragonite

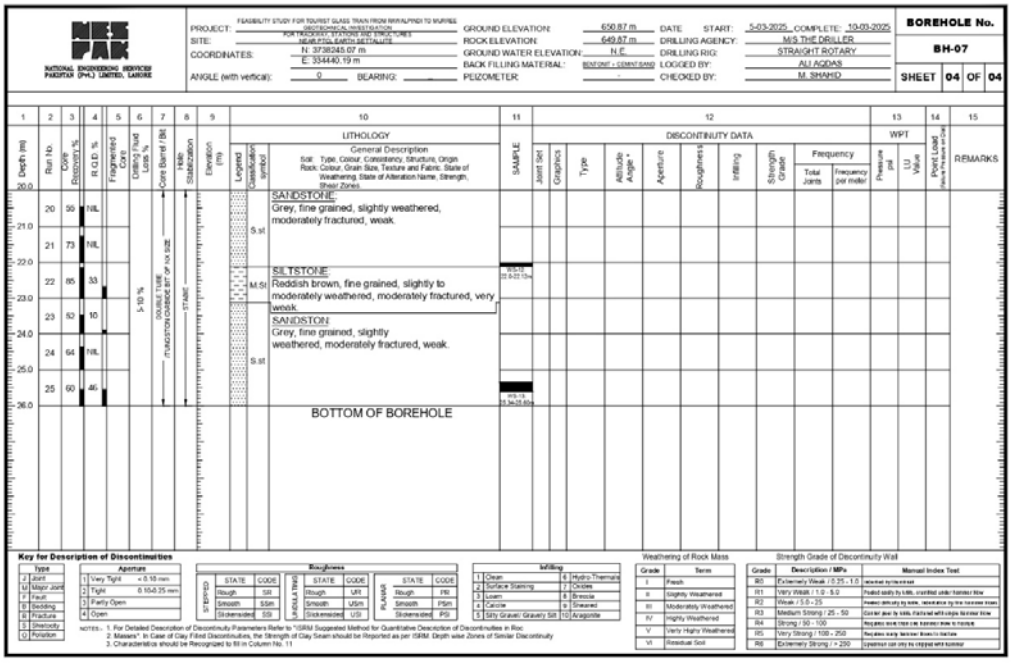
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, indentance by one hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR PROPOSED STATIONS AND STRUCTURES NEAR PTCL EARTH SETTALITE
COORDINATES: N: 3738245.07 m, E: 334440.19 m
ANGLE (with vertical): 0 BEARING: ____

GROUND ELEVATION: 650.87 m
ROCK ELEVATION: 649.67 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMENT SAND
PEIZOMETER: -

DATE START: 5-03-2025 COMPLETE: 10-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-07
SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Diam. of Hole Less %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY: Legend, Classification symbol, General Description (Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones)	SAMPLE	DISCONTINUITY DATA: Joint Set, Graphics, Type, Altitude Angle*, Aperture, Roughness, Infilling, Strength Grade, Frequency (Total Joints, Frequency per meter)	WPT: Pressure psf, UU Value, Point Load (Field Test)		REMARKS
20.0														
21.0	20	59	NIL						S.St: SANDSTONE: Grey, fine grained, slightly weathered, moderately fractured, weak.					
22.0	21	73	NIL											
23.0	22	85	33		5-10 %	DOUBLE TUBE / TUNGSTEN CARBIDE BIT OF NX SIZE	STABLE		M.St: SILTSTONE: Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, very weak.	WS-12 22.6-22.13m				
24.0	23	52	10						S.St: SANDSTONE: Grey, fine grained, slightly weathered, moderately fractured, weak.					
25.0	24	64	NIL											
26.0	25	60	46						BOTTOM OF BOREHOLE	WS-13 25.34-25.60m				

Key for Description of Discontinuities

Type	
J	Joint
U	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
O	Pyrolation

Aperture	
1	Very Tight < 0.10 mm
2	Tight 0.10-0.25 mm
3	Partly Open
4	Open

Roughness								
	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
STEPPED	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SS		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Brecsia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravelly Silt	10	Aragonite

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, indentance by one hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	7	BOX No	1-5	NESPAK
LOCATION	Near PTCL Earth Settallite	DEPTH (m)	1.0-26.00m	



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-08
SHEET 1 OF 4

BOREHOLE LOG

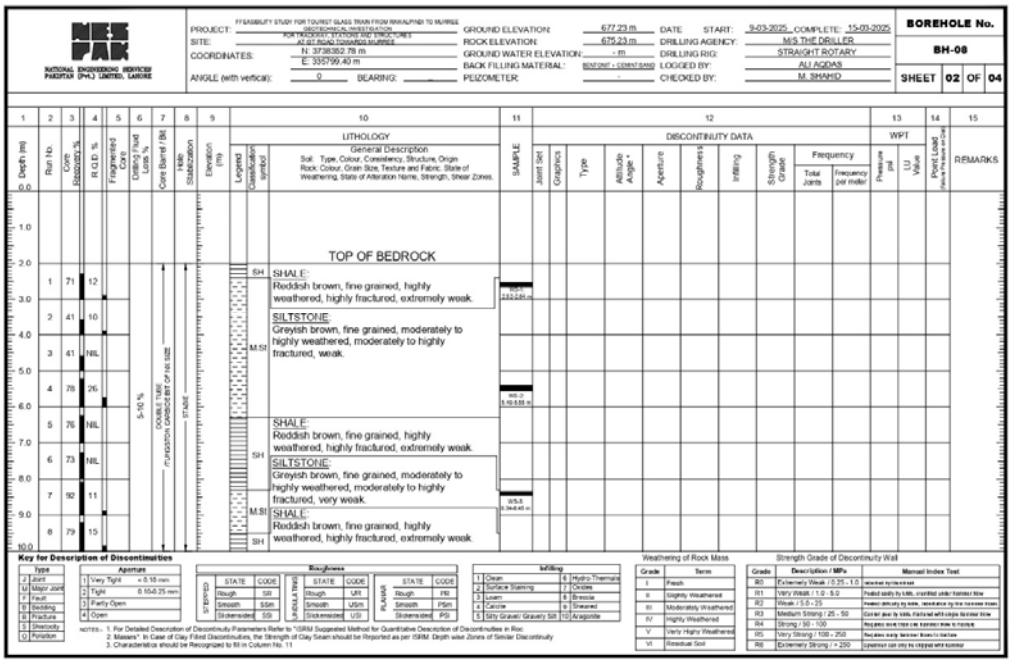
Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location AT GT ROAD TOWARDS MURREE

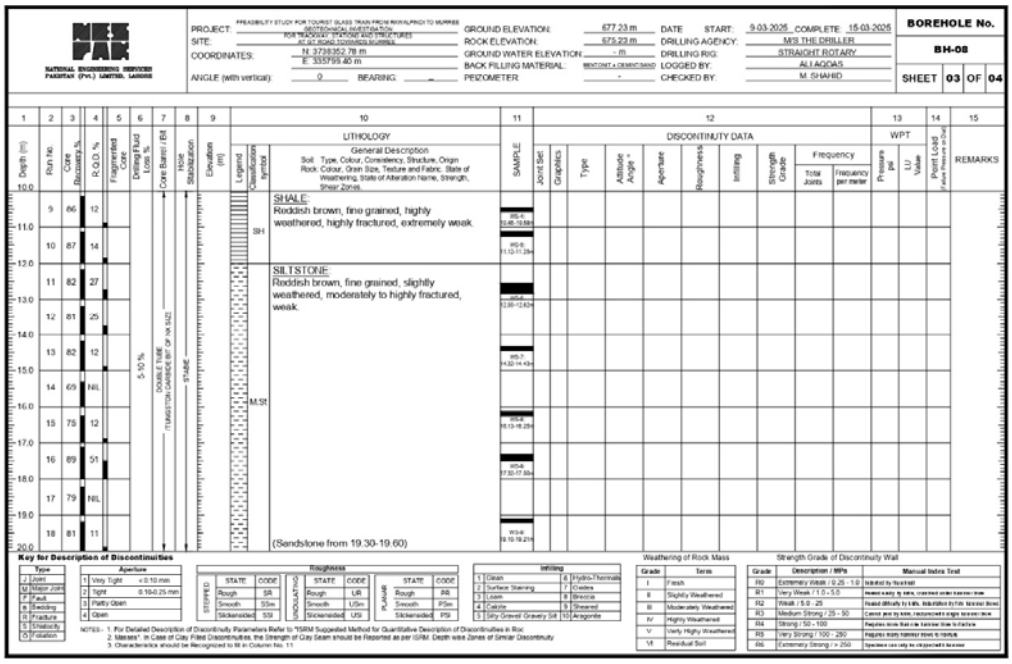
Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

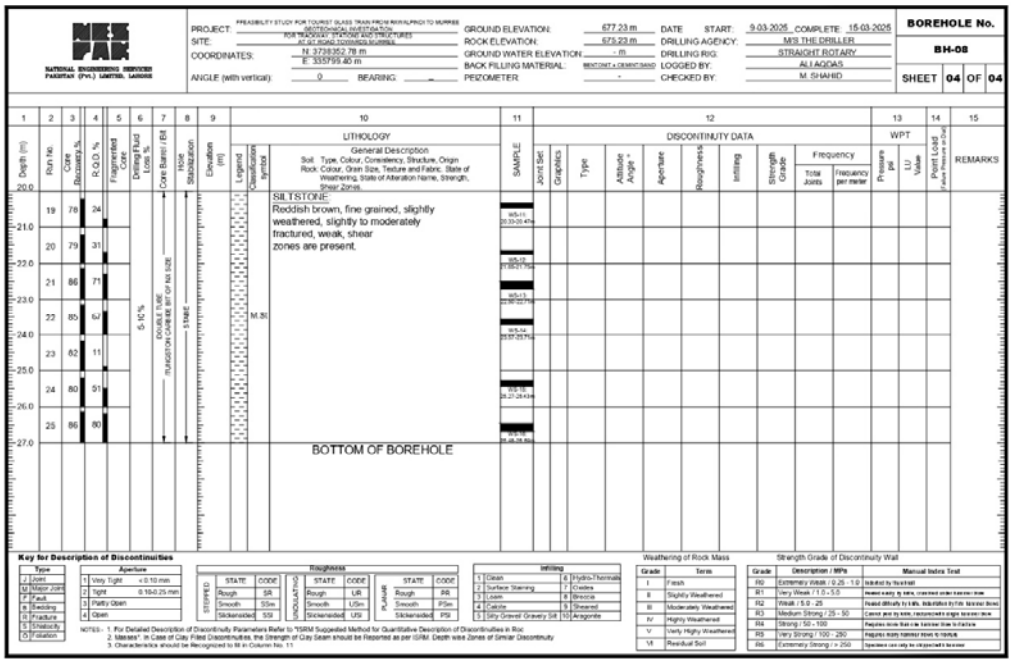
Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3738352.78 m E: 335799.40 m Ground Elevation 677.23 m Date 9-03-2025 To 15-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm (10 20 30 40 50 60 70 80 90 100)	Remarks
0.0							
	SPT-1		CL	Dark brown, very stiff, LEAN CLAY with SAND, low plastic, low dry strength, trace gravels, trace grass roots, etc.	75 mm	22	
1.0							
	SPT-2					REFUSAL	
2.0				TOP OF BEDROCK ENCOUNTERED AT 2.0 M DEPTH			


NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED, LAHORE
FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES AT 457 RGING TOWARDS MURREE
PROJECT:
SITE:
COORDINATES: N: 3738352.78 m E: 335799.40 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 677.23 m
ROCK ELEVATION: 675.23 m
GROUND WATER ELEVATION: - m
BACK FILLING MATERIAL: BENTONIT + CEMENT SAND
PEIZOMETER: -
DATE START: 9-03-2025 COMPLETE: 15-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-08
SHEET 02 OF 04
TOP OF BEDROCK
SH SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.
M.St SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.
SH SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.
SH SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, very weak.
M.St SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.
SH
5-10 %
DOUBLE TUBE (TUNGSTEN CARBIDE BIT OF HX SIZE)
CASING
Key for Description of Discontinuities
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses*: In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11
Weathering of Rock Mass
Strength Grade of Discontinuity Wall


NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED, LAHORE
FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES AT 457 RGING TOWARDS MURREE
PROJECT:
SITE:
COORDINATES: N: 3738352.78 m E: 335799.40 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 677.23 m
ROCK ELEVATION: 675.23 m
GROUND WATER ELEVATION: - m
BACK FILLING MATERIAL: BENTONIT + CEMENT SAND
PEIZOMETER: -
DATE START: 9-03-2025 COMPLETE: 15-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-08
SHEET 03 OF 04
SH SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.
M.St SILTSTONE: Reddish brown, fine grained, slightly weathered, moderately to highly fractured, weak.
(Sandstone from 19.30-19.60)
5-10 %
DOUBLE TUBE (TUNGSTEN CARBIDE BIT OF HX SIZE)
CASING
Key for Description of Discontinuities
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses*: In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11
Weathering of Rock Mass
Strength Grade of Discontinuity Wall


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION
FOR TRACKWAY, TYLPONE AND STRUCTURES
SITE: AT GIT ROAD TOWARDS MURREE
COORDINATES: N: 3738352.78 m
E: 333795.80 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 677.23 m
ROCK ELEVATION: 673.23 m
GROUND WATER ELEVATION: - m
BACK FILLING MATERIAL: BENTONIT + CEMENT/SAND
PEIZOMETER: -
DATE START: 9-03-2026 COMPLETE: 15-03-2026
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No.
BH-08
SHEET 04 OF 04
LITHOLOGY
General Description
Soil: Type, Colour, Consistency, Structure, Origin
Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.
DISCONTINUITY DATA
WPT
REMARKS
Depth (m)
Run No.
Core Recovery %
R.Q.D. %
Fragmented Core
Drilling Fluid Loss %
Core Barrel / Bit
Hole Stabilization
Elevation (m)
Legend
Classification symbol
SAMPLE
Joint Set
Graphics
Type
Altitude Angle °
Aperture
Roughness
Infilling
Strength Grade
Frequency
Total Joints
Frequency per meter
Pressure psi
LU Value
Point Load Strength Index
20.0
19 78 24
20 79 31
21 86 71
22 85 62
23 82 11
24 80 91
25 86 80
5-10 %
DOUBLE TUBE
RUNGSTON CHROME BIT OF NX SIZE
3 RIMS
M.St
SILTSTONE:
Reddish brown, fine grained, slightly weathered, slightly to moderately fractured, weak, shear zones are present.
BOTTOM OF BOREHOLE
Key for Description of Discontinuities
Type
J Joint
M Major Joint
F Fault
B Bedding
R Fracture
S Schistocity
T Foliation
Aperture
1 Very Tight < 0.10 mm
2 Tight 0.10-0.25 mm
3 Partly Open
4 Open
Roughness
STEPPED: Rough SR; Smooth SSm; Slickensided SSl
UNDULATING: Rough UR; Smooth USm; Slickensided USl
PLANAR: Rough PR; Smooth PSm; Slickensided PSl
Infilling
1 Clean
2 Surface Staining
3 Loam
4 Calcite
5 Silty Gravel/ Gravelly Silt
6 Hydro-Thermals
7 Oxides
8 Breccia
9 Sheared
10 Aragonite
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" in Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth was Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11
Weathering of Rock Mass
Grade Term
I Fresh
II Slightly Weathered
III Moderately Weathered
IV Highly Weathered
V Verly Highly Weathered
VI Residual Soil
Strength Grade of Discontinuity Wall
Grade Description / MPa Manual Index Test
R0 Extremely Weak / 0.25 - 1.0 Indicted by thumbnail
R1 Very Weak / 1.0 - 5.0 Peeled easily by knife, crumbled under hammer blow
R2 Weak / 5.0 - 25 Peeled difficulty by knife, indentation by firm hammer blow
R3 Medium Strong / 25 - 50 Cannot peel by knife, fractured with single hammer blow
R4 Strong / 50 - 100 Requires more than one hammer blow to fracture
R5 Very Strong / 100 - 250 Requires many hammer blows to fracture
R6 Extremely Strong / > 250 Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	8	BOX No	1-5	NESPAK
LOCATION	At GT Road Murree	DEPTH (m)	2.0-27.00m	



Depth (m)

2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-09
SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR CHATTAR PARK

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3738546.21 m E: 336741.14 m Ground Elevation 661.55 m Date 12-03-2025 To 19-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm (10 20 30 40 50 60 70 80 90 100)	Remarks
0.0							
	SPT-1		CL-ML	Dark brown, hard, SILTY CLAY with SAND, low to medium plastic, low dry strength, trace gravels, trace grass roots etc.	75 mm	57	
1.0							
	SPT-2					REFUSAL	
2.0				TOP OF BEDROCK ENCOUNTERED AT 2.0 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY STATIONS AND STRUCTURES MURREE-CHATTAR PARK
COORDINATES: N 3738546.21 m, E 336741.14 m
ANGLE (with vertical): 0 BEARING: —

GROUND ELEVATION: 661.65 m
ROCK ELEVATION: 659.55 m
GROUND WATER ELEVATION: -- (ft)
BACK FILLING MATERIAL: BENTONIT + CEMENT/SAND
PEIZOMETER: -

DATE START: 12-03-2025 COMPLETE: 19-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQQAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-09
SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10				11	12										13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY				SAMPLE	DISCONTINUITY DATA										WPT		Point Load Strength Index	REMARKS
									Legend	Classification Symbol	General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.			Joint Set	Graphics	Type	Altitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: per meter	Pressure psi	LU Value		
0.0																											
1.0											TOP OF BEDROCK																
2.0	1	55	NIL								SILTSTONE: Reddish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.																
3.0	2	47	NIL							M.St				J1		R	45°		PR	2	R2-R3	1	1				
4.0	3	73	NIL											J1		R	46°		PR	2	R2-R3	1	1				
5.0	4	50	NIL																								
6.0	5	75	29								SANDSTONE: Greenish grey, fine grained, slightly to moderately weathered, highly fractured, medium strong.																
7.0	6	95	38										RS-1 6.45-6.67 m														
8.0	7	71	41							S.St			RS-2 7.82-7.99 m														
9.0	8	72	37										RS-3 9.00-9.66 m														
10.0					5-10 %	DOUBLE TUBE TUNGSTEN CARBIDE BIT OF NX SIZE	STABLE																				

5-10 % — DOUBLE TUBE TUNGSTEN CARBIDE BIT OF NX SIZE — STABLE

Key for Description of Discontinuities

Type	Aperture
J Joint	1 Very Tight < 0.10 mm
M Major Joint	2 Tight 0.10-0.25 mm
F Fault	3 Partly Open
B Bedding	4 Open
R Fracture	
S Shear/Schistosity	
V Foliation	

Roughness	STATE	CODE	STATE	CODE	STATE	CODE
STEPPED	Rough	SR	Rough	UR	Rough	PR
	Smooth	SSm	Smooth	USm	Smooth	PSm
	Slickensided	SSl	Slickensided	USl	Slickensided	PSl

UNDULATING / PLANAR

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty-Gravel/ Gravely Silt	10	Aragonite

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses* in Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth was Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY STATIONS AND STRUCTURES MURREE-CHATTAR PARK
COORDINATES: N 3738546.21 m, E 336741.14 m
ANGLE (with vertical): 0 BEARING: —

GROUND ELEVATION: 661.65 m
ROCK ELEVATION: 659.55 m
GROUND WATER ELEVATION: -- (ft)
BACK FILLING MATERIAL: BENTONIT + CEMENT/SAND
PEIZOMETER: -

DATE START: 12-03-2025 COMPLETE: 19-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQQAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-09
SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10				11	12										13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY				SAMPLE	DISCONTINUITY DATA										WPT		Point Load Strength Index	REMARKS
									Legend	Classification Symbol	General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.			Joint Set	Graphics	Type	Altitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: per meter	Pressure psi	LU Value		
10.0											SANDSTONE: Grey, fine grained, slightly weathered, moderately to highly fractured, weak, Shear zones are present.																
11.0	9	67	12										RS-4 11.35-11.42m														
12.0	10	59	18																								
13.0	11	56	NIL																								
14.0	12	54	NIL																								
15.0	13	69	20							S.St			RS-5 14.32-14.52m														
16.0	14	79	55											J1		R	37°		UR	2	R3-R4	3	3				
17.0	15	76	35										RS-6 15.9-16.22m	J1		J	55°		PR	2	R3-R4	4	4				
18.0	16	54	NIL																								
19.0	17	54	12																								
20.0	18	20	NIL																								

5-10 % — DOUBLE TUBE TUNGSTEN CARBIDE BIT OF NX SIZE — STABLE

Key for Description of Discontinuities

Type	Aperture
J Joint	1 Very Tight < 0.10 mm
M Major Joint	2 Tight 0.10-0.25 mm
F Fault	3 Partly Open
B Bedding	4 Open
R Fracture	
S Shear/Schistosity	
V Foliation	

Roughness	STATE	CODE	STATE	CODE	STATE	CODE
STEPPED	Rough	SR	Rough	UR	Rough	PR
	Smooth	SSm	Smooth	USm	Smooth	PSm
	Slickensided	SSl	Slickensided	USl	Slickensided	PSl

UNDULATING / PLANAR

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty-Gravel/ Gravely Silt	10	Aragonite

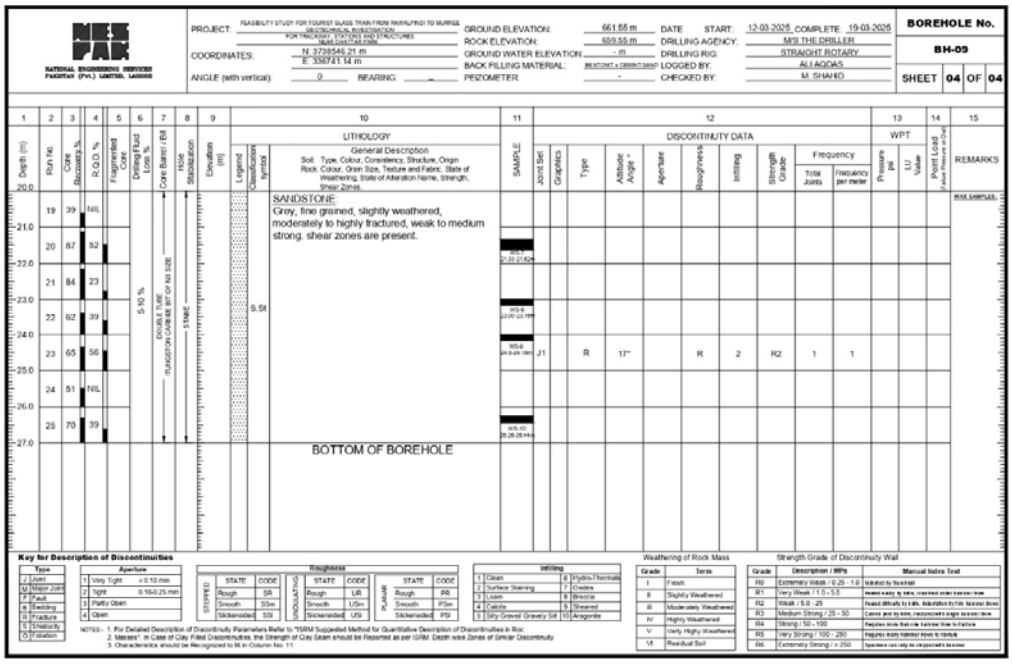
Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses* in Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth was Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE (MUZAFFARABAD, MANSEHRA) FOR TRACKWAY STATIONS AND STRUCTURES (MURREE-KOHALA PARK)

COORDINATES: N 3738546.21 m, E 358741.14 m

ANGLE (with vertical): 0 BEARING: —

GROUND ELEVATION: 661.65 m
ROCK ELEVATION: 659.55 m
GROUND WATER ELEVATION: - m
BACK FILLING MATERIAL: BENTONIT + CEMENT/SAND
PEIZOMETER: -

DATE START: 12-03-2026 COMPLETE: 19-03-2026
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQQAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-09

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUITY DATA										WPT		Point Load Strength Index	REMARKS
									Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones		Joint Set	Graphics	Type	Altitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value		
20.0											SANDSTONE: Grey, fine grained, slightly weathered, moderately to highly fractured, weak to medium strong. shear zones are present.																WAS SAMPLES:
21.0	19	39	NIL																							
22.0	20	87	52									RC-7 21.22-21.82m														
23.0	21	84	23									RC-8 22.00-22.70m														
24.0	22	62	39		5-10 %	DOUBLE TUBE						RC-9 24.0-24.18m	J1		JR	17°		R	2	R2	1	1				
25.0	23	65	56			RUNGSTON COARSE BIT OF NX SIZE	STABLE																			
26.0	24	51	NIL																							
27.0	25	70	39									RC5-10 25.28-26.44m														
											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Schistocity
T	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness								
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro-Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel/ Gravely Silt	10	Aragonite

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses * in Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth was Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Verly Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Peeled easily by knife, crumbled under hammer blow
R2	Weak / 5.0 - 25	Peeled difficulty by knife, indentation by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	9	BOX No	1-5	NESPAK	Depth (m)
LOCATION	Near Chattar Park	DEPTH (m)	2.0-27.00m		



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-10
SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BAHRIA GOLF CITY

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3740742.70 m E: 340248.37 m Ground Elevation 790.27 m Date 25-03-2025 To 28-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. O SPT Blows/30cm 10 20 30 40 50 60 70 80 90 100	Remarks
0.0				Dark brown, stiff to hard, SANDY LEAN CLAY, low plastic, low dry strength, trace gravels, trace concretion trace grass roots etc.	75 mm	16, 10	
1.0	SPT-1		CL				
2.0	SPT-2						
	SPT-3					REFUSAL	
				TOP OF BEDROCK ENCOUNTERED AT 3.3 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TUNNEL STATIONS AND STRUCTURES NEAR BANTA GOLF CITY
COORDINATES: N: 3740742.70 m, E: 340248.37 m
ANGLE (with vertical): 0 BEARING:

GROUND ELEVATION: 790.27 m
ROCK ELEVATION: 786.97 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT.
PEIZOMETER:

DATE START: 25-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-10
SHEET 02 OF 04

1 Depth (m)	2 Run No.	3 Core Recovery %	4 R.Q.D. %	5 Fragmented Core	6 Drilling Tool Used	7 Core Barrel / Bit	8 Hole Stabilization	9 Elevation (m)	10 LITHOLOGY: Legend	Classification symbol	General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	11 SAMPLE	12 DISCONTINUITY DATA: Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency per meter	13 WPT: Pressure psi	LU Value	14 Point Load (Is50) MPa	15 REMARKS
0.0																										
1.0																										
2.0																										
3.0											TOP OF BEDROCK															
4.0	1	84	NIL		15-30 % DOUBLE TUBE / PLUNGTON CARBIDE BIT/ DIA 101.6MM	STABLE			SH		SHALE: Reddish brown, fine grained, moderately weathered, moderately to highly fractured, extremely weak.															
5.0	2	99	54									BS-1 4.41-4.86 m														
6.0	3	95	32																							
7.0	4	65	NIL						S.St		SANDSTONE: Grey, fine grained, moderately weathered, moderately fractured, weak.	BS-2 6.72-6.95 m														
8.0	5	66	NIL						SH		SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.															
9.0	6	61	NIL																							
10.0	7	52	NIL																							

Key for Description of Discontinuities

Type	Aperture
J Joint	1 Very Tight < 0.10 mm
U Major Joint	2 Tight 0.10-0.25 mm
F Fault	3 Partly Open
B Bedding	4 Open
R Fracture	
S Shelocity	
O Foliation	

Roughness	STATE	CODE	STATE	CODE	STATE	CODE
STEPPED	Rough	SR	Rough	UR	Rough	PR
	Smooth	SSm	Smooth	USm	Smooth	PSm
	Slickensided	SSl	Slickensided	USl	Slickensided	PSl
UNDULATING					PLANAR	

Infilling			
1 Clean	6 Hydro Thermals		
2 Surface Staining	7 Oxides		
3 Loam	8 Breccia		
4 Calcite	9 Sheared		
5 Silty Gravel Gravely Silt	10 Aragonite		

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Very Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by fingernail
R1	Very Weak / 1.0 - 5.0	Pared easily by knife, crumbled under firmer blow
R2	Weak / 5.0 - 25	Pared only by knife, indentable by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot pare by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be replaced with hammer

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TUNNEL STATIONS AND STRUCTURES NEAR BANTA GOLF CITY
COORDINATES: N: 3740742.70 m, E: 340248.37 m
ANGLE (with vertical): 0 BEARING:

GROUND ELEVATION: 790.27 m
ROCK ELEVATION: 786.97 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT.
PEIZOMETER:

DATE START: 25-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-10
SHEET 03 OF 04

1 Depth (m)	2 Run No.	3 Core Recovery %	4 R.Q.D. %	5 Fragmented Core	6 Drilling Tool Used	7 Core Barrel / Bit	8 Hole Stabilization	9 Elevation (m)	10 LITHOLOGY: Legend	Classification symbol	General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	11 SAMPLE	12 DISCONTINUITY DATA: Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency per meter	13 WPT: Pressure psi	LU Value	14 Point Load (Is50) MPa	15 REMARKS
10.0																										
11.0	8	72	41		15-30 % DOUBLE TUBE / PLUNGTON CARBIDE bit	STABLE			SH		SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.															
12.0	9	74	26						M.St		SILTSTONE: Brown, fine grained, slightly to moderately weathered, moderately to highly fractured, weak.	BS-3 11.45-11.85 m														
13.0	10	67	33									BS-4 12.0-12.17m														
14.0	11	99	27						SH		SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.	BS-5 13.40-13.58 m														
15.0	12	80	10						M.St																	
16.0	13	80	NIL						SH		SILTSTONE: Brown, fine grained, slightly to moderately weathered, highly fractured, weak.															
17.0	14	40	NIL								SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.															
18.0	15	33	NIL						M.St		SILTSTONE: Brown, fine grained, slightly to moderately weathered, moderately to highly fractured, weak.															
19.0	16	35	10									BS-6 18.11-18.21 m														
20.0	17	37	NIL																							

Key for Description of Discontinuities

Type	Aperture
J Joint	1 Very Tight < 0.10 mm
U Major Joint	2 Tight 0.10-0.25 mm
F Fault	3 Partly Open
B Bedding	4 Open
R Fracture	
S Shelocity	
O Foliation	

Roughness	STATE	CODE	STATE	CODE	STATE	CODE
STEPPED	Rough	SR	Rough	UR	Rough	PR
	Smooth	SSm	Smooth	USm	Smooth	PSm
	Slickensided	SSl	Slickensided	USl	Slickensided	PSl
UNDULATING					PLANAR	

Infilling			
1 Clean	6 Hydro Thermals		
2 Surface Staining	7 Oxides		
3 Loam	8 Breccia		
4 Calcite	9 Sheared		
5 Silty Gravel Gravely Silt	10 Aragonite		

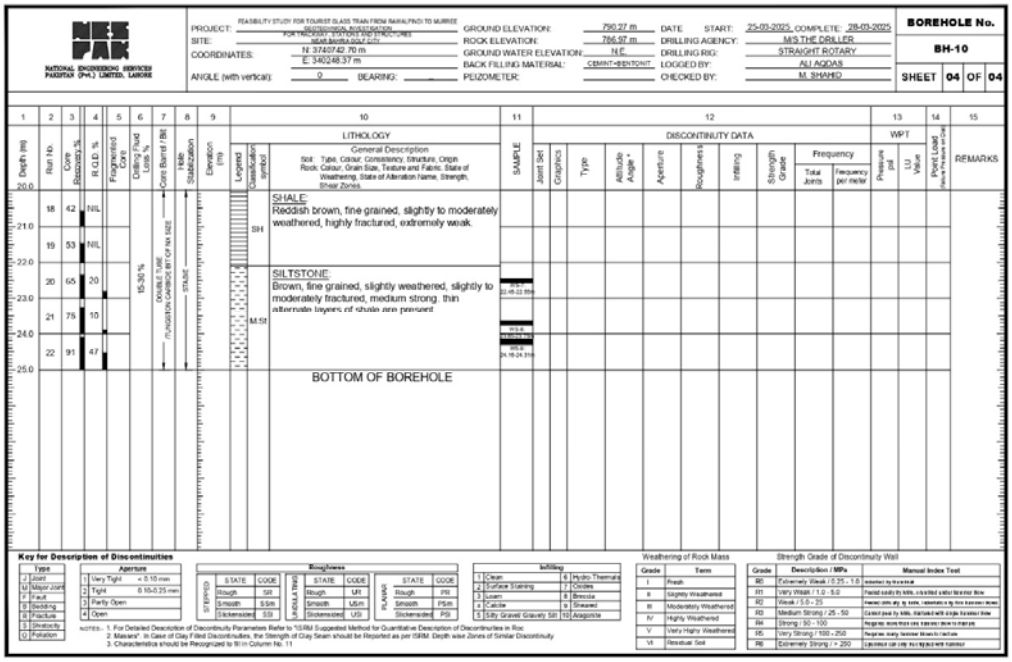
Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Very Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by fingernail
R1	Very Weak / 1.0 - 5.0	Pared easily by knife, crumbled under firmer blow
R2	Weak / 5.0 - 25	Pared only by knife, indentable by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot pare by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be replaced with hammer

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE (RESTORATION, ROAD ALIGNMENT, FOR TRENCHES, TUNNELS AND STRUCTURES)
SITE: NEAR BHITA GALI / GPO
COORDINATES: N: 3740742.76 m, E: 340248.37 m
ANGLE (with vertical): 0 BEARING:

GROUND ELEVATION: 790.27 m
ROCK ELEVATION: 786.97 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER:

DATE START: 25-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-10
SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12									13		14	15
									LITHOLOGY				DISCONTINUITY DATA									WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Tool Used	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Attitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psf	LU Value	Point Load Strength Index	REMARKS
20.0																										
21.0	18	42	NIL		15-30 %	DOUBLE TUBE PLUNGSTON CARBIDE BIT OF NX SIZE	STAGE			SH	SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, extremely weak.															
22.0	19	53	NIL																							
23.0	20	65	20							M.St	SILTSTONE: Brown, fine grained, slightly weathered, slightly to moderately fractured, medium strong. thin alternate layers of shale are present	SS-3 22.45-22.59m													
24.0	21	75	10									SS-4 23.45-23.59m														
25.0	22	91	47									SS-5 24.15-24.31m														
											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness							
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	St		Rough	Ur		Rough	Pr
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel Gravely Silt	10	Aragonite

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Very Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Pared easily by knife, crumbled under firmer blow
R2	Weak / 5.0 - 25	Pared difficulty by knife, indentable by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot pare by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	10	BOX No	1-5	NESPAK
LOCATION	Near Bahria Golf City	DEPTH (m)	3.30-25.00m	



Depth (m)
3.30
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-11
SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR MANGA

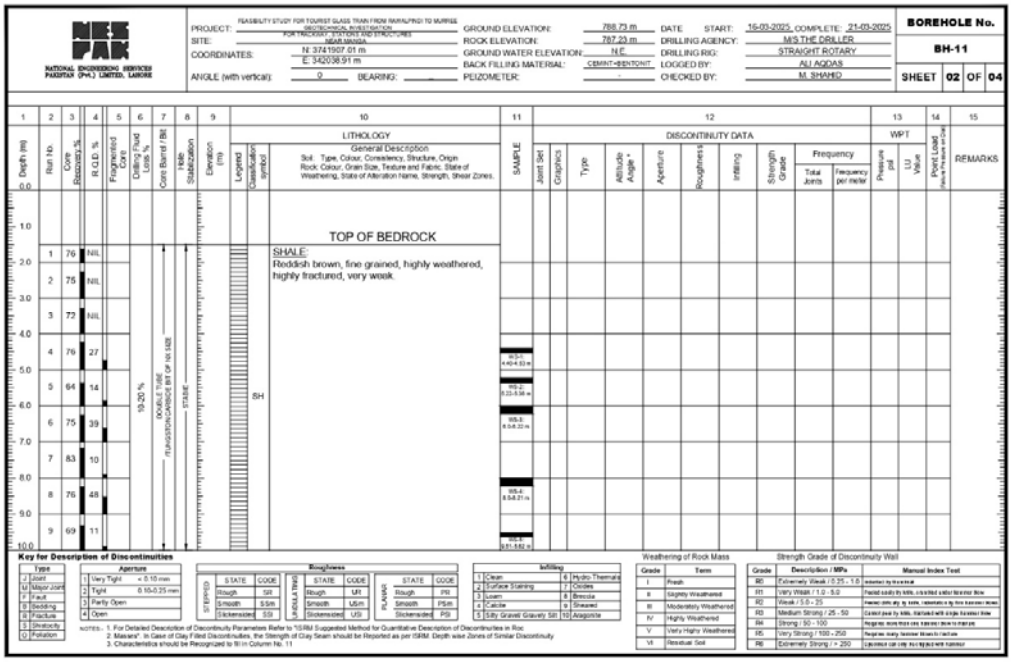
Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

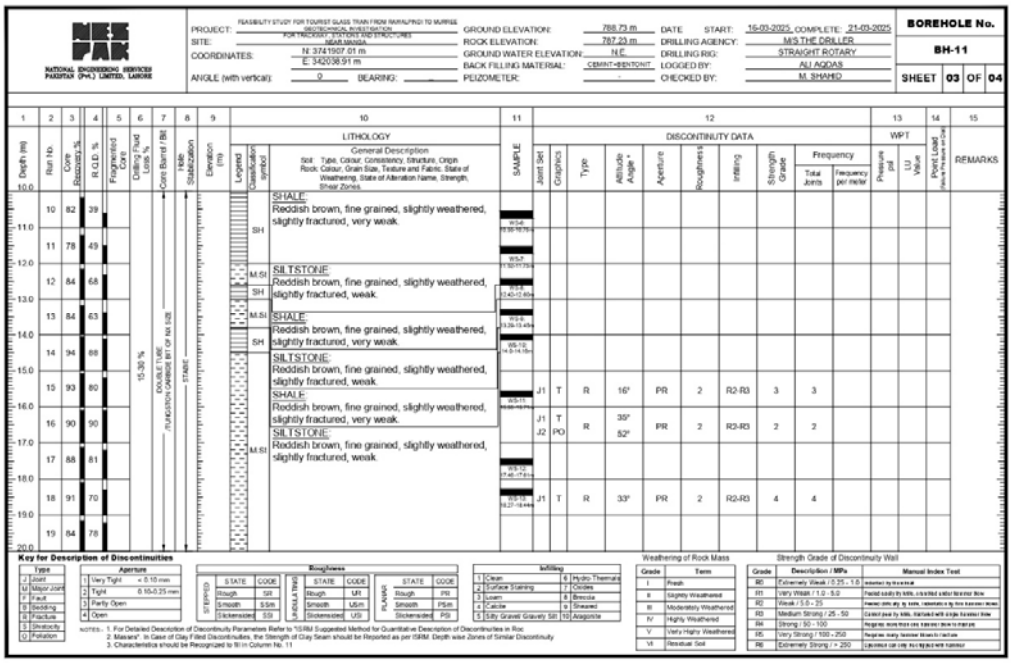
Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

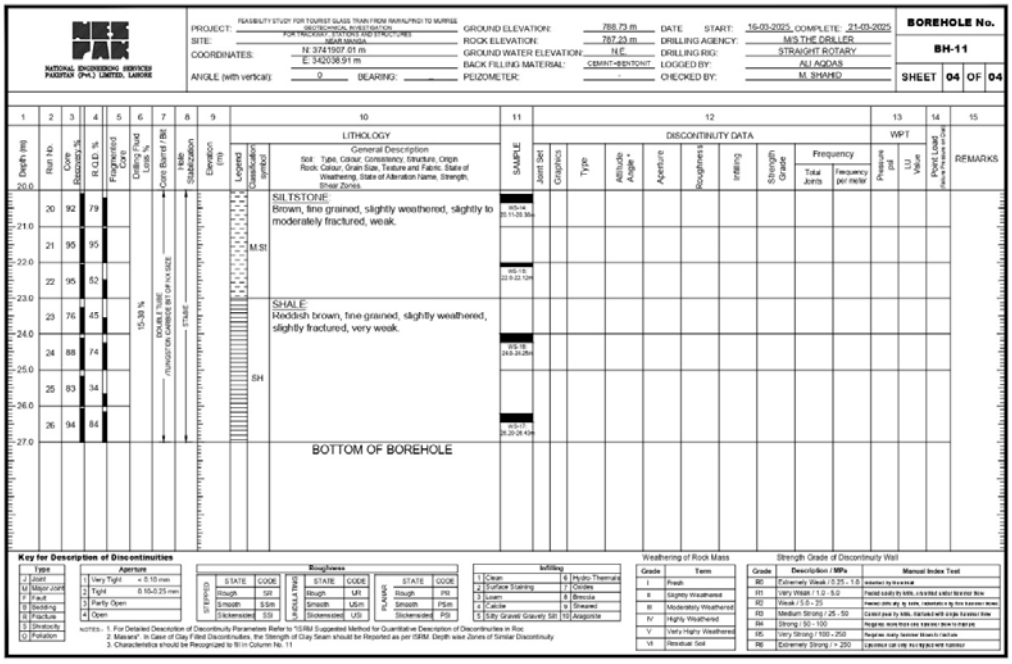
Coordinates N: 3741907.01 m E: 342038.91 m Ground Elevation 788.73 m Date 16-03-2025 To 21-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0							
	SPT-1		CL	Dark brown, hard, LEAN CLAY, low plastic, medium dry strength, trace grass roots, etc.	75 mm	44	
1.0				TOP OF BEDROCK ENCOUNTERED AT 1.5 M DEPTH			
2.0							

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR MANSA
SITE:
COORDINATES: N: 3741907.01 m E: 342038.91 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 788.73 m
ROCK ELEVATION: 787.23 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -
DATE START: 16-03-2025 COMPLETE: 21-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-11
SHEET 02 OF 04
TOP OF BEDROCK
SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.
19.20 %
DOUBLE TUBE
TUNGSTEN CARBIDE BIT OF NX SIZE
STABLE
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR MANSA
SITE:
COORDINATES: N: 3741907.01 m E: 342038.91 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 788.73 m
ROCK ELEVATION: 787.23 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -
DATE START: 16-03-2025 COMPLETE: 21-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-11
SHEET 03 OF 04
SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, very weak.
SILTSTONE: Reddish brown, fine grained, slightly weathered, slightly fractured, weak.
SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, very weak.
SILTSTONE: Reddish brown, fine grained, slightly weathered, slightly fractured, weak.
SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, very weak.
SILTSTONE: Reddish brown, fine grained, slightly weathered, slightly fractured, weak.
15.30 %
DOUBLE TUBE
TUNGSTEN CARBIDE BIT OF NX SIZE
STABLE
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION
FOR TRACKWAY, STATIONS AND STRUCTURES
NEAR MANSA

PROJECT:
SITE:
COORDINATES: N 3741907.01 m, E 342038.91 m
ANGLE (with vertical): 0 BEARING:

GROUND ELEVATION: 788.73 m
ROCK ELEVATION: 787.23 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 16-03-2025 COMPLETE: 21-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAMID

BOREHOLE No. BH-11

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	LITHOLOGY			SAMPLE	DISCONTINUITY DATA										WPT		Point Load Strength Index	REMARKS
									Legend	Classification symbol	General Description Soil : Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.		Joint Set	Graphics	Type	Attitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: per meter	Pressure psi	LU Value		
20.0																										
21.0	20	92	79								SILTSTONE: Brown, fine grained, slightly weathered, slightly to moderately fractured, weak.	WS-14 20.11-20.56m													
22.0	21	95	95							M.St																
23.0	22	95	82									WS-15 22.0-22.12m														
24.0	23	76	45		15-30 %	DOUBLE TUBE TUNGSTEN CARBIDE BIT OF NX SIZE	STABLE				SHALE: Reddish brown, fine grained, slightly weathered, slightly fractured, very weak.															
25.0	24	88	74									WS-16 24.6-24.85m														
26.0	25	83	34							SH																
27.0	26	94	84									CS-17 26.20-26.40m														
											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
U	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
O	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness						
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel Gravely Silt	10	Aragonite

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Very Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Partial crumbly by knife, crumbled under firmer blow
R2	Weak / 5.0 - 25	Partial crumbly by knife, indentable by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot peel by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	11	BOX No	1-5	NESPAK
LOCATION	Near Manga	DEPTH (m)	1.50-27.00m	



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-12
SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR NANDKOT

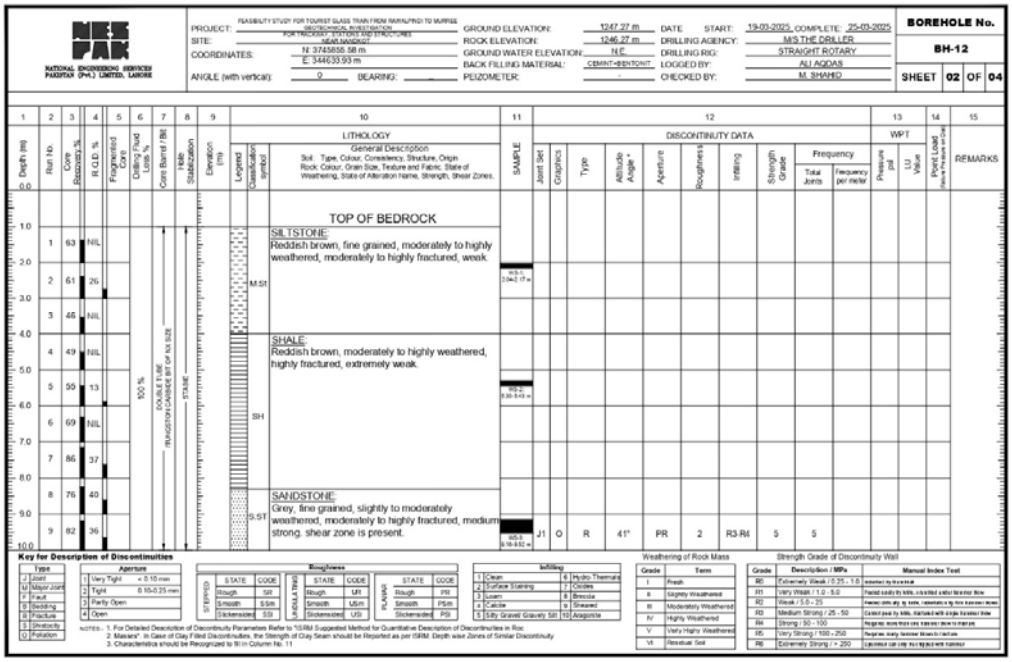
Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

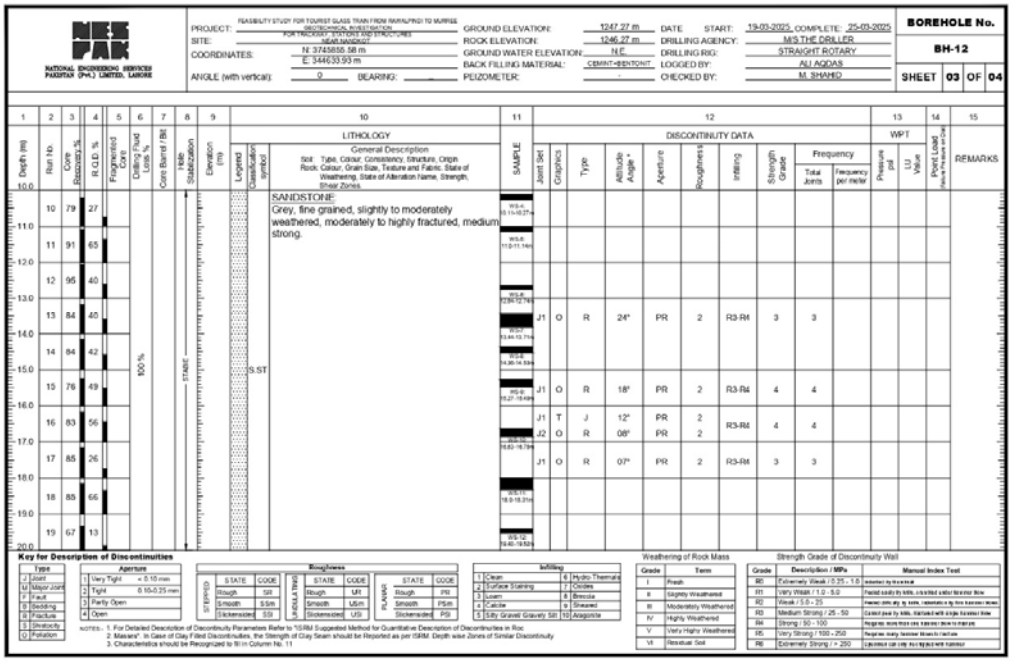
Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

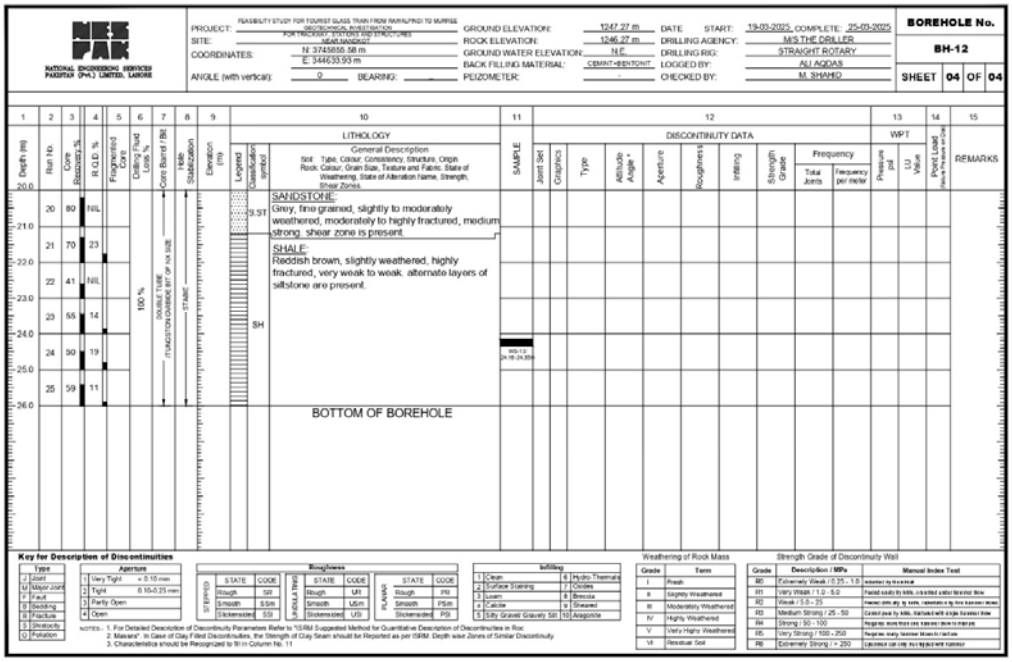
Coordinates N: 3745855.58 m E: 344633.93 m Ground Elevation 1247.27 m Date 19-03-2025 To 25-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0							
	SPT-1		CL-ML	Dark brown, SILTY CLAY with SAND, low plastic, low dry strength, trace gravels, trace grass roots etc.	75 mm	REFUSAL	
1.0				TOP OF BEDROCK ENCOUNTERED AT 1.0 M DEPTH			

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR SANDIKOT
COORDINATES: N 3745855.58 m E 3446393.93 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1247.27 m
ROCK ELEVATION: 1246.27 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -
DATE START: 19-03-2025 COMPLETE: 25-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-12
SHEET 02 OF 04
TOP OF BEDROCK
SILTSTONE: Reddish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.
SHALE: Reddish brown, moderately to highly weathered, highly fractured, extremely weak.
SANDSTONE: Grey, fine grained, slightly to moderately weathered, moderately to highly fractured, medium strong. shear zone is present.
100 %
DOUBLE TUBE
RHINOSTONE/DIBEE BIT OF NX SIZE
STABLE
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR SANDIKOT
COORDINATES: N 3745855.58 m E 3446393.93 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1247.27 m
ROCK ELEVATION: 1246.27 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -
DATE START: 19-03-2025 COMPLETE: 25-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-12
SHEET 03 OF 04
SANDSTONE: Grey, fine grained, slightly to moderately weathered, moderately to highly fractured, medium strong.
100 %
STABLE
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR MASHRIOT
SITE:
COORDINATES: N 3745855.58 m, E 344633.93 m
ANGLE (with vertical): 0 BEARING:

GROUND ELEVATION: 1247.27 m
ROCK ELEVATION: 1246.27 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 19-03-2025 COMPLETE: 25-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12

SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUITY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil : Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psf	LU Value	Point Load Strength Index	REMARKS
20.0																										
	20	80	NIL		100 %	DOUBLE TUBE ITURGSTON CHANGE BIT OF NX SIZE	STAINE			S.ST	SANDSTONE: Grey, fine grained, slightly to moderately weathered, moderately to highly fractured, medium strong, shear zone is present.															
21.0	21	70	23																							
22.0	22	41	NIL							SH	SHALE: Reddish brown, slightly weathered, highly fractured, very weak to weak, alternate layers of siltstone are present.															
23.0	23	55	14																							
24.0	24	90	19									SS-13 24.15-24.35ft														
25.0	25	59	11																							
26.0											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
C	Foliation

Aperture		
1	Very Tight	< 0.10 mm
2	Tight	0.10-0.25 mm
3	Partly Open	
4	Open	

Roughness						
	STATE	CODE		STATE	CODE	
STEPPED	Rough	St	UNDULATING	Rough	Ur	PLANAR
	Smooth	Ssm		Smooth	Usm	
	Slickensided	Ssl		Slickensided	Usl	

	STATE	CODE
PLANAR	Rough	Pr
	Smooth	Psm
	Slickensided	Psl

Infilling			
1	Clean	6	Hydro Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel Gravely Silt	10	Aragonite

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

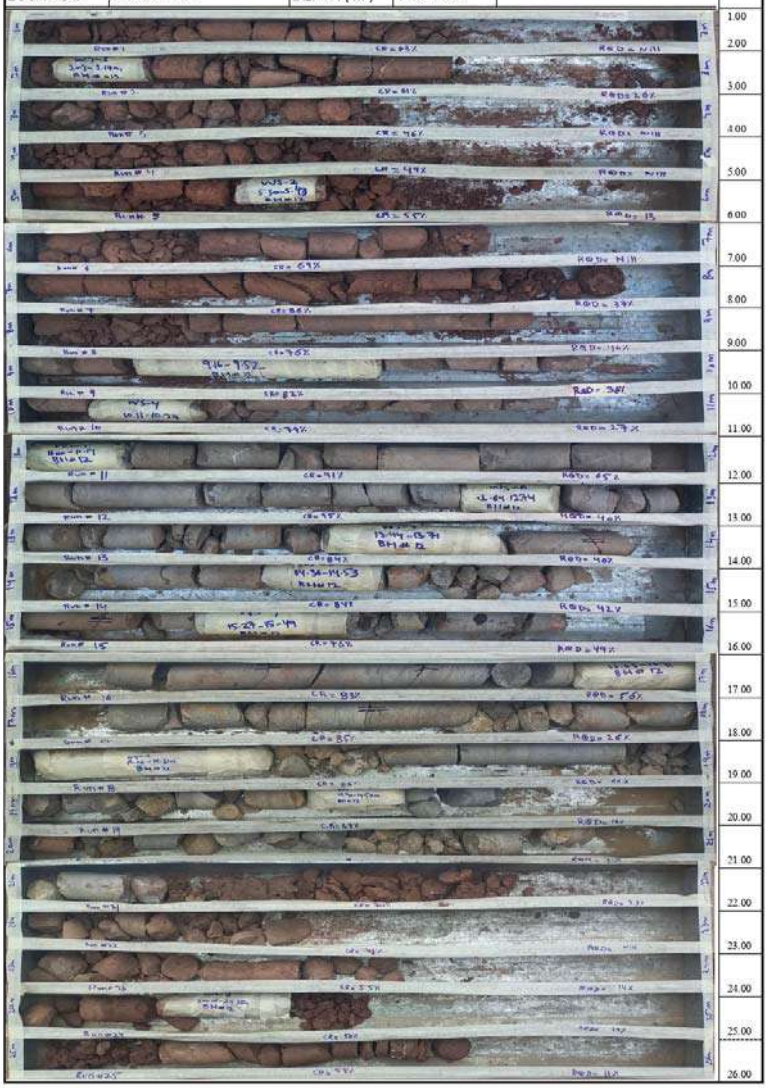
Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Very Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Pierced easily by knife, crumbled under firmer blow
R2	Weak / 5.0 - 25	Pierced only by knife, indentable by firm hammer blows
R3	Medium Strong / 25 - 50	Carved easy by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	12	BOX No	1-5	NESPAK	Depth (m)
LOCATION	Near Nandkot	DEPTH (m)	1.0-26.00m		



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-12A
SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR NUM VILLAGE

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3744876.22 m E: 344879.77 m Ground Elevation 941.70 m Date 23-03-2025 To 28-03-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0							
	SPT-1		CL-ML	Dark brown, very stiff to hard, SANDY SILTY CLAY, low plastic, low dry strength, trace concretion, trace grass roots, etc.	75 mm	26	
1.0							
	SPT-2					REFUSAL	
2.0				TOP OF BEDROCK ENCOUNTERED AT 2.0 M DEPTH			

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE (GEOTECHNICAL INVESTIGATION)
SITE: FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NU10 VILLAGE
COORDINATES: N: 3744876.22 m, E: 344879.77 m
ANGLE (with vertical): 0 BEARING: ____

GROUND ELEVATION: 941.70 m
ROCK ELEVATION: 939.70 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT.
PEIZOMETER: -

DATE START: 23-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12A
SHEET 02 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUITY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Tool Used	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Is50) MPa	REMARKS
0.0																										
1.0																										
2.0											TOP OF BEDROCK															
3.0	1	48	NIL								SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.															
4.0	2	55	NIL																							
5.0	3	79	13		15-30 %	DOUBLE TUBE (TUNGSTEN CARBIDE BIT OF NX SIZE)	STABLE					BS-1 4.0-4.65 m														
6.0	4	66	NIL							SH																
7.0	5	63	NIL																							
8.0	6	60	NIL																							
9.0	7	61	NIL																							
10.0	8	66	NIL																							

Key for Description of Discontinuities

Type	
J	Joint
U	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
O	Foliation

Aperture	
1	Very Tight < 0.10 mm
2	Tight 0.10-0.25 mm
3	Partly Open
4	Open

Roughness							
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel Gravely Silt	10	Aragonite

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Very Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by fingernail
R1	Very Weak / 1.0 - 5.0	Pared easily by knife, crumbled under firmer blow
R2	Weak / 5.0 - 25	Pared with difficulty by knife, indentable by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot pare by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be replaced with hammer

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE (GEOTECHNICAL INVESTIGATION)
SITE: FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NU10 VILLAGE
COORDINATES: N: 3744876.22 m, E: 344879.77 m
ANGLE (with vertical): 0 BEARING: ____

GROUND ELEVATION: 941.70 m
ROCK ELEVATION: 939.70 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT.
PEIZOMETER: -

DATE START: 23-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12A
SHEET 03 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUITY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Tool Used	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil: Type, Colour, Consistency, Structure, Origin Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load (Is50) MPa	REMARKS
10.0																										
11.0	9	62	NIL								SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.															
12.0	10	71	NIL									BS-2 12.15-12.34 m														
13.0	11	70	NIL																							
14.0	12	55	NIL							SH																
15.0	13	92	44		15-30 %	DOUBLE TUBE (TUNGSTEN CARBIDE BIT OF NX SIZE)	STABLE					BS-3 14.45-14.65 m														
16.0	14	93	51									BS-4 15.81-15.79 m														
17.0	15	86	14								SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, highly fractured, weak.														
18.0	16	70	NIL							M.St																
19.0	17	82	26									BS-5 19.40 - 19.54 m														
20.0	18	64	24							SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, weak.	BS-6 19.27 - 19.40 m														

Key for Description of Discontinuities

Type	
J	Joint
U	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
O	Foliation

Aperture	
1	Very Tight < 0.10 mm
2	Tight 0.10-0.25 mm
3	Partly Open
4	Open

Roughness							
STEPPED	STATE	CODE	UNDULATING	STATE	CODE	PLANAR	STATE	CODE
	Rough	SR		Rough	UR		Rough	PR
	Smooth	SSm		Smooth	USm		Smooth	PSm
	Slickensided	SSl		Slickensided	USl		Slickensided	PSl

Infilling			
1	Clean	6	Hydro Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel Gravely Silt	10	Aragonite

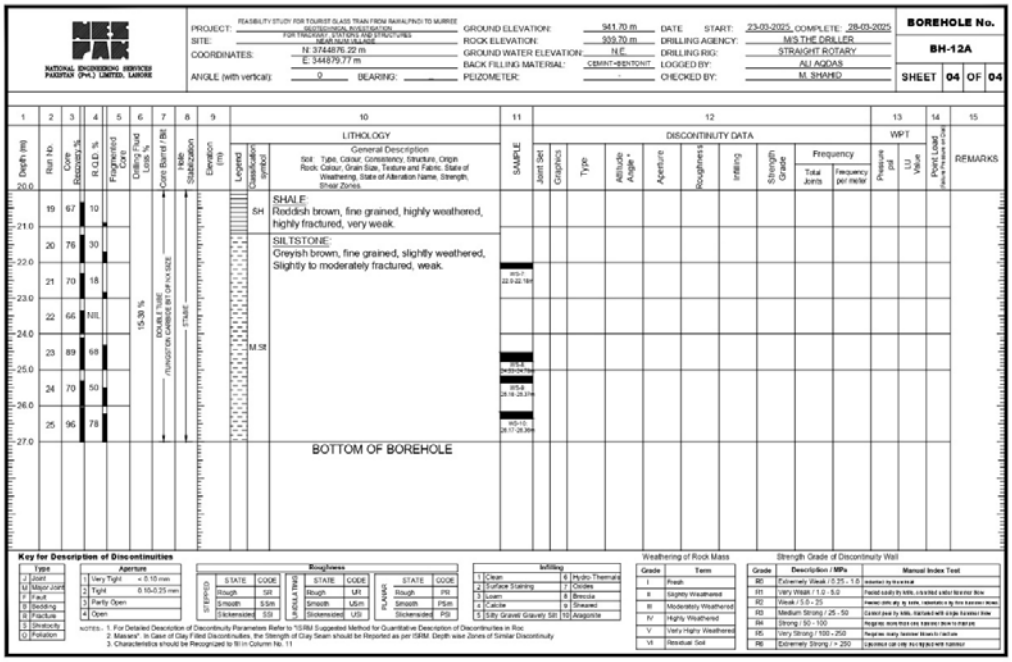
Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Very Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by fingernail
R1	Very Weak / 1.0 - 5.0	Pared easily by knife, crumbled under firmer blow
R2	Weak / 5.0 - 25	Pared with difficulty by knife, indentable by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot pare by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be replaced with hammer

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE (SECTION-III: BOARDINGS FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NURI VILLAGE)
SITE:
COORDINATES: N 3744876.22 m, E 344879.77 m
ANGLE (with vertical): 0 BEARING:

GROUND ELEVATION: 941.70 m
ROCK ELEVATION: 939.70 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: CEMINT+BENTONIT
PEIZOMETER: -

DATE START: 23-03-2025 COMPLETE: 28-03-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-12A
SHEET 04 OF 04

1	2	3	4	5	6	7	8	9	10			11	12										13		14	15
									LITHOLOGY				DISCONTINUITY DATA										WPT			
Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	General Description Soil : Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	Pressure psi	LU Value	Point Load Strength Index	REMARKS
20.0																										
	19	67	10							SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.															
21.0																										
	20	76	30								SILTSTONE: Greyish brown, fine grained, slightly weathered, Slightly to moderately fractured, weak.														
22.0												BS-1 22.0-22.18ft														
	21	70	18																							
23.0																										
	22	66	NIL		15-30 %	DOUBLE TUBE, TUNGSTEN CARBIDE BIT OF HX SIZE	STAGE																			
24.0																										
	23	89	68							M St		BS-3 24.59-24.79ft														
25.0												BS-4 25.18-25.37ft														
	24	70	50																							
26.0												BS-5 25.97-26.39ft														
	25	96	78																							
27.0											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type	
J	Joint
M	Major Joint
F	Fault
B	Bedding
R	Fracture
S	Shelocity
O	Foliation

Aperture	
1	Very Tight < 0.10 mm
2	Tight 0.10-0.25 mm
3	Partly Open
4	Open

Roughness						
	STATE	CODE		STATE	CODE	
STEPPED	Rough	St	UNDULATING	Rough	Ur	PLANAR
	Smooth	Ssm		Smooth	Usm	
	Slickensided	Ss		Slickensided	Us	

	STATE	CODE
	Rough	Pr
	Smooth	Psm
	Slickensided	Ps

Infilling			
1	Clean	6	Hydro Thermals
2	Surface Staining	7	Oxides
3	Loam	8	Breccia
4	Calcite	9	Sheared
5	Silty Gravel Gravely Silt	10	Aragonite

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses" In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

Grade	Term
I	Fresh
II	Slightly Weathered
III	Moderately Weathered
IV	Highly Weathered
V	Very Highly Weathered
VI	Residual Soil

Strength Grade of Discontinuity Wall

Grade	Description / MPa	Manual Index Test
R0	Extremely Weak / 0.25 - 1.0	Indented by thumbnail
R1	Very Weak / 1.0 - 5.0	Fractured easily by knife, crumbled under firmblow
R2	Weak / 5.0 - 25	Fractured only by knife, indentable by firm hammer blows
R3	Medium Strong / 25 - 50	Cannot be by knife, fractured with single hammer blow
R4	Strong / 50 - 100	Requires more than one hammer blow to fracture
R5	Very Strong / 100 - 250	Requires many hammer blows to fracture
R6	Extremely Strong / > 250	Specimen can only be chipped with hammer

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	12A	BOX No	1-5	NESPAK
LOCATION	Near Num Village	DEPTH (m)	2.0-27.00m	



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-13
SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR PERRAH VILLAGE

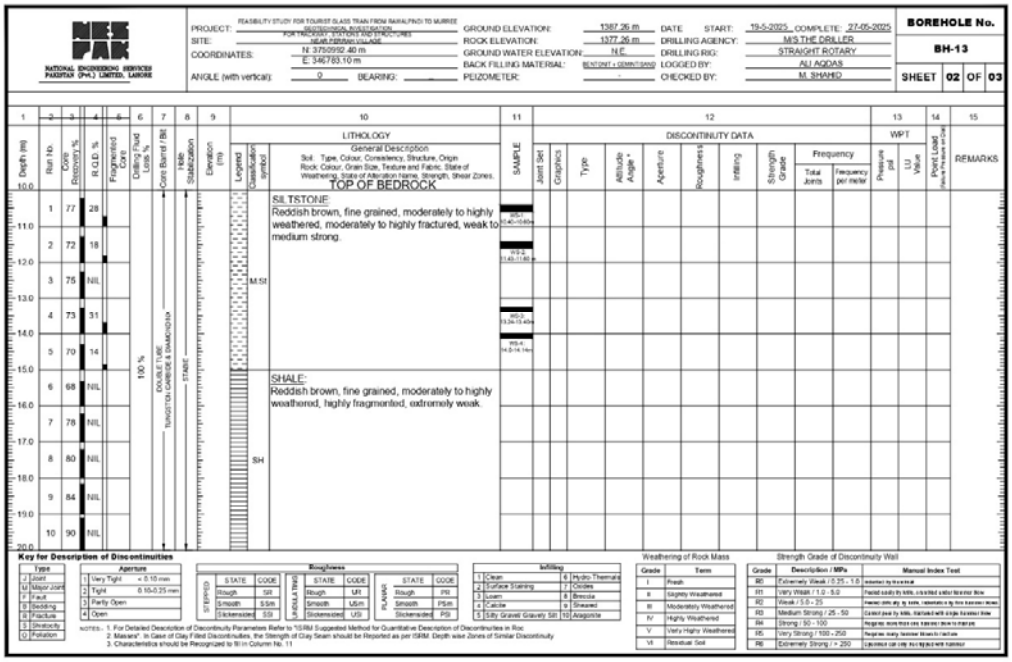
Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3750992.40 m E: 346783.10 m Ground Elevation 1387.26 m Date 19-5-2025 To 27-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. O)	Remarks
0.0							
			CI -MI	Blackish grey, SILTY CLAY, low plastic, medium dry strength, trace fine gravels, moist.			
1.0	SPT-1					48	
			GC-GM	Blackish grey, dense, SILTY CLAYEY GRAVEL, angular to subangular, size 5-10 mm, moist.			
2.0	SPT-2					19	
				Blackish brown, very stiff to hard, SILTY CLAY, low plastic, medium dry strength, trace fine gravels, moist.			
3.0	SPT-3					20	
			CL-ML				
4.0						41	
	SPT-4 DS-1						
5.0	SPT-5(c) DS-2						REFUSAL
				Brownish grey, very dense, SILTY CLAYEY GRAVEL, angular to sub-angular, size 5-30 mm, moist.			
6.0	SPT-6(c) DS-3						REFUSAL
7.0	SPT-7(c) DS-4		GC-GM				REFUSAL
8.0	SPT-8(c)						REFUSAL
9.0	SPT-9			Reddish brown, hard, SILTY CLAY, low plastic, medium dry strength, moist.			REFUSAL
			CL-ML				

TOP OF BEDROCK ENCOUNTERED AT 10.0 M DEPTH



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATORS AND STRUCTURES NEAR FEROZAI VILLAGE
COORDINATES: N 3750992.40 m, E 346783.10 m
ANGLE (with vertical): 0 BEARING: ___

GROUND ELEVATION: 1387.26 m
ROCK ELEVATION: 1377.26 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + GEMNITSAND
PEIZOMETER: -

DATE START: 19-5-2025 COMPLETE: 27-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-13
SHEET 02 OF 03

Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	LITHOLOGY General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	WPT: Pressure psi	WPT: LU Value	Point Load (Axial/Diametral)	REMARKS
10.0											TOP OF BEDROCK															
11.0	1	77	28								SILTSTONE: Reddish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak to medium strong.	MS-1 10.40-10.60m													
12.0	2	72	18									WS-2 11.40-11.60 m														
13.0	3	75	NIL							M.St																
14.0	4	73	31									MS-3 13.24-13.40m														
15.0	5	70	14									MS-4 14.0-14.14m														
16.0	6	68	NIL								SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fragmented, extremely weak.															
17.0	7	78	NIL																							
18.0	8	80	NIL							SH																
19.0	9	84	NIL																							
20.0	10	90	NIL																							

Core Barrel / Bit: 100 % DOUBLE TUBE TUNGSTEN CARBIDE & DIAMOND bit
Hole Stabilization: STABLE

Key for Description of Discontinuities

Type: J Joint; M Major Joint; F Fault; B Bedding; R Fracture; S Shistocity; O Foliation

Aperture: 1 Very Tight < 0.10 mm; 2 Tight 0.10-0.25 mm; 3 Partly Open; 4 Open

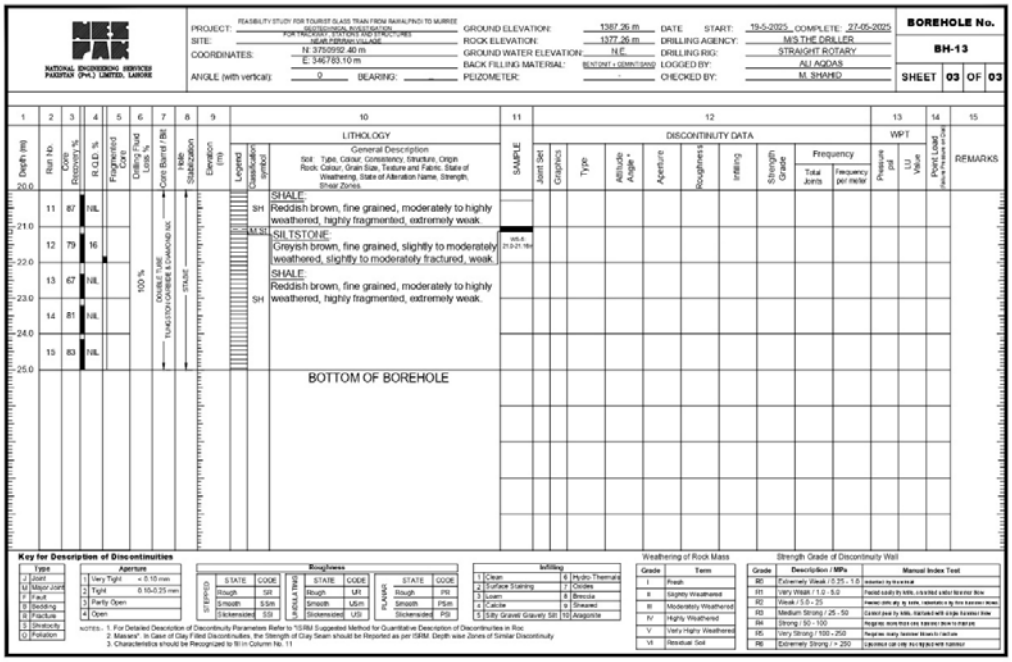
Roughness: STEPPED — Rough St, Smooth SSm, Slickensided SSl; UNDULATING — Rough Ur, Smooth USm, Slickensided USl; PLANAR — Rough Pr, Smooth PSm, Slickensided PSl

Infilling: 1 Clean; 2 Surface Staining; 3 Loam; 4 Calcite; 5 Silty Gravel Gravelly Silt; 6 Hydro Thermals; 7 Oxides; 8 Breccia; 9 Sheared; 10 Aragonite

Weathering of Rock Mass: I Fresh; II Slightly Weathered; III Moderately Weathered; IV Highly Weathered; V Very Highly Weathered; VI Residual Soil

Strength Grade of Discontinuity Wall: R0 Extremely Weak / 0.25 - 1.0; R1 Very Weak / 1.0 - 5.0; R2 Weak / 5.0 - 25; R3 Medium Strong / 25 - 50; R4 Strong / 50 - 100; R5 Very Strong / 100 - 250; R6 Extremely Strong / > 250

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses". In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATORS AND STRUCTURES NEAR FEROZAI VILLAGE
COORDINATES: N 3750992.40 m, E 346783.10 m
ANGLE (with vertical): 0 BEARING: ___

GROUND ELEVATION: 1387.26 m
ROCK ELEVATION: 1377.26 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + GEMNITSAND
PEIZOMETER: -

DATE START: 19-5-2025 COMPLETE: 27-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-13
SHEET 03 OF 03

Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	LITHOLOGY General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle *	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	WPT: Pressure psi	WPT: LU Value	Point Load (Axial/Diametral)	REMARKS
20.0																										
21.0	11	87	NIL							SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fragmented, extremely weak.															
22.0	12	79	16							M.St	SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, slightly to moderately fractured, weak.	MS-5 21.0-21.18m														
23.0	13	67	NIL							SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fragmented, extremely weak.															
24.0	14	81	NIL																							
25.0	15	83	NIL								BOTTOM OF BOREHOLE															

Core Barrel / Bit: 100 % DOUBLE TUBE TUNGSTEN CARBIDE & DIAMOND bit
Hole Stabilization: STABLE

Key for Description of Discontinuities

Type: J Joint; M Major Joint; F Fault; B Bedding; R Fracture; S Shistocity; O Foliation

Aperture: 1 Very Tight < 0.10 mm; 2 Tight 0.10-0.25 mm; 3 Partly Open; 4 Open

Roughness: STEPPED — Rough St, Smooth SSm, Slickensided SSl; UNDULATING — Rough Ur, Smooth USm, Slickensided USl; PLANAR — Rough Pr, Smooth PSm, Slickensided PSl

Infilling: 1 Clean; 2 Surface Staining; 3 Loam; 4 Calcite; 5 Silty Gravel Gravelly Silt; 6 Hydro Thermals; 7 Oxides; 8 Breccia; 9 Sheared; 10 Aragonite

Weathering of Rock Mass: I Fresh; II Slightly Weathered; III Moderately Weathered; IV Highly Weathered; V Very Highly Weathered; VI Residual Soil

Strength Grade of Discontinuity Wall: R0 Extremely Weak / 0.25 - 1.0; R1 Very Weak / 1.0 - 5.0; R2 Weak / 5.0 - 25; R3 Medium Strong / 25 - 50; R4 Strong / 50 - 100; R5 Very Strong / 100 - 250; R6 Extremely Strong / > 250

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses". In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	13	BOX No	1-3	NESPAK
LOCATION	Near Perrah Village	DEPTH (m)	10.0-25.00m	



Depth (m)

10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-14
SHEET 1 OF 3

BOREHOLE LOG

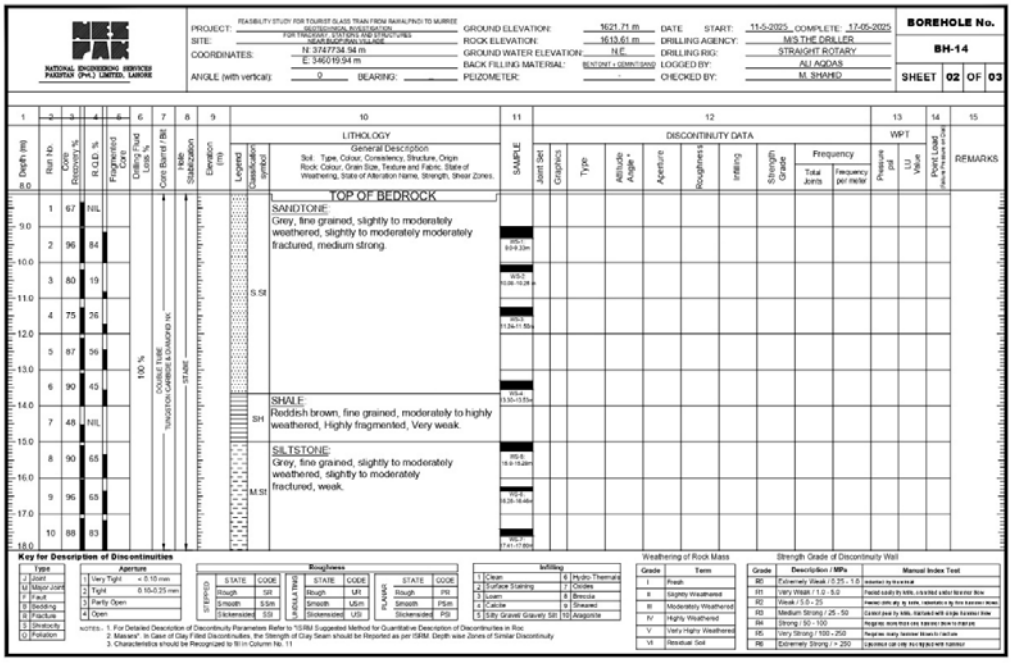
Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BUDPIRAN VILLAGE

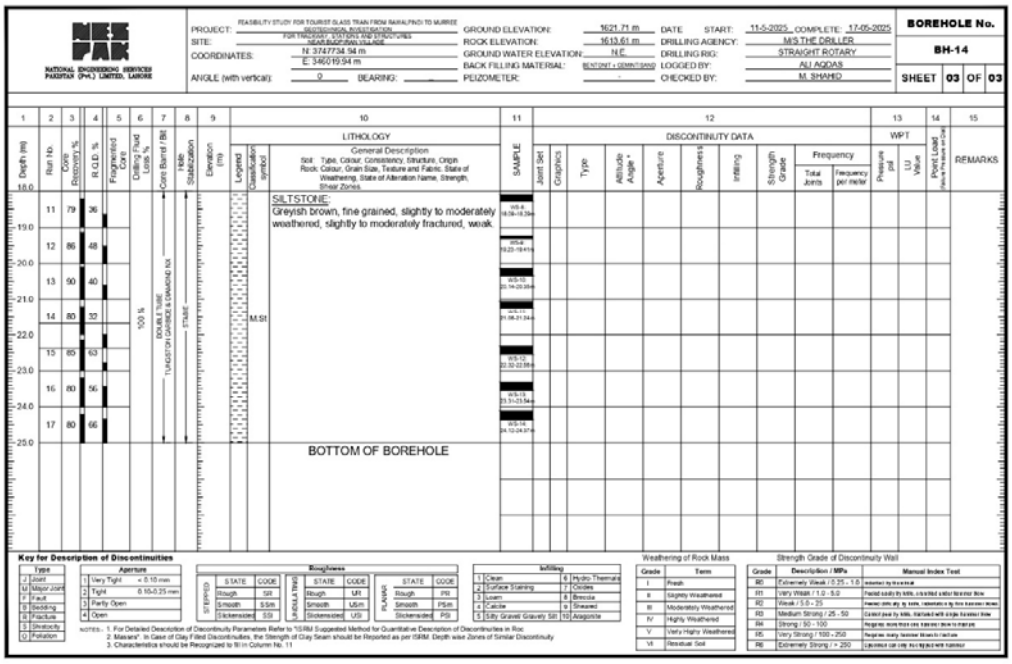
Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3747734.94 m E: 346019.94 m Ground Elevation 1621.71 m Date 11-5-2025 To 17-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0				Reddish brown, SILT with concretion, low plastic, medium dry strength, moist.	75 mm		
1.0	SPT-1		ML			38	
2.0	SPT-2						REFUSAL
				Reddish brown, very dense, SILTY SAND, trace mica, moist. (COBBLE FROM 2.0 -2.30 m)			
3.0	SPT-3		SM			30	
4.0	SPT-4						REFUSAL
				Reddish brown, hard, SILT with SAND, low plastic, medium dry strength, trace concretion, moist. (COBBLE FROM 4.0-4.40 m and from 7.0-7.70 m)			
5.0	SPT-5					60	
6.0	SPT-6		ML			75	
7.0							
8.0	SPT-7						REFUSAL
				TOP OF BEDROCK ENCOUNTERED AT 8.10 M DEPTH			


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TUNNELS, STATIONS AND STRUCTURES NEAR BHOOTWAL VILLAGE
COORDINATES: N: 3747734.94 m E: 3460119.94 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1621.71 m
ROCK ELEVATION: 1613.61 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + GEMNITSAND
PEIZOMETER: -
DATE START: 11-5-2025 COMPLETE: 17-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-14
SHEET 02 OF 03
TOP OF BEDROCK
SANDTONE: Grey, fine grained, slightly to moderately weathered, slightly to moderately moderately fractured, medium strong.
SHALE: Reddish brown, fine grained, moderately to highly weathered, Highly fragmented, Very weak.
SILTSTONE: Grey, fine grained, slightly to moderately weathered, slightly to moderately fractured, weak.
100 %
DOUBLE TUBE
TUNGSTON CARBIDE & DIAMOND bit
STAINLESS
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TUNNELS, STATIONS AND STRUCTURES NEAR BHOOTWAL VILLAGE
COORDINATES: N: 3747734.94 m E: 3460119.94 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1621.71 m
ROCK ELEVATION: 1613.61 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + GEMNITSAND
PEIZOMETER: -
DATE START: 11-5-2025 COMPLETE: 17-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-14
SHEET 03 OF 03
SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, slightly to moderately fractured, weak.
BOTTOM OF BOREHOLE
100 %
DOUBLE TUBE
TUNGSTON CARBIDE & DIAMOND bit
STAINLESS
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	14	BOX No	1-4	NESPAK
LOCATION	Near Budpiran Village	DEPTH (m)	8.0-25.00m	



Depth (m)

8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-15
SHEET 1 OF 3

BOREHOLE LOG

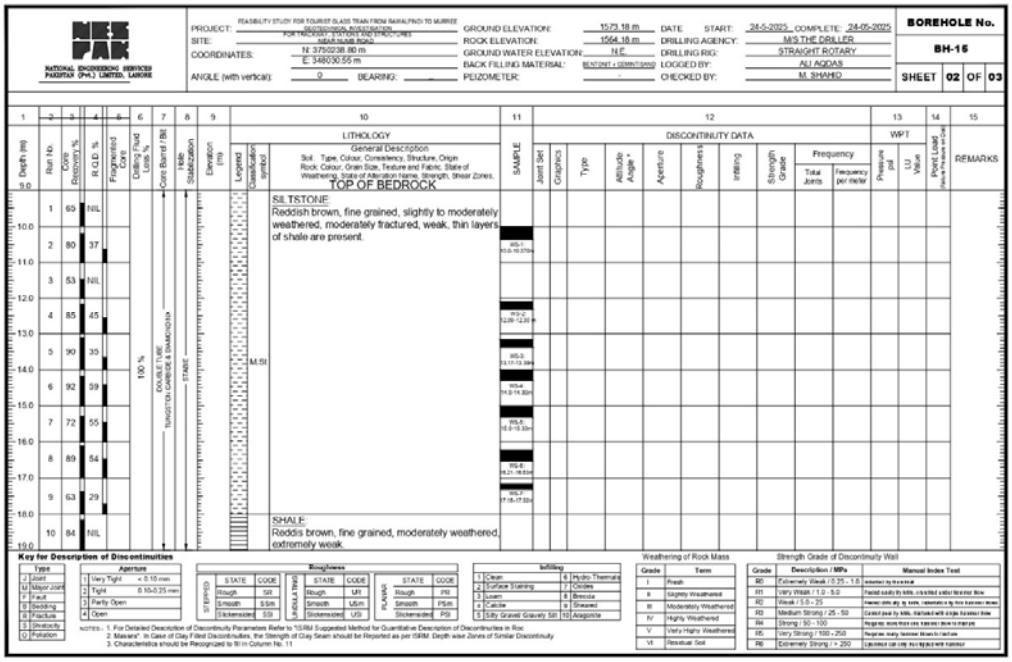
Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR NUMB ROAD

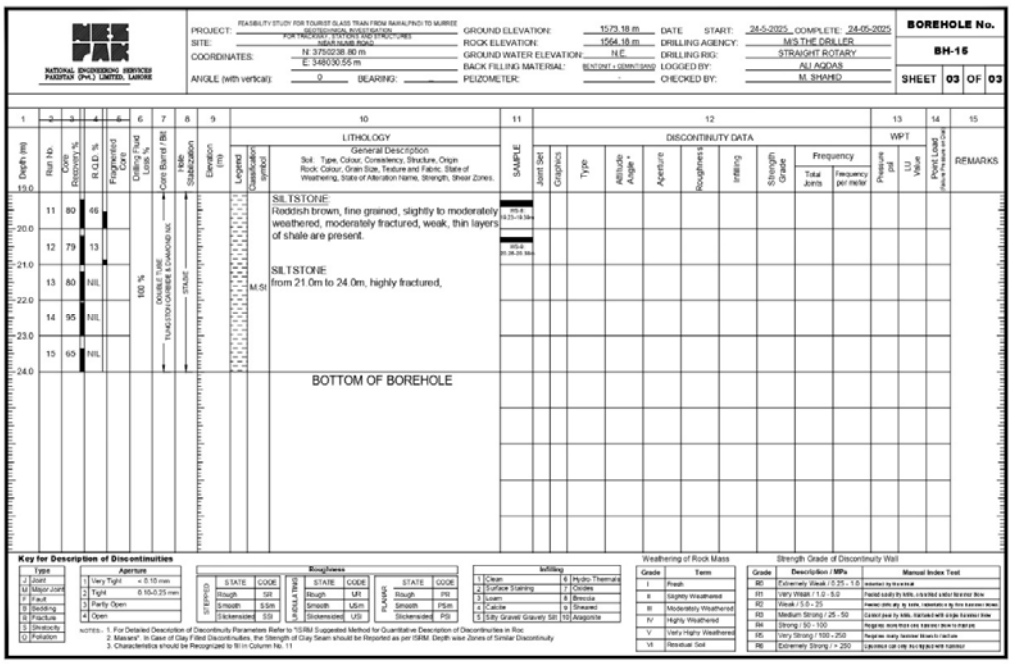
Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3750238.80 m E: 348030.55 m Ground Elevation 1573.18 m Date 24-5-2025 To 24-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0							
	SPT-1		ML	Reddish brown, medium dense, SANDY SILT, trace to little clay, trace fine gravels, moist.		18	
1.0							
	SPT-2					10	
2.0			CL-ML	Dark brown, stiff to hard, SILTY CLAY, low plastic, medium dry strength, trace fine gravels, moist.			
	SPT-3					71	
3.0							
	DS-1		GC-GM	Dark brown, very dense, SILTY CLAYEY GRAVEL, gravels are rounded to sub angular size 5-70mm, moist.			
	SPT-4					REFUSAL	
4.0							
			CL-ML	Dark brown, hard, SILTY CLAY, low plastic, medium dry strength, trace fine gravels, moist			
	SPT-5					69	
5.0							
	DS-2		GC-GM	Brownish grey, very dense, SILTY CLAYEY GRAVEL, angular to sub-angular, size from 5-40 mm, moist.			
	SPT-6(c)					REFUSAL	
6.0	DS-3						
	SPT-7(c)					REFUSAL	
7.0	DS-4						
	SPT-8(c)					REFUSAL	
8.0	DS-5		GM	Grey, very dense, SILTY GRAVEL, angular to sub-angular, size from 5-80mm, moist			
9.0				TOP OF BEDROCK ENCOUNTERED AT 9.0 M DEPTH			


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NJAMB RIDGE
COORDINATES: N: 3750238.80 m E: 348030.55 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1573.18 m
ROCK ELEVATION: 1564.18 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINTSAND
PEIZOMETER: -
DATE START: 24-5-2025 COMPLETE: 24-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-15
SHEET 02 OF 03
LITHOLOGY
General Description
Soil: Type, Colour, Consistency, Structure, Origin
Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.
TOP OF BEDROCK
SILTSTONE:
Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, weak, thin layers of shale are present.
M-St
SHALE:
Reddis brown, fine grained, moderately weathered, extremely weak.
100 %
DOUBLE TUBE
TUNGSTEN CARBIDE & DIAMOND BIT
STABLE
DISCONTINUITY DATA
WPT
REMARKS
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR NJAMB RIDGE
COORDINATES: N: 3750238.80 m E: 348030.55 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1573.18 m
ROCK ELEVATION: 1564.18 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINTSAND
PEIZOMETER: -
DATE START: 24-5-2025 COMPLETE: 24-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-15
SHEET 03 OF 03
LITHOLOGY
General Description
Soil: Type, Colour, Consistency, Structure, Origin
Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.
SILTSTONE:
Reddish brown, fine grained, slightly to moderately weathered, moderately fractured, weak, thin layers of shale are present.
SILTSTONE
from 21.0m to 24.0m, highly fractured,
M-St
BOTTOM OF BOREHOLE
100 %
DOUBLE TUBE
TUNGSTEN CARBIDE & DIAMOND BIT
STABLE
DISCONTINUITY DATA
WPT
REMARKS
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	15	BOX No	1-4	NESPAK
LOCATION	Near Numb Road	DEPTH (m)	9.0-24.00m	



Depth (m)

9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-16
SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BRURI

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3750808.30 m E: 348454.74 m Ground Elevation 1746.49 m Date 06-5-2025 To 20-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
0.0							
	SPT-1(c)			Reddish brown, very dense, Cobbles and Boulders of SILTSTONE, angular to sub-angular, trace fine gravels.	75 mm		
1.0						REFUSAL	
	SPT-2(c)						
2.0	DS-1					REFUSAL	
				Reddish brown, hard, SILTY CLAY, low plastic, medium dry strength, trace to little fine gravels, trace clay, moist.			
	SPT-3						
3.0	DS-2		CL-ML			REFUSAL	
	SPT-4						
4.0	DS-3			Reddish brown, very dense, Gravels and Cobbles, angular to sub angular.		REFUSAL	
	SPT-5(c)						
5.0	DS-4			Reddish brown, hard, SILT with SAND, low plasticity, medium dry strength, trace to little fine gravels, moist.			
			ML				
6.0	SPT-6					REFUSAL	
	DS-5			Reddish brown, very dense, SILTY CLAYEY GRAVELS, angular to sub-angular, trace concretion, moist.			
			GC-GM				
7.0	SPT-7(c)					REFUSAL	
	DS-6			Grey, very dense, Poorly graded GRAVELS with SAND, angular to sub-angular.			
	SPT-8(c)					REFUSAL	
8.0	DS-7						
			GP				
	SPT-9(c)					REFUSAL	
9.0	DS-8						
10.0						REFUSAL	

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-16
SHEET 2 OF 4

BOREHOLE LOG

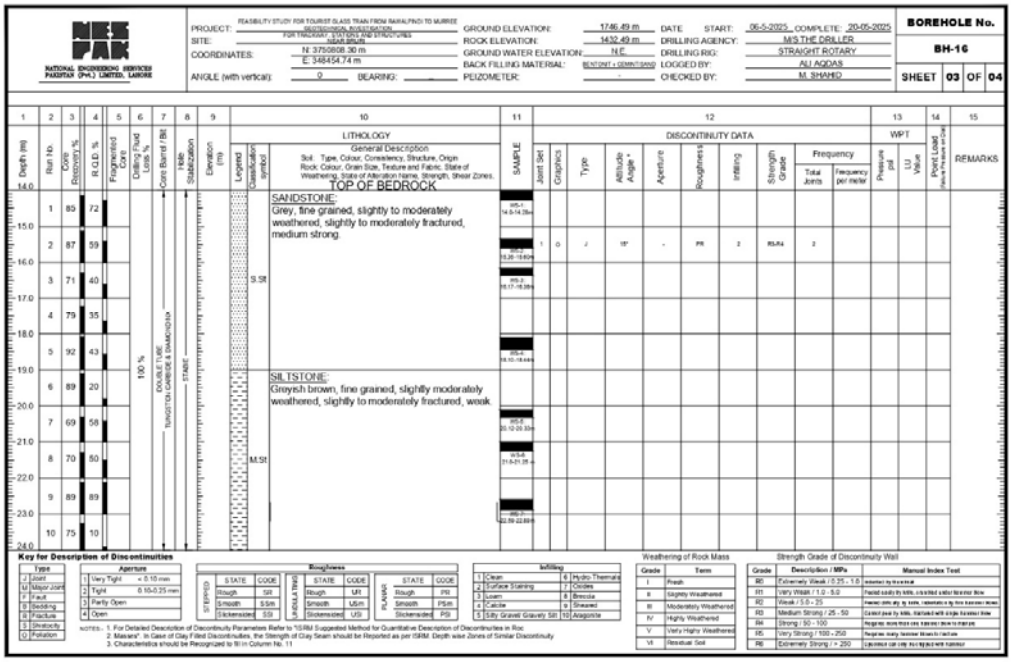
Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BRURI

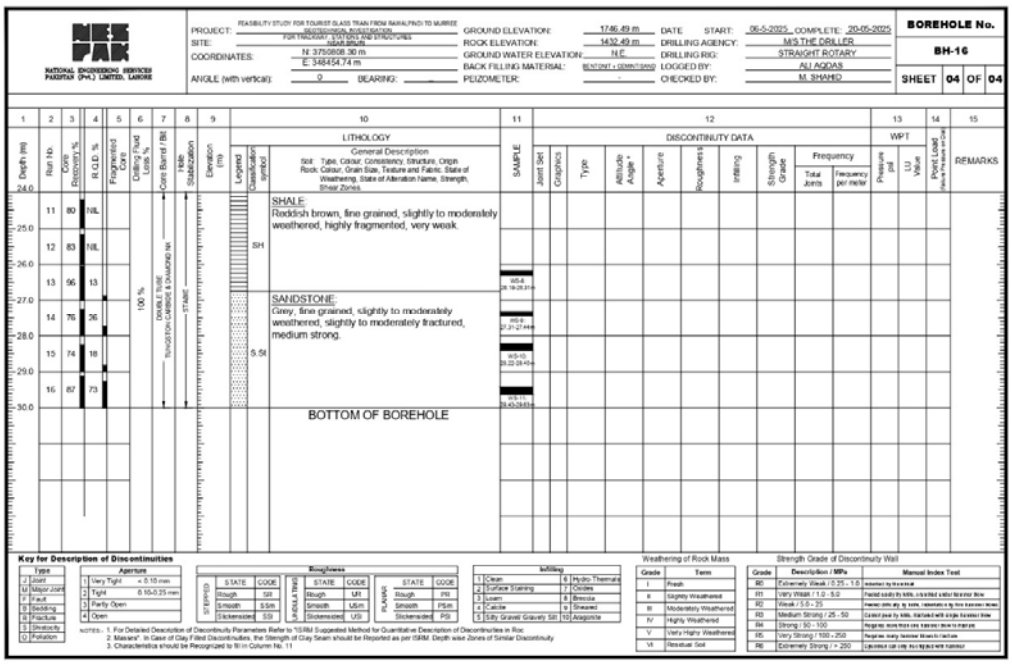
Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3750808.30 m E: 348454.74 m Ground Elevation 1746.49 m Date 06-5-2025 To 20-05-2025
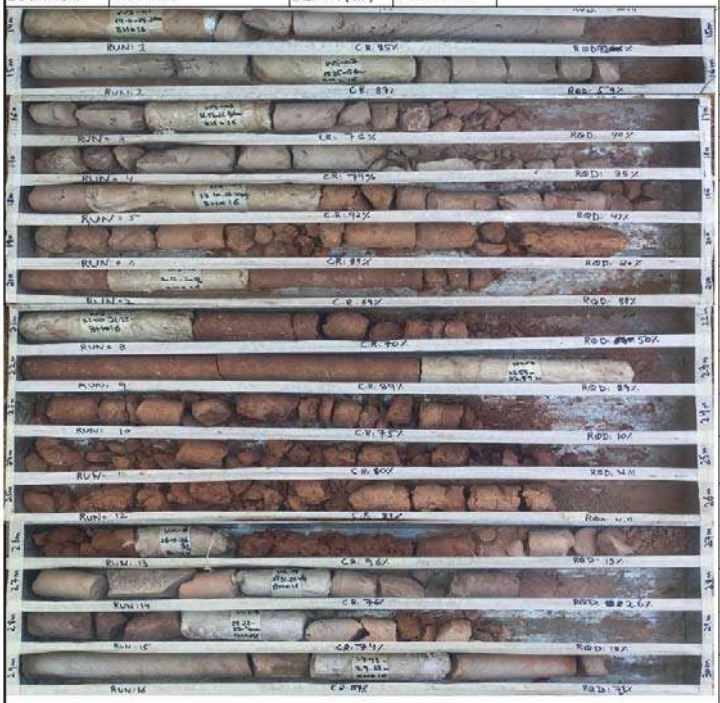
Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○)	Remarks
10.0				Grey, very dense, SILTY GRAVELS with SAND, SANDSTONE, angular to sub-angular, (AT PLACES COBBLES AND BOULDER)	75 mm	REFUSAL	
11.0	SPT-10(c) DS-09		GM			REFUSAL	
12.0	SPT-11(c) DS-10					REFUSAL	
13.0	DS-11					REFUSAL	
14.0	SPT-12(c)			TOP OF BEDROCK ENCOUNTERED AT 14.0 M DEPTH		REFUSAL	
15.0							
16.0							
17.0							
18.0							
19.0							
20.0							


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATION AND STRUCTURES NEAR BHURBAN
COORDINATES: N 375808.30 m, E 348454.74 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1746.49 m
ROCK ELEVATION: 1432.49 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + GEMNITSAND
PEIZOMETER: -
DATE START: 06-5-2025 COMPLETE: 20-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-16
SHEET 03 OF 04
TOP OF BEDROCK
SANDSTONE: Grey, fine grained, slightly to moderately weathered, slightly to moderately fractured, medium strong.
SILTSTONE: Greyish brown, fine grained, slightly moderately weathered, slightly to moderately fractured, weak.
100 %
DOUBLE TUBE
TUNGSTEN CARBIDE & DIAMOND BIT
STABLE
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATION AND STRUCTURES NEAR BHURBAN
COORDINATES: N 375808.30 m, E 348454.74 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1746.49 m
ROCK ELEVATION: 1432.49 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + GEMNITSAND
PEIZOMETER: -
DATE START: 06-5-2025 COMPLETE: 20-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-16
SHEET 04 OF 04
SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fragmented, very weak.
SANDSTONE: Grey, fine grained, slightly to moderately weathered, slightly to moderately fractured, medium strong.
BOTTOM OF BOREHOLE
100 %
DOUBLE TUBE
TUNGSTEN CARBIDE & DIAMOND BIT
STABLE
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	16	BOX No	1-4	NESPAK
LOCATION	Near Bruri	DEPTH (m)	14.0-30.00m	



Depth (m)

14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00
28.00
29.00
30.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-17
SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BANSRA GALI CHAIR LIFT

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

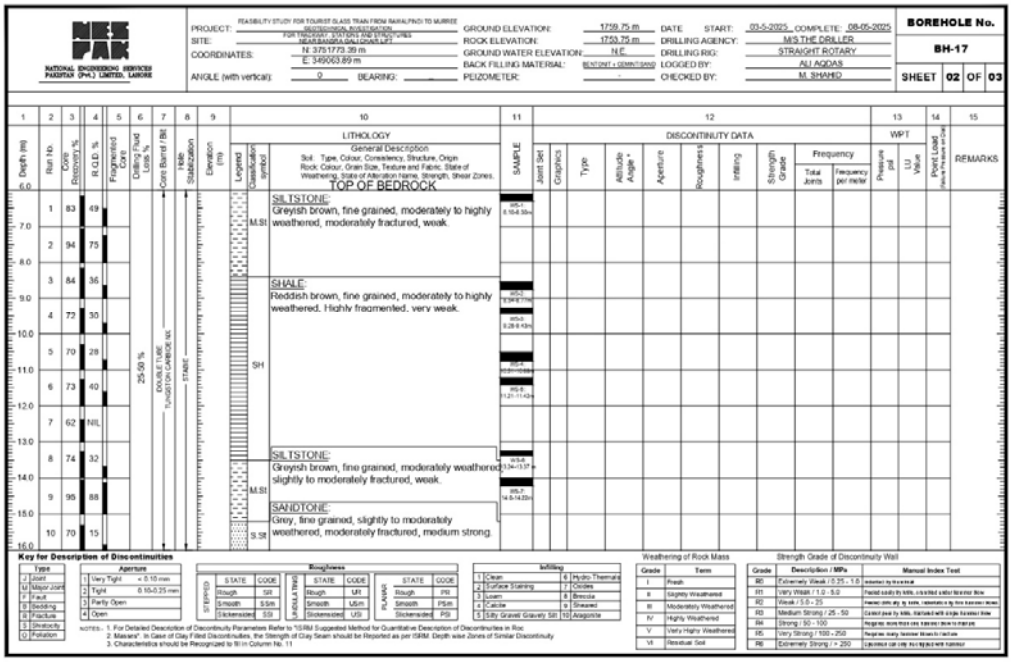
Coordinates N: 3751773.39 m E: 349063.89 m Ground Elevation 1759.75 m Date 03-5-2025 To 08-05-2025

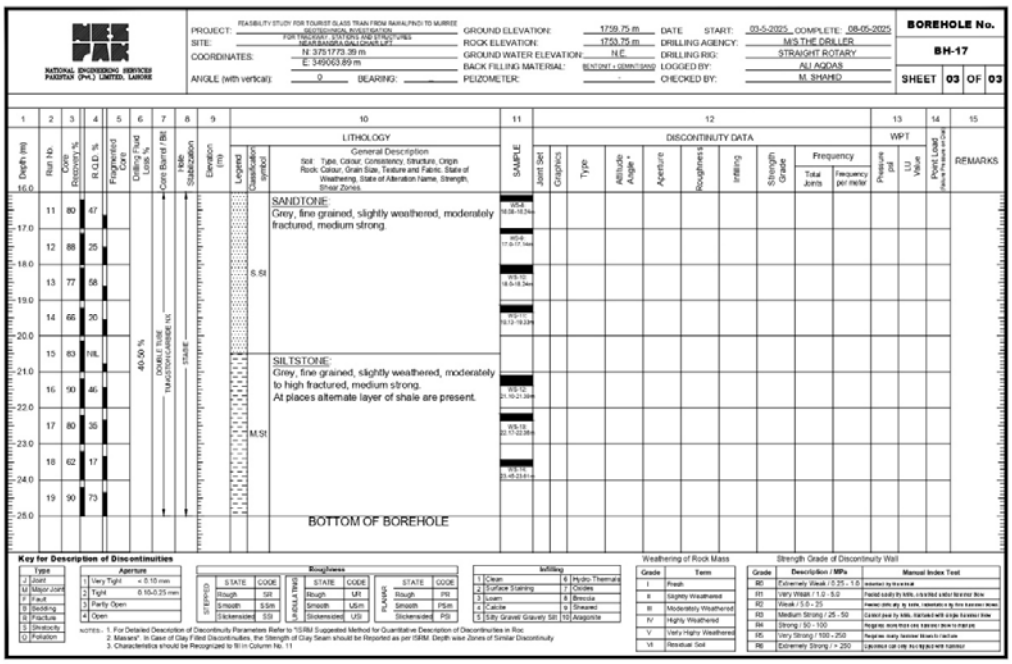
Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	Remarks
0.0						
1.0	SPT-1		ML	Radish brown, very stiff to hard, SILT, medium dry strength, low plastic, strength, moist.	75 mm	
2.0	SPT-2					
3.0	SPT-3		CL	Dark brown, hard, LEAN CLAY, low to medium plastic, medium dry strength, trace to little concretion, moist.		
4.0	SPT-4(c)		GC-GM	Grey, very dense, SILTY CLAYEY GRAVELS, angular to sub angular, moist.		REFUSAL
5.0				Grey, very dense, COBBLES and BOULDER of SANDSTONE origin, angular to sub angular.		
6.0				TOP OF BEDROCK ENCOUNTERED AT 6.0 M DEPTH		
7.0						
8.0						

P.L. ▽ N.M.C. x L.L. ○

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

SPT-1: 24
SPT-2: 65
SPT-3: 69


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TUNNELS, STATIONS AND STRUCTURES NEAR BANSRA GALI (DAWN LIFT)
COORDINATES: N 3751773.39 m, E 349063.89 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1759.75 m
ROCK ELEVATION: 1753.75 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINTSAND
PEIZOMETER: -
DATE START: 03-5-2025 COMPLETE: 08-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-17
SHEET 02 OF 03
TOP OF BEDROCK
SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately fractured, weak.
SHALE: Reddish brown, fine grained, moderately to highly weathered. Highly fracmented. very weak.
SILTSTONE: Greyish brown, fine grained, moderately weathered slightly to moderately fractured, weak.
SANDTONE: Grey, fine grained, slightly to moderately weathered, moderately fractured, medium strong.
25-50 %
DOUBLE TUBE
TUNGSTEN CARBIDE bit.
STABLE
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses". In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TUNNELS, STATIONS AND STRUCTURES NEAR BANSRA GALI (DAWN LIFT)
COORDINATES: N 3751773.39 m, E 349063.89 m
ANGLE (with vertical): 0 BEARING:
GROUND ELEVATION: 1759.75 m
ROCK ELEVATION: 1753.75 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINTSAND
PEIZOMETER: -
DATE START: 03-5-2025 COMPLETE: 08-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-17
SHEET 03 OF 03
SANDTONE: Grey, fine grained, slightly weathered, moderately fractured, medium strong.
SILTSTONE: Grey, fine grained, slightly weathered, moderately to high fractured, medium strong. At places alternate layer of shale are present.
BOTTOM OF BOREHOLE
40-50 %
DOUBLE TUBE
TUNGSTEN CARBIDE bit.
STABLE
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall
NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses". In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	17	BOX No	1-4	NESPAK
LOCATION	Near Bansra Gali Chair lift	DEPTH (m)	6.0-25.00m	



Depth (m)
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-18
SHEET 1 OF 3

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR BANSRA GAL

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

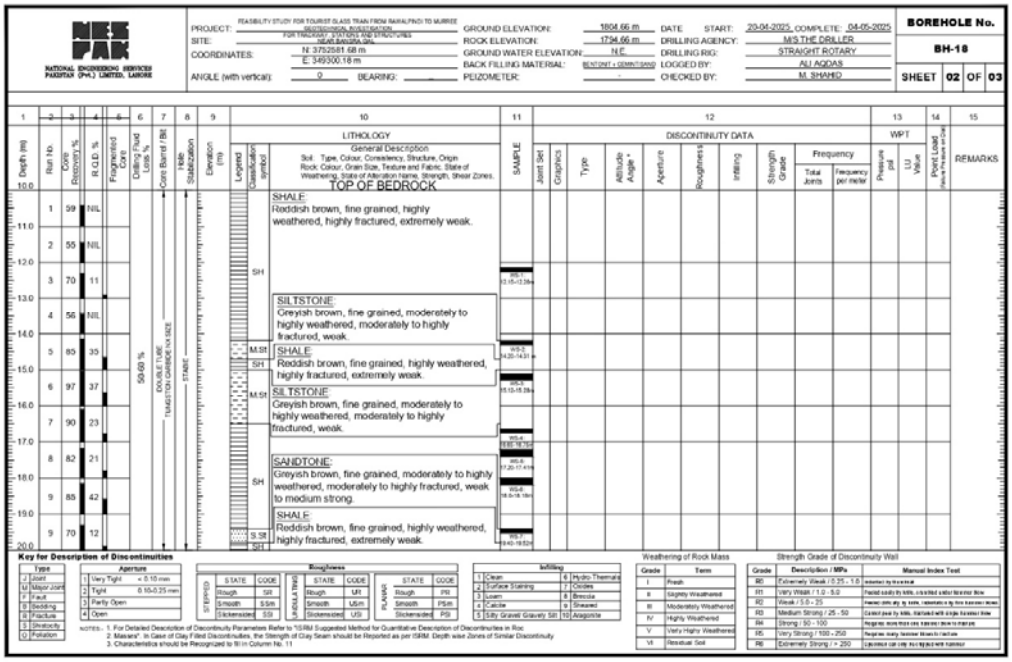
Coordinates N: 3752581.68 m E: 349300.18 m Ground Elevation 1804.66 m Date 20-04-2025 To 04-05-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	SPT Blows/30cm	Remarks
0.0				Fill material of road	75 mm		
1.0	DS-1		GP-GM	Dark brown, very dense, Poorly graded GRAVEL with SILT, moist.			
2.0	SPT-1						REFUSAL
3.0	SPT-2		CL	Dark brown, stiff to hard, GRAVELLY LEAN CLAY with SAND, low plastic, medium dry strength, moist.		9	
4.0	SPT-3					24	
5.0	SPT-4					33	
6.0	SPT-5					24	
7.0	SPT-6			Dark brown, hard, LEAN CLAY with SAND, low plastic, medium dry strength, moist.		66	
8.0	SPT-7					32	
9.0	SPT-8						REFUSAL
10.0	SPT-9						REFUSAL

P.L. ▽ N.M.C. x L.L. ○

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

TOP OF BEDROCK ENCOUNTERED AT
10.0 M DEPTH



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BANJARA GALI
COORDINATES: N 3752581.68 m, E 349300.18 m
ANGLE (with vertical): 0 BEARING: —

GROUND ELEVATION: 1804.66 m
ROCK ELEVATION: 1794.66 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINTSAND
PEIZOMETER: -

DATE START: 20-04-2025 COMPLETE: 04-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-18
SHEET 02 OF 03

Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	LITHOLOGY General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	WPT: Pressure psi	WPT: LU Value	Point Load: Point Load Strength Index	REMARKS
10.0											TOP OF BEDROCK															
10.0–11.0	1	59	NIL							SH	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.															
11.0–12.0	2	55	NIL																							
12.0–13.0	3	70	11									WS-7 13.15-13.39m														
13.0–14.0	4	56	NIL								SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.														
14.0–15.0	5	85	35		50-60 %	DOUBLE TUBE TUNGSTEN CARBIDE NX SIZE	STABLE			M.St	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.	WS-8 14.20-14.31 m														
15.0–16.0	6	97	37							SH		WS-9 15.10-15.39 m														
16.0–17.0	7	90	23							M.St	SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak.															
17.0–18.0	8	82	21									WS-6 16.80-16.75 m														
18.0–19.0	9	85	42							SH	SANDTONE: Greyish brown, fine grained, moderately to highly weathered, moderately to highly fractured, weak to medium strong.	WS-6 17.20-17.41 m														
19.0–20.0	9	70	12									WS-6 18.9-19.19m														
										S.St	SHALE: Reddish brown, fine grained, highly weathered, highly fractured, extremely weak.															
										SH		WS-7 19.40-19.52 m														

Key for Description of Discontinuities

Type: J Joint; M Major Joint; F Fault; B Bedding; R Fracture; S Shistocity; O Foliation

Aperture: 1 Very Tight < 0.10 mm; 2 Tight 0.10-0.25 mm; 3 Partly Open; 4 Open

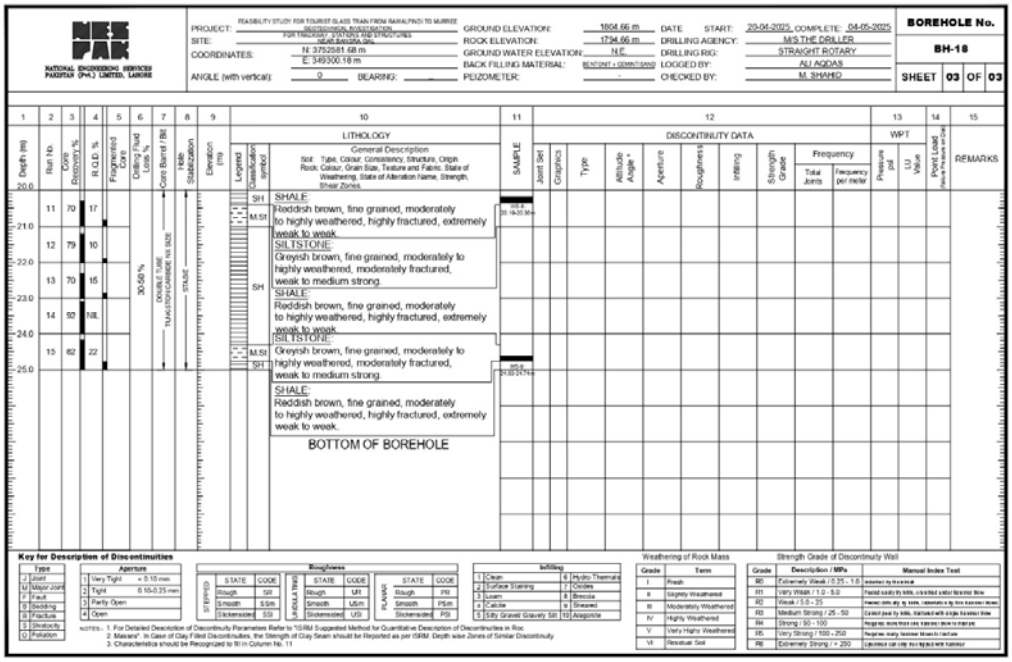
Roughness — STEPPED: Rough STR, Smooth SSm, Slickensided SSI; UNDULATING: Rough URI, Smooth USm, Slickensided USI; PLANAR: Rough PRI, Smooth PSm, Slickensided PSI

Infilling: 1 Clean; 2 Surface Staining; 3 Loam; 4 Calcite; 5 Silty Gravel Gravely Silt; 6 Hydro Thermals; 7 Oxides; 8 Breccia; 9 Sheared; 10 Aragonite

Weathering of Rock Mass: I Fresh; II Slightly Weathered; III Moderately Weathered; IV Highly Weathered; V Very Highly Weathered; VI Residual Soil

Strength Grade of Discontinuity Wall: R0 Extremely Weak / 0.25 - 1.0; R1 Very Weak / 1.0 - 5.0; R2 Weak / 5.0 - 25; R3 Medium Strong / 25 - 50; R4 Strong / 50 - 100; R5 Very Strong / 100 - 250; R6 Extremely Strong / > 250

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses". In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11



NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR BANJARA GALI
COORDINATES: N 3752581.68 m, E 349300.18 m
ANGLE (with vertical): 0 BEARING: —

GROUND ELEVATION: 1804.66 m
ROCK ELEVATION: 1794.66 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINTSAND
PEIZOMETER: -

DATE START: 20-04-2025 COMPLETE: 04-05-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID

BOREHOLE No. BH-18
SHEET 03 OF 03

Depth (m)	Run No.	Core Recovery %	R.Q.D. %	Fragmented Core	Drilling Fluid Loss %	Core Barrel / Bit	Hole Stabilization	Elevation (m)	Legend	Classification symbol	LITHOLOGY General Description: Soil: Type, Colour, Consistency, Structure, Origin. Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.	SAMPLE	Joint Set	Graphics	Type	Altitude Angle °	Aperture	Roughness	Infilling	Strength Grade	Frequency: Total Joints	Frequency: Frequency per meter	WPT: Pressure psi	WPT: LU Value	Point Load: Point Load Strength Index	REMARKS
20.0										SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fractured, extremely weak to weak.															
20.0–21.0	11	70	17							M.St		WS-6 20.18-20.36 m														
21.0–22.0	12	79	10								SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately fractured, weak to medium strong.															
22.0–23.0	13	70	15		30-50 %	DOUBLE TUBE TUNGSTEN CARBIDE NX SIZE	STABLE			SH	SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fractured, extremely weak to weak.															
23.0–24.0	14	92	NIL																							
24.0–25.0	15	82	22							M.St	SILTSTONE: Greyish brown, fine grained, moderately to highly weathered, moderately fractured, weak to medium strong.															
										SH		WS-6 24.82-24.74 m														
											SHALE: Reddish brown, fine grained, moderately to highly weathered, highly fractured, extremely weak to weak.															
											BOTTOM OF BOREHOLE															

Key for Description of Discontinuities

Type: J Joint; M Major Joint; F Fault; B Bedding; R Fracture; S Shistocity; O Foliation

Aperture: 1 Very Tight < 0.10 mm; 2 Tight 0.10-0.25 mm; 3 Partly Open; 4 Open

Roughness — STEPPED: Rough STR, Smooth SSm, Slickensided SSI; UNDULATING: Rough URI, Smooth USm, Slickensided USI; PLANAR: Rough PRI, Smooth PSm, Slickensided PSI

Infilling: 1 Clean; 2 Surface Staining; 3 Loam; 4 Calcite; 5 Silty Gravel Gravely Silt; 6 Hydro Thermals; 7 Oxides; 8 Breccia; 9 Sheared; 10 Aragonite

Weathering of Rock Mass: I Fresh; II Slightly Weathered; III Moderately Weathered; IV Highly Weathered; V Very Highly Weathered; VI Residual Soil

Strength Grade of Discontinuity Wall: R0 Extremely Weak / 0.25 - 1.0; R1 Very Weak / 1.0 - 5.0; R2 Weak / 5.0 - 25; R3 Medium Strong / 25 - 50; R4 Strong / 50 - 100; R5 Very Strong / 100 - 250; R6 Extremely Strong / > 250

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to "ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses". In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	18	BOX No	1-3	NESPAK
LOCATION	Near Bansra Gali	DEPTH (m)	10.0-25.00m	



Depth (m)
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-19
SHEET 1 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR CHITTA MOR

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

Coordinates N: 3753036.37 m E: 350338.41 m Ground Elevation 1859.60 m Date 17-04-2025 To 30-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
0.0	DS-1		GC	Dark brown, loose to dense, CLAYEY GRAVEL with SAND, moist.			
1.0	SPT-1					8	
2.0	SPT-2					19	
3.0	SPT-3					21	
	DS-2						
4.0	SPT-4					40	
5.0	SPT-5(c)						REFUSAL
				Grey, very dense, COBBLES AND BOULDER of sand stone origin.			
6.0							
7.0							
	DS-3						
			CL	Dark brown, very stiff to hard, GEAVELLY LEAN CLAY with SAND, low plastic, medium dry strength, moist.			
8.0	SPT-6(c)					30	
9.0	SPT-7					17	
10.0	SPT-8					25	

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-19
SHEET 2 OF 4

BOREHOLE LOG

Job No. SA-593 Project FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES Location NEAR CHITTA MOR

Site Incharge ALI AQDAS Client PUNJAB MASS TRANSIT AUTHORITY (PMA) Contractor M/S THE DRILLER

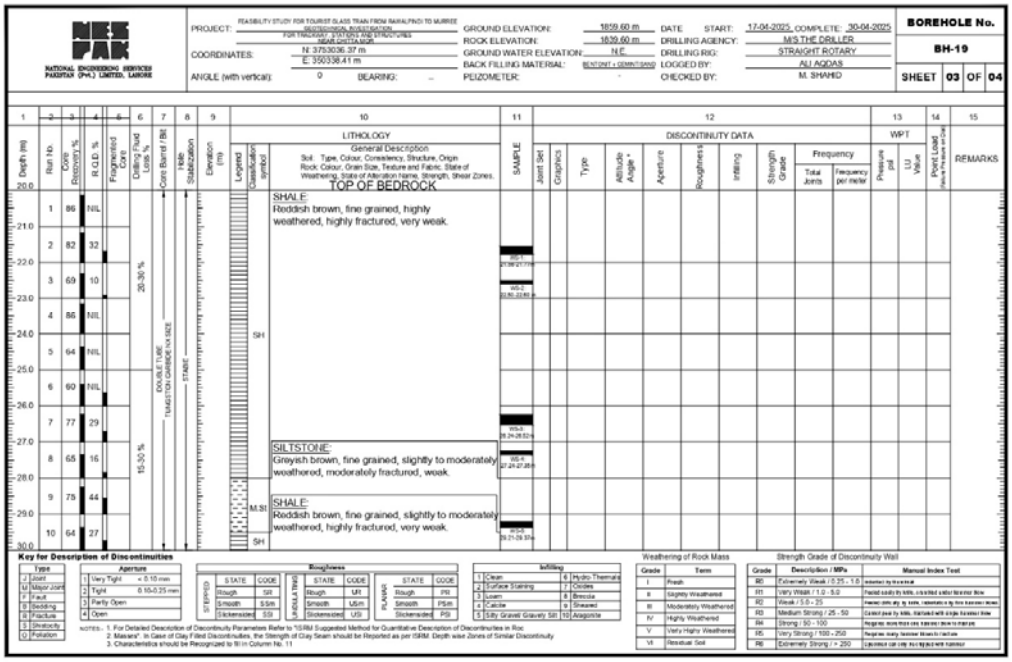
Type of boring STRAIGHT ROTARY Drilling Fluid PLAIN WATER Ground Water Depth NOT ENCOUNTERED

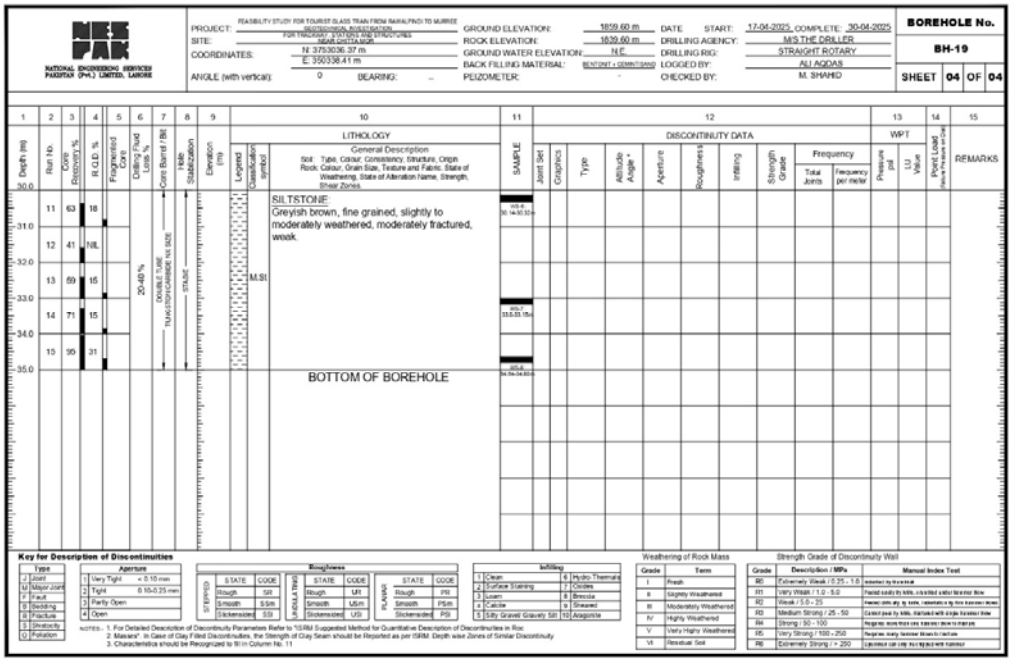
Coordinates N: 3753036.37 m E: 350338.41 m Ground Elevation 1859.60 m Date 17-04-2025 To 30-04-2025

Depth (m)	Sample No.	Legend	USCS Symbol	Description of Material	Dia of Casing/ Hole	P.L. ▽ N.M.C. x L.L. ○ SPT Blows/30cm	Remarks
10.0	SPT-8		CL	Dark brown, very stiff to hard, GEAVELLY LEAN CLAY with SAND, low plastic, medium dry strength, moist.		25	
11.0	SPT-9					20	
12.0	SPT-10					26	
13.0	SPT-11						REFUSAL
	DS-4						
14.0	SPT-12(c)		GC-GM	Brownish grey, very dense, SILTY CLAYEY GRAVELS, angular to sub-angular, ranging in size 25mm to 76mm, moist.			REFUSAL
	DS-5						
15.0	SPT-13(c)						REFUSAL
	DS-6						
16.0	SPT-14(c)						REFUSAL
	DS-7						
17.0	SPT-15(c)						
	DS-8						REFUSAL
18.0							
19.0	SPT-16(c)						REFUSAL
20.0							

SPT Blows/30cm: 10 20 30 40 50 60 70 80 90 100

TOP OF BEDROCK ENCOUNTERED AT
20.0 M DEPTH


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR GHATTA MOR
COORDINATES: N 3753036.37 m, E 350336.41 m
ANGLE (with vertical): 0 BEARING: ..
GROUND ELEVATION: 1859.60 m
ROCK ELEVATION: 1839.60 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINTSAND
PEIZOMETER: -
DATE START: 17-04-2025 COMPLETE: 30-04-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-19
SHEET 03 OF 04
LITHOLOGY
General Description
Soil: Type, Colour, Consistency, Structure, Origin
Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.
DISCONTINUITY DATA
WPT
TOP OF BEDROCK
SHALE: Reddish brown, fine grained, highly weathered, highly fractured, very weak.
SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, moderately fracturod, weak.
SHALE: Reddish brown, fine grained, slightly to moderately weathered, highly fractured, very weak.
20-30 %
15-30 %
DOUBLE TUBE TUNGSTEN CARBIDE NX SIZE
STABLE
SH
M.St
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall


NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE
PROJECT: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
SITE: GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES NEAR GHATTA MOR
COORDINATES: N 3753036.37 m, E 350336.41 m
ANGLE (with vertical): 0 BEARING: ..
GROUND ELEVATION: 1859.60 m
ROCK ELEVATION: 1839.60 m
GROUND WATER ELEVATION: N.E.
BACK FILLING MATERIAL: BENTONIT + CEMINTSAND
PEIZOMETER: -
DATE START: 17-04-2025 COMPLETE: 30-04-2025
DRILLING AGENCY: M/S THE DRILLER
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: ALI AQDAS
CHECKED BY: M. SHAHID
BOREHOLE No. BH-19
SHEET 04 OF 04
LITHOLOGY
General Description
Soil: Type, Colour, Consistency, Structure, Origin
Rock: Colour, Grain Size, Texture and Fabric, State of Weathering, State of Alteration Name, Strength, Shear Zones.
DISCONTINUITY DATA
WPT
SILTSTONE: Greyish brown, fine grained, slightly to moderately weathered, moderately fractured, weak.
BOTTOM OF BOREHOLE
20-40 %
DOUBLE TUBE TUNGSTEN CARBIDE NX SIZE
STABLE
M.St
Key for Description of Discontinuities
Weathering of Rock Mass
Strength Grade of Discontinuity Wall

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
COREBOX PHOTOGRAPHS

HOLE NO	19	BOX No	1-3	NESPAK
LOCATION	Near Chitta Mor	DEPTH (m)	20.0-35.00m	



Depth (m)

20.00
21.00
22.00
23.00
24.00
25.00
26.00
27.00
28.00
29.00
30.00
31.00
32.00
33.00
34.00
35.00

TABLE D-1: SUMMARY OF LABORATORY TEST RESULTS

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

SUMMARY OF LABORATORY TEST RESULTS

BH No.	Sample No.	Depth	Natural Moisture Content (NMC)	In-situ Bulk Density	In-situ Dry Density	Specific Gravity	Grain Size Analysis (% Passing)									Atterberg Limits			Material Classification as per USCS		Type of Rock	Direct Shear Test		Unconfined Compression Test		Consolidation Test with Swell Pressure Measurement				Uniaxial Compression Test		Elastic Modulus	Hoek Shear Test		Chemical Analysis of Soil			Chemical Analysis of Water			
																										e_o	C_c	m_v *	Swell Pressure											
																			Symbol	Material Description		c	Ø	q_u	Failure Strain				σ_{ci}	Failure Strain	E_{si}	c	Ø	Sulphate Content	Chloride Content	Organic Matter	Sulphate Content	Chloride Content	Total Dissolved Solids (TDS)	pH
		(m)	(%)	(kN/m³)	(kN/m³)		3"	3/4"	#4	#10	#40	#100	# 200	0.02	0.002	-	-	-				(kPa)	(deg.)	(kPa)	(%)	-	-	(m²/kN)	(kPa)				(MPa)	(%)	(MPa)	(kPa)	(deg.)	(%)	(%)	(%)	(ppm)	(ppm)	(ppm)	-
BH-01	SPT-01	1.00-1.45					100	100	100	100	100	99	98	62	2	28	21	7	CL-ML	Silty Clay																					
	SPT-08	8.00-8.45					100	100	98	95	94	3	91			24	19	5	CL-ML	Silty Clay																	0.01	0.02	0.11				
	UDS-01	13.50-14.00	17.1	19.2	16.4	2.68	100	100	100	100	100	100	100			33	22	11	CL	Lean Clay				69	14.3	0.63	0.13	$0.22x10^{-3}$	10												
	SPT-24	24.00-24.45					100	100	100	99	87	49	31						SM	Silty Sand																					
BH-02	SPT-01	1.00-1.45					100	45	26	18	12	11	8			27	19	8	GP-GC	Poorly Graded Gravel with Clay and Sand																	0.03	0.04	0.13				
	SPT-04	4.00-4.45					100	79	36	28	24	22	20			24	18	6	GC-GM	Silty Clayey Gravel with Sand																					
	UDS-01	6.50-7.00	18.1	19.0	16.1	2.68	100	100	100	100	99	97	95			27	19	8	CL	Lean Clay				49	7.1	0.66	0.09	$0.13x10^{-3}$	9												
	UDS-03	22.50-22.90	17.2	19.2	16.4		100	100	98	96	95	95	94			31	21	10	CL	Lean Clay				54	5.4																
BH-03	UDS-01	2.50-3.00	17.1	19.0	16.2	2.68	100	100	100	100	100	99	99	62	3	29	19	10	CL	Lean Clay				45	3.6	0.64	0.14	$0.24x10^{-3}$	9									0.03	0.02	0.13				
	SPT-08	8.00-8.45					100	99	90	88	87	87	86			28	21	7	CL-ML	Silty Clay																					
	SPT-10	10.00-10.45					100	100	100	100	98	95	80						ML	Silt with Sand																					
	DS-02	18.00-19.00					100	58	47	47	45	25	16						GM	Silty Gravel with Sand																					
	DS-07	23.00-24.00					100	14	12	12	4	1	1						GP	Poorly Graded Gravel																					
BH-04	UDS-01	2.50-3.00																																							
	DS-03	8.00-9.00																																							
	DS-06	11.00-12.00																																							
	DS-10	15.00-16.00																																							
	DS-13	18.00-19.00																																							
	DS-18	23.00-24.00																																							
	WAS																																								
BH-05	SPT-01	1.00-1.45																																							
	UDS-01	5.00-6.00																																							
	UDS-02	12.50-13.00																																							
	DS-02	19.00-20.00																																							
	DS-06	23.00-24.00																																							
BH-06	SPT-01	1.00-1.45																																							
	SPT-04	4.00-4.45																																							
	DS-04	8.00-9.00																																							
	DS-11	15.00-16.00																																							
	DS-15	19.00-20.00																																							
	DS-19	23.00-24.00																																							
	WAS																																								
BH-07	WS-02	3.58-3.74				2.68															Siltstone									2.31	0.010	2472								
	WS-04	6.61-6.89	3.2	25.8	25.0																Siltstone																				
	WS-09	15.81-15.91	1.3	21.8	21.5																Shale									0.97										
	WS-11	19.51-19.65	0.8	24.5	24.3																Sandstone									24.38										
BH-08	SPT-1	1.00-1.45					100	100	99	96	91	83	73			28	20	8	CL	Lean Clay with Sand																	0.03	0.04	0.08				
	WS-01	2.52-2.64	1.2	30.4	30.0																Siltstone									10.56										
	WS-03	8.34-8.45																			Siltstone									1.22										
	WS-06	12.55-12.82	3.7	25.4	24.5																Siltstone																				

	WS-13	22.50-22.71																	Siltstone								10.69											

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE
GEOTECHNICAL INVESTIGATION FOR TRACKWAY, STATIONS AND STRUCTURES

SUMMARY OF LABORATORY TEST RESULTS

BH No.	Sample No.	Depth	Natural Moisture Content (NMC)	In-situ Bulk Density	In-situ Dry Density	Specific Gravity	Grain Size Analysis (% Passing)									Atterberg Limits			Material Classification as per USCS		Type of Rock	Direct Shear Test		Unconfined Compression Test		Consolidation Test with Swell Pressure Measurement				Uniaxial Compression Test		Elastic Modulus	Hoek Shear Test		Chemical Analysis of Soil			Chemical Analysis of Water			
																										e_o	C_c	m_v *	Swell Pressure	σ_{ci}	Failure Strain	E_{si}	c	Ø	Sulphate Content	Chloride Content	Organic Matter	Sulphate Content	Chloride Content	Total Dissolved Solids (TDS)	pH
																LL	PL	PI	Symbol	Material Description		c	Ø	q_u	Failure Strain															
		(m)	(%)	(kN/m^3)	(kN/m^3)		3"	3/4"	#4	#10	#40	#100	# 200	0.02	0.002	-	-	-				(kPa)	(deg.)	(kPa)	(%)	-	-	(m^2/kN)	(kPa)	(MPa)	(%)	(MPa)	(kPa)	(deg.)	(%)	(%)	(%)	(ppm)	(ppm)	(ppm)	-
BH-09	SPT-1	1.00-1.45					100	100	92	86	81	78	72			26	19	7	CL-ML	Silty Clay with Sand																			
	WS-01	6.45-6.57	1.0	25.2	25.0																Sandstone									36.92									
	WS-03	9.30-9.66																			Sandstone																		
	WS-06	16.00-16.22	0.9	26.7	26.4	2.72															Sandstone									8.12									
	WS-07	21.33-21.62	1.1	26.7	26.4																Sandstone									15.05	0.009	1634							
	WS-09	24.00-24.18																			Sandstone									27.47									
BH-10	SPT-2	2.00-2.45					100	95	92	81	77	61	50			28	20	8	CL	Sandy Lean Clay																0.03	0.04	0.08			
	WS-01	4.41-4.55	5.9	24.7	23.3	2.69															Shale									0.42									
	WS-02	5.72--5.95																			Shale																		
	WS-04	12.00-12.17	1.4	24.2	23.8																Siltstone									16.60									
	WS-06	18.11-18.21																			Siltstone									18.38									
	WS-09	24.16-24.31	1.0	23.9	23.7																Siltstone									27.63									
BH-11	SPT-01	1.00-1.45					100	100	100	100	99	98	96			30	21	9	CL	Lean Clay																0.03	0.04	0.09			
	WS-02	5.22-5.36	6.4	23.8	22.4																Shale									2.76									
	WS-04	8.00-8.21																			Shale																		
	WS-11	15.55-15.71	0.8	25.4	25.2																Siltstone									20.58									
	WS-16	24.00-24.25	3.4	24.6	23.8	2.71															Shale									10.79	0.010	1273							
BH-12	WS-01	2.04-2.17	2.0	24.8	24.3																Siltstone									11.88									
	WS-02	5.30-5.43																			Shale									0.91									
	WS-07	13.44-13.71	0.8	26.5	26.3																Sandstone																		
	WS-11	18.00-18.31																			Sandstone									31.20									
BH-12A	SPT-02	2.00-2.45					100	100	99	85	69	66	65			26	19	7	CL-ML	Sandy Silty Clay																			
	WS-01	4.42-4.55	1.5	22.8	22.5																Shale									2.48									
	WS-03	14.45-14.65																			Shale									0.28									
	WS-05	18.40-18.54	0.9	23.0	22.8	2.72															Siltstone									18.40									
	WS-08	24.53-24.76																			Siltstone									12.72									
BH-13	SPT-01	1.00-1.45																																					
	SPT-03	3.00-3.4																																					
	DS-04	7.00-8.00																																					
	WS-02	11.43-11.60																			Siltstone																		
	WS-04	14.00-14.14																			Siltstone																		
	WS-05	21.00-21.16																			Siltstone																		
BH-14	SPT-03	3.00-3.45																																					
	SPT-05	5.00-5.45																																					
	WS-01	9.00-9.33																			Sandstone																		
	WS-03	11.24-11.50																			Sandstone																		
	WS-10	20.14-20.35																			Siltstone																		

	WS-14	24.12-24.37																		Siltstone																					
BH-15	SPT-1	1.00-1.45																																								
	SPT-3	3.00-3.45																																							
	DS-05	8.00-9.00																																							
	WS-01	10.00-10.37																																							
	WS-04	14.00-14.30																		Siltstone																					
	WS-07	17.15-17.30																		Siltstone																					

SUMMARY OF LABORATORY TEST RESULTS

BH No.	Sample No.	Depth	Natural Moisture Content (NMC)	In-situ Bulk Density	In-situ Dry Density	Specific Gravity	Grain Size Analysis (% Passing)									Atterberg Limits			Material Classification as per USCS		Type of Rock	Direct Shear Test		Unconfined Compression Test		Consolidation Test with Swell Pressure Measurement				Uniaxial Compression Test		Elastic Modulus	Hoek Shear Test		Chemical Analysis of Soil			Chemical Analysis of Water			
																										e_o	C_c	m_v *	Swell Pressure												
																						c	Ø	q_u	Failure Strain				σ_{ci}	Failure Strain	E_{si}	c	Ø	Sulphate Content	Chloride Content	Organic Matter	Sulphate Content	Chloride Content	Total Dissolved Solids (TDS)	pH
		(m)	(%)	(kN/m^3)	(kN/m^3)		3"	3/4"	#4	#10	#40	#100	# 200	0.02	0.002	LL	PL	PI	Symbol	Material Description		(kPa)	(deg.)	(kPa)	(%)	-	-	(m^2/kN)	(kPa)	(MPa)	(%)	(MPa)	(kPa)	(deg.)	(%)	(%)	(%)	(ppm)	(ppm)	(ppm)	-
BH-16	DS-01	2.00-3.00																			Siltstone																				
	DS-06	7.00-8.00																																								
	DS-09	11.00-12.00																																								
	WAS-01	14.00-14.28																			Sandstone																					
	WS-07	22.59-22.89																			Siltstone																					
	WS-10	28.22-28.40																			Sandstone																					
	WS-11	29.43-29.63																			Siltstone																					
BH-17	SPT-03	3.00-3.45					100	100	100	99	99	98	98	66	9	34	22	12	CL	Lean Clay																			0.05	0.02	0.14				
	WS-01	6.10-6.30				2.72															Siltstone												9.76										
	WS-03	9.28-9.43	2.3	23.0	22.5																Shale												4.16										
	WS-08	16.08-16.24				2.73															Sandstone												17.10	0.023	723.9								
BH-18	DS-01	1.00-2.00					100	19	12	11	9	9	8						GP-GM	Poorly Graded Gravel with Silt																								
	SPT-04	5.00-5.45					100	100	76	69	64	62	60	35	2	29	20	9	CL	Gravelly Lean Clay with Sand																			0.03	0.04	0.13				
	SPT-06	7.00-7.45					100	100	98	93	88	85	82			31	21	10	CL	Lean Clay with Sand																								
	WS-01	12.15-12.26	10.0	21.5	19.6	2.69															Shale												0.26										
	WS-03	15.12-15.28	1.8	26.0	25.5																Siltstone												23.81	0.02	1607								
	WS-05	17.20-17.41																			Shale																						
	WS-06	20.19-20.36	7.2	19.7	18.4																Shale												0.31										
	WS-07	24.63-24.74				2.72															Siltstone												1.64										
BH-19	SPT-01	1.00-1.45					100	85	71	62	52	49	44			27	19	8	GC	Clayey Gravel with Sand																			0.03	0.02	0.11				
	DS-03	7.40-8.00					100	89	71	68	62	61	56			32	21	11	CL	Gravelly Lean Clay with Sand																								
	SPT-09	11.00-11.45					100	100	76	70	65	63	57			28	19	9	CL	Gravelly Lean Clay with Sand																								
	DS-06	15.00-16.00					100	34	22	21	20	19	16						GC-GM	Silty Clayey Gravel																								
	WS-01	21.56-21.77				2.72															Shale												2.51	0.023	104.28								
	WS-05	29.21-29.37	1.6	26.1	25.7																Siltstone												13.30										
	WS-06	30.14-30.32	5.2	22.6	21.5																Shale												1.19										

NOTE:

LEGENDS:

BH: BOREHOLE **UDS: UNDISTURBED SAMPLE** **SPT: STANDARD PENETRATION TEST** **WAS: WATER SAMPLE** **WS: WAXED SAMPLE** **DS: DISTURB SAMPLE** **RESULT AWAITED**

PUNJAB MASS TRANSIT AUTHORITY (PMA)
GOVERNMENT OF THE PUNJAB

FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MUREE



ENVIRONMENTAL IMPACT ASSESSMENT (EIA) STUDY

VOLUME-I

MAY, 2025

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01								

DISCLAIMER

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Feasibility Study for Tourist Glass Train from Rawalpindi to Muree

ENVIRONMENTAL IMPACT ASSESMENT STUDY

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LIST OF ABBREVIATONS

AOI	Area of Influence
BCP	Buildig Code of Pakistan
BRBD	Bambawali Ravi Bedian Depalpur
BOD	Biological Oxygen Demand
CC	Construction Contractor
CCMP	Construction Camp Management Plan
COVID-19	Coronavirus disease
CoI	Corridor of Impact
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
DC	Design Consultant
ECO	Economic Cooperation Organization
EIA	Environmental Impact Assessments
EMP	Environmental Management Plan
EMMM	Environmental Mitigation and Management Matrix
EPA	Environmental Protection Agency
ERP	Emergency Response Plan
ESEs	Environmental and Social Experts
FGDs	Focused Group Discussions
FFD	Fire Fighting Department
GoP	Government of Pakistan
GoPb	Government of Punjab
HSE	Health Safety & Environment
IEE	Initial Environmental Examination
ILO	International Labour Organization
KPH	Kilometres Per Hour
LAA	Land Acquisition Act
LOS	Level of Service
LWMC	Lahore Waste Management Company
MSDS	Material Safety Data Sheets
NESPAK	National Engineering Services Pakistan
NO	Nitrogen Oxide
NESPAK	National Engineering Services Pakistan
NL	Noise Level
NOC	No Objection Certificate
NPO	No Project Option
NPZ	Noise Perimeter Zones
NGO's	Non-Governmental Organizations
NCS	Pakistan National Conservation Strategy
O&M	Operation and Maintenance
OHS	Occupational Health and Safety
O3	Ozone
PDMA	Provincial Disaster Management Authority
PMD	Pakistan meteorological department
PGA	Peak Ground Acceleration
PHA	Parks & Horticulture Authority
PPE	Personnel Protective Equipment

PAPs	Project Affected Persons
PEPA	Punjab Environmental Protection Agency
PEQs	Punjab Environmental Quality Standards
PM	Particulate Matter
PRSP	Punjab Rural Support Program
QMP	Quarry Management Plan
RE	Resident Engineer
RUDA	Ravi Urban Development Authority
RRUDP	River Ravi Urban Development Project
SBC	Seismic Building Code of Pakistan
SC	Supervision Consultant
STP	sewerage treatment plant
STDs	Sexually-Transmitted Disease
SSEMP	Site Specific EMP
SOP	Standard Operating Procedures
SO2	Sulfur Dioxide
SPM	Suspended Particulate Matter
SC	Supervisory Consultant
TA	Technical Assistance
VICS	Vehicle Inspection & Certification System
WASA	Water and Sanitation Agency

EXECUTIVE SUMMARY

ES-1 INTRODUCTION

The Government of Punjab has introduced a transformative scheme to establish a scenic rail link between Rawalpindi/Islamabad and Murree, designed to enhance accessibility for both the public and tourists. This initiative aims to provide an alternative and sustainable transportation mode for tourists, many of whom currently rely on private vehicles to reach Murree. By reducing vehicular traffic, the Glass Train project is envisioned as a step towards sustainable tourism and improved accessibility. This document presents the findings of Environmental Impact Assessment (EIA) of Tourist Glass Train Murree Project.

ES-2 REGULATORY AND POLICY REVIEW

The EIA Study has been conducted for the subject project as a mandatory requirement of Punjab Environmental Protection Act, 1997 (Amended 2012 & 2017). Section 12 (1) of the Act states that *"*No proponent of a Project shall commence construction or operation unless he has filed with the Provincial Agency an Environmental Impact Assessment or, where the Project is likely to cause an adverse environmental effect, an environmental impact assessment, and has obtained from the Provincial Agency approval in respect thereof." Other relevant laws have also been discussed briefly in Chapter-2.

According to the Pakistan Environmental Protection Agency (Review of IEE and EIA) Regulations 2022, the proposed project falls under Category 'D' of the Schedule-II. This category requires an EIA study to be conducted for urban development projects to initiate the process of environmental approval.

ES-3 DESCRIPTION OF PROJECT

The glass train will provide a direct and scenic connection between Rawalpindi and Murree, making it easier for tourists to access this popular hill station. Proposed Glass Train project starts from H-9 Margalla Station and ends at Muree Bus Stand. The proposed track spans a total length of 59 kilometers, with an estimated travel time of 114 minutes. Tentative cost of the proposed Project is about PKR.255 Billion.

ES-4 DESCRIPTION OF THE ENVIRONMENT

Physical Environment

The proposed Project falls under administrative jurisdiction of Islamabadd and Muree District. The study area of the proposed Project pass through diverse terrain, starting from the relatively flat plains of Islamabad at an elevation of around 471 meters and gradually ascending into the hilly and rugged landscapes of the Murree, reaching elevations up to approximately 2,262 meters. The Project corridor is surrounded by forests, agricultural lands,

road infrastructure, residential areas, mosques, rivers, waterfalls, nullahs, and commercial establishments.

As per Building Code of Pakistan (BCP), 2007 (Seismic Provisions), the proposed Project falls in the Zone-B & 3 with Peak Ground Acceleration (PGA) from 0.16g to 0.32g of the seismic zonation. Major sensitive receptors in the project area are protected areas, health facilities, educational institutions, and religious places (mosques, shrines and graveyard) which has been recorded based on site survey and by using the GIS tool for the proposed Project.

Ecological Environment

Islamabad city falls in sub-tropical broad leaved evergreen scrub forest. Dominant tree species include Phulai (Acacia modesta), Wild olive (Olea ferruginea), Sanatha (*Dodonaea viscosa*), Black berries (*Monotheca buxifolia*), *Reptonia buxifolia*, Beri (*Zizyphus mauritiana*), Royle's Spike Thorn (*Gymnosporia royleana*), Baikarh (*Adhatoda vasica*), Zebrawood (*Pistacia integerrima*), and *Capparis decidua* on drier slopes. Muree is dominated by Sub-Tropical Chir Pine Forest and Himalayan Moist Temperate Forests.

Common animals found in the area are Golden Jackal, Kashmir Flying Squirrel, Indian Crested Porcupine, Indian Hare, Cobra, Black Partridge, White Wagtail, Rufous-bellied Niltava, Variable Wheatear, etc. Margalla Hills National Park (MHNP), Murree, Kotli Sattian and Kahuta National Park and Forest Reserves, Nandkot Reserved Forest and Guzara Forest in Murree are the major protected areas in the Project Area.

Socio-Economic Environment:

The project area falls in ICT and District Muree. Based on the District Census Report, 2017, The socio-economic survey was carried out in the month of April 2025. A sample size of 115 (103 Males & 12 Females) was taken by using random sample technique. During the socio-economic survey, respondents were informed about the Project objectives, its location and basic design features.

ES-5 STAKEHOLDER CONSULTATION

A series of public consultations were conducted to get the feedback/concerns of the different category of stakeholders including provincial departments i.e., Pak-EPA, Punjab-EP&CCD, TMA Murree, Punjab Tourism Development Cooperation of Punjab (TDCP), Forest Department, Wildlife Department, CDA, Islamabad Wildlife Management Board, line agencies, potential Project Affected Persons (PAPs), local community and other general public residing in the Study Area. Consultation process included Focus Group Discussions, semi-structured interviews, one to one meeting and interviews with the government and private institutions. Basic concerns of the stakeholders were related to land acquisition, disturbance to Murree forest areas, construction phase impacts including dust, air & noise pollution, health & safety and privacy issues etc. and implementation of mitigation measures.

ES-6 ANTICIPATED PROJECT IMPACTS AND MITIGATION MEASURES

Significant efforts were made to identify the main environmental issues related to the design, construction and operation of the proposed project. The significant adverse impacts and their mitigations during the design, construction and operation phases are here under:

- The noise and vibration will be produced due to the operation of construction machinery and equipment. Noise and vibration are perceived as one of the most undesirable consequences of construction activities. There are a variety of ways by which construction equipment and worksite noise can be controlled that includes use of quieter equipment, modification of existing old equipment, barrier protection, change in work activity schedule and maintenance of vehicle/equipment.
- Wastewater will be generated at the construction camps and from construction activities. If the generated wastewater is not properly treated or disposed of, this may contaminate the surface water sources such as water channels. The wastewater generation is estimated to be 6,600 liters/day[1] for 200 construction workers; and sewage from construction camps will be disposed of after proper pre-treatment and processes such as soakage pit.
- A total of about 120 kg of solid waste will be generated from construction camps on daily basis. All the solid waste from the camps will be properly collected at source by placing containers and disposed of through proper solid waste management system;
- Air quality will be affected by fugitive dust emissions from construction machinery; dust from the unpaved surface and construction vehicles. Emissions from batching / asphalt plants can be controlled efficiently by the installation of cyclone / scrubbers. In addition to that, regular maintenance activities comprising changing of lubricating oil, changing the air and fuel filter, cleaning the fuel system, draining the water separators and proper tuning may also help in reducing the emissions from diesel generators;
- The project will involve clearing of vegetation cover on construction areas particularly along proposed track construction. A afforestation/plantation program will be formulated with the recommendations of compensatory planting against fallen trees of similar floral function in close coordination with the Forest Department;
- Due to the construction camps, number of impacts may arise that include waste, soil pollution, groundwater pollution, dust, etc. The construction activities and vehicular movement at construction sites may result in road side accidents particularly inflicting local communities who are not familiar with presence of heavy equipment. Institutions along the route may also suffer during construction period due to air, noise and road accidents. Conflicts may arise between the local community and the construction workers, which may be related to religious, cultural or ethnic differences, or based on competition for local resources. Contractor will ensure the proper control on construction activities. Contractor will also take due care of the local community and observe sanctity of local customs and traditions by his staff. Contractor will warn the staff strictly not to involve in any unethical activities and to obey the local norms and cultural restrictions.

ES-7 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The EMP of the proposed project mainly comprises institutional requirements; environmental mitigation and management; environmental monitoring plan; planning for EMP

[1] Design Criteria of Public Health Engineering for Water Supply, Sewerage and Storm Water Drain (Domestic sewage generation = 80% of water consumed/day)

implementation; and EMP cost. PMA will be responsible for implementation of EMP of the proposed project during construction and operational phase. The total cost required to effectively implement the mitigation measures is approximately PKR 26.541 Million (exclusive of afforestation/plantation cost), which includes cost of environmental monitoring and Health and Safety and environmental management, etc. during construction and operational phases. The EMP will be part of the contract document with the Contractor(s).

ES-8 CONCLUSION AND RECOMMENDATIONS

Results of the EIA Study have shown that the impacts of the project activities on the physical environment will be low to moderate significant. However, there will be significant impacts on the ecological and social environment. These impacts could be reduced by proper and judicious compensation to the affectees and well planned meticulous design and by implementing an appropriate tree plantation.

The EIA Study concludes that there are no critical environmental impacts associated with the project. An Environmental Management Plan (EMP) for all the phases (pre-construction, construction and operation) has been developed as part of the report that covers impacts, mitigation measures roles and responsibilities and timings to avoid, minimize or mitigate the adverse impacts of the project. The EMP, its mitigation and monitoring programs, contained herewith will be included within the Bidding documents for project works for all Project components.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Murree is a district of the Rawalpindi Division in the northernmost part of the Pakistani province of Punjab. The Murree region in Pakistan is a popular hill station and a major tourist destination. Murree attracts a large number of tourists, especially during peak seasons (summer, long weekends, and holidays).

This influx creates severe traffic jams along the main roads leading to and within the town. The narrow roads, limited parking spaces, and high number of vehicles lead to gridlock, which can last for hours. There is a significant shortage of designated parking spaces for tourists. Vehicles often end up parked along roadsides, further contributing to congestion.

When putting an eye on public transport of Murree private taxis, cars, and buses are available, there is a limited public transportation network within the Murree region and on connecting routes form Murree to Islamabad/Rawalpindi. Most visitors prefer traveling by their own vehicles or hire private transport, which increases the number of cars on the roads whereas public buses or shuttles are not frequent, and those that exist often do not adhere to a fixed schedule and regulated fare, which makes it challenging for tourists who do not have personal transport.

The Government of Punjab has introduced a transformative scheme to establish a scenic rail link between Rawalpindi/Islamabad and Murree, designed to enhance accessibility for both the public and tourists. This initiative aims to provide an alternative and sustainable transportation mode for tourists, many of whom currently rely on private vehicles to reach Murree. By reducing vehicular traffic, the Glass Train project is envisioned as a step towards sustainable tourism and improved accessibility.

This document presents the findings of Environmental Impact Assessment (EIA) of Tourist Glass Train Project.

1.2 NEED FOR ENVIRONEMTNAL ASSESSMENT STUDY OF THE PROPOSED PROJECT

As per Punjab Environmental Protection Act (Amendment) 2017, under Section 12 (1) IEE/EIA is mandatory which states that:

"No proponent of a project of public and private sector shall commence construction or operation unless he has filed an Initial Environmental Examination / Environmental Impact Assessment with the Punjab Environmental Protection Agency, as the case may be, or, where the project is likely to cause adverse environmental effects; an environmental impact assessment, and has obtained from the Provincial Agency approval in respect thereof".

According to the Pakistan Environmental Protection Agency (Review of IEE and EIA) Regulations 2022, the proposed project falls under Category "**D**" (*Transport)* of Schedule-II, which requires an EIA before commencement of construction.

1.3 NATURE, SIZE AND LOCATION OF THE PROJECT

The glass train will provide a direct and scenic connection between Rawalpindi and Murree, making it easier for tourists to access this popular hill station. Proposed Glass Train project starts from H-9 Margalla Station, Islamabad, passes through Khyaban-Johar Metro Station, bypasses parade ground and runs along Lake View Park. It will then cross Barakahu, Chattar Park, Manga continue through Ghora Gali and terminates at Muree Bus Stand.

The proposed track spans a total length of 59 kilometers, with an estimated travel time of 114 minutes. **Figure 1-1** shows the location map of the proposed Project.

1.4 SCOPE OF STUDY

The scope of this EIA Study aims at collection and scrutinizing of data related to physical, biological and socio-economic environment of the project area and to prepare the baseline environmental profile. It also aims the identification, prediction and evaluation of the possible environmental impacts of the proposed project on its immediate surroundings on both short and long-term bases. Based on the nature and scale of those impacts, appropriate mitigation measures are proposed in this EIA Report.

1.5 PURPOSE OF EIA REPORT

The purpose of this EIA Report is to identify and assess significant adverse environmental and social impacts and to suggest mitigation and remedial measures to make the proposed project environmentally friendly and sustainable during the construction and operational stages. Also, to propose intuitional arrangement and to develop cost estimate to implement those mitigation measures.

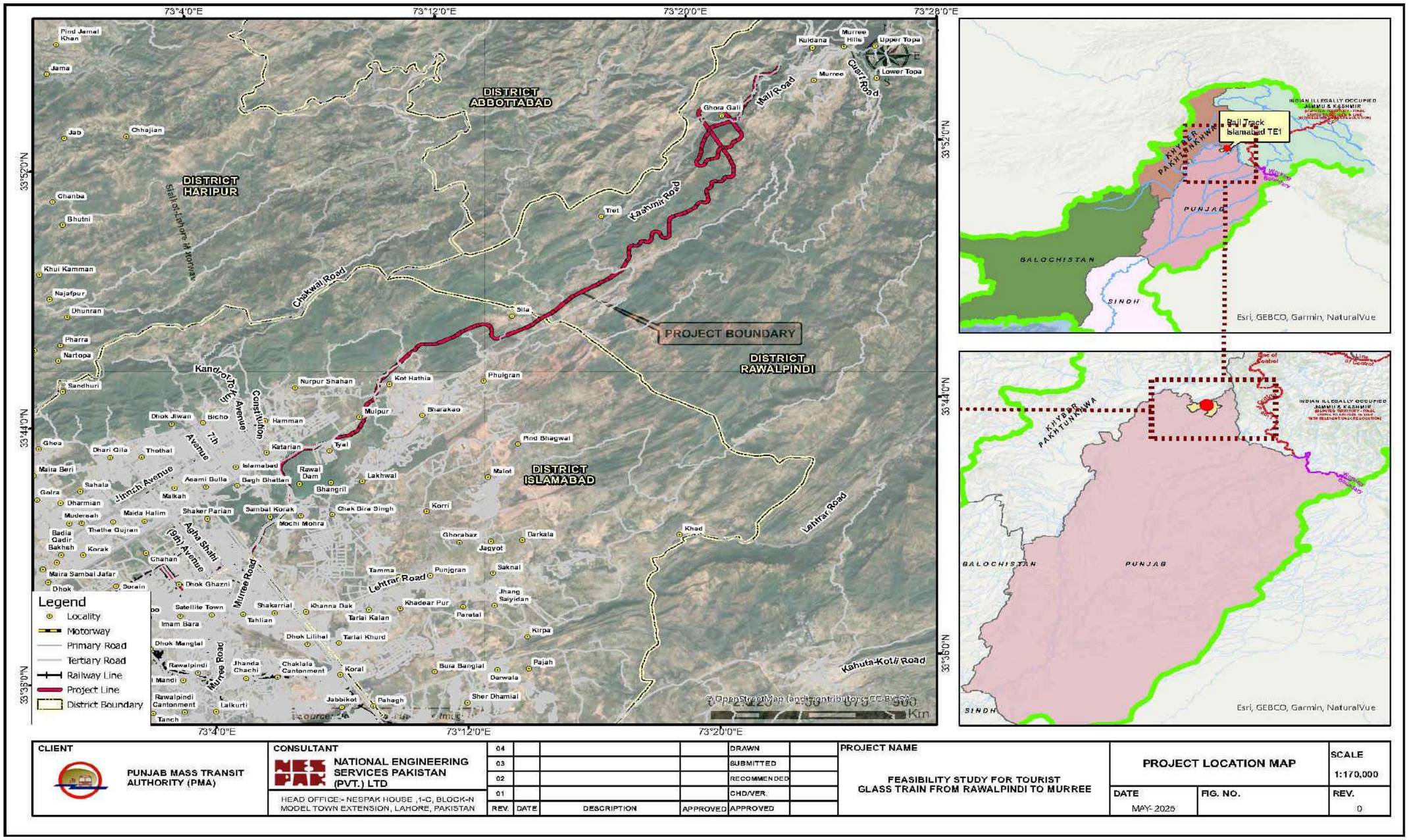
1.6 THE PROPONENT AND CONSULTANT

a) Proponent Contact/Address

Chairman/ Project Director
Punjab Mass Transit Authority (PMA)
Government of Punjab

b) Consultant Contact/Address

National Engineering Services Pakistan Private Limited (NESPAK)
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CLIENT: PUNJAB MASS TRANSIT AUTHORITY (PMA)	CONSULTANT: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD HEAD OFFICE:- NESPAK HOUSE ,1-C, BLOCK-N MODEL TOWN EXTENSION, LAHORE, PAKISTAN	04				DRAWN		PROJECT NAME: FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	PROJECT LOCATION MAP	SCALE: 1:170,000
		03				SUBMITTED				
		02				RECOMMENDED				
		01				CHD/VER.			DATE: MAY- 2025	FIG. NO.	REV.: 0
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED				

Figure 1.1: Location Map of the Proposed Project

1.7 EIA TEAM COMPOSITION

Based on the requirements of ToR and objectives of the study, NESPAK formed a team of experts comprising a team leader (Environmental Expert) with professional support from the Environmental Scientists, Sociologist and Ecologist. The professional staff was involved in analyzing the data, impact assessment and mitigation measures and report compilation. In addition, the EIA team worked in close coordination with the design team and several inputs were provided by the design engineers to the EIA team. Detail of EIA team is given in **Table 1.1** below:

Table 1.1: Team Composition for the EIA Study

Sr. No.	Name of Expert	Designation
1.	Mir. Ghnzanfar Afzal	Principal Engineer/Head ERSD Section
2.	Ms. Shehnila Hanif	Senior Environmental Scientist
3.	Ms. Ridha Kamran	Senior Environmental Scientist
4.	Mr. Muhammad Sajjad	Senior Sociologist
5.	Mr. Ibadullah Khan	Senior Ecologist
6.	Muhammad Farooq	Forester
7.	Mr. Muneeb Yousaf	GIS Analyst

1.8 METHODOLOGY

The following methodology was adopted for carrying out the EIA study of the proposed project:

1.8.1 Orientation

Meetings and discussions were held among the members of the EIA Consulting Team. This activity was aimed at achieving a common ground of understanding of various issues of the study. Subsequent to the concept clarification and understanding, a detailed data acquisition plan was developed for the internal use of the EIA consulting team. The plan identified specific data requirements and their sources; determined time schedules and responsibilities for their collection; and indicated the logistics and facilitation needs for the execution of the data acquisition plan.

1.8.2 Data Collection

In this step, primary and secondary data were gathered through field observations, concerned departments and published materials to establish baseline of physical, biological and socio-economic environmental conditions.

- Literature Review;
- Site Reconnaissance;
- Analysis of Maps and Plans;
- Public Consultations; and

- Environmental Sampling, Testing and Analysis.

1.8.3 Review of Environmental Laws and Institutional Requirements

All applicable national and international laws, legislations, guidelines and treaties were reviewed relevant to the proposed project components.

1.8.4 Delineation of Area of Influence (AOI)

AOI includes the area in the surroundings of the proposed alignment receiving direct impact of project activities. The AOI delineated for the proposed project is 25 m from the boundary of the project area. The AOI map is shown as **Figure 1.2.**

1.8.5 Survey of AOI

A team of Environmental Scientists, Ecologist and Sociologist carried out the environmental and social survey of the AOI in April, 2025 to familiarize themselves with the local conditions and the environmental settings. During the survey, the information regarding the topography, soils, surface water, groundwater, flora & fauna, affected infrastructure, social settings and villages/towns along the AOI was observed.

1.8.6 Environmental Baseline Survey of the Project

Detailed environmental and social survey was carried out within the AOI as mentioned above. For data collection, formal meetings were held and data collected through visual observations, interviews with the local residents and officials. In order to collect the relevant published information, government offices were also visited.

Prior to the start of field activities comprehensive checklists, proformas and maps were developed to collect the information related to following parameters:

Physical Environment

The information acquired for the establishment of physical environment baseline included the following main parameters:

- Land resources (including land use pattern, soil composition, topography, etc.);
- Water resources (including available surface and groundwater resources and natural streams, hydrology, spring water, water supply, water contamination etc.);
- Climate data (including temperature, rainfall, humidity, wind speed and direction etc.);
- Ambient air quality and noise level monitoring data;
- Existing solid waste management and effluents disposal practices and storm water drainage;
- Buildings and infrastructure details, including residential, commercial and animal shed for complete/partial relocation;
- Religious, cultural and heritage information (mosques, shrines, graveyards);

- Archaeological monuments; and
- Other private/public infrastructures such as roads, telephone poles, hand pumps, tube wells etc.

Ecological Environment

The status of the flora and fauna of the study area were determined by a review of literature of the area, and an assessment of both terrestrial and aquatic environments.

a) Flora

The vegetative communities were identified and classified into community types. Identification was carried out of dominant tree species, assessment of stage of growth (mature or sapling), etc.

b) Fauna

Information on fauna was gathered from existing literature on reported species as well as observations in the field.

c) Endangered species

Data related to endangered species (both flora and fauna,) was collected and no endangered species has been found in the project area.

Socio-Cultural Environment

The consultants utilized a combination of literature, field investigations, census report, meetings through public consultation and interviews to describe the existing social environment and assessment of the potential impact of the construction of the proposed project. Data was gathered on the following aspects of the social environment:

- Land use and Municipal Status;
- Demographics;
- Livelihoods;
- Community Facilities;
- Solid Waste Management;
- Proposed Developments;
- Archaeological and Cultural Heritage; and
- Identification and Evaluation of Environmental Impacts.

1.8.7 Stakeholder Consultations

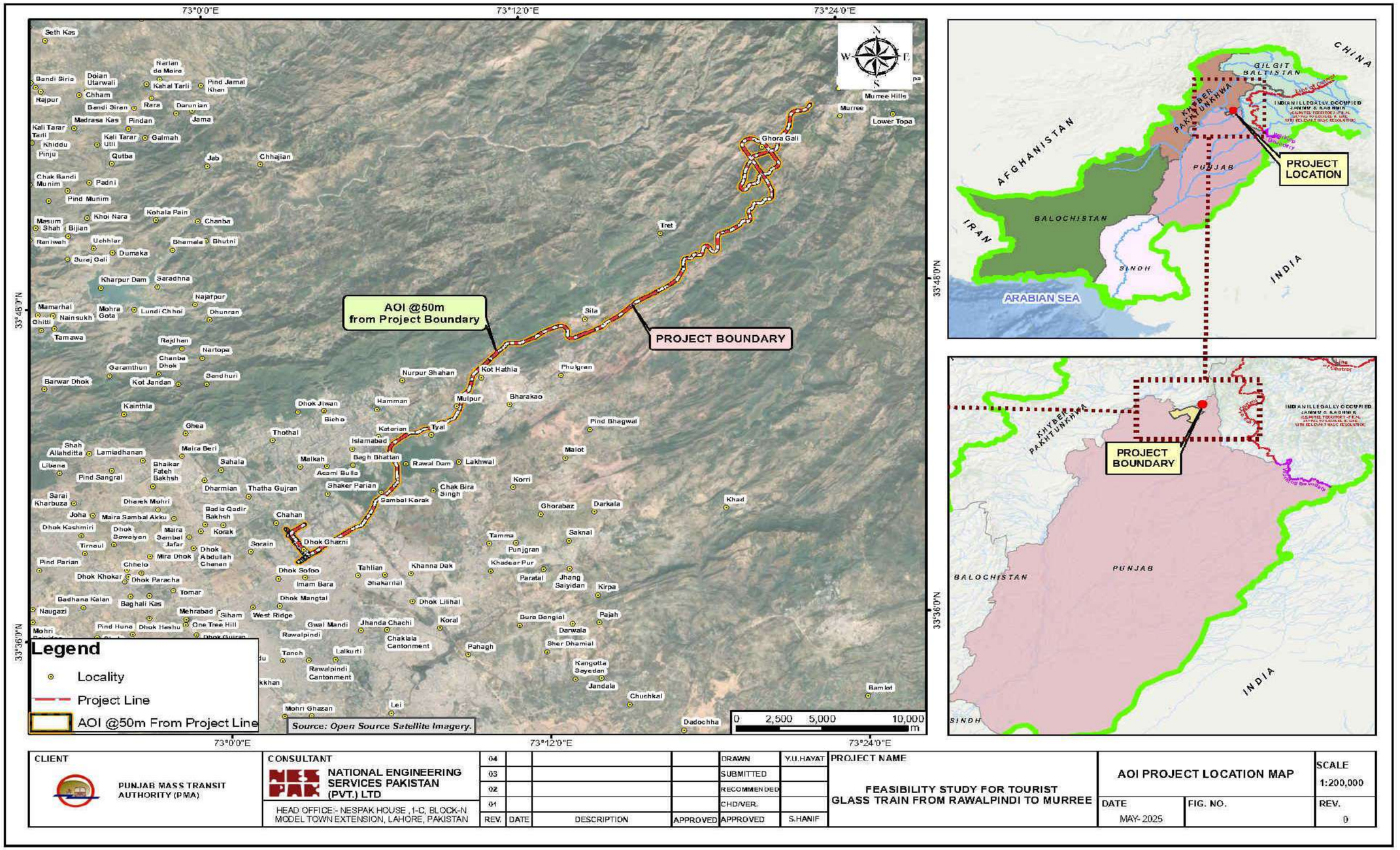
The Consultant identified Project stakeholders and held meetings with them during the surveys to receive feedback on the expected environmental issues related to the Project impacts and suggested mitigation measures. Meetings were carried out with the Project affectees, relevant departments including Environment Protection Department, Forest & Wildlife Department, Capital Development Authority (CDA), etc. to discuss the issues/constraints and get their views and feedback to mitigate the potential environmental as well as social impacts associated with the implementation and operation of the Project.

1.8.8 Screening of Potential Environmental Impacts and Mitigation Measures

Based on the generally established baseline conditions in the adjacent as well as in the Project Area, potential physical, ecological and social impacts of the proposed Project were identified, evaluated and quantified, wherever possible. A logical and systematic approach was adopted for impact identification and assessment by utilizing a combination of the secondary data, satellite imagery, environmental checklists, socioeconomic survey proformas, field observations and discussion with the local residents of the Project Area. To mitigate the significant adverse impacts, adequate mitigation measures and implementation framework were proposed so that the proponent could incorporate them beforehand in the design phase.

1.8.9 Environmental Management Plan (EMP)

An Environmental Management Plan (EMP) has been prepared to ensure the adequacy and effectiveness of the suggested mitigation measures by clearly identifying the roles and responsibilities of the agencies, monitoring mechanism, monitoring plan for environmental and social parameters to be monitored with their frequency, existing and suggested framework, necessary approvals and the required further studies. Similarly, costs for environmental monitoring and social component/social mitigation measures were also estimated.



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		02				RECOMMENDED			
		01				CHD/VER.			DATE: MAY- 2025
		REV.	DATE	DESCRIPTION	APPROVED	APPROVED	S.HANIF		FIG. NO.
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Figure 1.2: AOI for the Proposed Project

1.9 STRUCTURE OF THE REPORT

Section 1 **"Introduction"** briefly presents the project background, objectives, methodology and need of the EIA study.

Section 2 **"Policy, Legal and Administrative Framework"** comprises policy guidelines, statutory obligations and roles of institutions concerning EIA study of the proposed Project.

Section 3 **"Description of Project"** furnishes information about the studied alternatives, location of the proposed project, cost and size of the project, its major components and alternatives considered for the proposed project.

Section 4 **"Environmental Baseline"** describes physical, biological and socio-economic conditions prevalent in the project area.

Section 5 **"Stakeholder Consultation"** identifies the main stakeholders and their concerns raised through scoping sessions, and presents the measures to mitigate the social impacts.

Section 6 **"Anticipated Environmental Impacts and Mitigation Measures"** identifies and evaluates impacts of the project activities during the construction and operation stages and recommends with the measures proposed to mitigate potential environmental impacts of the proposed project.

Section 7 **"Environmental Management Plan"** outlines environmental mitigation plan, institutional arrangements for the implementation of the proposed mitigation measures, monitoring requirements, environmental cost etc.

Section 8 **"Conclusion and Recommendations"** elaborates the conclusion of subject environmental study and suggests the recommendations to address the issues raised from proposed construction activities.

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORKS

2.1 GENERAL

This Chapter provides an overview of the policy framework and legislation that applies to control the environmental consequences as a result of the proposed Project implementation and operation. The Project needs to comply with all the applicable environmental policies, laws, guidelines, acts and legislations of Government of Pakistan and Provincial Government (Punjab).

2.2 SUMMARY OF RELEVANT STRATEGIES, POLICIES, ACTS AND LEGISLATION

The summary of major relevant strategies, policies, acts and legislation from environmental perspective are briefly described in Tables 2-1 & 2-2 below.

Table 2-1: Main Strategies/Policies Related to Environment and their Relevance to the Project

Sr. No.	Policy /Strategy	Brief Coverage	Relevance to Project
1	National Conservation Strategy, 1992	Pakistan National Conservation Strategy (NCS), which was approved by the federal cabinet in March 1992, is the principal policy document on environmental issues in the Country. The NCS outlines the Country's primary approach towards encouraging sustainable development, conserving natural resources and improving efficiency in the use and management of resources. The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment.	The core areas that are relevant in the context of the proposed Project are pollution prevention during construction, conserving biodiversity and supporting forestry and plantation.
2	National Environmental Policy, 2005	In March 2005, GoP launched its National Environmental Policy, which provides a framework for addressing the environmental issues. Section 5 of the policy commits for integration of environment into development planning as instrument for achieving the objectives of National Environmental Policy. It also provides broad guidelines to the Federal Government, Provincial Governments, Federally Administered Territories and Local Governments to address their environmental concerns and to ensure effective management of their	Clause (b) of sub-section 5.1 states that Environmental Assessment related provisions in Environmental Protection Act, 1997, will be diligently enforced for all developmental projects.

Sr. No.	Policy /Strategy	Brief Coverage	Relevance to Project
		environmental resources.	
3	National Climate Change Policy, 2012	The National Climate Change Policy provides a framework for addressing the issues that Pakistan faces or will face in future due to the changing climate. In view of Pakistan's high vulnerability to the adverse impacts of climate change, in particular extreme events, adaptation effort is the focus of this policy document. The vulnerabilities of various sectors to climate change have been highlighted and appropriate adaptation measures spelled out. The policy covers measures to address issues in various sectors such as water, agriculture, forestry, coastal areas, biodiversity and other vulnerable ecosystems. Notwithstanding the fact that Pakistan's contribution to global Greenhouse Gas (GHG) emissions is very small, its role as a responsible member of the global community in combating climate change has been highlighted by giving due importance to mitigation efforts in sectors such as energy, forestry, agriculture and livestock. Furthermore, appropriate measures relating to disaster preparedness, capacity building, institutional strengthening; technology transfer; introduction of the climate change issue in higher education curricula; ensuring environmental compliance through Initial IEE and EIA in the development process; addressing the issue of deforestation and illegal trade in timber; promoting Clean Development Mechanisms (CDM); and raising Pakistan's stance regarding climate change at various international forums, have also been incorporated as important components of the policy. The policy thus provides a comprehensive framework for the development of Action Plans for national efforts on adaptation and mitigation.	This policy document is a 'living' document and will be reviewed and updated regularly to address emerging concepts and issues in the ever-evolving science of climate change. This policy will accelerate due to the emissions from the construction machinery and equipment.
4	National Drinking Water	The National Drinking Water Policy provides a framework for addressing the	This policy is applicable for the proposed Project during

Sr. No.	Policy /Strategy	Brief Coverage	Relevance to Project
	Policy, 2009	key issues and challenges facing Pakistan in the provision of safe drinking water to the people. Drinking water is the constitutional responsibility of the provincial governments and the specific provision function has been devolved to specially created agencies in cities and Town and Tehsil Municipal Administrations under the Local Government Ordinance 2001.	construction and operational phases in terms of regular water quality monitoring.
5	National Water Policy, 2018	The National Water Policy aims at efficient management and conservation of existing water resources, optimal development of potential water resources, steps to minimize time and cost overruns in completion of water sector projects, improving urban water management by increasing system efficiency and reducing non-revenue water through adequate investments to address drinking water demand, sewage disposal, handling of wastewater and industrial effluents; equitable water distribution in various areas and canal commands, measures to reverse rapidly declining groundwater levels in low-recharge areas, increased groundwater exploitation in high-recharge areas, effective drainage interventions to maximize crop production, improved flood control and protective measures, steps to ensure acceptable and safe quality of water, minimization of salt build-up and other environmental hazards in irrigated areas, institutional reforms to make the managing organizations more dynamic and responsive.	The core areas that are relevant in the context of the proposed Project are drinking water demand, sewage disposal, and handling of wastewater.
6	National Forest Policy, 2015	The goal of this policy is to expansion, protection and sustainable use of national forests, protected areas, natural habitats and watersheds for restoring ecological functions, improving livelihoods and human health in line with the national priorities and international agreements. In line with the Federal functions of national policy, planning and implementation of international agreements, specific objectives of the National Forest Policy include:	The proposed Project passes through the reserved forests, protected areas, guzara forest and natural habitats, so this policy is applicable to the proposed project.

Sr. No.	Policy /Strategy	Brief Coverage	Relevance to Project
		Promoting ecological, social and cultural functions of forests through sustainable management and use of forest produce including wood and non-wood forest products; Implementing a national level mass afforestation programme to expand and maintain optimum forest cover; Maximizing forest areas by investing in available communal lands/ shamlat, and Guzara forests and urban forestry; Facilitating and harmonizing inter-provincial movement, trade and commerce of wood and non-wood forest products through the Federal Forestry Board; Inter-linking natural forests, protected areas, wetlands and wildlife habitats to reduce fragmentation; Enhancing role and contribution of forests in reducing carbon emissions and enhancing forest carbon pools; Facilitating implementation of international conventions and agreements related to Forestry, Wetlands, Biodiversity and Climate Change; and Promoting standardized and harmonized scientific forest planning, research and education including for community-based management.	
7	Biodiversity Action Plan, 1999	The basic aim of the plan is to ensure conservation and sustainable use of biodiversity.	The plan recognizes EIA as an effective tool for identifying and assessing the effects of a proposed project operation on biodiversity.
8	Pakistan Labour Policy, 2010	The main objective of the Labour Policy, 2010 is the social and economic well-being of the labour of Pakistan. The Labour Policy, 2010 has following 4 parts: Legal Framework; Advocacy: rights of workers and employers; Skill development and employment; and Manpower export.	The labour force will be employed for construction of the proposed Project. The provision of policy will apply to all the employed laborers.

Sr. No.	Policy /Strategy	Brief Coverage	Relevance to Project
9	National Disaster Risk Reduction Policy, 2013	NDMA, being the lead focal agency for disaster preparedness and management, has therefore, embarked upon formulation of a comprehensive National Disaster Risk Reduction Policy through wider consultations with all stakeholders including all provinces, state of AJ&K and regions. This policy covers disasters risk reduction in a more holistic way and introduces a proactive and anticipatory approach by laying special emphasis on risk assessment and prevention.	This policy will be elicited if any unforeseen natural and man-made disaster occurs during construction and operation phases.
10	Punjab Climate Change Policy, 2017	This policy proposes measures which address Punjab specific climate change impacts and is in line with National Climate Change Policy (2012) and its Framework for Implementation (2013) Mainstream climate change in long term development planning as a vehicle for the implementation of the provincial Punjab Growth Strategy (PGS)	This policy will accelerate due to the emissions from the construction machinery and equipment.

Table 2-2: Main Legislation/Acts Related to Environment and their Relevance to the Project

Sr. No.	Act	Brief Coverage	Relevance to Project
1	Pakistan Environmental Protection Act, 1997	The Pakistan Environmental Protection Act, 1997 is comprehensive legislation and provides the legislative framework for protection, conservation, rehabilitation and improvement of the environment. The 'environment' has been defined in the Act as: (a) air, water and land; (b) all layers of the atmosphere; (c) all organic and inorganic matter and living organisms; (d) the ecosystem and ecological relationships; (e) buildings, structures, roads, facilities and works; (f) all social and economic conditions affecting community life; and (g) the interrelationships between any of the factors specified in sub-clauses 'a' to 'f'. The notable points of the law are: No proponent of a project shall commence construction or operation unless he has filed an IEE/EIA with the Provincial Agency	The provision of the act is applicable to proposed Project for conducting an EIA according to section 12 and to obtain environmental approval from Pak-EPA.

Sr. No.	Act	Brief Coverage	Relevance to Project
		designated by the Provincial EPAs an EIA, and has obtained an approval; Establishment and formation of the Environmental Protection Council (EPC); Prohibition of certain discharges or emissions; National Environmental Quality Standards (NEQS) for wastewater, air emissions and noise; and Federal Government can issue notices and enforce them to protect the environment.	
2	Punjab Environmental Protection Act, 1997 (Amended, 2012 & 2017)	The Punjab Environmental Protection Act, 1997 (Amended, 2012 & 2017) is comprehensive legislation and provides the legislative framework for protection, conservation, rehabilitation and improvement of the environment. The 'environment' has been defined in the Act as: (a) air, water and land; (b) all layers of the atmosphere; (c) all organic and inorganic matter and living organisms; (d) the ecosystem and ecological relationships; (e) buildings, structures, roads, facilities and works; (f) all social and economic conditions affecting community life; and (g) the interrelationships between any of the factors specified in sub-clauses 'a' to 'f'. The notable points of the law are: No proponent of a project shall commence construction or operation unless he has filed an IEE/EIA with the Provincial Agency designated by the Provincial EPAs an EIA, and has obtained an approval; Establishment and formation of the Punjab Environmental Protection Council(PEPC); Prohibition of certain discharges or emissions; Punjab Environmental Quality Standards (PEQS) for wastewater, air emissions and noise; and Provincial Government can issue notices and enforce them to protect the environment. In the recent amendment of 2012, legislatives powers related to environment and ecology are given to provincial governments from the Federal government. The provinces are required to enact their own legislation for environmental protection. Other amendments include increasing the	The provision of the act is applicable to proposed Project for conducting an EIA according to section 12 and to obtain environmental approval from Punjab EP&CCD. The section 11 of the act is applicable in term of compliance with Punjab Environmental Quality Standards (PEQS). Similarly, section 13 of the act prohibits the import of hazardous waste. The provisions of section 16 are also applicable to comply with the discharge or emission of any effluent, waste, air pollutant or noise or disposal of waste or handling of hazardous substance. Under section 17, penalties will apply if anyone fails to comply with the provisions of section 11, 12, 13 and 16.

Sr. No.	Act	Brief Coverage	Relevance to Project
		penalties for violations. For the proposed Project, Environmental Protection Department (EPD)/Environmental Protection Agency (EPA), Government of Punjab (GoPb) is the concerned authority. The capability of regulatory institutions for environmental management is ultimately responsible for the success of environmental assessments and that development projects are environmentally sound and sustainable.	
3	Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000	The Regulation classifies projects on the basis of expected degree of adverse environmental impacts and lists them in two separate schedules. The Schedule I list projects that may not have significant environmental impacts and therefore require an IEE. The Schedule II list projects of potentially significant environmental impacts requiring an EIA. The Regulations also require that all projects located in environmentally sensitive areas require preparation of an EIA. It also lists Projects not requiring either an EIA or an IEE.	Punjab Mass Transit Authority will be responsible to file an EIA for obtaining environmental approval before the construction of the proposed Project as proposed Project falls under Category D (Transport) of Schedule II, which requires EIA study before the construction of the works.
4	Punjab Environmental Protection Agency, (Review of IEE and EIA) Regulations, 2022	These regulations set out: Key policy and procedural requirements for filing an EIA; The purpose of environmental assessment; The goals of sustainable development; The requirement that environmental assessment be integrated with feasibility studies; The jurisdiction of the Federal and Provincial EPA's and Planning & Development (P&D) Departments; The responsibilities of proponents; Duties of responsible authorities; Provides schedules of proposals that the project requires either IEE or an EIA; The environmental screening process of the projects under schedule I, II and III; and The procedure for the environmental approval for filing the case with the concerned EPA for the granting of the NOC.	The provisions of these regulations are applicable for environmental screening of the Project, which implies that an EIA is required for the proposed Project as proposed Project falls under Category D (Transport) of Schedule II. The process described in the regulation will be useful for PMA to follow the procedure to file an EIA with Punjab EP&CCD and to understand its review process along with timelines to be followed.

Sr. No.	Act	Brief Coverage	Relevance to Project
5	National Environmental Quality Standards (NEQS), 2010	The National Environmental Quality Standards (NEQS), 2010 were established with the primary objective of safeguarding Pakistan's environmental integrity by setting permissible limits for pollutants discharged into the air, water, and land. These standards aim to regulate industrial, municipal, and vehicular emissions to minimize environmental degradation and protect public health. By defining clear limits for various contaminants and encouraging cleaner production practices, the NEQS promote sustainable development, ensure compliance with national environmental policies, and support enforcement mechanisms under the Pakistan Environmental Protection Act, 1997.	NEQS, 2010 are applicable to the proposed Project, as they establish regulatory limits for air emissions, noise levels, and wastewater discharges that may arise during the construction and operational phases. Adhering to these standards will support environmentally responsible Project implementation and is a prerequisite for obtaining environmental approvals from relevant regulatory body.
6	Punjab Environmental Quality Standards (PEQS), 2016	PEQS promulgated recently in 2016. Specified standards under PEQS are for: Drinking Water; Ambient Air; Noise; Industrial Gaseous Emissions; Municipal and Liquid Industrial Effluents; Motor vehicle exhaust and noise; and Treatment of Liquid and Bio-Medical Waste.	PEQS, 2016 are applicable to the proposed Project, as they establish regulatory limits for air emissions, noise levels, and wastewater discharges that may arise during the construction and operational phases. Adhering to these standards will support environmentally responsible Project implementation and is a prerequisite for obtaining environmental approvals from relevant regulatory body.
7	Guidelines for the Preparation and Review of Environmental Reports, 1997	These guidelines describe the format and content of IEE/EIA reports to be submitted to PEPA for obtaining NOC/approval. The guidelines present: The environmental assessment report format; Assessing impacts; Mitigation and impact management and preparing an environmental management plan; Reporting; Review and decision making; Monitoring and auditing; and Project Management.	The guidelines are applicable for the preparation of the EIA.
8	Islamabad Capital Territory Building Control Regulations, 2020	These regulations provides standards for the design and construction of buildings to ensure the safety and health for people in or about those buildings. They also include	These regulations will be applicable during design and construction phases of the proposed Project.

Sr. No.	Act	Brief Coverage	Relevance to Project
		requirements to ensure that the facilities are provided for people to access and move around inside buildings.	
9	Pak-EPA Ban on (Manufacturing, Import, Sale, Purchase, Storage and Usage) Polythene Bags Regulations, 2019	These regulations extended to the entire ICT and provided that all manufacturing, import and wholesale trading of polythene bags shall be banned along with all sale purchase, supply, trade, storage, distribution and use of polythene bags. However, permission has been granted for the use of large-sized polythene bags for hospital waste, hazardous waste and municipal waste. Under the Regulations, the organizations wishing to use polythene flat bags will have to pay an Rs 10,000 fee. While any manufacturer, importer or wholesaler found supplying polythene bags will be fined a sum ranging from Rs 50,000 to Rs 500,000. A shopkeeper or hawker violating the regulation will be fined Rs 10,000 for the first time. The fine may go up to Rs 50,000 for repeated violations.	As proposed Project, activities will generate municipal and hazardous waste therefore, these regulations will trigger during the construction and operational phases.
10	CDA Building Standards for Fire Prevention and Life Safety, 2010	The Building Standards have been divided into three clauses: fire prevention, life safety and fire protection. The fire prevention covers the aspects pertaining to design and construction of buildings on passive fire protection measures, describing various types of building material and their fire safety rating. The life safety provision deals with events of fire and similar emergencies, addressing construction and occupancy features that are necessary to minimize danger to life from fire, smoke, fumes or panic. The protection aspect relates to appurtenance, their related components and guidelines for selecting correct types of equipment and installations meant for fire protection of buildings depending on their classifications and types.	These Standards are applicable to the proposed Project because it involves the construction of building structures (stations).
11	Murree Building Bye-Laws, 2021	The Murree Building Bye-Laws aim to regulate and guide construction activities within the Murree Special Area to ensure environmentally sustainable development, preservation of the area's natural landscape, and protection of its architectural heritage. These bye-laws set standards for building	The Murree Building Bye-Laws are relevant to the construction of the Project, as they establish the regulatory standards for all construction activities within the Murree Special Area. Given that the

Sr. No.	Act	Brief Coverage	Relevance to Project
		height, plot coverage, floor area ratio (FAR), setbacks, and aesthetic design to maintain the scenic and ecological integrity of Murree, which is a prominent tourist destination and environmentally sensitive zone. Additionally, the bye-laws seek to control haphazard urban expansion, minimize deforestation, prevent soil erosion, and safeguard against geological and climatic hazards such as landslides and heavy snowfall.	Project involves the development of infrastructure such as stations, tunnels, and bridges in this environmentally sensitive and ecologically fragile region, strict compliance with these bye-laws is necessary. They are designed to minimize environmental impacts, protect the natural landscape, and preserve the distinctive architectural character of Murree. Adhering to these regulations will also help mitigate risks such as soil erosion, landslides, and deforestation, thereby promoting sustainable development consistent with the region's conservation goals.
12	Islamabad Fire Prevention and Life Safety Regulations, 2010	It provide measures to prevent and control the fire to cope with any untoward incident in case of fire and to control damage and casualties in buildings and premises in the Islamabad Capital Territory. Under the safety regulations CDA has the powers to get vacated or seal any building or impose fine up to Rs. 500,000/- if it finds any violation of Fire Prevention and Life Safety regulations.	These Regulations are applicable to the proposed Project because it involves the construction of building structures.
13	Standard Operating Procedure (SOP) for Management of Sanitation Services in Islamabad, 2008	SOP provides procedure for adequate measures for efficient sanitation and solid waste collection, storage, disposal and management.	These SOP are applicable to the proposed Project for the efficient management of solid waste and sanitation facilities during the construction and operational phases.
14	Solid Waste Management Guidelines, 2005	Guidelines for Solid Waste Management have been issued as a draft by the Pakistan Environmental Protection Agency in coordination with JICA and UNDP in 2005. These guidelines explain the waste generation, discharge, composition and its handling and management.	The handling, transportation and final disposal of waste generated during construction and operation phases of the proposed Project will be done in view of these guidelines.
15	Pakistan Trade Control of Wild Fauna and Flora	The rule requires to safeguard the trade of endangered wildlife flora and fauna and it also established a permit system to control	These rules will be applicable as Endangered Species of wild fauna and flora is present

Sr. No.	Act	Brief Coverage	Relevance to Project
	Rules, 2018	imports and exports of these wild species.	in the vicinity of the Project area as proposed Project alignment passes through reserved forests and protected areas.
16	Pakistan Climate Change Act, 2017	This Act aims to meet obligations under international conventions relating to climate change and to provide for adoption of comprehensive adaptation and mitigation policies, plans, programmes, projects and other measures required to address the effects of climate change and for matters connected herewith and ancillary thereto.	This Act will accelerate due to the emissions from the construction machinery.
17	Land Acquisition Act (LAA), 1894 Including Later Amendments	The Land Acquisition Act, 1894, is a "law for the acquisition of land needed for public purposes and for companies and for determining the amount of compensation to be paid on account of such acquisition". The exercise of the power of acquisition has been limited to public purposes. The principles laid down for the determination of compensation, as clarified by judicial pronouncements made from time to time, reflect the anxiety of the law-giver to compensate those who have been deprived of property, adequately. The land needed for the construction of development projects will be acquired under normal conditions based on prevailing market prices or negotiated prices between client and the owners of land. Section 17(4) of the LAA will not be used in the absence of an emergency. Instead, the land will be purchased under willing-seller willing-buyer deal at agreed upon market rates and the seller will have the option not to sell the land, in case an acceptable deal for both the parties is not reached.	This Act will be applicable if the proposed Project involves land acquisition for the establishment of contractor camps during the construction phase, as well as for the overall construction of the Project infrastructure.
18	Punjab Wildlife (Protection, Preservation, Conservation and Management) Act, 1974 (Amended 2007 & 2021)	This Act provides the legal framework for the protection and conservation of wildlife in Punjab. It defines categories of protected species, regulates hunting, and establishes protected areas such as national parks, wildlife sanctuaries, and game reserves.	The Act is applicable to the Project, as the proposed alignment traverses protected areas and reserved forests within Murree and Islamabad. This legislation provides a legal framework for the conservation of wildlife and their habitats, particularly in ecologically sensitive zones such as wildlife sanctuaries

Sr. No.	Act	Brief Coverage	Relevance to Project
			and national parks. Compliance with the provisions of this Act will be essential to ensure that the Project does not adversely impact wildlife and protected species or disturb ecological balance. Accordingly, necessary permissions from the Punjab Wildlife Department will be required, along with detailed ecological assessments and the implementation of appropriate mitigation measures.
19	Pakistan Antiquities Act 1975 & Punjab Antiquities Amendment Act 2012	The Punjab Antiquities Amendment Act, 2012 is adopted from the Pakistan Antiquities Act of 1975 with a few minor changes. The Antiquities Act, 1975 (amended in 1990) states the following: "Ancient" is any object that is at least 75 years old; The Government is the owner of all buried antiquities discovered on any site, whether protected or otherwise; All new construction within a distance of 200 feet from protected antiquities is forbidden; No changes or repairs can be made to a protected monument, even if it is owned privately, without approval of the responsible authorities; and The cultural heritage laws of Pakistan are uniformly applicable to all categories of sites regardless of their state of preservation and classification as monuments of national or world heritage.	The law will be applicable to the Project mainly due to its two provisions: According to the law, any construction activity within 61 m or 200 ft. of protected antiquities, are prohibited. The provisions of this act would also be applicable, if any accidental archaeological discoveries may occur during the excavation works for the construction of proposed Project.
20	The Punjab Special Premises (Preservation), Ordinance, 1985	The Punjab Special Premises (Preservation), Ordinance (1985) provides the legal framework for preservation of premises of historical, cultural, archaeological, and architectural value in the Punjab province. This legislation empowers the provincial government to notify heritage sites and sites of cultural and archaeological importance and to prohibit implementation of developmental schemes or new constructions within the notified areas around	The provision of the ordinance is applicable for protection and conservation of special premises declared by department of Youth Affairs, Sports, Archeology & Tourism, Punjab. The ordinance is applicable in terms of land acquisition, entrance, exploitation and destruction of special

Sr. No.	Act	Brief Coverage	Relevance to Project
		the special premises. So far 246 sites stand notified under the Punjab Ordinance.	premises near site.
21	Pakistan Penal Code, 1860	The Code deals with the offences where public or private property or human lives are affected due to intentional or accidental misconduct of an individual or organization. The Code also addresses control of noise, noxious emissions and disposal of effluents.	The provisions of the Penal Code, 1860 are applicable to the Project in terms of penalties for effecting human lives and public property. It also addresses the control of noise, air emissions and effluent disposal.
22	Labour Laws as part of Constitution of Pakistan 1973,	The Constitution of Pakistan contains a range of provisions with regards to labour rights, in particular: Article 11 of the Constitution prohibits all forms of slavery, forced labour and child labour; Article 17 provides a fundamental right to exercise the freedom of association and the right to form unions; Article 25 lays down the right to equality before the law and prohibition of discrimination on the grounds of sex alone; and Article 37(e) makes provision for securing just and human conditions of work, ensuring that children and women are not employed in vocations unsuited to their age or sex, and for maternity benefits for women in employment. Labour law is controlled at both provincial and national levels with compulsory employment agreements containing the terms set out by the labour laws. The labour laws are a comprehensive set of laws in Pakistan dealing with the following aspects: Contract of Employment; Termination of Contract; Working Time and Rest Time; Working hours; Paid Leave; Maternity Leave and Maternity Protection; Other Leave Entitlements; Minimum Age and Protection of Young Workers; Equality Pay Issues; Workers' Representation in the Enterprise; Trade Union and Employers Association	The labour laws will be relevant as it would deal with employment of labour for the construction of proposed Project. Following are the major labour laws which are applicable to the Project: Bonded Labour System (Abolition) Act, 1992 Employment of Child Act, 1991 Minimum Wages Ordinance, 1961 Industrial Relations Act, 2010 West Pakistan Minimum Wages for Unskilled Workers' Ordinance, 1969

Sr. No.	Act	Brief Coverage	Relevance to Project
		Regulation; and Other Laws.	
23	Punjab Municipal Water Act, 2014	The basic aim of the Act is to recognize, regulate and manage present and future municipal water supply and sanitation services and to establish rights of access to basic water supply and basic sanitation, and to ensure conservation of water resources in the Province. This Act is in draft stage.	This Act will elicit if there is misappropriation of water supply during construction and operational phases.
24	The Punjab Water Act, 2019	This act ensures comprehensive management and regulation of water resources in the Punjab in the interest of conservation and sustainability.	This Act will be triggered due to the presence of water bodies (Rawal Lake, Lai Nullah, Korang River Tributary, Jinnah Stream and Murree Water Fall) within the vicinity of the study area.
25	Hazardous Substance Rules, 2003	The rule describes the procedure of handling, transportation and disposal of hazardous substances and hazardous waste. Inter alia, general safety precautions for handling hazardous substances as well as safety precautions for workers, and notification requirements in the event of an accident are described in these rules. Requirements for project waste management plans are also defined. These include a requirement for updating the plan every three years, the need to provide for management of hazardous waste in a manner that will prevent adverse environmental impacts and to ensure that hazardous and non-hazardous waste are not mixed.	This rule is applicable to the proposed Project due to involvement of hazardous waste handling, use and disposal during the construction stage.
26	Punjab Environmental Protection (Motor Vehicles) Rules, 2013	Subject to the provisions of this act, and the rules and regulations, no person shall operate a motor vehicle from which air pollutants and noise are being emitted in an amount, concentration or level which is in excess of the Punjab Environmental Quality Standards, or where applicable the standards established under clause (g) of subsection (1) of section 6 of the act.	This act will be elicited during construction phase due to use of motor vehicles that produces air pollutants and noise.
27	Pakistan Occupational Health and Safety Act, 2018	The main objective of this Act is to provide for a balanced and nationally consistent framework to secure the health and safety of workers and workplaces by: Protecting workers and other persons against harm to their health, safety and welfare through the elimination or	This act will be triggered during construction and operational phases to ensure health and safety of skilled and unskilled workers associated with the Project activities.

Sr. No.	Act	Brief Coverage	Relevance to Project
		minimization of risks arising from work or from specified types of substances or plant; Providing for fair and effective workplace representation, consultation, Co-operation and issue resolution in relation to work health and safety; Encouraging unions and employer organizations to take a constructive role in promoting improvements in health and safety practices at work and assisting persons conducting businesses or undertakings and workers to achieve a healthier and safer working environment; Promoting the provision of advice, information, education and training in relation to work health and safety; Securing compliance with this Act through effective and appropriate compliance and enforcement measures; Ensuring appropriate scrutiny and review of actions taken by persons exercising powers and performing functions under this Act; Providing a framework for continuous improvement and progressively higher standards of health and safety at work; and Maintaining and strengthening the national harmonization of laws relating to work health and safety and to facilitate a consistent national approach to work health and safety in this jurisdiction.	
28	The Punjab Occupational Safety And Health Act, 2019	This Act entails provision of occupational safety and health of the workers at workplace and to protect them against risks arising out of the occupational hazards; to promote safe and healthy working environment catering to the physiological and psychological needs of the employees at workplace.	The Act will trigger during construction and operational phases to ensure health and safety of workers at workplace associated with the Project activities.
29	Punjab Restriction on Employment of Children Act, 2016	According to the sub-section 11(a) of this Act, an occupier who employs or permits a child (person under the age of 15 years) to work in an establishment shall be liable to punishment with imprisonment for a term which may extend to six months, but which shall not be less than seven days, and a mandatory fine between 10,000 and 50,000 rupees.	This Act will trigger if contract hire skilled and unskilled labour under age 15.

Sr. No.	Act	Brief Coverage	Relevance to Project
30	Punjab Protection of Women against Violence Act, 2016	The act is administered by federal government which provides guidelines for the provision of disaster management plans, offer necessary technical assistance to the Provincial Governments and Provincial Authorities as well for preparing their disaster management plans in case of any mishap.	This act is valid to the subject Project in case of any unseen situation.
31	ISO 18001 Occupation Health and Safety Assessment Series (OHSAS)	OHSAS 18001 is an Occupation Health and Safety Assessment Series for health and safety management systems to help organizations to control occupational health and safety risks. The OHSAS specifications are applicable to any institute that desires to establish an OH&S management system to eradicate or reduce risk to employees and other interested parties who may be exposed to the risks allied with the project activities.	This series will be triggered during construction and operational phases to ensure health and safety of skilled and unskilled workers associated with the Project activities.
32	Electricity Act, 1910	The Act provides a legal basis for distribution of Power. It enables a licensee to conduct operations for supply of electricity and binds the license to payment of compensation in respect of any damages caused during the construction, Operation and Maintenance (O&M) of Power distribution facilities.	This act will be applicable if any damages occur during construction of the power facilities.
33	Cutting of Trees (Prohibition) Act, 1975	The Act was enforced in 1975 to place restrictions on cutting of trees in order to restrain unchecked trend of tree felling without replacement plantations.	This act will be applicable to the subject Project as the cutting of trees may be involved.
34	Islamabad Nature Conservation and Wildlife Management Act, 2023	The Islamabad Nature Conservation and Wildlife Management Act, 2023 aims to provide a comprehensive legal framework for the protection, preservation, and sustainable management of biodiversity and natural habitats within the Islamabad Capital Territory. Its objective is to conserve wildlife species, safeguard ecological balance, and promote the sustainable use of natural resources while enhancing public awareness and ensuring effective governance.	The Act is directly pertinent to the Project, as the proposed alignment traverses ecologically sensitive areas within the Islamabad Capital Territory (ICT), including the Margalla Hills National Park (MHNP). This legislation provides a comprehensive framework for the protection, preservation, and sustainable management of nature in ICT. It empowers the Islamabad Wildlife Management Board (IWMB) to oversee conservation efforts, enforce regulations, and manage protected areas effectively. The Act prohibits activities detrimental to wildlife and

Sr. No.	Act	Brief Coverage	Relevance to Project
			their habitats, including unauthorized construction and encroachments within designated conservation areas. Given that the Murree Glass Train's route intersects these protected zones, the Project must adhere to the provisions of this Act. This includes obtaining necessary clearances from the IWMB, conducting thorough ecological assessments, and implementing mitigation measures to minimize adverse effects on biodiversity and ecosystem services. Non-compliance with the Act could result in legal repercussions and hinder Project approval.
35	Punjab Forest Act (Amended), 2010 and 2016	The act empowers the provincial forest departments to declare any forest area as reserved or protected. It empowers the provincial forest departments to prohibit the clearing of forest for cultivation, grazing, hunting, removing forest produce, quarrying and felling, lopping and topping of trees, branches in reserved and protected forests. 2016 Amendment, made provisions for the use of reserved or protected forest land for national projects of strategic importance, included clauses for reforestation and the declaration of substitute land as reserved or protected forest.	The Act is relevant to the Project since the proposed alignment passes through protected and reserved forest areas in ICT and Murree. The 2010 amendment, which impacted the classification of reserved and protected forests, raised concerns regarding forest conservation. Adhering to these requirements is essential to avoid legal obstacles and ensure the sustainable and lawful execution of the Project.
36	The Punjab Protected Areas Act, 2020	The Act provides provisions for the protection, preservation, conservation and management of ecologically important areas such as National parks, Nature reserves, Wildlife sanctuaries, Wilderness areas, Buffer zone, Wetlands, etc.	The Act is applicable to the Project, as the proposed alignment passes through protected and reserved forest areas in Murree. This legislation provides a framework for the conservation, management, and sustainable use of ecologically sensitive regions within Punjab. It authorizes

Sr. No.	Act	Brief Coverage	Relevance to Project
			the Punjab Wildlife and Parks Department to designate and oversee protected areas to preserve biodiversity and natural resources. Consequently, the Project must comply with the requirements of this Act by securing necessary approvals for any land use changes, conducting thorough ecological assessments, and implementing appropriate mitigation measures to minimize negative effects on the ecosystem. Adherence to this Act is crucial to align the Project with regional conservation goals and promote sustainable development.
37	Guzara Forest Rules, 1950	The Guzara Forest Rules designed to govern the sustainable management and protection of Guzara forests, which are community-owned forest lands commonly found in and around Hazara, Murree, and Rawalpindi. These rules aim to conserve forest resources, prevent unauthorized logging, and promote community involvement in forest stewardship, ensuring that local populations can sustainably use the forests for fuelwood, grazing, and other minor products without harming the ecosystem.	The Guzara Forest Rules, are applicable to the Project, as the proposed alignment passes through designated Guzara Forest areas. These rules offer a regulatory framework for the sustainable management of communal forest lands, aiming to safeguard both the ecological integrity of the forests and the rights of local communities. Compliance with these rules is essential to ensure that Project-related activities do not result in environmental degradation or disrupt community access to forest resources. Integrating these regulatory requirements into the planning and implementation phases of the Project will support environmentally responsible development while fostering local community well-being.

Sr. No.	Act	Brief Coverage	Relevance to Project
38	The Punjab Heritage Foundation Act, 2005	This act entails preservation, conservation, maintenance and rehabilitation of the Punjab Heritage through various means, including technical or financial assistance and to create awareness among the people for preservation of the Punjab Heritage.	This act will not be triggered as no heritage sites are present in and around the proposed Project boundary.
39	The Canal and Drainage Act, 1873	The Canal and Drainage Act 1873 (CDA) focuses on construction and maintenance of drainage channels and defines powers to prohibit obstruction or order their removal. It also covers issues related to canal navigation. It briefly addresses issues relating to environmental pollution. Section 70(5) of the CDA clearly states that no one is allowed to "corrupt or foul the water of any canal so as to render it less fit for the purposes for which it is ordinarily used." In addition, Section 73 of the CDA gives power to arrest without warrant or to be taken before the magistrate a person who has wilfully damaged or obstructed the canal or "rendered it less useful."	This Act will be triggered due to the presence of water bodies (Rawal Lake, Korang River and other water resources) within the vicinity of the study area.
40	The Punjab Emergency Service Act, 2006	It deals with the establishment of emergency service for a purpose of maintaining a state of preparedness to deal with emergencies, to provide timely response, rescue and emergency medical treatment to the affected persons and recommending measures to be taken by related organizations to avoid any emergency situation. It describes procedures to establish emergency service, emergency board, emergency fund, emergency ambulance and rescue vehicles, offence and punishment, etc.	This act is applicable to the proposed Project to provide timely response, rescue and emergency medical treatment to the affected persons during construction and operation phases of the Project.
41	National Disaster Management Act, 2010	National Disaster Management Act, 2010 was passed by Parliament of Pakistan in 2010. The Act applies to whole Pakistan. The Act was passed in backdrop of 2010 Floods in Pakistan and strengthens Disaster Management system.	This Act will be triggered due to the presence of water bodies (Rawal Lake, Lai Nullah, Korang River Tributary, Jinnah Stream and Murree Water Fall) within the vicinity of the study area, which are subject to flooding in the past. Therefore, this acts necessities consideration to disasters and risk management strategies during design, construction and operational phases.

Sr. No.	Act	Brief Coverage	Relevance to Project
42	Seismic Building Code of Pakistan 2007	This code stipulates the minimum requirements for seismic safety of building and structures and the provisions of the Building Code of Pakistan (Seismic Provisions-2007) shall apply for engineering design of buildings, like structures and related components. Construction of buildings shall be considered as violation of professional engineering work specified under clause (XXV) of section 2 of the Act.	This Code is applicable to the proposed Project as it includes the formation of structures.
43	Building code of Pakistan, Fire Safety Provisions, 2016	Building Code of Pakistan-Fire Safety Provisions-2016 provide rules for fire prevention, life safety in relation to fire and fire protection of buildings and structures as prescribed. Building Code of Pakistan-Fire Safety Provisions-2016 is applicable in the design of proposed expansion.	Building Code of Pakistan-Fire Safety Provisions-2016 is applicable in the design of proposed Project. The Project contractors are bound by regulations to consider this for the activities which involve the related activities.
44	Building code of Pakistan, 2021	Building code of Pakistan 2021 is a code to establish the minimum requirements for safety, health and general welfare through structural strength, means of egress, stability and sanitation, light and ventilation, energy conservation and for providing a reasonable level of life safety and property from fire hazards, explosion or dangerous conditions.	This Code is applicable to the proposed Project to ensure the health and safety of workers against fire and explosion.

2.3 INTERNATIONAL PROTOCOL / CONVENTIONS

All applicable international conventions for the proposed Project to which Pakistan is signatory are discussed briefly in Table 2-3.

Table 2-3: International Conventional and its Relevancy to the Proposed Project

Sr. No.	Name of International Convention	Brief Coverage	Relevancy to the Proposed Project
1	United Nation Framework Convention on Climate Change (UNFCCC) Amended, 2015	The objective of the Convention is to stabilize greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system." Such a level should be achieved within a time frame	The implementation of the proposed Project is expected to result in greenhouse gas (GHG) emissions, primarily arising from construction activities. During the operational phase, emissions may occur due to the use of generators at stations and energy consumption associated with the operation of the electric train system.

Sr. No.	Name of International Convention	Brief Coverage	Relevancy to the Proposed Project
		sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.	
2	Kyoto Protocol (Amended), 2012	The Kyoto Protocol aimed to reduce carbon dioxide (CO2) emissions and the presence of greenhouse gases (GHG) in the atmosphere.	The implementation of the proposed Project is expected to result in greenhouse gas (GHG) emissions, primarily arising from construction activities. During the operational phase, emissions may occur due to the use of generators at stations and energy consumption associated with the operation of the electric train system.
3	UNESCO Convention on the Protection of the World's Cultural and Natural Heritage, 1972	The convention aims the protection of the natural and cultural heritages.	At this stage convention will not be applicable as no world's cultural and natural heritage site is present in and around the Project area. However; this convention will be applicable if any cultural property will be found during excavation.
4	Paris Agreement, 2015	The Paris Agreement's central goal is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below to two degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to one and half degrees celsius. Additionally, the agreement aims to increase the ability of countries to deal with the impacts of climate change, and at making finance flows consistent with a low GHG emissions and climate-resilient pathway.	The proposed Project is expected to generate greenhouse gas (GHG) emissions, mainly during the construction phase as a result of machinery use, material transport, and related activities. In the operational phase, emissions may arise from the use of backup generators at stations.
5	The Convention on Conservation of Migratory	The Convention requires countries to take action to	There are no Migratory Species of Wild Animals in the vicinity of the

Sr. No.	Name of International Convention	Brief Coverage	Relevancy to the Proposed Project
	Species of Wild Animals, 1979	avoid endangering migratory species. The term "migratory species" refers to the species of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries. The parties are also required to promote or cooperate with other countries in matters of research on migratory species.	Project area.
6	Basel Convention, 1994	In 1994, Pakistan signed Basel Convention that restricts trans-boundary movements of "Hazardous Waste and their Disposal'' with aim to protect human health and surrounding environment by minimizing the use of hazardous waste production.	The proposed Project will not be necessitating the endowment of this convention.
7	International Union for Conservation of Nature and Natural Resources Red List, 2000	This enlists wildlife species experiencing various levels of threats internationally. Some of the species indicated in the IUCN red list are also present in the wetlands of Pakistan.	Several wildlife species found in and around the Project area are subject to varying degrees of threat, as identified in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2000). This list categorizes species based on their risk of extinction, and the presence of such species in the vicinity underscores the ecological sensitivity of the area and the need for appropriate conservation measures.
8	Millennium Development Goals (MDGs)	The Millennium Development Goals (MDGs) were adopted in the General Assembly of the United Nations in the year 2000 by all the countries of world and the world's leading developmental institutions.	The MDGs that will prevail for the proposed Project are as follows: Promote Gender Equality and Empower Women: PMA during operational phase will be responsible to hire women for operational activities to elude gender discrimination and to promote women empowerment. Combat HIV/AIDS Malaria and Other

Sr. No.	Name of International Convention	Brief Coverage	Relevancy to the Proposed Project
			Diseases: Contractor and PMA will be responsible to conduct medical surveillance of the workers before hiring to combat HIV/AIDS, Malaria, COVID-19 and other diseases. Ensure Environmental Sustainability: Contractor and PMA will be responsible to ensure environmental sustainability of the proposed Project area by ensuring implementation of EMP to mitigate adverse environmental impacts from construction and operational activities during implementation stage.
9	Convention on the International Trade of Endangered Species (CITES), 1975	The Convention requires countries to safeguard the trade in rare or endangered species and it established a permit system to control imports and exports of wild fauna and flora.	Endangered species of wild fauna and flora are present in the vicinity of the Project area, which brings the site under the purview of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1975. This convention aims to ensure that international trade in specimens of endangered species does not threaten their survival, highlighting the need for careful assessment and protection measures during Project planning and implementation.

2.4 ADMINISTRATIVE FRAMEWORK

2.4.1 PUNJAB MASS TRANSIT AUTHORITY (PMA)

The implementing agency of the proposed Project is Punjab Mass Transit Authority (PMA). The management of PMA will ensure that all the proposed mitigation measures are effectively implemented at the design, construction, and operation stages of the proposed Project.

Since the proposed alignment of the Project passes through both Islamabad and Murree, therefore, PMA will be responsible for obtaining the necessary No Objection Certificates (NOCs) from the Pakistan Environmental Protection Agency (Pak-EPA) and the Environmental Protection Department & Climate Change Directorate (EP&CCD), Punjab.
Pakistan Environmental Protection Agency (Pak-EPA)

2.4.2 Pakistan Environmental Protection Agency (Pak-EPA)

As the proposed Project falls under the administration jurisdiction of Islamabad therefore; Pak-EPA will be responsible for reviewing the proposed Project report, issuing environmental approval and overall/broad-based monitoring of the proposed Project activities, in accordance with the Pakistan Environmental Protection Act, 1997

Environmental Protection and Climate Change Department (EP&CCD), Punjab

2.4.3 Environmental Protection and Climate Change Department (EP&CCD), Punjab

As the proposed Project falls under the administration jurisdiction of Murree District, Punjab therefore; EP&CCD-Punjab will be responsible for reviewing the proposed Project report, issuing environmental approval and overall/broad-based monitoring of the proposed Project activities, as per Punjab Environmental Protection Act, 2017 (Amended).

3 PROJECT DESCRIPTION

3.1 GENERAL

This Chapter presents the detailed project description along with project cost, land requirement, implementation schedule, workforce and water requirements, etc.

3.2 VISION OF THE PROJECT

The Murree Glass Train project embodies a visionary initiative by the Punjab government to revolutionize tourism and regional connectivity in Pakistan. This ambitious endeavor aims to blend modern infrastructure with the country's natural beauty, offering a unique travel experience while fostering economic growth and environmental sustainability.

3.3 OBJECTIVES OF THE PROJECT

The proposed project aims to enhance tourism by introducing a glass train that offers panoramic views of the scenic mountainous landscapes, similar to those found in other countries of the globe. The main objective of the proposed project is to provide an alternative mode of transport for tourists who typically rely on private vehicles.

3.4 PROJECT ADMINISTRATIVE JURISDICTION

The proposed Project lies in District Lahore, Punjab.

3.5 PROJECT IMPLEMENTATION SCHEDULE

The tentative implementation period for proposed Project is twenty-four (24) months.

3.6 COST OF THE PROJECT

Tentative cost of the proposed Project is about PKR 255 Billion.

3.7 PROPOSED PROJECT

The glass train will provide a direct rail link between Rawalpindi and Murree, making it easier for tourists to access this popular hill station. Proposed Glass Train project starts from H-9 Margalla Station, Islamabad, passes through Khyaban-Johar Metro Station, bypasses parade ground and runs along Lake View Park. It will then cross Barakahu, Chattar Park, Manga continue through Ghora Gali and terminates at Muree Bus Stand.

The proposed track spans a total length of 59 kilometers, with an estimated travel time of 114 minutes. The proposed Alignment plan of the Tourist Glass Project is provided as **Figure 3.1**.

3.7.1 Salient Features of the Project

Table 3.1 summarizes the salient features of proposed project.

Table 3.1: Technical Parameters of proposed Project

Murree Glass Train	
Origin	H-9 Margalla Station
Destination	Murree Bus Stand
Stations	11
Travel Time (min)	114
Length(Km)	59
Bridges (No.)	9
Bridges (km)	21
Tunnels (No.)	2
Tunnels (km)	8.2
Gradient (%)	max. 4.8%

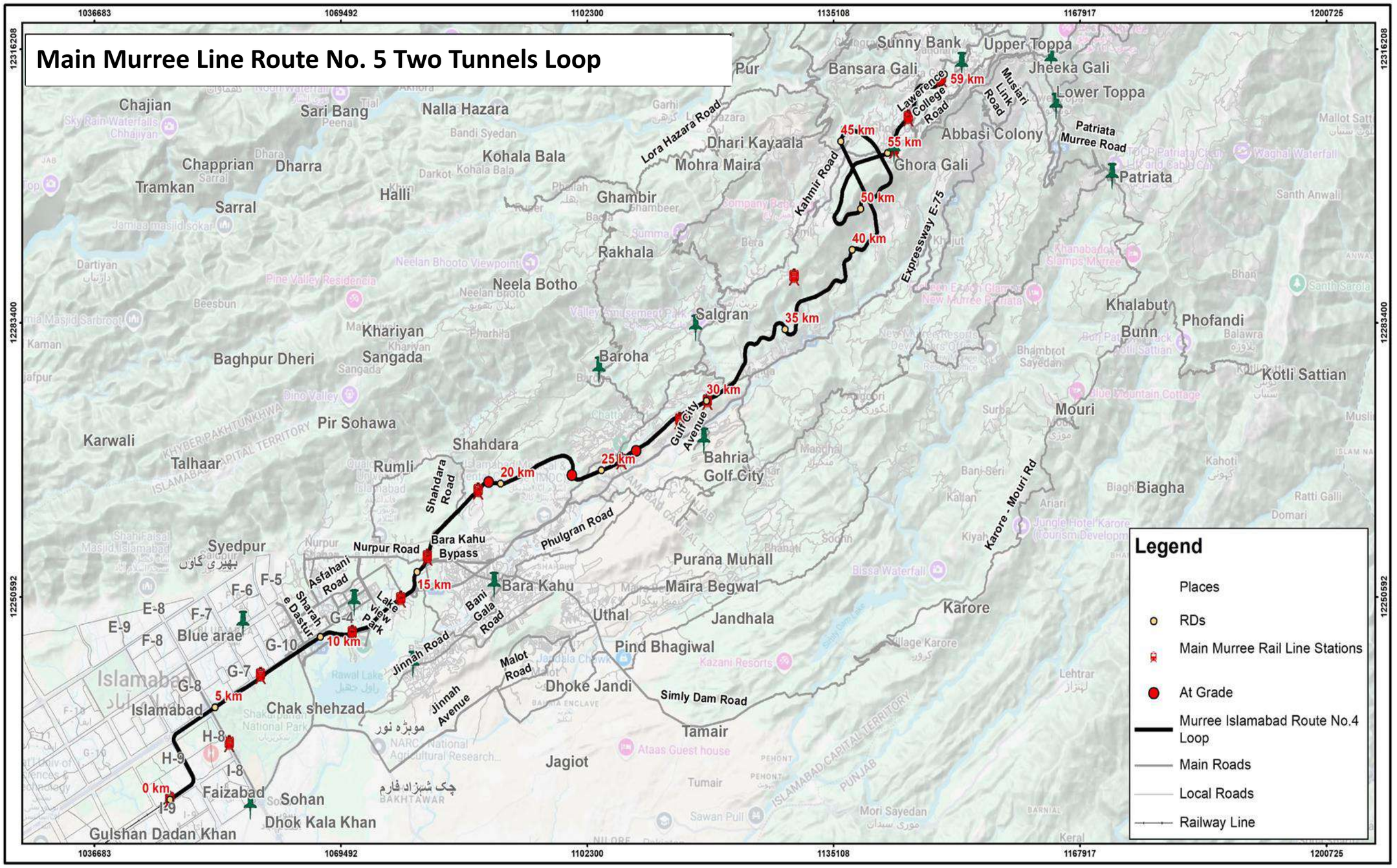


Figure 3.1: Route Alignment of the Muree Glass Train Project

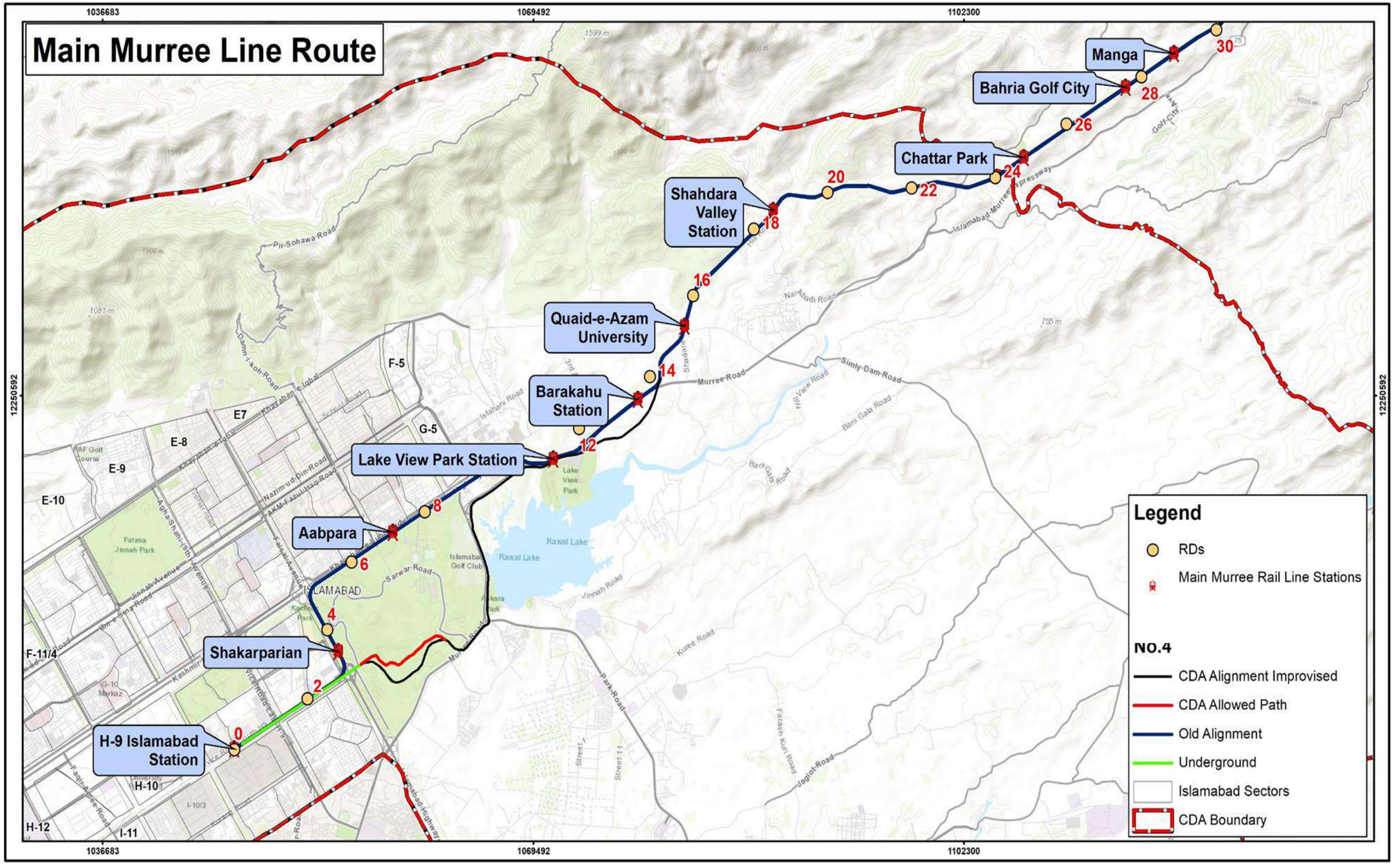


Figure 3.2: Proposed Stations of the Muree Glass Train Project

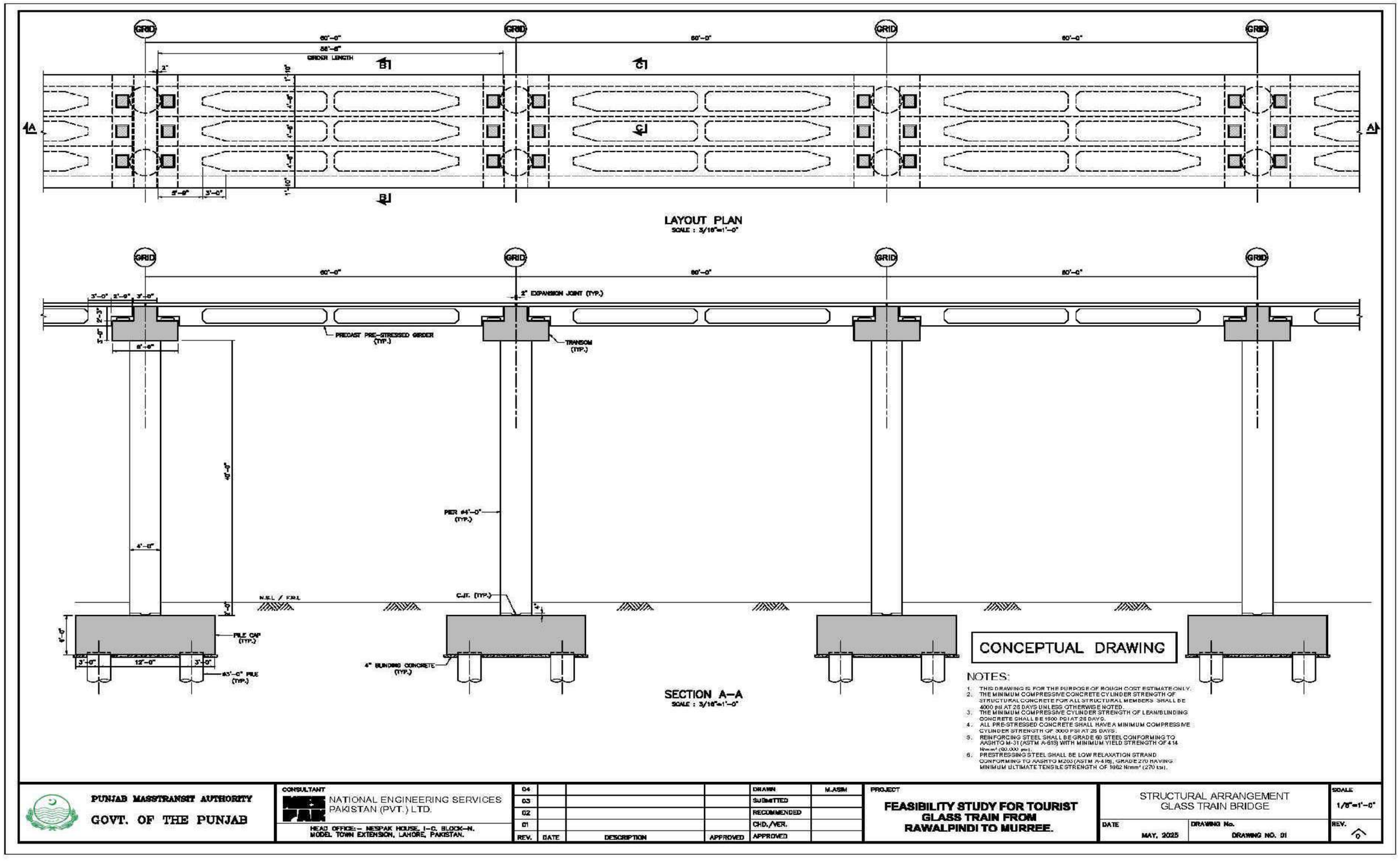


Figure 3.3: Typical Cross-section of the Bridge for Muree Glass Train Project

3.8 CONSTRUCTION MATERIAL

The materials used in construction of the proposed project would include following but not limited to: cement, sand, aggregates, stones, reinforced cement concrete frame (RCC Frame), brick infill, brick cladding coarse aggregates (crush), fine aggregates (sand), water, asphalt, reinforcement cement and steel.

a) Crushed Aggregate of required specifications will be utilized by the contractor from available sources nearby the project area.

b) Good quality natural fine aggregate or sand of acceptable gradation will be obtained from nearby licensed or approved entities dealing with fine aggregates.

c) Asphalt, reinforcement and cement material will be transported from the nearby factories or approved dealers for construction purposes.

3.9 EXPECTED EQUIPMENT'S FOR CONSTRUCTION

The list of the machinery and the equipment expected to be used for the proposed Project are provided in **Table 3.3**.

Table 3.2: Machinery and Equipment Requirement for the Proposed Project

Sr. No.	Machinery Name	Sr. No.	Machinery Name
1	Dump Truck	12	Self-Propelled Pneumatic Roller
2	Front End Loader	13	Asphalt Distributor
3	Dozer	14	Batching Plant
4	Grader	15	Concrete Transit Truck
5	Vibratory Roller	16	Concrete Pump
6	Water Tankers	17	Excavator
7	Aggregate Spreader	18	Water Pumps
8	Three Wheel Rollers	19	Cranes
9	Tandem Roller	20	Vibrators
10	Asphalt Plant	21	Generators
11	Paver		

3.10 CONSTRUCTION CAMPS

Construction camps for the construction of proposed Project components will be located within the premises of proposed Project.

However, if construction camp is to be located outside the project boundary, following criteria shall be adopted by the Contractor to identify and for the establishment of the construction camp sites before start of the construction:

- There should be no or minimum resettlement issues for the location of the camps;
- Camp site should be away from the residential areas and sensitive receptors;

- Selection of sites for construction camps shall be near the project area having proper access to the nearby main/link road;
- The camps must be located in a place where the drainage from and through the camps will not threaten any domestic or public water supply;
- Camp site must be adequate in size to prevent overcrowding of necessary structures;
- The camp site should consider avoiding any damage of property, vegetation, irrigation, and drinking water supply systems;
- The camp site must not be subject to periodic flooding; and
- There should not be any ecological sensitive areas e.g. wildlife sanctuaries, game reserves, national parks, forest areas, etc. near to the construction camp site.

3.11 WORKFORCE REQUIREMENTS

Manpower demand estimation is an essential component to facilitate deployment of manpower. Tentative workforce required for proposed Project during construction phase will be about 200 workers/employees. Unskilled labor should be hired locally.

3.12 SOURCE OF WATER

Contractor will be responsible to arrange water for construction works. However, it is supposed that water bowsers will be used by the contractor on the site for construction activities. The source of water during the operation phase for the proposed Project will be the tube wells installed inside the project boundary.

3.13 WATER REQUIREMENT

The water consumption for construction phase is estimated to be 8,000 liters/day for 200 workers during construction phase of the proposed Project.

3.14 WASTEWATER GENERATION AND TREATMENT MECHANISM

The wastewater generation is estimated to be 6,600 liters/day for 200 construction workers during construction phase of the proposed Project[2]. Temporary toilets with cesspit will be adequately installed and treated periodically, and after the completion of work, the ground will be restored.

3.15 SOLID WASTE

The solid waste generation is estimated to be 120 kg/day for 200 construction workers during construction phase of the proposed Project[3].

[2] Design Criteria of Public Health Engineering for Water Supply, Sewerage and Storm Water Drain (Domestic sewage generation = 80% of water consumed/day

[3] Source: Estimated solid waste generation rate in major cities of Punjab is about 0.6 kg/person/day (https://www.lwmc.com.pk/uc-plan.php).

3.16 POWER REQUIREMENT / POWER SOURCE

The main source of electricity/electric power during construction phase will be diesel generators for construction camps. The source of power for operation phase will be Islamabad Electric Supply Company (IESCO).

3.17 ALTERNATIVE ASSESSMENT

This section presents the different alternatives that have been considered in the project. The analysis has been carried out critically so as to justify the need of the project and the selected options. Besides the economic viability, environmental sustainability and social soundness of the proposed project have also been considered when analyzing various alternatives. The alternatives that have been considered during this study are:

- No Project Option (NPO);
- Route Alternatives; and
- Technological Alternatives.

3.17.1 No Project Option

Presently, people rely on private vehicles to approach the Murree and surrounding areas. In the absence of the proposed project, the region is likely to face several issues due to the continued reliance on private vehicles and un-regulated tourism. One of the most immediate consequences would be a sharp increase in traffic congestion, especially during peak tourist seasons. The growing number of vehicles will also contribute to higher levels of air pollution and greenhouse gas emissions, further deteriorating air quality and posing serious health risks to the local population.

Moreover, without a sustainable transport solution, the pressure to expand road infrastructure and parking spaces will likely result in deforestation and the encroachment of forested areas. This will lead to habitat loss, reduced biodiversity, and an overall decline in the ecological health of Murree's sensitive environment.

The cumulative effect of these challenges may deter tourists over time, resulting in a gradual economic decline. Furthermore, the opportunity to develop a cleaner, more efficient, and potentially iconic transport system that could enhance Murree's appeal and support local livelihoods would be lost. Thus, it is important to provide the public transport facilities to cater the increased vehicular movement and traffic congestion.

3.17.2 Route Alternatives

The Train route selection is the process of selecting an optimized route for the construction of a rail track and all efforts were made to cause no or minimum damage to the environment. Optimization of track route helps not only in minimizing the superfluous level of efforts but also to optimize the time and resources. The route alignment has been finalized by

considering following features and efforts have been made to avoid or minimize impacts to the environment and social aspects.

- Game reserves;
- Wildlife sanctuaries;
- Reserved forest and ecologically important areas;
- Settlements;
- Topography steep slopes and high altitudes for construction ease;
- Water source (large water bodies, major rivers, etc.);
- Major roads and transmission line crossings;
- Archaeological historical spots; and
- Graveyards and culturally important areas.

3.17.2.1 Route Analysis

The approach for alignment design focuses on selecting a technically viable, cost-effective, and environmentally sustainable route. To achieve this, the consultant has identified five (05) potential route options for the proposed railway line, tentatively spanning 50 km from the starting point to the hilltop destination. **Figure 3.4** shows the alternative routs of proposed project.

Option-I: Red Line

Proposed Option-I starts at H-9 Islamabad takes a relatively direct path through Islamabad's central sectors, passing via Diplomatic Enclave, Bani Gala, and Bara Kahu, before moving into the forested hilly terrain leading to Patriata. While this route provides a central and accessible connection for commuters and tourists alike, it intersects significantly with sensitive forest zones and strategic areas raising potential environmental and security concerns.

Option-II: Blue Line

Proposed Option-II starts from Islamabad Railway Station runs north through Diplomatic Enclave and curves eastward past Shahdara, Bastal Morr, and connects to Murree Hill Top and Upper Murree areas.

This route offers strong access to traditional Murree settlements and scenic viewpoints, making it ideal for tourism. However, it traverses steeper gradients and denser forested zones, which may make construction more challenging and environmentally disruptive. Moreover, it also intersects the extensive built-up area which may lead significant displacement of residents, loss of livelihoods, and disruption of local communities.

Option-III: Black Line

Proposed Option-III moves parallel to the proposed Red Line, starts at H-9 Islamabad, passes through Khyaban-Johar Metro Station, bypasses parade ground and move towards Lake View Park station, Barakahu station, Chattar Park station and Manga Station then separates from red line and passes through forest area and terminates at Muree Bus Stand. The proposed alignment also passes through forest area and various settlements. The accessibility issues

ollows a southern alignment from Islamabad, bypassing central Murree altogether and heading toward Patriata through Karore. This route has the advantage of lower environmental sensitivity due to fewer forest intersections. However, it lacks connectivity to major urban settlements, which might reduce its utility for regular commuters.

Option-IV: Green Line

Green Line follows a practical route through Shahdara, Ghora Gali, and Bastal Morr, aligning closely with the existing Murree Road corridor. This route offers a balance between accessibility and feasibility, as it partially overlaps with developed areas, reducing the need for extensive forest clearing. It also provides strategic access to both tourism and residential nodes, making it highly functional for daily and seasonal ridership.

Option-V: Pink Line

Pink Line takes a long eastern path via Karore-Mouri Road, ultimately reaching Patriata**,** New Murree. This option may be visually appealing due to its scenic isolation and reduced urban interference, but it is the longest route and passes through remote terrain, increasing the construction and maintenance complexity.

3.17.2.2 Selected Route

After evaluating all five alignments, **Option 4 (Green Line)** appears to be the most balanced and suitable route. It offers effective connectivity to both Islamabad and Murree's main urban and tourist areas, aligns with existing infrastructure where possible, and minimizes major ecological disruption compared to Option 1 or 2. While some forest areas will still be affected, the route’s integration with existing road networks can reduce the need for excessive land clearance. Furthermore, its moderate slope and central location enhance its feasibility for both tourism and daily use, making it a strong candidate for sustainable development.

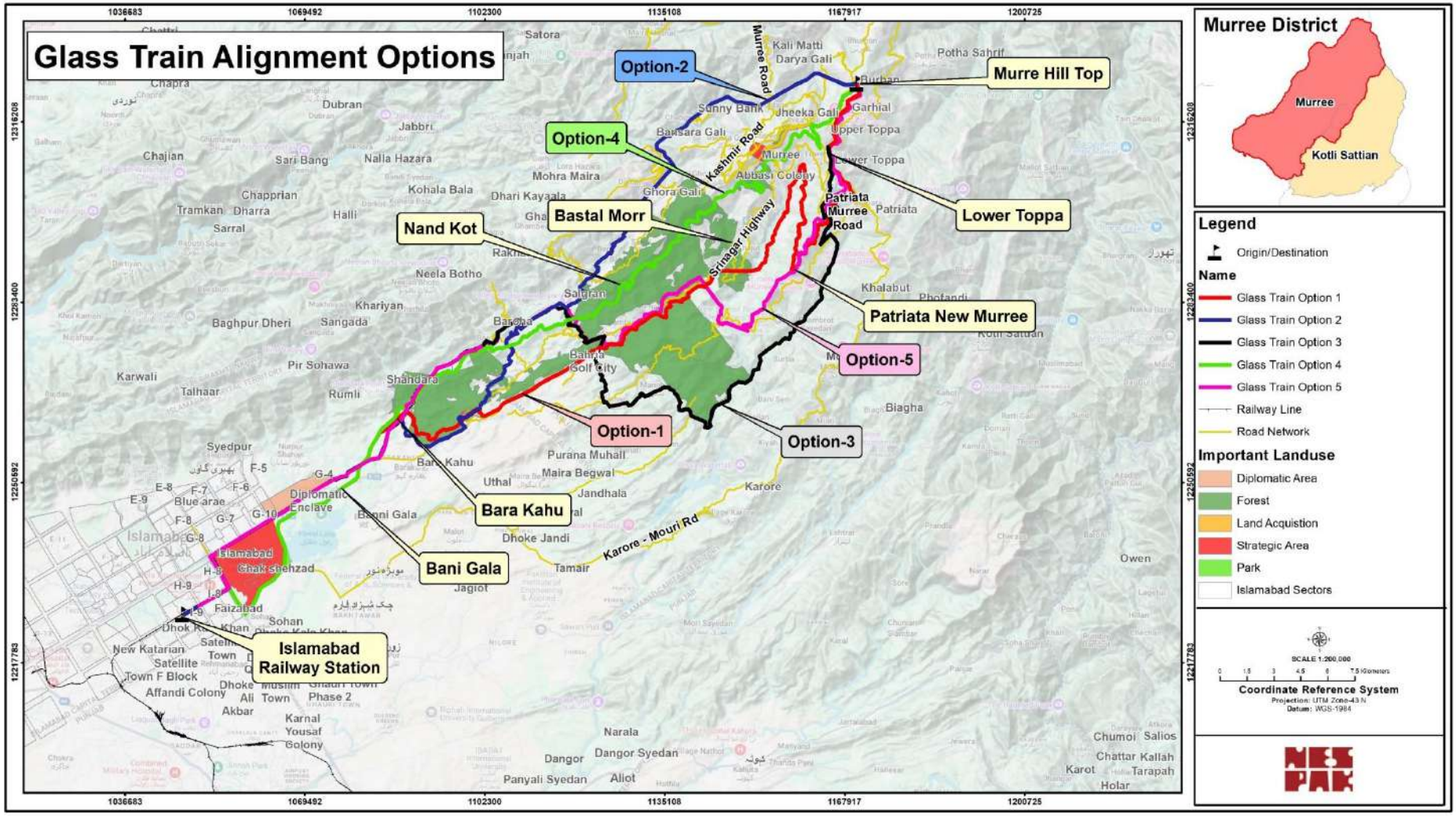


Figure 3.4: Murree Glass Train Glass Train Alternate Routes

3.17.3 Technological Alternatives

Three rail transport options were considered for the proposed Murree train system that includes the Conventional Rail System, the Elevated Light Rail System, and the Straddle Mono Rail System as shown in **Figure 3.5**.

A detailed cost and technical comparison of three proposed rail system options was carried out. Each option varies in terms of alignment, construction complexity, infrastructure components, and financial implications.

3.17.3.1 Option 1 – Conventional Rail System

The Conventional Rail System relies on a mix of at-grade (ground level) tracks, bridges, and tunnels. This alignment uses EMU (Electric Multiple Unit) or DMU (Diesel Multiple Unit) trains and requires an Overhead Catenary System (OCS) for electrification along the entire route.

Due to the extensive construction and engineering requirements with highest construction cost. This option, while technically feasible, poses environmental and cost challenges due to the high number of bridges and tunnels needed in hilly terrain.

3.17.3.2 Option 2: Elevated Light Rail Transit (LRT)

The Elevated Light Rail System consists of trains operating on elevated concrete structures with embedded rails, allowing it to bypass road-level obstructions and terrain irregularities. It uses EMU trains and is powered by third rail electrification, which provides power through a rail located alongside or between the tracks. This system is suitable for urban and semi-urban areas and can be integrated into existing transport infrastructure with fewer disruptions to ground-level activities. The construction cost is significantly lower than the conventional rail.

3.17.3.3 Option 3: Straddle Monorail

The Straddle Mono Rail System offers a more futuristic and compact design, operating on elevated concrete beams without traditional rails. Trains "straddle" a single beam, and power is supplied via an electric channel embedded within the beam itself. This system minimizes land use and visual obstruction, making it ideal for tourist-centric or environmentally sensitive zones. This is the most cost-effective option among the three.

3.17.3.4 Selected option

Overall, while the Conventional Rail system presents the most traditional and structurally robust design, it also proves to be the most expensive and technically complex due to extensive requirements for bridges, tunnels, and land acquisition. The Elevated Light Rail Transit (LRT) offers a more balanced solution, combining moderate cost with reasonable travel time and simplified construction, making it a practical choice for the region. In contrast,

the Straddle Monorail emerges as the most cost-effective and fastest option, ideally suited for Murree's scenic and tourism-oriented corridor. However, it may require higher gradient that may pose operational challenges in steep and mountainous terrain, which would require careful technical evaluation during detailed design.

1. Conventional Rail System



- Mix and Match of At-grade, bridges, and Tunnels Alignment
- Requiring EMU/DMUs Trains
- An Overhead Catenary System (OCS) will be Required through out for Electrification

2. Elevated Light Rail System



- Throughout Elevated on Concrete structure with Embedded Rails
- Requiring EMU Trains
- Third Rail Electrification will be Required through out for Electrification

3. Straddle Mono Rail System



- Elevated on Concrete beams without Rails
- Straddle Mono Trains will be required
- Electrification through an electric Channel provided in Beam

Figure 3.5: Technological Alternatives for Murree Glass Train Glass

Engineering Criteria			
Feature	**Conventional Rail**	**Elevated LRT Rail**	**Straddle Mono Rail**
Support	Ground-level	Pillars and viaducts	Single narrow beam (elevated)
Speed	60–120 km/h	60–90 km/h	60–80 km/h
Capacity	High (passenger & freight)	Medium to high	Low to medium
Land Requirement	Greater ROW Required	Minimal ground-level land	Very minimal land use
Use Case	Intercity, regional, freight	Urban metro, suburban corridors	Hilly Areas and Tourism
Turning Radius	Wide	Medium	Tight (suited for hilly areas)
Noise	High (steel wheels)	Moderate	Low
Aesthetics	Disruptive if in cities	Better urban integration	Sleek, compact, often futuristic look

Figure 3.6: Requirements of Transport Alternatives for Murree Glass Train Glass

4 ENVIRONMENTAL BASELINE

4.1 GENERAL

For any development project, the prevailing environmental conditions need to be assessed prior to the stages of planning, designing and execution of the project. Identification of physical, ecological and social aspects of environment and collection of relevant data is essentially important for the evaluation of impacts as well as for the suggestion of adequate mitigation measures, which forms the basis for the implementation of the proposed project in terms of prevailing environmental and social conditions in the study area.

The existing environmental conditions of the proposed project have been considered within the AOI as shown in **Figure 1.2** with respect to physical, biological and socio-economic aspects. The Study Area is selected on the basis of the Project's potential environmental and social impacts on the local resources. Information has been collected from variety of sources, including published literature, DCRs, field observations and surveys, conducted specifically for this Project have been analyzed for this study. Consultations were also held with the general public and stakeholders of the project area in order to seek the public opinion on the implementation of the proposed Project. Survey tool used for public consultation for baseline data collection during field visit is attached as **Annex-I**.

4.2 PHYSICAL RESOURCES

The following section provides an overview of the information on physical environment of the proposed Project study area collected from primary as well as secondary sources. The major parameters covered include Physiographic and Topography, Geology, Soil, Seismicity, Climate and Meteorology, Ambient Air & Noise, Water Resources, Solid Waste, and Land Use.

4.2.1 Topography

Islamabad

Islamabad is located at 33.43°N 73.04°E at the northern edge of the Pothohar Plateau, between Rawalpindi District and at the foot of the Margalla Hills in Islamabad Capital Territory with general height of 540 m (1,770 ft.) above the mean sea level (MSL).The terrain in Islamabad consists of plains and mountains whose total relief exceeds 1,600 m. The modern capital and the ancient Gakhar City of Rawalpindi form a conurbation, and are commonly referred to as the Twin Cities

The city is divided into four physiographic[4] zones i.e.:

- Margalla Hills;

[4] *JICA (2003) The Study on Comprehensive Flood Mitigation and Environmental Improvement Plan of Lai Nullah Basin in The Islamic Republic of Pakistan, Final Report, CTI Engineering International Co., Ltd., Pacific Consultants International*

- Higher Plain;
- Lower Plain; and
- Valley Area.

Margalla hills are located in the north of the area. The dominant formations are composed of sandstone, shale, and lenses of conglomerates and are covered with permanent mixed scrub and coniferous forest. The ground elevation is up to 1,240 m at the upstream end. There are three major tributaries of Lai Nullah namely Saidpur Kas, Tenawali Kas and Bedarawali Kas, which originate from the Margalla Hills forming a very steep channel bed slope of about 1/10.

The **higher plain** expands over the built-up area of Islamabad City with a gradual slope from North to South. Saidpur Kas, Tenawali Kas and Bedarawali Kas run southward in the plain and finally flow into Lai Nullah just upstream of Kattarian Bridge.

The **lower plain** extends over the upper part of the Rawalpindi area above Chaklala Bridge. This area is flatter than the upper Higher Plain and the lower Valley Area forming a bowl shaped topography.

The **valley area** is located below Chaklala Bridge. The valley area, falling down to the Soan River, a tributary of the River Indus is composed of gravel/boulder and sand/silt. **Figure 4-1** represents the topography of the Islamabad.

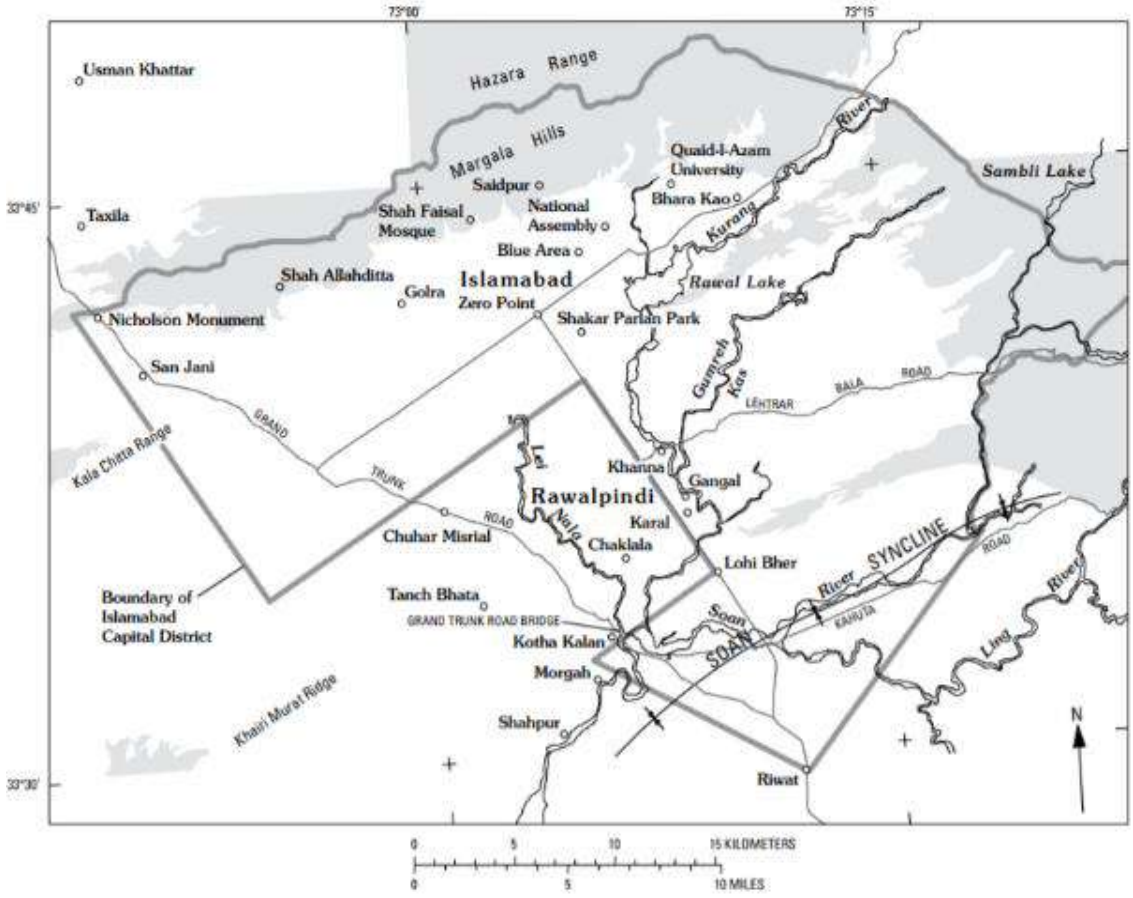


Figure 4-1: Topography of the Islamabad

Murree

Murree, situated in the sub-Himalayan foothills of the Pir Panjal Range in northern Punjab, Pakistan, features a complex and diverse topography shaped by both tectonic activity and climatic forces over geological time. It lies between latitudes 33°48′ and 34°00′ N and longitudes 73°15′ and 73°30′ E. The region is predominantly mountainous, marked by steep slopes, rugged ridgelines, and narrow valleys that reflect its geologically young and active nature. The elevation of Murree ranges from approximately 463[5] meters in the lower valleys (particularly along river courses) to about 2,623 meters at the highest ridges, with an average elevation of around 2,291 meters above sea level at the main town center. This altitudinal variation results in a steep vertical relief, often exceeding 1,000 meters over short horizontal distances, producing steep slopes of 30° to over 50° in several areas.

The topography of Murree can be divided into the following physiographic zones:

- **Ridges and Peaks:** High elevation zones composed of elongated ridges with narrow crests (e.g., Patriata), often aligned in a NE-SW direction. These are typically forested and support limited development.
- **Terraced Slopes:** Moderately steep to steep slopes that have been cut into terraces for agriculture and settlement. These areas are vulnerable to erosion and landslides if not properly managed.
- **Valley Floors and Nullahs:** Narrow, incised valleys and stream channels that drain rainfall toward the south and southwest. The gradient of these streams is steep, promoting rapid runoff and potential for flash floods.
- **Plateaus and Saddles:** Intermittent flat to gently undulating zones like Ghora Gali and Jhika Gali that allow for denser human settlement due to relatively easier topographic conditions.

Digital Elevation Model (DEM) data and slope gradient analysis indicate that more than **65%** of the Murree region has slopes greater than **20% which includes** Jhika Gali to Lawrence College Bypass, Aliot village, including Birgran and Kasseri[6], Dewal Village along Murree-Muzaffarabad Road[7] and Upper and Lower Reaches of Murree Hills[8], making it a high-risk area for slope instability and landslides, especially during heavy rainfall. Slopes between **10–20%** are more stable and have been traditionally used for habitation and agriculture, which includes Ghora Gali & Jhika Gali Plateaus and Bhurban & Surrounding Areas[9].

Murree's terrain is heavily forested, especially on the upper slopes, with dominant vegetation including Chir Pine, Himalayan Oak, and Blue Pine. The combination of elevation and vegetation cover contributes to soil stability and regulates surface runoff.

[5] http://www.gsp.gov.pk
[6] https://squ.elsevierpure.com/en/publications/geological-controls-in-slope-failure-and-landslide-hazards-main-b?utm_source
[7] https://link.springer.com/article/10.1007/s12594-018-0931-9?utm_source
[8] https://proceedings.esri.com/library/userconf/proc05/papers/pap1984.pdf?utm_source
[9] https://www.eorc.jaxa.jp/ALOS/en/dataset/aw3d30/aw3d30_e.htm?utm_source

Murree lies in the upper catchments of several tributaries of the Soan River system. The area exhibits a dendritic drainage pattern, with numerous first and second-order streams that converge into larger nullahs (e.g., Bhurban Nullah, Soan Kas). The drainage density is high, and runoff is fast due to impermeable underlying geology and steep slopes, enhancing the potential for flash flooding and surface runoff during periods of heavy rainfall.

Project Area:

The study area of the proposed Project pass through diverse terrain, starting from the relatively flat plains of Islamabad at an elevation of around 471 meters and gradually ascending into the hilly and rugged landscapes of the Murree, reaching elevations up to approximately 2,262 meters. The Project corridor is surrounded by forests, agricultural lands, road infrastructure, residential areas, mosques, rivers, waterfalls, nullahs, and commercial establishments. The topographic features along the alignment are depicted in **Figure 4-3**.

4.2.2 Geology

Islamabad

The geological structure and stratigraphy of the Islamabad-Rawalpindi area is very complex due to the convergence of the Pakistan-India and Eurasian tectonic plates and their collision that began about 20 million years ago. The geological history records a long period of gentle geological fluctuations and slow deposition in the Study Area while the Pakistan-India plate drifted northward. This period is followed by more vigorous tectonic processes and rapid deposition since the convergence of the Pakistan-India and Eurasian plates. Therefore, the period from the Middle Jurassic to the Lower Miocene (150 million years) is represented by only 675 m of primarily marine sedimentary rocks, whereas the last 20 million years are represented by more than 7,570 m of continental sedimentary rock[10].

The sedimentary rocks exposed in the Islamabad area date from the Middle Jurassic to the Quaternary. Three structural zones can be pointed out in the Study Area:

- **Mountainous Margalla Hills in the North**: Jurassic through Eocene limestone and shale complexly folded and thrust along the Hazara fault zone;
- **South of the Margalla Hills**: the southward-sloping piedmont bench (piedmont fold belt) is underlain mainly by truncated folds in the sandstone and shale of the Rawalpindi Group; and
- **Southernmost Area**: fluvial sandstone, clay stone and conglomerate deposits along the axis of the Soan syncline west-southwestward.

The **Hazara Fault Zone** is located in the north of the Islamabad-Rawalpindi area and affects a scope of about 25 km of width and 150 km of length. The area is convex to the south and extends west-southwestward away from the Himalayan syntaxes. Hence, the thrust and fold

[10] *Iqbal M. Sheikh, Mustafa K. Pasha, Van S. Williams, S. Qamer Raza, and Kanwar S.A. Khan (2007), Environmental Geology of the Islamabad-Rawalpindi Area, Northern Pakistan, Study by Geological Survey of Pakistan, under the auspices of the U.S. Agency for International Development, U.S. Department of State, and the Government of Pakistan*

structure of the Margalla Hills immediately north of Islamabad is complex: there are at least five principal thrust sheets repeating the pre-Miocene marine section.

In the **Piedmont Fold Belt Area**, Pleistocene conglomerate, overlying sandstone of the lower Miocene, is folded in the broad anticline at Shakar Parian Park in Islamabad.

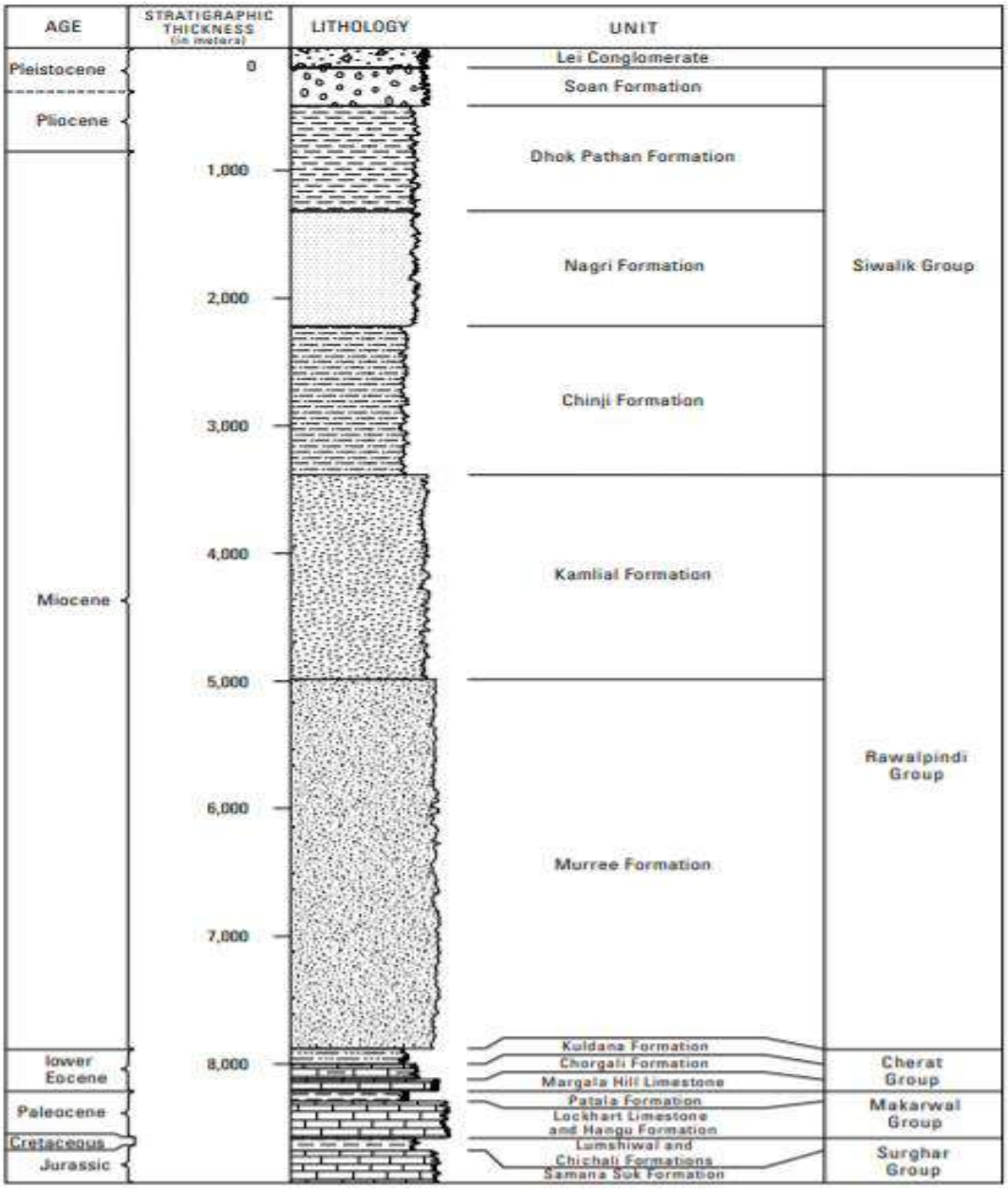
The **Soan Syncline** is an asymmetric, faulted fold of regional extent, plunging west-southwestward where fluvial sandstone, clay stone and conglomerate were deposited. The maximum width of the synclinal in the Study Area is about 11 km, but the fold extends 100 km to the southwest.

The **Quaternary Deposits** are generally heterogeneous. The subsurface mainly presents silt and clay deposits. The gravel beds are present in discontinuous layers with silty clay. Their thickness decreases in the south and west. The average thickness of the alluvium is more than 200 m, and can even be 300 m in some areas.

Four different main lithological units are present in the Islamabad-Rawalpindi area: (i) Sandstone and limestone of Cretaceous age, (ii) Margalla Hill limestone of Eocene age, (iii) Nimadrics of Miocene to Lower Pleistocene, and (iv) Deposits of Pleistocene and Quaternary age. The stratigraphic section of consolidated rocks in the Islamabad-Rawalpindi area is shown in **Figure 4-2** and **Table 4-1** showing the different formations of the Pleistocene and Holocene in the Study Area and their main lithology characteristics.

Table 4-1: Lithology Characteristics of Geological Units of the Pleistocene and Holocene Formation

Sr. No.	Unit Name	Lithology	Thickness (m)
1.	Stream-Channel Alluvium	Unconsolidated, channel-cross bedded, moderately sorted channel and bar deposits of sand and gravel.	3
2.	Flood Plain	Unconsolidated, channel cross bedded, moderately sorted channel and bar deposits of sand and gravel, overlain by relatively thin veneer of silt, clay and organic material.	6
3.	Fan Alluvium	Primarily unconsolidated sand and gravel of a mixture of the lithologies found in the tributary watersheds. The surface may be covered with thin soil of silt and clay. Poorly sorted and bedded. Debris-flow deposits are common.	20
4.	Alluvium and Windblown Silt	Eolian silt and stream-channel, flood plain, terrace and slope-wash alluvium.	10
5.	Terrace Alluvium	Unconsolidated, channel-cross bedded, moderately sorted channel and bar deposits of sand and gravel, overlain by relatively thin veneer of silt, clay and organic material.	6
6.	Potwar Clay	Windblown clay and silt and subordinate amounts of alluvial gravel. Fine grained, hard, compact and calcareous.	1-35
7.	Lei Conglomerate	Sub angular cobbles of Eocene limestone as large as 30 cm. Matrix of reworked eolian silt. Conglomerate is thickly interbedded with sandy silt beds and gravel beds.	106



Source: *Geological Survey of Pakistan, under the auspices of the U.S. Agency for International Development, U.S. Department of State, and the Government of Pakistan (2007).*

Figure 4-2: Generalized Composite Stratigraphic Section of Consolidated Rocks in the Islamabad-Rawalpindi

Murree

The geological framework of Murree is predominantly defined by the Murree Formation, a significant sedimentary sequence within the Himalayan Foreland Basin. This formation offers insights into the tectonic and sedimentary processes that have shaped the region during the Miocene epoch.

The Murree Formation is characterized by a substantial sequence of reddish to purple siltstone, claystone, and sandstone, interspersed with conglomerates and calcrete layers.

This lithological assemblage suggests deposition in a fluvial environment, likely within a meandering river system during the Miocene epoch. The formation is typically divided into two subunits[11]:

- **Lower Murree Formation:** Dominated by argillaceous materials, including cross-laminated and ripple-marked sandstones, siltstones, conglomerates, and calcrete**.**
- **Upper Murree Formation:** Composed mainly of arenaceous rocks, featuring light gray, fine to medium-grained thick sandstones and brick-red claystones.

Stratigraphically, the Murree Formation unconformably overlies the Eocene-aged Kuldana Formation and is succeeded by the Siwalik Group, indicating a transition from marine to continental depositional environments.

The sedimentary features of the Murree Formation, including cross-bedding, ripple marks, and fining-upward sequences, indicate deposition in a fluvial environment, likely within a mature, meandering river system. The presence of thick clay deposits suggests floodplain settings, while conglomerates point to channel deposits formed during high-energy flood events[12].

Situated within the Hazara-Kashmir Syntaxis, the Murree Formation has been significantly influenced by tectonic activities associated with the collision of the Indian and Eurasian plates. This region is characterized by complex folding and faulting, with the Murree Formation often involved in thrust faulting over younger formations. In the southwest, a fault separates the Murree Formation from the Margala and Kuldana limestone formations of Paleocene age. To the northwest, the Muzaffarabad limestone and Hazara slates are present. These structural features contribute to the complex geology of the area, influencing erosion patterns and slope stability.

The Project site is situated within a broad valley characterized by steep slopes, resulting from the rapid erosion of the relatively weak rocks of the Murree Formation. This valley, extending from Murree to Bhara Kahu, exhibits tightly folded structures forming a series of sharply bending anticlines and synclines. These tight folds have created numerous weak zones susceptible to erosion, leading to the formation of narrow, steep-sided valleys along the corridor. Rocks present at the Project site are sandstone and shales. The sandstone is present in the form of thick beds. These sandstones are moderately hard to well cemented. The texture of sandstone is fine to medium grained, however, some coarse grained sand stone is also present. The tract is generally covered with the colluvium material comprising of silt clay with embedded angular rocks fragment of various sizes covered with grass. The shales beds are thick in the proposed Project site; the lower Murree formations have dominantly these shales of clay stone. Except the Murree Formation Colluvial deposits are also present with slope wash deposits.

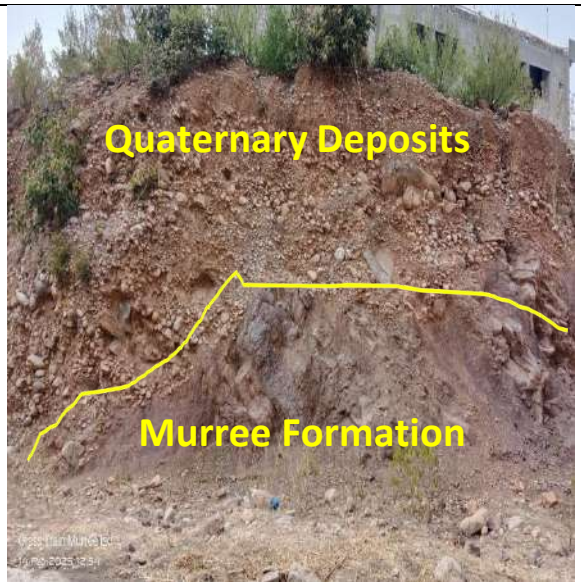
Project Area:

[11] *http://journal.indiansedimentologists.com/ojs/index.php/1/article/view/295*
[12] *earthsciencesmalaysia.com*

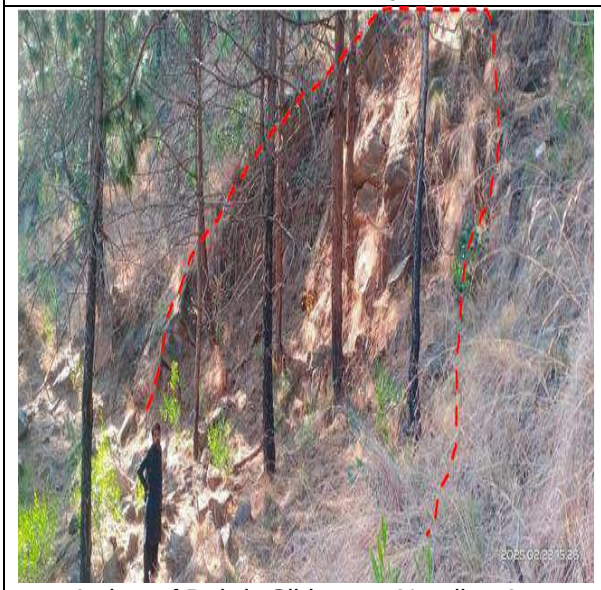
The geological composition of the proposed Project area primarily consists of Strem Deposits, Murree Formation, Siwalik Group, Precambrian Metamorphic and Sedimentary Rocks, Miocene Rocks, Holocene and Mesozoic Rocks as discussed above. **Figure 4-4** shows the Geological Map of the Study Area and **Plate 4-1** shows the geological conditions in the Study Area.



Medium to Weak Sandstone exposed near Shahdara Valley



Lithological Setup near Manga



A view of Debris Slide near Nandkot Area



Tunnel Inlet Portal having thick Sandstone beds of Murree Formation

Plate 4-1: A View of Geological Conditions in the Study Area

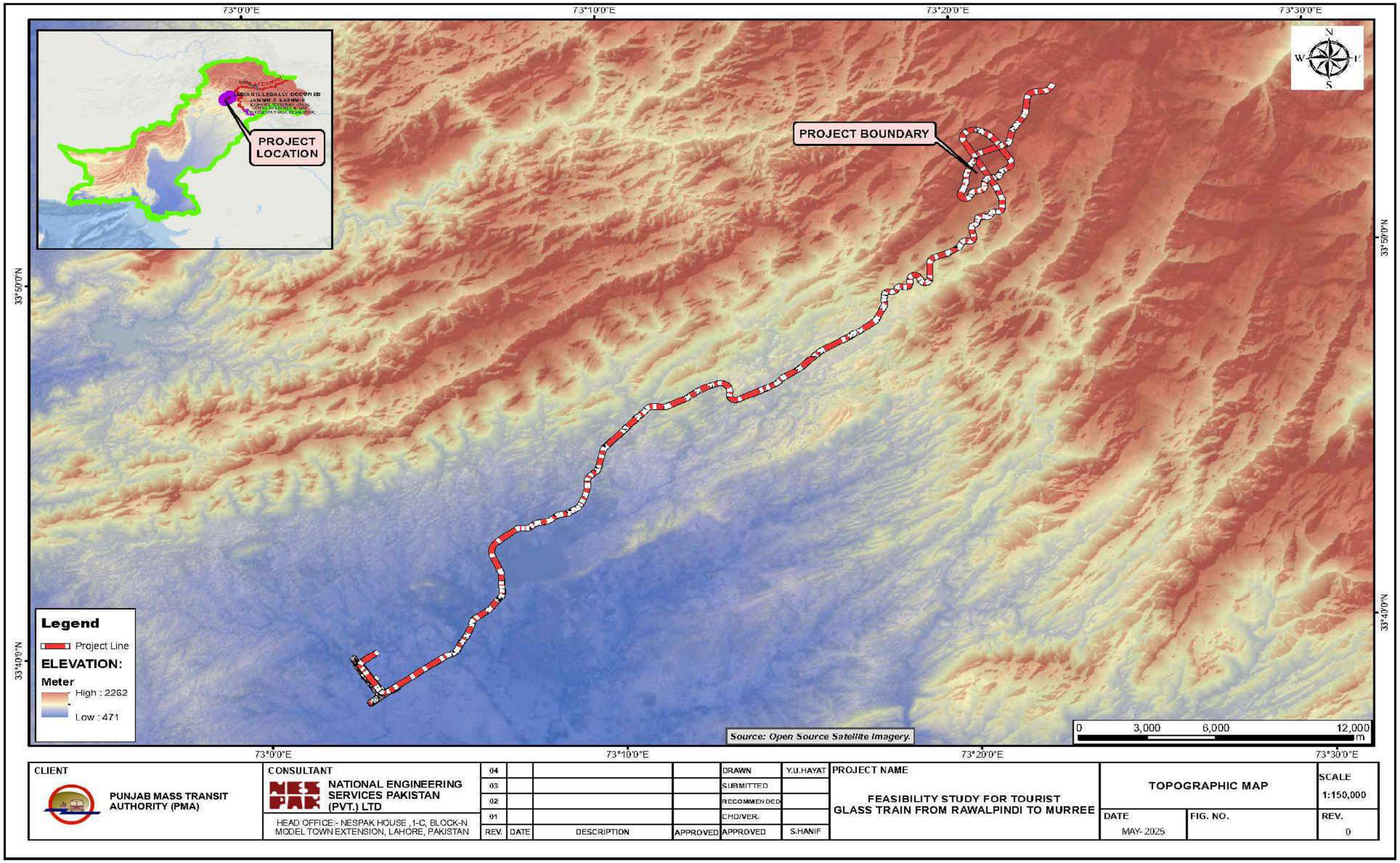


Figure 4.3: Topography Map of the Study Area

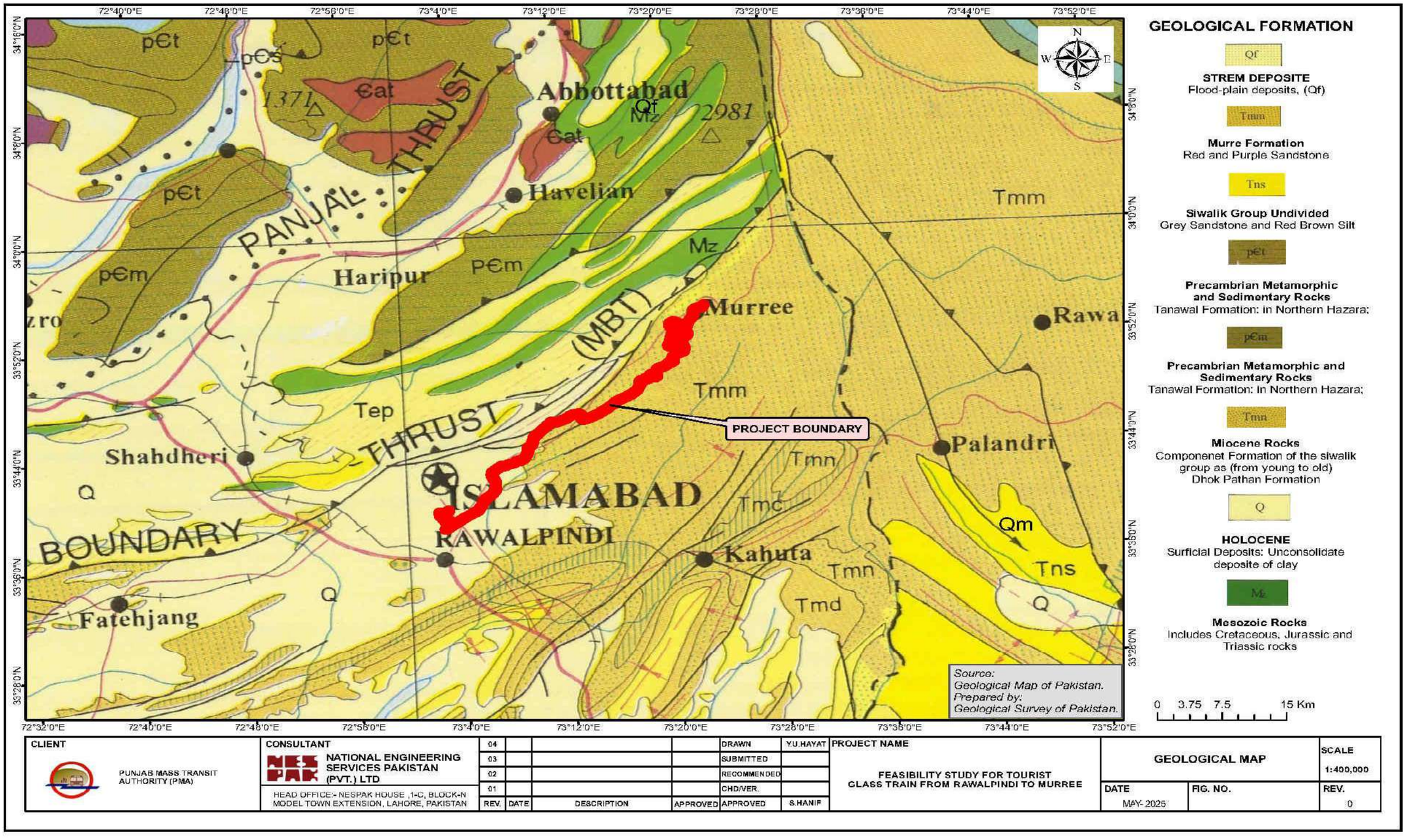


Figure 4.4: Regional Geological Map of the Study Area

4.2.3 Soil

Islamabad

Soil in the area is derived from rocks in the Punjab province, as well as originates from fluvial deposits. In zones where depositional landforms are present, the surface can be: (i) without any soil development (stream beds, low islands and bars), (ii) covered with fine sand, silt and clay with a relatively high organic content and fertile soil (stream flood plains), (iii) covered with a thin layer of fine-textured soil overlying channel deposits of sand and gravel (stream and fan terraces), and (iv) covered with fertile and easy tilled soil overlying fine silt and clay deposits (loess plains).

In areas where erosional landforms are present, the surface can be covered with thin sandy soil derived from weathering of the underlying rock (conglomerates of the Soan formation or Lei conglomerate, and Kamlial formation).

Murree

The soils in the Murree region are predominantly classified as Entisols and Inceptisols, reflecting their relatively young development stages. Soil pH varies with altitude: acidic soils are more common above 2,000 meters, while alkaline soils prevail below this elevation. The region's soils are derived from the weathering of molasse deposits, primarily sandstone and siltstone, resulting in textures ranging from sandy loam to silty clay. These formations, part of the Shiwalik and Sirmar series, were deposited in a tidal-fluvial estuarine environment within a foredeep basin. The Lower Murree Formation is primarily argillaceous (clay-rich), while the Upper Murree Formation is more arenaceous (sand-rich), featuring light gray, fine to medium-grained sandstones and brick-red claystones[13].

Forest cover contributes to higher organic matter content, enhancing soil fertility. Wildfires, frequent in the subtropical Chir Pine forests of Murree, significantly affect soil properties. Post-fire soils exhibit reduced bulk density, moisture content, and concentrations of nitrogen and carbon, while showing increased pH, phosphorus, and potassium levels. Murree's steep slopes and high rainfall make the region susceptible to soil erosion and landslides, particularly in areas with loose, weathered materials and sparse vegetation cover. Understanding these soil characteristics is crucial for sustainable land management and hazard mitigation in the region

Project Area:

The soil in the Study Area varies from sandy loam to sandy clay loam, silty and loamy. The soil map of the Study Area is shown in **Figure 4-5.**

[13] https://www.researchgate.net/publication/225189614_Causes_and_extent_of_environmental_impacts_of_landslide_hazard_in_the_Himalayan_region_A_case_study_of_Murree_Pakistan

4.2.4 Seismology

The Islamabad–Murree region is situated within a seismically active zone due to its proximity to the Main Boundary Thrust (MBT), a significant tectonic boundary between the Indian and Eurasian plates. This fault system, along with the Rawat Fault extending from Rawat near Islamabad to Kashmir, contributes to the region's susceptibility to seismic events.

Seismic hazard assessments for Islamabad have been conducted using probabilistic methods to estimate ground motion parameters essential for earthquake-resistant design. These analyses have indicated that areas within the capital, particularly those situated on soft sediments, are more prone to seismic hazards[14]. For instance, spectral accelerations at a 0.2-second period for a 475-year return period have been estimated to range between 0.59 and 0.65 g[15], highlighting the need for robust structural designs in these zones.

Historically, the region has experienced several significant earthquakes. The 2005 Muzaffarabad earthquake, with a magnitude of 7.6, caused extensive damage in northern Pakistan, including Islamabad. More recently, in 2015, a magnitude 5.1 earthquake centered near Murree resulted in casualties and structural damage. Additionally, in February 2025, a magnitude 4.8 earthquake occurred approximately 17 km from Islamabad, causing noticeable tremors and raising concerns about the proximity of seismic activity to urban areas.

The local geology of Murree further exacerbates the seismic hazard. The area is underlain by the Murree Formation, consisting of molasse sediments such as siltstone and sandstone. These sediments are prone to disruption during seismic events, leading to secondary hazards like landslides. For instance, the LangarPura landslide, initially triggered by the 2005 earthquake and subsequently by heavy monsoon rains in 2010, remains a significant concern. Monitoring of such landslides is crucial for assessing ongoing risks[16].

According to Building code of Pakistan, 2007 prepared by NESPAK, the Project area falls in Seismic Zone 2B (low to moderate damage) and Zone 3 (high damage) of Pakistan, and peak ground acceleration (PGA) from 0.16 to 0.32g **Figure 4-6** shows the seismic zoning map of Project area.

[14] https://www.researchgate.net/publication/257552658_Probabilistic_seismic_hazard_analysis_of_Islamabad_Pakistan

[15] https://www.researchgate.net/publication/339994687_Probabilistic_Seismic_Hazard_Assessment_of_Pakistan_Territory_Using_an_Areal_Source_Model

[16] https://www.researchgate.net/figure/Massive-disruption-of-the-Murree-formation-at-the-hillcrest-between-the-communication_fig7_226868491

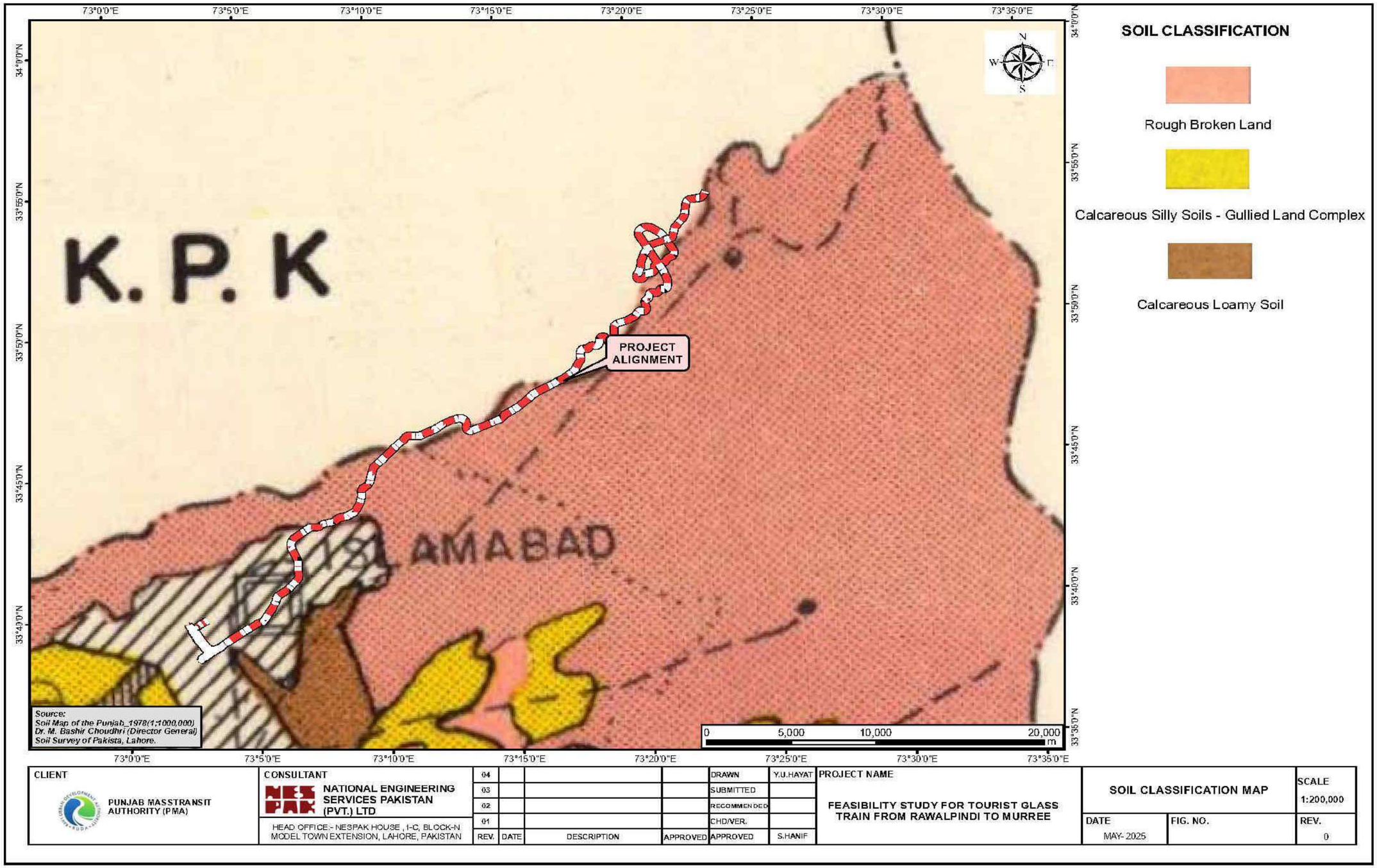


Figure 4.5: Soil Map of the Study Area

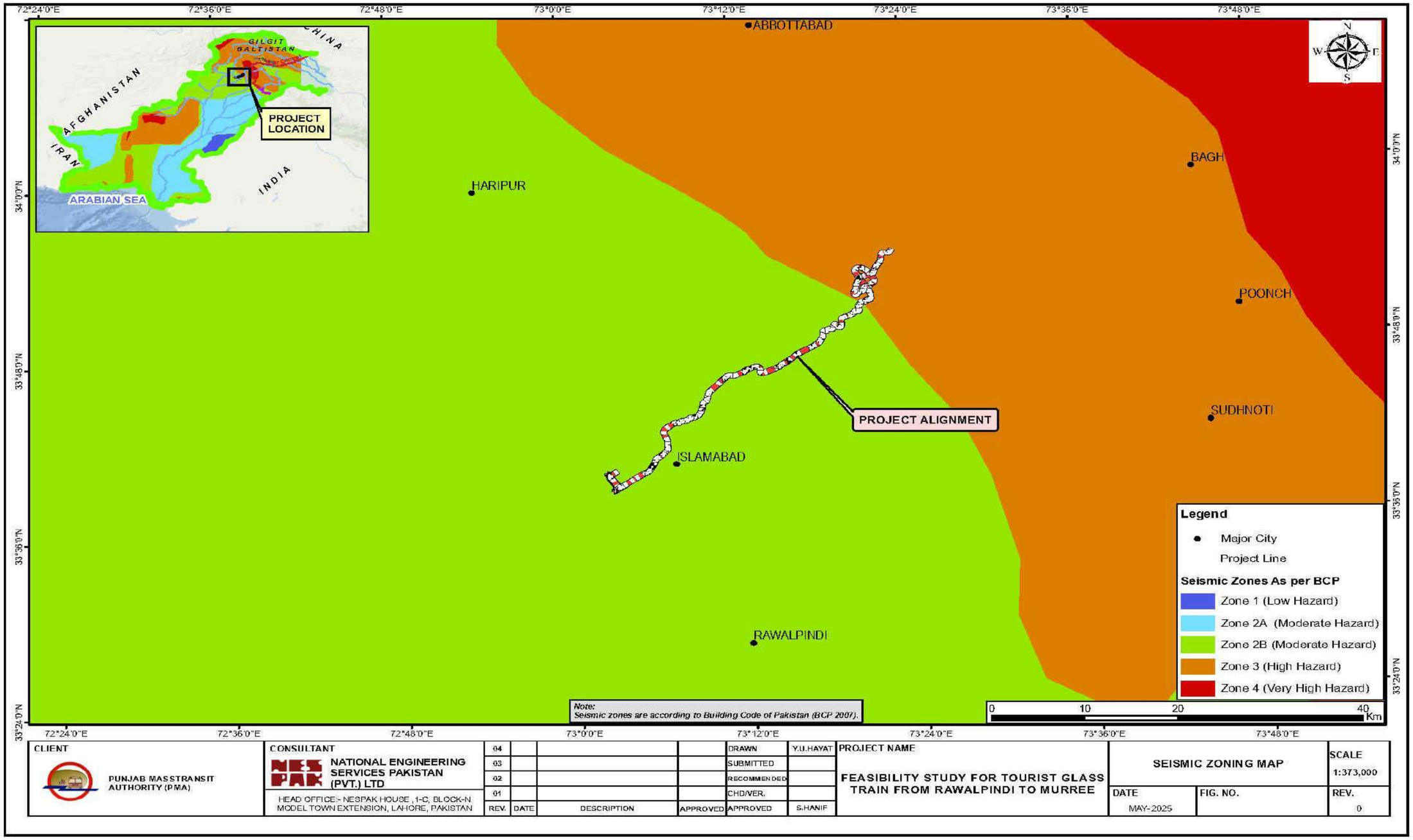


Figure 4.6: Seismic Zoning Map of the Study Area

4.2.5 Climate and Meteorology

The seasonal climatic conditions must be considered for the design and execution of the developmental projects. The climate including air, temperature, precipitation, humidity and evaporation are an influencing factor, affecting the construction of engineering structures. However, to determine the overall effect of the climatic stresses, daily and seasonal temperature changes, site altitude, direct solar radiation, and precipitation must be considered.

Islamabad

The climate of Islamabad is a humid subtropical climate (Köppen climate classification) with five seasons as discussed above. Temperature, precipitation, relative humidity, wind speed and gust of the Study Area (Islamabad) is discussed below.

Temperature

Table 4-2 and **4-3** shows minimal and maximal temperatures observed for each month between year 2011 to 2022 in the study area. The highest temperature measured is 43°C in May, 2022, and the lowest temperature was observed in December, 2011 i.e. 0.5°C.

Table 4-2: Maximum Temperatures (°C) between 2011 and 2022[17]

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2011	16.8	17.9	26.5	29.6	42.0	38.8	34.0	34.0	33.4	30.5	25.3	20.9
2012	17.0	18.0	25.6	29.8	36.3	39.7	38.9	34.5	32.4	30.1	25.1	18.9
2013	17.8	18.8	25.7	30.5	37.4	37.7	35.3	31.4	31.4	30.5	24.1	19.9
2014	19.0	19.3	22.0	29.6	33.5	40.0	36.2	35.9	31.4	29.0	25.0	19.1
2015	18.7	20.9	23.0	29.1	35.6	35.3	34.0	34.2	34.2	29.9	23.0	19.5
2016	19.0	22.0	24.0	31.0	37.0	40.0	37.0	36.0	36.0	32.0	27.0	24.0
2017	16.0	21.0	25.0	33.0	37.0	38.0	37.0	36.0	34.0	31.0	24.0	20.0
2018	19.0	21.0	26.0	30.0	35.0	38.0	36.0	35.0	33.0	31.0	25.0	21.0
2019	17.0	18.0	23.0	32.0	36.0	41.0	38.0	36.0	34.0	30.0	24.0	20.0
2020	15.0	21.0	22.0	30.0	36.0	41.0	41.0	35	36.0	33.0	24.0	19.0
2021	19.0	25.0	28.0	31.0	36.0	41.0	38.0	36.0	35.0	32.0	27.0	21.0
2022	16.0	20.0	31.0	40.0	43.0	42.0	35.0	34.0	35.0	33.0	25.0	22.0

Table 4-3: Minimal Temperatures (°C) between 2011 and 2022[18]

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2011	2.8	6.8	11.9	15.5	23.0	25.8	24.4	24.3	22.7	16.1	11.2	0.5
2012	2.0	4.5	9.8	16.1	19.6	21.5	26.2	24.0	20.6	15.3	8.4	5.1
2013	2.4	6.9	11.7	16.1	20.8	24.9	24.0	23.2	21.0	17.7	7.1	3.9
2014	2.2	5.5	9.0	14.4	19.2	23.2	23.9	25.1	19.0	15.3	6.5	4.3
2015	4.4	8.4	11.3	17.2	21.1	23.9	24.0	24.6	21.8	12.1	10.3	5.4

[17] *Meteorological Data for Islamabad (2011-2022)*
[18] *Meteorological Data for Islamabad (2011-2022)*
https://www.worldweatheronline.com/islamabad-weather-averages/islamabad/pk.aspx

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2016	8.0	10.0	14.0	18.0	24.0	29.0	28.0	27.0	25.0	20.0	14.0	11.0
2017	8.0	10.0	13.0	19.0	25.0	27.0	28.0	27.0	24.0	19.0	14.0	10.0
2018	8.0	11.0	15.0	18.0	23.0	29.0	28.0	27.0	24.0	23.0	17.0	12.0
2019	9.0	10.0	13.0	21.0	25.0	29.0	30.0	27.0	25.0	21.0	15.0	10.0
2020	8.0	12.0	14.0	20.0	25.0	30.0	31.0	28.0	27.0	23.0	14.0	10.0
2021	10.0	14.0	17.0	19.0	26.0	31.0	30.0	27.0	24.0	19.0	13.0	9.0
2022	8.0	8.0	16.0	22.0	27.0	28.0	27.0	25.0	23.0	19.0	13.0	10.0

Figure 4-7 shows the graphical presentation of average temperatures in the Study Area from the year 2011 to 2022.

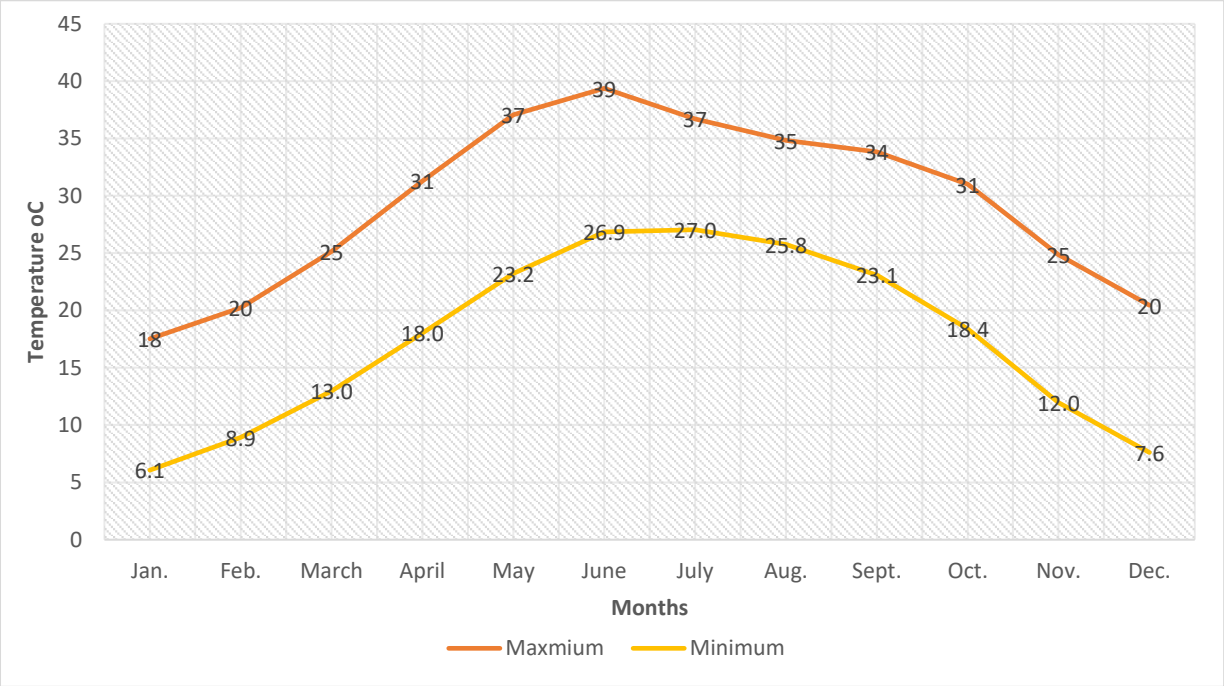


Figure 4-7: Average Maximum and Minimum Temperature in the Study Area (2011-2022)

Precipitation (Rainfall)

Table 4-4 shows mean monthly precipitation observed in the study area with an average rainfall of 591.5 mm. **Figure 4-8** shows the mean monthly precipitation in the study area from 2011 to 2022.

Table 4-4: Mean Monthly Precipitation from 2011 to 2022[19]

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2011	7.89	98.57	50.0	63.57	41.83	44.75	76.9	79.39	43.05	33.44	5.09	0.65
2012	15.09	36.96	22.21	61.06	33.63	7.22	29.85	60.66	39.94	10.67	3.25	32.32
2013	4.94	90	40.72	26.97	10.75	47.35	59.18	85.16	42.13	11.77	3.13	1.12
2014	5.68	26.21	87.93	34.93	28.32	17	60.76	69.04	67.59	17.42	4.84	0.01
2015	7.76	33.36	87.93	45.62	7.96	14.31	72.38	52.24	54.11	16.73	7.03	9.86

[19] https://www.worldweatheronline.com/islamabad-weather-averages/islamabad/pk.aspx

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2016	7.26	10.95	87.93	23.15	15.1	10.19	72.03	27.82	10	0.83	0.52	0.35
2017	52.35	18.67	22.51	40.04	9.8	26.71	39.55	44.42	11.03	0.12	2.12	16.75
2018	0.65	24.36	11.45	39.66	11.56	26.88	107.13	62.1	27.77	4.1	17.6	2.9
2019	77.8	156.2	110.5	57.9	35.7	28.9	257	323.7	157	52.3	55.2	33.4
2020	187.0	30.0	231.7	78.7	68.5	65.9	118.0	406.8	60.1	0.0	14.0	32.0
2021	71.8	0.9	81.1	58.6	56.6	45.0	477.0	274.7	41.4	15.6	0.0	1.1
2022	37.9	9.2	5.5	0.3	8.3	23.6	110.5	66.7	29.5	0.5	6.6	0.7

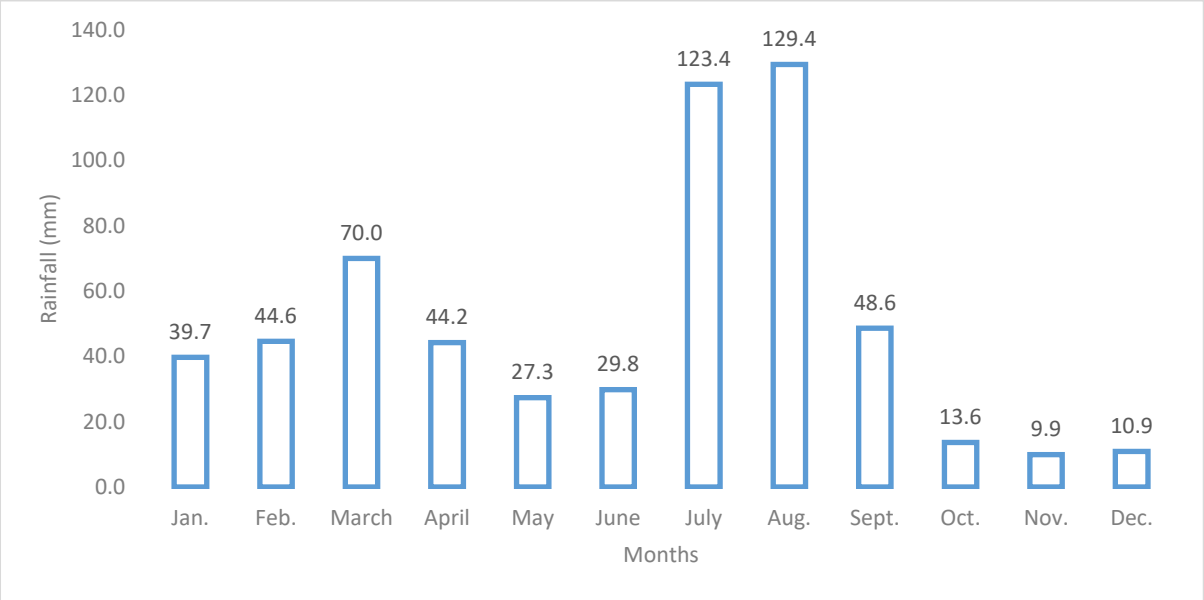


Figure 4-8: Average Precipitation in the Study Area

Relative Humidity

A monthly data of Relative humidity from 2011 to 2022 is shown in **Table 4-5** and yearly average relative humidity is shown in **Figure 4-9**.

Table 4-5: Mean Relative Humidity (%) in the Study Area (2011-2022)[20]

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2011	38	60	49	45	28	32	48	60	53	37	30	21
2012	38	47	38	43	28	20	35	54	46	30	23	34
2013	32	52	39	33	21	29	44	58	47	38	25	23
2014	31	38	45	36	32	24	40	47	51	38	25	18
2015	28	43	49	38	21	27	48	51	38	33	31	29
2016	33	31	46	33	24	26	45	43	37	21	18	18
2017	47	40	36	29	25	31	45	46	39	24	26	29
2018	27	38	38	36	25	29	48	55	47	28	28	24
2019	42	54	48	36	26	24	45	59	52	41	46	37
2020	56	43	58	47	33	27	35	61	42	22	32	41
2021	37	31	36	34	31	26	48	57	59	43	27	32

[20] https://www.worldweatheronline.com/islamabad-weather-averages/islamabad/pk.aspx

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2022	59	49	37	19	19	24	63	66	60	37	38	30

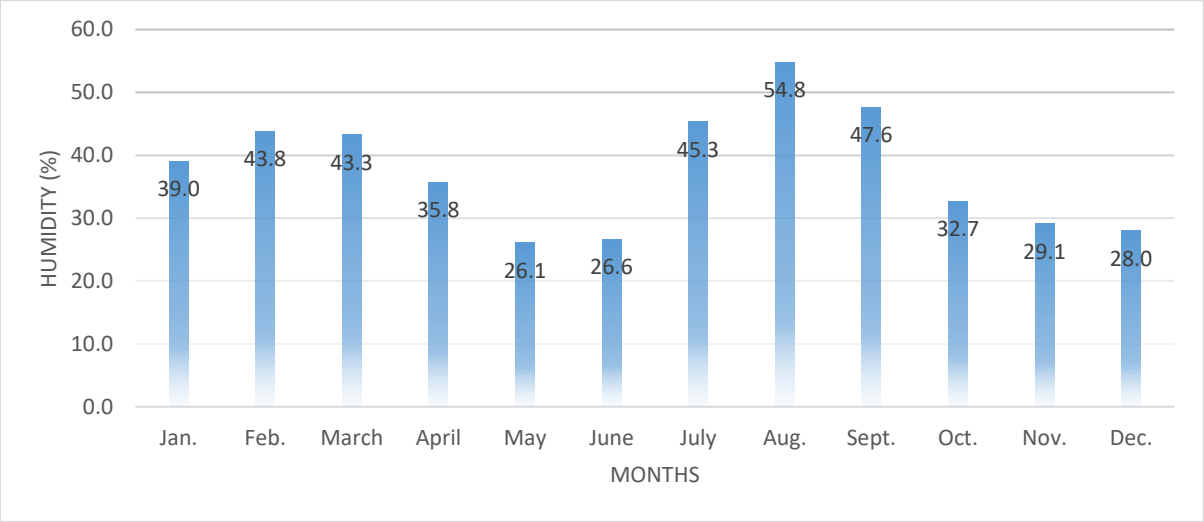


Figure 4-9: Average Relative Humidity in the Study Area (2011-2022)

Wind Speed and Wind Gust

Table 4-6 & 4-7 depicts average wind speed and wind gust on a monthly basis in the study area from year 2011 to 2022.

Table 4-6: Average Wind Speed (Km/h) in the Study Area (2011-2022)[21]

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2011	8.1	8.5	9.0	8.8	9.6	9.6	7.5	7.4	7.6	8.6	9.2	9.1
2012	8.8	9.5	10.4	9.3	11.4	11.9	9.1	8.0	8.5	9.2	8.9	9.1
2013	9.6	10.3	10.2	11.2	12.7	9.6	8.8	7.1	7.6	7.7	8.9	8.5
2014	8.3	8.9	9.5	10.8	10.8	10.8	9.0	8.0	7.5	8.4	9.0	8.3
2015	7.5	8.7	9.1	9.8	10.5	10.0	7.9	7.8	8.7	8.3	8.1	7.7
2016	6.9	8.5	9.8	10.5	11.0	10.2	8.6	8.3	8.5	9.2	8.6	7.4
2017	8.3	9.2	9.8	10.8	10	9.6	8.1	8.8	8.4	8.0	7.7	7.5
2018	7.6	8.8	9.3	10.5	10.3	10.0	8.9	9.2	8.6	10.2	9.2	8.2
2019	8.6	9.1	9.4	10.5	11.2	11.5	10.4	8.8	8.8	7.3	7.2	6.2
2020	7.3	8.2	9.1	8.4	10.2	11.2	10.3	8.6	7.7	8.4	8.2	7.4
2021	7.2	7.8	10.9	10.3	10.7	10.7	11.2	9.5	7.9	8.2	7.1	6.5
2022	6.5	7.7	9.1	10.4	11.8	11.5	9.2	7.5	7.1	7.8	7.1	6.6

Table 4-7: Average Wind Gust (Km/h) in the Study Area (2011-2022)[22]

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2011	14.6	15.1	15.3	14.7	14.8	13.0	9.8	10.7	11.3	14.3	16.5	16.9
2012	15.4	15.5	17.2	14.8	17.9	17.1	11.8	11.2	12.9	15.3	15.4	16.1
2013	17.2	17.2	16.9	18.4	20.4	12.8	11.8	10.0	11.8	12.0	15.2	15.7
2014	15.3	15.2	15.6	17.7	16.7	15.4	11.8	11.9	11.5	13.5	16.2	15.3

[21] https://www.worldweatheronline.com/islamabad-weather-averages/islamabad/pk.aspx
[22] https://www.worldweatheronline.com/islamabad-weather-averages/islamabad/pk.aspx

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2015	13.3	14.7	15.1	15.9	16.5	14,9	10.9	12.0	14.2	13.7	14.1	13.5
2016	12.1	14.5	16.6	17.1	17.3	14.8	12.1	12.6	13.8	15.4	15.2	13.2
2017	14.6	15.8	16.2	17.9	15.8	13.9	10.9	13.1	13.0	12.7	12.9	13.0
2018	12.8	14.6	15.3	16.5	14.8	13.4	12.0	13.7	13.4	17.2	16.3	14.2
2019	14.2	15.2	15.3	16.7	16.4	17.6	15.9	13.4	13.0	10.8	11.4	9.6
2020	11.5	12.9	14.2	12.9	14.4	15.6	14.0	13.1	11.5	13.1	13.1	12.0
2021	11.9	12.7	17.4	15.7	14.6	14.1	15.2	14.3	12.8	13.7	12.2	11.1
2022	10.5	12.6	15.2	17.1	18.0	17.0	12.9	11.2	11.8	13.5	12.0	11.1

Figure 4-10 shows average wind speed and gust in the Study Area from 2011 to 2022.

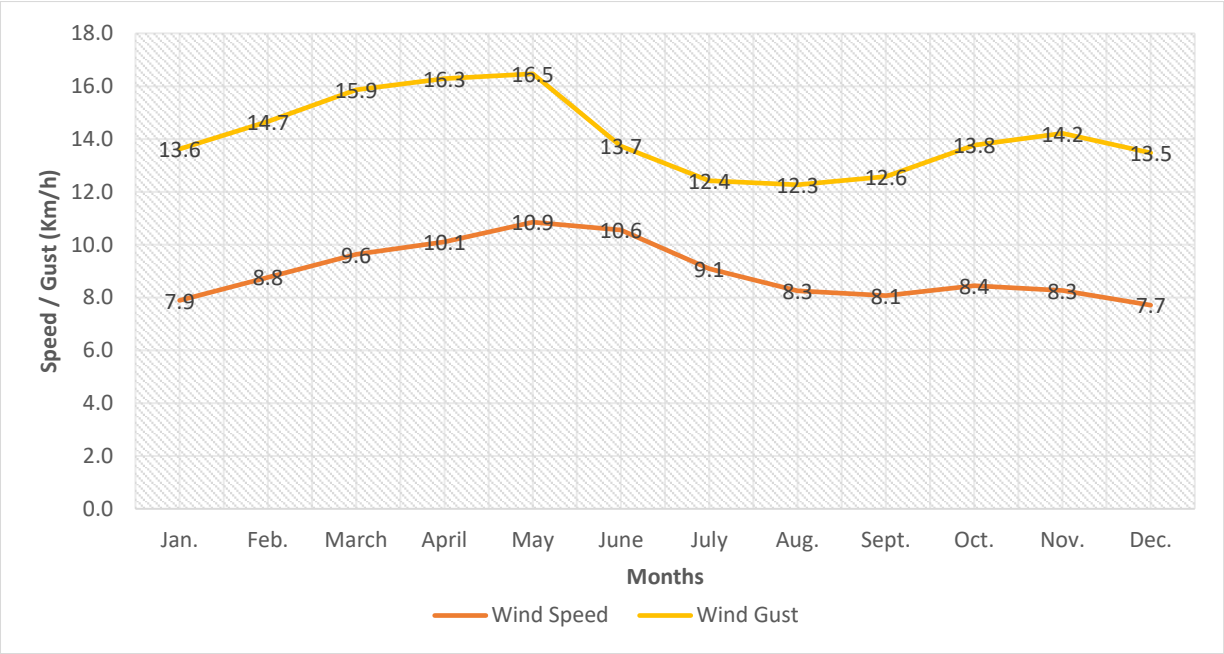


Figure 4-10: Average Wind Speed and Gust in the Study Area from 2011 to 2022

Murree

Murree, located in the outer Himalayas of Punjab, Pakistan, experiences a monsoon-influenced subtropical highland climate (Köppen classification Cwb), characterized by cool summers and cold, snowy winters. The average annual temperature is approximately 14.8°C (58.6°F), with summer highs typically ranging between 21°C and 24°C (70°F–75°F), and winter lows often dropping below freezing, particularly in January and February. The region receives substantial precipitation throughout the year, averaging between 1,789 mm and 1,904 mm annually, with two distinct peaks: one during the winter months due to western disturbances, and another in July and August from the South Asian monsoon. Snowfall is common in the winter, with heavy snow typically occurring in January and February. Additionally, the area frequently experiences fog, especially during the monsoon season, contributing to reduced visibility and damp conditions. These climatic factors are crucial considerations for infrastructure development, tourism planning, and environmental management in the region

For the analysis, historical data on temperature, rainfall, relative humidity, and wind speed from 1981 to 2020 recorded at the Murree weather station have been used as a representative dataset for the Project area. The subsequent sections present this climatic information, which provides insights into the prevailing weather conditions in Murree.

Temperature

Table 4-8 shows mean minimal and maximal temperatures observed for each month between 1991 and 2020 in the Study Area. The highest temperature measured between 1991 and 2020 was 34.5 °C in June 17, 1995, and the lowest temperature was measured in January 14, 2000 i.e. -10°C.

Table 4-8: Mean Maximum Temperatures (^{O}C) between 1991 and 2020

Sr. No.	Months	Mean Minimal Temperature	Mean Maximum Temperature
1.	January	- 1.6	8.6
2.	February	- 0.5	9.6
3.	March	4.0	13.9
4.	April	8.7	19.0
5.	May	13.0	23.6
6.	June	15.3	25.6
7.	July	15.7	23.5
8.	August	15.6	22.8
9.	September	13.8	22.3
10.	October	10.5	20.3
11.	November	5.7	16.3
12.	December	1.0	12.4

Source: Climate Normal of Pakistan (1991-2020)

Precipitation (Rainfall)

Table 4-9 shows mean monthly precipitation observed in the Study Area from 1991 to 2020 with an annual average rainfall of 1,713.6 mm.

Table 4-9: Mean Monthly Precipitation (1991 and 2020)

Sr. No.	Month	Precipitation (millimeters)
1.	January	119.3
2.	February	167.3
3.	March	170.7
4.	April	139.3
5.	May	82.1
6.	June	153.6
7.	July	315.3
8.	August	272.0
9.	September	148.3
10.	October	56.5
11.	November	39.5
12.	December	49.5
Annual		**1,713.6**

Source: Climate Normal of Pakistan (1991-2020)

Relative Humidity

Table 4-10 shows the mean relative monthly humidity observed in the Study Area from 1991 to 2020.

Table 4-10: Relative Humidity in Percentage (1991 and 2020)

Sr. No.	Month	At 00UTC	At 03 UTC	At 12 UTC
1.	January	62.9	60.7	62.9
2.	February	66.6	58.5	63.5
3.	March	58.8	51.3	58.7
4.	April	54.5	47.1	54.5
5.	May	49.8	43.2	45.5
6.	June	58.8	51.4	53.2
7.	July	81.0	76.7	80.0
8.	August	86.8	79.5	86.8
9.	September	75.5	68.2	77.8
10.	October	58.7	49.3	62.5
11.	November	52.9	45.1	56.8
12.	December	53.4	47.1	54.1

Source: Climate Normal of Pakistan (1991-2020)

Wind Speed and Wind Direction

Table 4-11 depicts the average wind speed in the Study Area from 1991 to 2020 and **Table 4-12** wind direction.

Table 4-11: Average Wind Speed in Knots (1991 and 2020)

Sr. No.	Month	At 00UTC	At 03 UTC	At 12 UTC
1.	January	2.1	2.3	1.8
2.	February	2.4	3.3	2.5
3.	March	2.7	3.3	2.6
4.	April	3.5	3.3	2.5
5.	May	3.3	3.1	2.5
6.	June	2.1	2.2	2.2
7.	July	1.4	1.5	1.7
8.	August	1.3	1.4	1.4
9.	September	1.9	1.7	1.3
10.	October	1.9	1.9	1.2
11.	November	2.0	2.0	1.4
12.	December	1.8	2.2	1.7

Source: Climate Normal of Pakistan (1991-2020)

Table 4-12: Average Wind Direction in Degrees (1991 and 2020)

Sr. No.	Month	At 00UTC	At 03 UTC	At 12 UTC
1.	January	20	76	122
2.	February	16	82	127
3.	March	10	71	126
4.	April	12	63	119
5.	May	7	67	114
6.	June	7	96	131
7.	July	31	107	132
8.	August	20	99	127
9.	September	3	84	128
10.	October	4	61	116
11.	November	9	67	103

Sr. No.	Month	At 00UTC	At 03 UTC	At 12 UTC
12.	December	10	58	85

Source: Climate Normal of Pakistan (1991-2020)

4.2.6 Ground Water

Islamabad

Groundwater resources in the Islamabad area are mainly contained in and discharged from the recent Quaternary alluvium deposits. Recharge is principally due to precipitation and supplied by nearby streams.

Currently, Capital Development Authority (CDA) is supplying the ground water of 190 tube wells to Islamabad by extracting about 127 MCM annually to manage water supply (Iqbal et al., 2023). Private and municipal wells are also used to fulfill the water requirements. However, the amount of private wells is difficult to estimate, but NESPAK study (2007) identified 129 tube wells in Islamabad and their total daily discharge of about 63 MGD. The extraction of groundwater is also comprehended by a public bore well network which consists of about 200 bore wells.

In addition to above 37 Nos. small water filtration plants have also been installed in various sectors of Islamabad by CDA to provide clean drinking water to the residents. Moreover, a water tanker service is also running under Water Supply Directorate of CDA to attend water shortage complaints. However, the city faces a significant water deficit, with a daily shortfall of approximately 52 million gallons. This has led to an increased dependence on private water tankers, which are often costly and unregulated. Concurrently, the groundwater table has experienced a substantial decline, dropping from an average depth of 22.8 meters to 56 [23]meters over recent years, primarily due to over-extraction and rapid urban development.

Murree

Murree, located in the Sub-Himalayan zone of northern Pakistan, relies heavily on groundwater resources, particularly in urban areas where surface water sources are limited. A study indicates that approximately 85% of households in Murree depend on groundwater for domestic use.[24]

A study analyzing water availability and consumption in Murree revealed that approximately 85% of households heavily depend on groundwater. The Water Sufficiency Ratio (WSR), which assesses the adequacy of water supply relative to demand, was found to be 1.92 for Murree, indicating a surplus in available water. However, when considering national standards for water consumption, the WSR drops to 0.68, suggesting that the available water may not meet the standard consumption needs. Factors such as rapid urbanization, population growth, and climate change have been identified as contributing to the increasing

[23] https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0293927&utm_source

[24] *researchgate.net/publication/333364195_Water_availability_consumption_and_sufficiency_in_Himalayan_towns_a_case_of_Murree_and_Havellian_towns_from_Indus_River_Basin_Pakistan*

demand and potential strain on water resources[25]. The hill station received a water supply of 1.2 million gallons per day, falling short of its daily requirement of 3 million gallons.

In response to these challenges, the Punjab government has initiated several projects aimed at improving Murree's water infrastructure. Notably, the Dhar Jawa Dam Project[26] has been approved, which will not only serve as a recreational area but also support a new water supply scheme for Murree. Additionally, a rainwater harvesting project has been launched to provide sustainable water solutions for approximately 3,000 households.

Despite these efforts, issues persist. Reports have highlighted that contaminated water, filled with mud and debris, is being supplied to residents and tourists. This contamination is attributed to the lack of maintenance of water storage tanks and the aging water supply system, some parts of which date back to the British era. Furthermore, the absence of proper sanitation facilities has led to raw sewage draining into natural water sources, exacerbating water pollution and posing health risks[27].

Project Area:

In the Study Area (Islamabad), masses dependent on municipal water supplies, water tanker services provided by CDA, and underground borings for drinking water and other domestic uses; however, the groundwater has also been rapidly depleting in the area. In Murree, the main source of drinking water is natural springs and shallow wells.

4.2.7 Surface Water Hydrology

Due to the location of Islamabad at the foot of the Margalla Hills on the north and the Murree and Kotli Sattian Hills on the east, the area benefits from the natural slope in terms of surface water resources. The various streams flow in and around the city of Islamabad as shown in **Figure 4-11.**

In the jurisdiction of Islamabad the river system is composed of three major tributaries, namely (i) Saidpur Kas, (ii) Tenawali Kas, and (iii) Bedarawali Kas. They originate from the Margalla Hills and flows into the mainstream of Nullah Lai just upstream from Kattarian Bridge, at I.J. Principal Road forming the administrative boundary between Islamabad and Rawalpindi.

Below Kattarian Bridge, in the jurisdiction of Rawalpindi, the mainstream meets other major tributaries; namely (i) Nikki Lai, (ii) Pir Wadhai Kas, and (iii) Dhok Ratta Nullah one after another, then flows down through the center of Rawalpindi City and finally pours into Soan River.

[25] *https://www.researchgate.net/publication/333364195_Water_availability_consumption_and_sufficiency_in_Himalayan_towns_a_case_of_Murree_and_Havellian_towns_from_Indus_River_Basin_Pakistan?utm_source*

[26] https://tribune.com.pk/story/2492394/govt-okays-rs107b-water-projects?utm_source

[27] *https://iucn.org/sites/default/files/import/downloads/new_murree_report.pdf?utm_source*

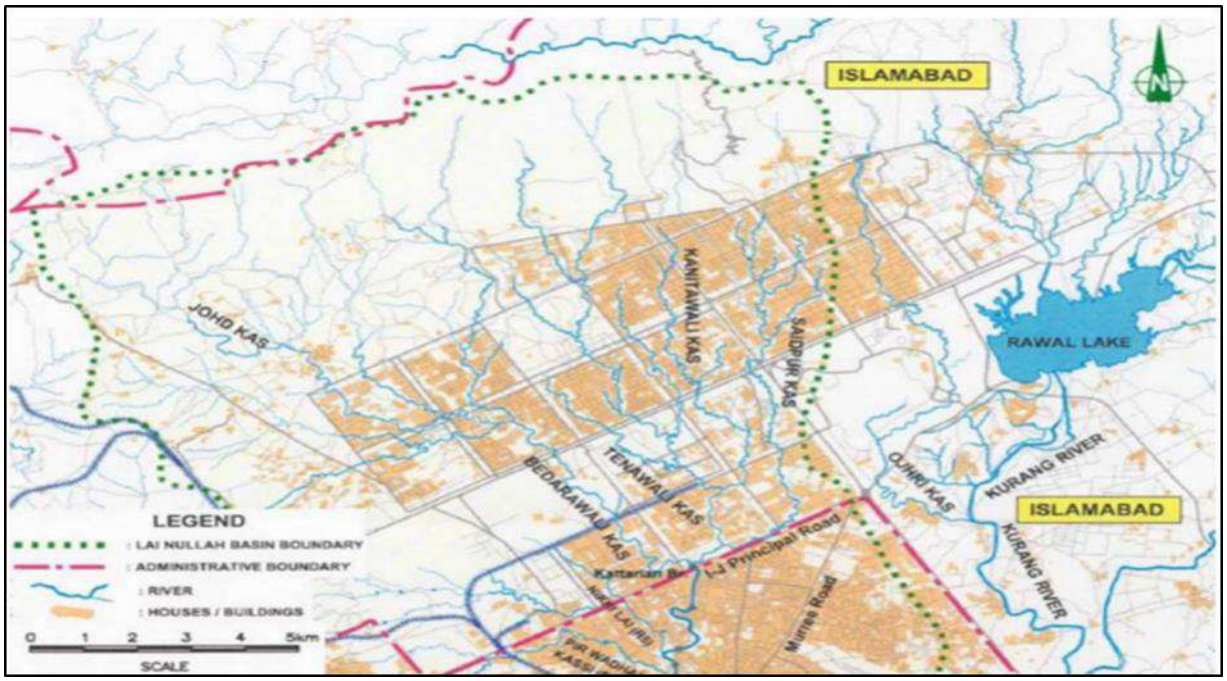


Figure 4-11: Streams Network in and around the City of Islamabad (Source JICA, 2003)

In addition to these major tributaries, there are other six (06) tributaries or drainage channels / sewerage channels, which joint the mainstream between the confluences of Dhok Ratta Nullah and Soan River. The name and the catchment area of the whole tributaries are given in **Table 4-13**.

Table 4-13: Name and the Catchment Area of the whole Tributaries

Location of Confluence with Main Stream	No. and Name of Tributary		
	No.	Name	Catchment Area (km^2)
Islamabad	-	Saidpur Kas	24.7
	-	Tenawali Kas (Including Kanitawali Kas as the secondary tributary)	39.7
	-	Bedarawali Kas (Including Johd Kas as the secondary tributary)	79.9
		Total =	**144.3**

The different surface water resources[28] present in and around the study area are discussed below and shown in **Figure 4-12**.

A) Soan River

Soan River rises near the small village Bun in the foothills of Patriata and Murree and drains much of the water of the Potohar region. Its water is stored in the Simly Dam. After treading a long path of 250 km, this relatively small stream falls into the Indus River near by the Kalabagh close to Pirpiyahi.

B) Korang River

[28] *Nestle Water Factory Islamabad Study (2016), Constructive Critical Review of Hydrogeological Reports.*

Korang River is the main stream draining the area of Islamabad. Its main tributary is Gumrah Kas, which drains westward into the Korang River from the area between Korang and Soan River.

C) Rawal Lake or Rawal Dam

Rawal Lake is an artificial reservoir located in an isolated section of the Margalla Hills National Park. It is fed by water from Korang River and other small streams coming from the Margalla Hills like the Jinnah Stream. Its storage capacity is about 58,600,000 m^3 and the discharge capacity of its spillway is about 2,300m^3/s. It provides drinking water for the population of Islamabad and Rawalpindi. Mean annual water available is 72 MGD (million gallons per day). Approximately 70% of its catchment area lies within Murree, highlighting the interdependence between the two regions.

D) Simly Dam

Simly dam is located on the Soan River at some 30 km east of Islamabad and fed by melting snow and natural springs of Murree Hills. It is the largest reservoir of drinking water for the population of Islamabad. The storage capacity of the dam is about 35,463,000 m^3 with a spillway of discharge capacity of 1,275 m^3 /s. Mean annual water available is 68 MGD.

E) Khanpur Dam

Khanpur Dam is located on the Haro River in the north of the Margalla Hills at about 40 km from Islamabad. Its stored water provides domestic water to Rawalpindi and Islamabad as well as irrigation water for agriculture and industries in the surroundings of these cities. The storage capacity of the dam is about 140,000,000 m^3. Mean annual water available is 198 MGD.

F) Headwork's

Headwork water is diverted from springs located at Saidpur, Nurpur and Shahdara**.** The capacity of the four headwork's sources is as follows: (i) Kurang River: 4 MGD, (ii) Saidpur: 0.8 MGD, (iii) Nurpur: 0.7 MGD, and (iv) Shahdara: 1.6 MGD.

G) Nullah Lai

The Lai Nullah Basin is located between 33º 33´ and 33º 46´ North and 72º 55´ and 73º 07´ East. It has a catchment area of 239.8 Km^2 (161.2 Km^2 in Islamabad and 73.6 Km^2 in Rawalpindi) and a length of about 30 Km, stretching from the Margalla hills in Federal Capital City Islamabad at the Northwestern edge until Soan River at the South-eastern edge in District Rawalpindi of Province of the Punjab. The principal surface water sources in Lai Nullah basin come from Simly Dam on Soan River, Khanpur Dam on Haro River and Rawal Dam on Kurang River and the current land use in the Lai Nullah basin is 38.6 % of residential and 14.2 % of agricultural areas, 14.8 % of forest and the rest are grass and bare land surfaces.

The present water supply capacity in the Lai Nullah Basin area is about 785 million liters per day in total. Out of the total water supply, the service area of Capital Development Authority in federal Capital, Islamabad shares 507.33 million liters per day, while the service area of

Water & Sanitation Agency (WASA) of Rawalpindi city and its Cantonment share 122.74[29] million.

H) Natural Springs[30]

These springs not only provide potable water but also contribute to the region's ecological balance and tourism appeal. Notable among them is the Sandhian Natural Spring, located along the Murree-Abbottabad Road, celebrated for its crystal-clear waters and serene environment, making it a popular spot for both locals and tourists seeking tranquility and natural beauty. Other significant springs include Nara and Chalaar, traditional water sources known for their pure and refreshing water, historically vital for nearby communities. Changla Gali, situated on the slopes of the Murree Hills, is home to numerous springs whose waters are collected in reservoirs, ensuring a steady supply for various uses. Similarly, Dunga Gali, near the Mushkpuri Hill, hosts several springs that not only fulfill local water needs but also enhance the area's appeal as a tourist destination, offering scenic views and hiking opportunities. These natural springs are crucial for sustaining the water needs of Murree's residents and visitors.

4.2.8 Drainage

Islamabad

Islamabad, despite being a meticulously planned city, faces increasing challenges related to flooding and drainage. The city's stormwater management infrastructure is under significant strain due to rapid urbanization, inadequate maintenance, and the impacts of climate change.

The Lai Nullah, a seasonal stream flowing through Rawalpindi and Islamabad, has been a significant contributor to urban flooding. Notably, on July 23, 2001, Islamabad experienced a record-breaking 620 mm of rainfall in just 10 hours, leading to severe flooding in the Lai Nullah and its tributaries. This event resulted in the loss of 61 lives and extensive property damage.

More recently, in July 2021, a cloudburst led to urban flooding in parts of Islamabad, including sectors E-11, F-10, and D-12. The heavy rainfall overwhelmed drainage systems, causing water to enter basements and streets, and leading to the loss of two lives. The city's infrastructure struggles with inadequate stormwater drainage capacity, particularly in low-lying areas[31].

Murree

The existing drainage system in Murree is largely inadequate. Many areas lack proper roadside drains, and where they exist, they are often clogged with debris and seldom

[29] *Pakistan: Lai Nullah Basin Flood Problem Islamabad – Rawalpindi Cities, The Associated Programme On Flood Management by World Meteorological Organization (2004)*

[30] https://murreepakistan.tumblr.com/post/81804479009/pure-drinking-water-source-in-murree-spring?utm_source

[31] https://tribune.com.pk/story/2486165/torrential-downpours-hit-islamabad-and-rawalpindi-cause-traffic-disruptions-and-inundation?utm_source

maintained. Unplanned construction has disrupted natural watercourses, leading to uncontrolled surface runoff during precipitation events. This situation is exacerbated by the region's steep slopes, which increase the velocity of runoff, causing soil erosion and destabilizing streambeds and banks[32].

Murree has experienced multiple flooding events, particularly during the monsoon season. Heavy rainfall often leads to the overflow of drains, inundating roads and low-lying areas. For instance, in September 2021[33], intense rainfall caused drains to overflow, flooding roads and entering buildings, including the Judicial Complex Jhika Gali, Neelum Point and residential areas like Majeed Estate. The gushing water inundated roads, shops, mosques, and residential areas, causing widespread damage.

The region's vulnerability to flooding is exacerbated by deforestation, unregulated construction, and the lack of effective drainage infrastructure. These factors contribute to increased runoff and reduced water absorption, heightening the risk of flash floods.

4.2.9 Solid Waste

Islamabad

Islamabad Municipal Corporation (IMC) and Sanitation Directorate, CDA is responsible authority to ensure efficient collection, transportation, recovery, treatment and disposal of waste generation in Islamabad. In Islamabad, with a population of approximately 2.6 million, the city generates about 1,535[34] tons of solid waste daily. However, the Capital Development Authority (CDA) manages to collect only 60-70% of this waste, which is collected and dumped at the temporary landfill in Sector I-12[35], leaving the remainder to accumulate in open dumps or be burned, contributing to air pollution and health hazards.

Murree

Rawalpindi Waste Management Company (RWMC) is a responsible authority to ensure efficient collection, transportation, recovery, treatment and disposal of waste generation in Murree.

Murree, a prominent hill station in Pakistan, faces significant challenges in solid waste management, primarily due to its fluctuating population dynamics influenced by tourism. During peak tourist seasons, the town's population can swell from approximately 40,000 residents to nearly 1,000,000 visitors, leading to a substantial increase in waste generation. Estimates indicate that solid waste production can escalate from about 39 tons per day in the off-season to approximately 850 tons per day during peak tourist influxes[36].

[32] https://iucn.org/sites/default/files/import/downloads/new_murree_report.pdf?utm_source
[33] https://tribune.com.pk/story/2319441/flooding-in-murree-as-drains-overflow?utm_source
[34] https://en.wenews.pk/addressing-solid-waste-management-in-islamabad/
[35] https://tribune.com.pk/story/1784246/cda-mci-collect-almost-700-tons-solid-waste-daily-basis
[36] https://medium.com/%40saadrashid_52427/solid-waste-management-challenges-due-to-tourism-in-murree-pakistan-91afe9b698ed

The existing waste management infrastructure in Murree is inadequate to handle such surges. The town's waste storage capacity is limited to around 13.8 tons per day, with a maximum capacity of 24 tons per day under optimal conditions. This discrepancy between waste generation and storage capacity results in the accumulation of unmanaged waste.

Project Area

RWMC and CDA are the designated authorities responsible for the collection and management of municipal waste in the Study Area. However, during the field survey (**Plate 4-2**), it was noted that waste collection and management facilities are currently limited, as waste was frequently observed in open piles along roadsides, vacant plots near residential areas, and adjacent to wastewater drains, likely due to the lack of adequate disposal options for residents and road users.



Plate 4-2: A Pictorial View of Waste Management in Study Area

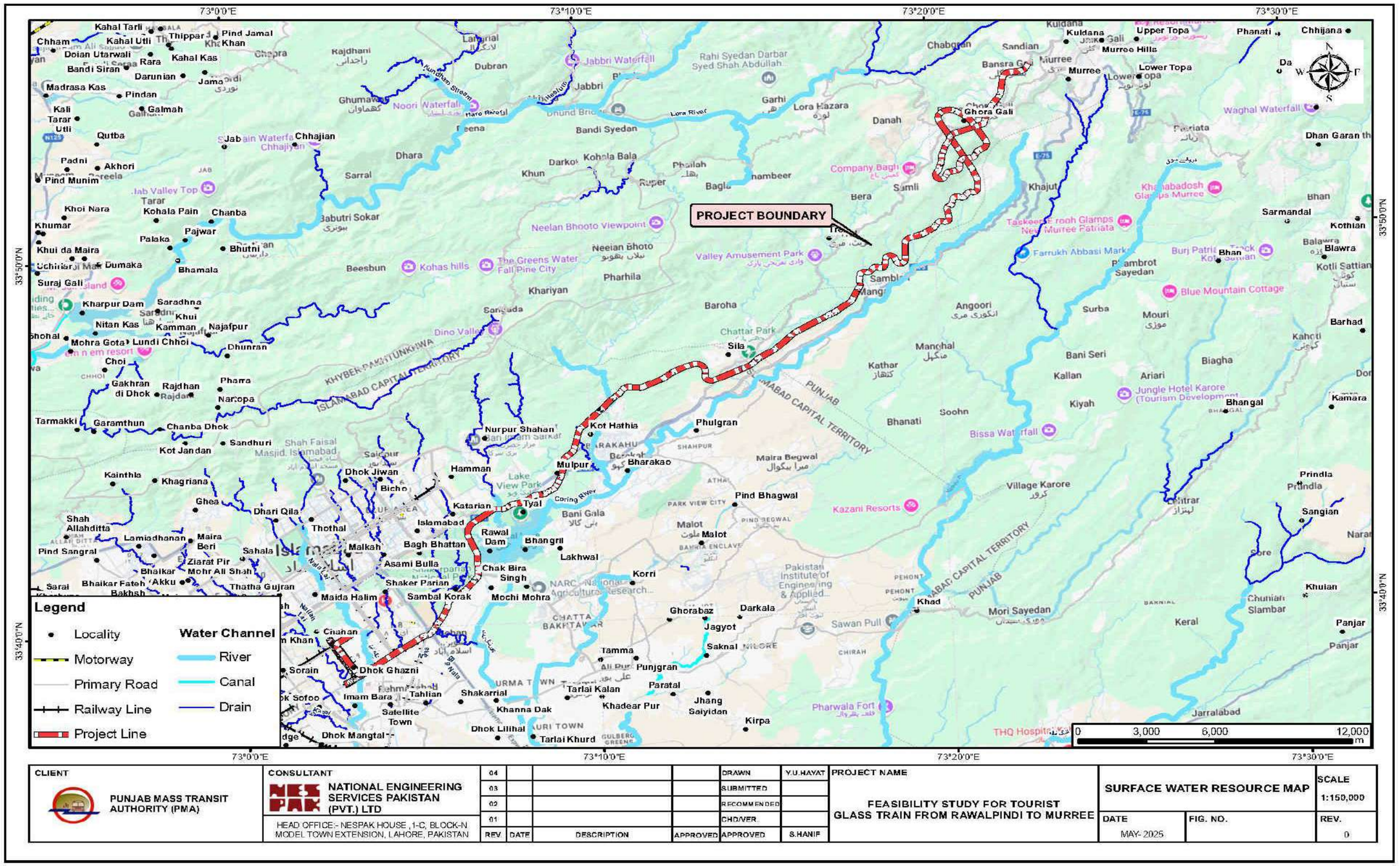


Figure 4.12: Surface Water Resources Map of the Study Area

4.3 ENVIRONMENTAL MONITORING

The environmental parameters for ambient air, noise level and groundwater were monitored in April, 2025 and these results were used for establishing the baseline profile of the Study Area. Environmental monitoring reports of are attached as **Annex-II**. An Environmental Monitoring Map is shown in **Figure 4.13**.

Table 4-14 Locations of Environmental Monitoring Points

Sr. No.	Parameter for Monitoring	Location	Rationale of Selection
1.	**Surface Water**	Location 1: Waterfall Near Bansra Gali, Murree (31°36'37.0"N 74°23'35.4"E)	Sampling points were selected keeping in view the proximity to the Project site to assess the potential impact on water sources that could be directly or indirectly affected by the Project's activities and the Consultant's experience. Moreover, for the selection of the surface water bodies, consideration was given to the vulnerability of water sources to potential contamination.
		Location 2: Korang River Tributary (33°45'37"N 73°10'33"E)	
		Location 3: Rawal Lake (33°42'02"N 73°07'12"E)	
		Location 4: Jinnah Stream (33°44'09"N 73°07'10"E)	
2.	**Wastewater**	Location 1: Lai Nullah (33°39'54"N 73°03'21"E)	
3.	**Drinking Water**	Location 1: Near Chitta Mor, Murree (33°54'29"N 73°22'54"E)	
		Location 2: Near Ghora Gali (33°52'57"N 73°21'34"E)	
		Location 3: Near Malpur (33°43'48"N 73°8'54"E)	
		Location 4: Near Murree Road (33°41'16"N 73°6'38"E)	
		Location 5: 9th Avenue 1-9/3 (33°40'08"N 73°03'32"E)	
4.	**Ambient Air Particulate Matter and Gases**	Location 1: Near Shifa Tree Plantation H Islamabad -8/1 (33°40'03.4"N 73°03'35.0"E)	The monitoring points were selected with reference to the location of receptors and pollution sources. The samples were selected based on the land use of the ROW and COI and sensitive receptors in the proximity of the proposed Project
		Location 2: Near Murree Road (33°41'21.6"N 73°06'34.7"E)	
		Location 3: Near Bara Kahu Bypass (33°44'01.3"N 73°09'10.7"E)	
		Location 4: Near Ghora Gali (33°52'56.7"N 73°21'34.2"E)	
		Location 5: Near Chitta Mor (33°54'31.4"N 73°22'54.8"E)	
5.	**Noise**	Location 1: Near Shifa Tree Plantation H Islamabad -8/1 (33°40'03.4"N 73°03'35.0"E)	The samples were selected based on the land use of the ROW and COI and sensitive receptors in the proximity of the proposed Project
		Location 2: Near Murree Road (33°41'21.6"N 73°06'34.7"E)	
		Location 3: Near Bara Kahu Bypass (33°44'01.3"N 73°09'10.7"E)	
		Location 4: Near Ghora Gali (33°52'56.7"N 73°21'34.2"E)	
		Location 5: Near Chitta Mor (33°54'31.4"N 73°22'54.8"E)	

4.3.1 Air Quality

The ambient air quality monitoring for Nitrogen Dioxide (NO_2), Nitrogen Oxide (NO), Sulfur Dioxide (SO_2), Carbon Monoxide (CO), Ozone (O_3), Particulate Matter ($PM_{2.5}$), Particulate Matter (PM_{10}) and Suspended Particulate Matter (SPM) was carried at five (05) locations within the proposed Project Site as outlined in **Table 4-14**. The sampling was conducted for 24 hours duration for NO_2, NO, SO_2, Lead, $PM_{2.5}$, PM_{10} and SPM, 1 hour for O_3 and 8 hours for CO.

The detailed results of ambient air quality monitoring have been attached in **Annex-II**, while the average concentrations of ambient air pollutants are given in **Table 4-15**. A pictorial view of ambient air monitoring is shown in **Plate 4-3**.



Plate 4-3: A view of Ambient Air and Noise Level Monitoring at Project Site

Table 4-15: Average Concentration of Ambient Air Pollutants

Sr. No.	Monitoring Points	Pollutants								
		CO	NO	NO_2	SO_2	Lead	PM_{10}	$PM_{2.5}$	O_3	SPM
Monitoring Duration		**8 Hr**	**24 Hr**	**24 Hr**	**24 Hr**	**24 Hr**	**24 Hr**	**24 Hr**	**1 Hr**	**24 Hr**
NEQS, 2010		5.0 µg/m³	40 µg/m³	80 µg/m³	120 µg/m³	1.5 µg/m³	150 µg/m³	35 µg/m³	130 µg/m³	500 µg/m³
PEQS, 2016		5.0 µg/m³	40 µg/m³	80 µg/m³	120 µg/m³	1.5 µg/m³	150 µg/m³	35 µg/m³	130 µg/m³	500 µg/m³
ISLAMABAD										
1	AA-01	3.87	28.98	61.64	89.27	0.2	148.65	32.12	42.25	248.42
2	AA-02	3.54	25.77	54.82	79.47	0.15	110.51	32.36	38.92	177.87
3	AA-03	3.07	22.68	48.27	69.93	0.16	103.77	31.05	35.38	169.82
MURREE										
4	AA-04	2.52	18.60	39.58	59.66	0.15	107.63	26.51	28.23	169.14
5	AA-05	2.65	19.53	41.56	62.64	0.17	109.96	31.86	29.68	176.82

µg/m³: micrograms per cubic meter
NEQS: National Environmental Quality Standards
PEQS: Punjab Environmental Quality Standards

Table 4-15 demonstrates that all analyzed environmental parameters at the Islamabad Project site conform to the allowable thresholds prescribed under the National Environmental Quality Standards (NEQS), 2010, while those recorded at the Murree Project site remain within the permissible limits established by the Punjab Environmental Quality Standards (PEQS), 2016.

4.3.2 Noise Level

Noise levels were noted in the study area as outlined in **Table 4-14**. Major sources of noise observed at the site were traffic / vehicular movement and commercial activities in and around the study area.

The detailed results of noise levels have been attached in **Annex-II**, while the average concentrations of noise levels are given in **Table 4-16**. A pictorial view of noise level monitoring is shown in **Plate 4-2**.

Table 4-16: Average Concentration of Noise Level

Averaging Time	NEQS, 2010	PEQS, 2010	Unit	Average Concentration of Noise Level in dB (A)				
				Islamabad			Murree	
	Commercial Area			N-1	N-2	N-3	N-4	N-5
Day-Time (06:00 AM to 10:00 PM)	65	65	db (A)	**74.4**	**76.4**	**73.6**	**73.7**	**72.4**
Night-Time (10:00 PM to 06:00 AM)	55	55		**72.4**	**73.1**	**70.7**	**69.1**	**70.3**

As the Study Area falls under commercial land use, the recorded noise levels during monitoring have been evaluated against the standards for Category B (Commercial Area) as defined in the National Environmental Quality Standards (NEQS), 2010, and the Punjab Environmental Quality Standards (PEQS), 2016, based on noise level measured at the Project site.

The monitoring results indicate that the average noise levels recorded during both daytime and nighttime at the Project sites in Murree and Islamabad exceed the permissible limits specified under the National Environmental Quality Standards (NEQS) and Punjab Environmental Quality Standards (PEQS) for commercial areas. This exceedance is primarily attributed to continuous vehicular traffic, which is a significant source of noise pollution in these urbanized settings. In Islamabad, elevated noise levels are further influenced by ongoing infrastructure development and construction activities in the vicinity of the Project site. Similarly, in Murree a popular tourist destination heavy traffic flow, particularly from commercial and tourist vehicles, coupled with nearby construction and urban development, contributes to the elevated ambient noise levels.

4.3.3 Drinking Water Quality

Drinking water sample were taken near the Project site as outlined in **Table 4-14** and was analyzed for physical, chemical and microbiological parameters. **Table 4-17** shows the results of ground water analysis. A pictorial view of groundwater monitoring is shown in **Plate 4-4.**

Table 4-17: Results of Drinking Water Analysis

Sr. No.	Parameter	Unit	Results of Ground Water Sample					NEQS 2010 for Drinking Water Quality, 2010	PEQS 2016 for Drinking Water Quality
			DW-1	DW-2	DW-3	DW-4	DW-5		
1.	pH	-	6.76	7.24	6.98	7.22	7.15	6.5-8.5	6.5-8.5
2.	Odor	-	Odorless	Odorless	Odorless	Odorless	Odorless	Non-Objectionable	Non-Objectionable
3.	Taste	-	**Sweet**	**Sweet**	**Sweet**	**Sweet**	**Sweet**	Non-Objectionable	Non-Objectionable
4.	Color	Pt-Co	<1.0	<1.0	<1.0	<1.0	<1.0	≤15 TCU	<15
5.	Turbidity	NTU	<0.1	<0.1	<0.1	<0.1	<0.1	<5	<5
6.	Total Hardness	mg/l	308.0	168.0	352.0	232.0	312.0	< 500 mg/l	< 500 mg/l
7.	Total Dissolved Solid	mg/l	434.0	518.0	584.0	354.0	482.0	< 1000	< 1000
8.	Ammonia	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
9.	Chloride	mg/l	11.74	41.09	35.22	21.52	23.48	< 250	< 250
10.	Cyanide (CN)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	≤ 0.05	≤ 0.05
11.	Fluoride (F)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	≤ 1.5	≤ 1.5
12.	Nitrite	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	≤ 3 (P)	≤ 3 (P)
13.	Nitrate	mg/l	0.87	5.4	4.75	1.01	3.4	≤ 50	≤ 50
14.	Phenolic Compound	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
15.	Residual Chlorine	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	0.2-0.5	0.2-0.5
16.	Aluminum (Al)	mg/l	<0.028	<0.028	<0.028	<0.028	<0.028	≤ 0.2	≤ 0.2
17.	Cadmium	mg/l	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	0.01	0.01
18.	Copper	mg/l	<0.0045	<0.0045	<0.0045	<0.0045	<0.0045	2	2
19.	Chromium	mg/l	<0.0054	<0.0054	<0.0054	<0.0054	<0.0054	≤ 0.05 (P)	≤ 0.05 (P)
20.	Mercury	mg/l	<0.0008	<0.0008	<0.0008	<0.0008	<0.0008	≤ 0.001	≤ 0.001
21.	Antimony (Sb)	mg/l	ND	ND	ND	ND	ND	≤ 0.005 (P)	≤ 0.005 (P)
22.	Nickel	mg/l	<0.008	<0.008	<0.008	<0.008	<0.008	≤ 0.02	≤ 0.02
23.	Zinc	mg/l	<0.0033	<0.0033	<0.0033	<0.0033	<0.0033	5.0	5.0
24.	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	≤ 0.05 (P)	≤ 0.05 (P)
25.	Barium	mg/l	<0.031	<0.031	<0.031	<0.031	<0.031	0.7	0.7
26.	Manganese	mg/l	<0.0016	<0.0016	<0.0016	<0.0016	<0.0016	≤ 0.5	≤ 0.5
27.	Iron	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	-	-
28.	Boron	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.3
29.	Lead	mg/l	<0.013	<0.013	<0.013	<0.013	<0.013	≤ 0.05	≤ 0.05
30.	Selenium	mg/l	ND	ND	ND	ND	ND	0.01 (P)	0.01 (P)
31. .	Total Coliforms	CFU / 100ml	**03**	Absent	Absent	Absent	Absent	Must not be detectable in any 100ml Sample	Must not be detectable in any 100ml Sample
32.	Fecal Coliforms (Ecoli)		Absent	Absent	Absent	Absent	Absent		

mg/l: Milligram per Liter
ND: Not Detectable
NGVS = No Guideline Value Set
NTU = Nephlometric Turbidity Unit
TCU = True Color Unit

Table 4-17 indicates that all physical, chemical, and microbiological parameters of the sampled water fall within the permissible limits set by the National Environmental Quality Standards (NEQS) for Drinking Water Quality, 2010, and the Punjab Environmental Quality Standards (PEQS), 2016. However, the water exhibits slight salinity at the Project sites, likely due to the natural leaching of minerals from the surrounding rocky geological formations.

At the location near Chitta Mor, Murree, microbiological analysis revealed the presence of total coliforms at a concentration of 3 Most Probable Number (MPN) per 100 mL, whereas both NEQS and PEQS specify the complete absence of total coliforms as the acceptable standard. The presence of total coliforms may indicate possible contamination from surface runoff, leakage from nearby septic systems, or inadequate protection of water sources from environmental and anthropogenic influences (WHO, 2017; EPA, 2003). Such contamination underscores the need for improved source protection and regular disinfection of water supply systems in the area.

4.3.4 Wastewater Quality

A wastewater sample was collected from Lai Nullah for monitoring purposes. The sample was analyzed in accordance with the parameters outlined in the National Environmental Quality Standards (NEQS), 2010, as Lai Nullah flows through the Islamabad area. Comprehensive surface water quality results are presented in **Table 4-18**.

Table 4-18: Wastewater Quality Monitoring

Sr. No.	Parameters	Unit	Test Results	Discharge into Sewage Treatment NEQS, 2010
1.	Temperature	^{0}C	1.7	≤3
2.	pH	pH unit	7.10	6-9
3.	Total Dissolved Solid (TDS)	mg/l	496.0	3500
4.	Oil and Grease	mg/l	<0.2	10
5.	Biological Oxygen Demand	mg/l	19.0	80
6.	Chemical Oxygen Demand	mg/l	48.0	150
7.	Total Suspended Solid	mg/l	28.0	200
8.	Phenolic Compound	mg/l	<0.01	0.1
9.	Chloride (Cl)	mg/l	68.48	1000
10.	Fluoride (F)	mg/l	0.19	10
11.	Cyanide (CN)	mg/l	<0.01	1.0
12.	Detergent	mg/l	03	20
13.	Sulphate	mg/l	39.51	600
14.	Sulphide	mg/l	<0.4	1.0
15.	Ammonia	mg/l	1.12	40
16.	Silver	mg/l	<0.0032	1.0
17.	Cadmium	mg/l	0.0367	0.1

Sr. No.	Parameters	Unit	Test Results	Discharge into Sewage Treatment NEQS, 2010
18.	Chromium	mg/l	0.0914	1.0
19.	Copper	mg/l	0.0057	1.0
20.	Lead	mg/l	<0.013	0.5
21.	Mercury	mg/l	<0.0008	0.01
22.	Nickel	mg/l	0.0424	1.0
23.	Zinc	mg/l	0.1134	5.0
24.	Arsenic	mg/l	<0.01	1.0
25.	Barium	mg/l	<0.031	1.5
26.	Manganese	mg/l	0.1710	1.5
27.	Iron	mg/l	0.7012	8.0
28.	Boron	mg/l	<0.1	6.0
29.	Total Chlorine	mg/l	<0.1	1.0
30.	Selenium	mg/l	ND	0.5
31.	Pesticides	mg/l	ND	0.15
32.	Total Toxic Metals	mg/l	0.1762	2

mg/l: Milligram per Liter **ND:** Not Detectable

The above table illustrates that all parameters are well within permissible limits of NEQS, 2000 Standards for Discharge into Sewage Treatment.

4.3.5 Surface Water Quality

Surface water samples were collected from the designated Project sites, as detailed in **Table 4-14**. These samples were analyzed based on the parameters specified in the National Environmental Quality Standards (NEQS), 2000, and the Punjab Environmental Quality Standards (PEQS), 2016 for Inland Waters. The complete surface water quality analysis is presented in **Table 4-19.**

A visual representation of the water sampling activity is provided in **Plate 4-4**.



Ground Water Sampling Near Chitta Mor, Murree



Ground Water Sampling Near Ghora Gali



Ground Water Sampling Near Near Malpur



Ground Water Sampling Near Murree Road



Ground Water Sampling Near 9th Avenue I-9/3, Islamabad



Surface Water Sampling at Waterfall Near BansraGali, Murree



Surface Water Sampling at Korang River Tributary



Surface Water Sampling at Rawal Lake



Surface Water Sampling at Jinnah Stream



Waste Water Sampling at Lai Nullah

Plate 4-4: A view of Water Quality Monitoring at Project Sites

Table 4-19: Results of Drinking Water Analysis

Sr. No.	Parameter	Unit	Results of Ground Water Sample				NEQS 2000 for Inland Water, 2010	PEQS 2016 for Inland Water, 2016
			DW-1	DW-2	DW-3	DW-4		
1.	Temperature	^{0}C	1.6	1.5	1.5	1.4	---	---
2.	pH	--	7.74	7.81	7.80	7.39	6-9	6-9
3.	Total Dissolved Solid (TDS)	mg/l	872.0	308.0	261.0	458.0	3500	3500
4.	Oil and Grease	mg/l	<0.2	<0.2	<0.2	<0.2	10	10
5.	Biological Oxygen Demand	mg/l	9.0	1.0	8.0	7.0	80	80
6.	Chemical Oxygen Demand	mg/l	25.0	3.0	21.0	18.0	150	150
7.	Total Suspended Solid	mg/l	13.0	5.0	28.0	31.0	200	200
8.	Phenolic Compound	mg/l	<0.01	<0.01	<0.01	<0.01	0.1	0.1
9.	Chloride (Cl)	mg/l	166.33	7.82	25.43	33.26	1,000	1,000
10.	Fluoride (F)	mg/l	<0.01	<0.01	<0.01	<0.01	10	10
11.	Cyanide (CN)	mg/l	<0.01	<0.01	<0.01	<0.01	1.0	1.0
12.	Anionic detergents (MBAS)	mg/l	ND	ND	ND	ND	20	20
13.	Sulphate	mg/l	94.66	62.97	46.92	78.61	600	600
14.	Sulphide	mg/l	<0.2	<0.2	<0.2	<0.2	1.0	1.0
15.	Ammonia	mg/l	<0.002	<0.002	<0.002	1.12	40	40
16.	Silver	mg/l	<0.0032	<0.0032	<0.0032	<0.0032	1.0	1.0
17.	Cadmium	mg/l	0.0413	0.0150	0.0344	0.0329	0.1	0.1
18.	Chromium	mg/l	0.0173	0.0087	0.0132	<0.0045	1.0	1.0
19.	Copper	mg/l	<0.0045	<0.0045	<0.0045	<0.0045	1.0	1.0
20.	Lead	mg/l	0.1706	0.0516	<0.013	0.2712	0.5	0.5
21.	Mercury	mg/l	<0.0008	<0.0008	<0.0008	<0.0008	0.01	0.01
22.	Nickel	mg/l	<0.008	<0.008	<0.008	<0.008	1.0	1.0
23.	Zinc	mg/l	0.0069	0.0033	<0.0033	0.0023	5.0	5.0
24.	Arsenic	mg/l	<0.01	<0.01	<0.01	<0.01	1.0	1.0
25.	Barium	mg/l	<0.031	<0.031	<0.031	<0.031	1.5	1.5
26.	Manganese	mg/l	0.0952	0.0941	0.0177	0.1077	1.5	1.5
27.	Iron	mg/l	<0.1	0.7738	0.0343	<0.1	8.0	8.0
28.	Boron	mg/l	<0.1	<0.1	<0.1	<0.1	6.0	6.0

Sr. No.	Parameter	Unit	Results of Ground Water Sample				NEQS 2000 for Inland Water, 2010	PEQS 2016 for Inland Water, 2016
			DW-1	DW-2	DW-3	DW-4		
29.	Total Chlorine	mg/l	<0.1	<0.1	<0.1	<0.1	1.0	1.0
30.	Selenium	mg/l	ND	ND	ND	ND	0.5	0.5
31.	Pesticides	mg/l	ND	ND	ND	ND	0.15	0.15
32.	Total Toxic Metals	mg/l	0.2292	0.0753	0.0476	0.3041	2.0	2.0

mg/l: Milligram per Liter
ND: Not Detectable

The table above demonstrates that all analyzed parameters comply with the permissible limits established under the NEQS, 2000 and PEQS, 2016 standards for Inland Water.

4.4 LAND USE OF THE PROPOSED PROJECT

The Project site traverses both flat and hilly terrain featuring predominantly flat land in Islamabad, characterized by urban development and green belts, while transitioning into a hilly and forested landscape as it enters Murree. The alignment is surrounded by a mix of natural vegetation, roadside green belts, seasonal streams (nullahs), and urban settlements, including commercial areas, government and private offices, healthcare and educational institutions, residential communities, and religious sites.

The land use index map of the proposed Project site is shown in **Figure 4-13** and land use statistics is provided in **Table 4-19**. **Annexure-III** shows the detailed land use maps of the study area. Whilst, **Plate 4-5** shows pictorial view of land use

Table 4-20: Land Use Stats in the Study Area

Sr. No.	Land Use	Area (Acres)
1.	Forest	1255.64
2.	Built-up	168.97
3.	Graveyard	0.13
4.	Road	119.78
5.	Vacant/Open Spaces/Barren	208.98



NUML University



Government Girls Higher Secondary School



Margalla Railway Station Islamabad



Iqra University



Green Belt



Nurseries



Islamabad Dry Port



Graveyard



Stormwater Channel



Masjid



Shrine



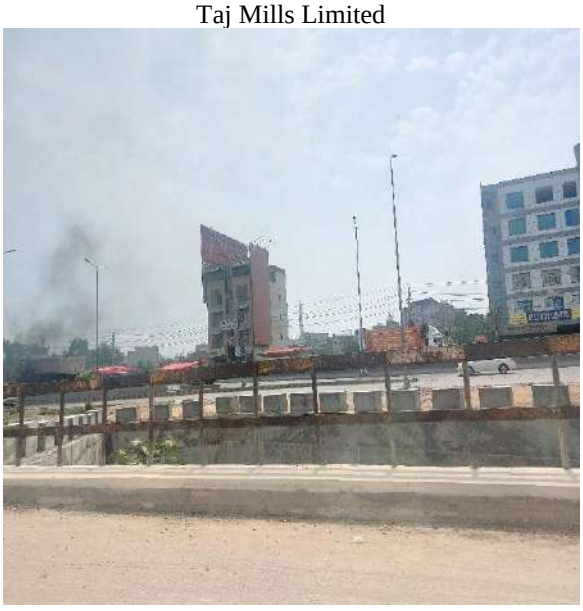
Nullah



Taj Mills Limited



Hassan Steel Mills



Commercial Area



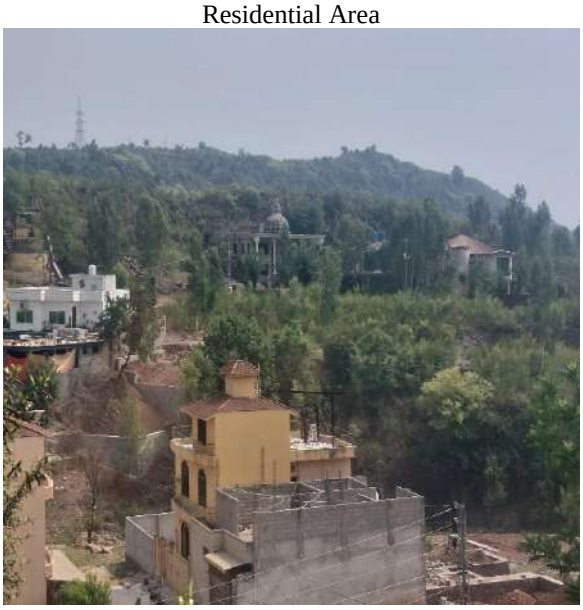
Shahdara Valley



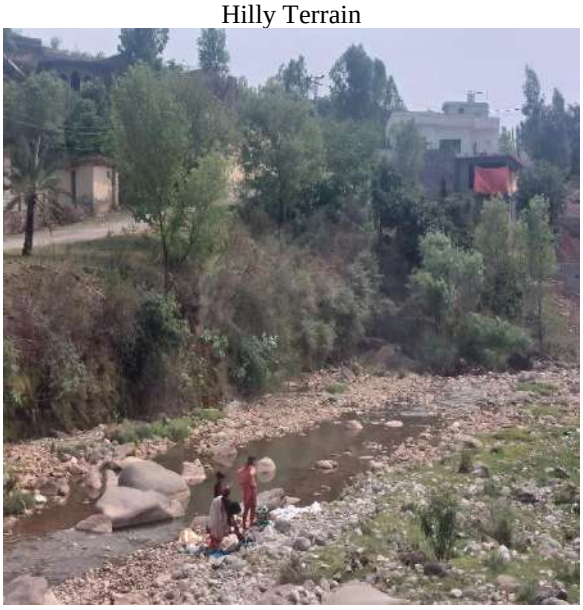
Residential Area



Hilly Terrain



Residential Area



Korang River Tributary

Plate 4-5: A Pictorial View of Land Use in Study Area

4.5 ENVIRONMENTAL SENSITIVE RECEPTOR OF THE PROPOSED PROJECT

Sensitive receptors are mainly people or other organisms that may have a significantly increased sensitivity and exposure to the pollutants and social disturbance, due to the developmental Projects. Thus, sensitive receptors are necessary to be identified, to evaluate the potential impacts of the proposed Project on public health and the surrounding environment.

Sensitive receptor identified within COI of the proposed site includes educational and health institutions, and religious places (shrines, mosques and graveyards). They will be prone to sensitivity during construction phase, due to emission of air pollutants, noise and vibration, traffic jams/access, temporary edifice of construction camps and mobilization issues. The index map of sensitive receptor of the Study Area is shown in **Figure 4-13**. **Annexure-IV** shows the detailed sensitive receptors maps of the study area.

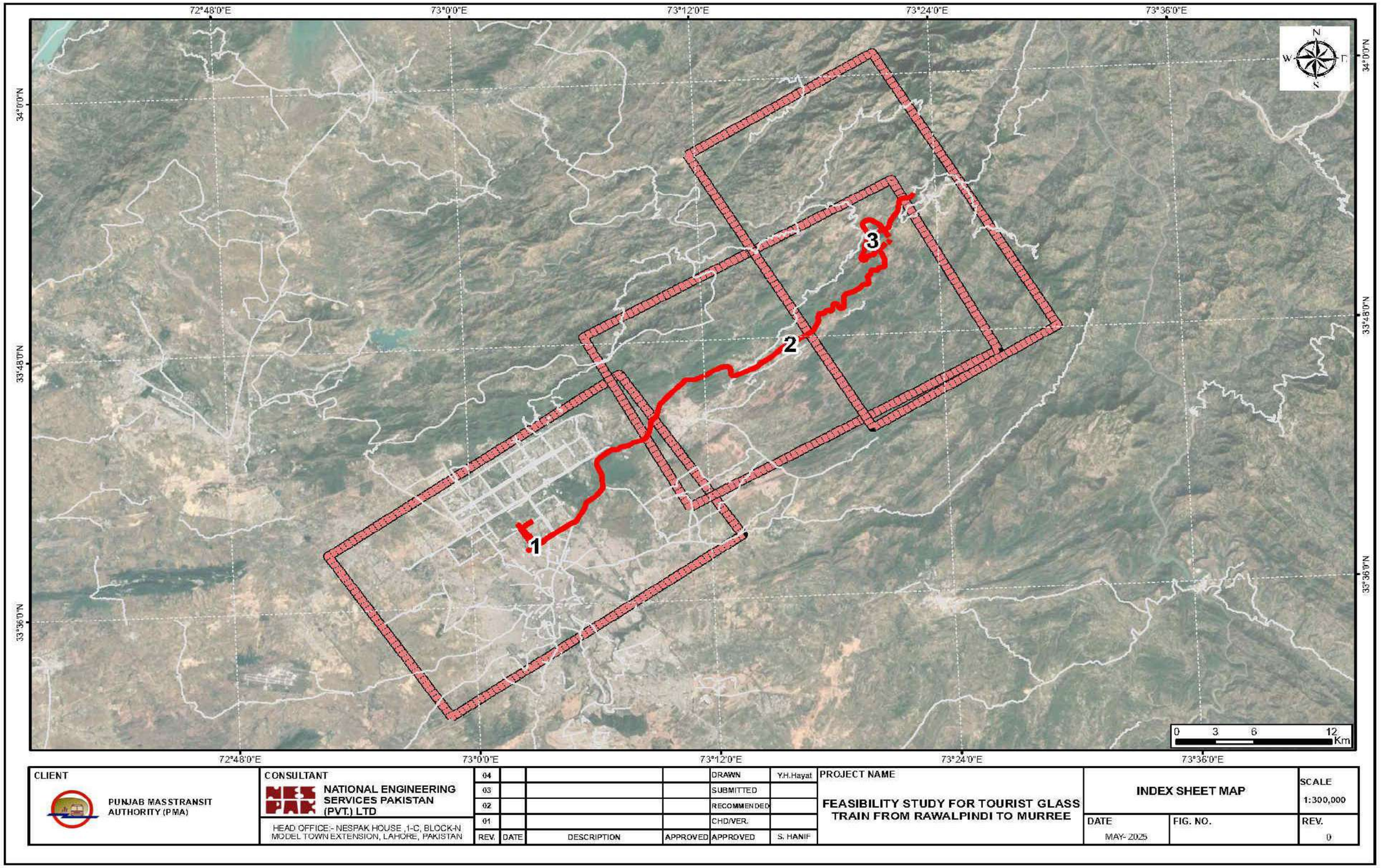


Figure 4-13: Index Map of the Study Area

4.6 ECOLOGICAL ENVIRONMENT

Islamabad

Islamabad is known as a relatively clean, and green city. The climate of Islamabad has a typical version of humid subtropical climate, with five seasons. Islamabad region lies in sub-tropical scrub zone. The dominant trees species of this natural zone are Kau (*Olea ferruginea*), Phulai (*Acacia modesta*) and sanatha (*Dodonaea viscosa*).

Islamabad is known for Margalla Hills National Park and Rawal Lake. Margalla Hills in Islamabad have been declared as National Park since 1980 to conserve the existing flora and fauna.

There are around 250 to 300 species of plants in Islamabad (Capital Development Authority). As many as two third of them are used by the people for their medicinal effects to treat or cure various diseases.

In order to improve the landscape and living environment of the Islamabad the traits like color or blossom, shade, form or shape, scent and free from disease and nuisance are considered during the selection of trees and shrubs for given location.

4.6.1 Floristic Composition

Islamabad city falls in sub-tropical broad leaved evergreen scrub forest. Dominant tree species include Phulai (Acacia modesta), Wild olive (Olea ferruginea), Sanatha (*Dodonaea viscosa*), Black berries (*Monotheca buxifolia*), *Reptonia buxifolia*, Beri (*Zizyphus mauritiana*), Royle's Spike Thorn (*Gymnosporia royleana*), Baikarh (*Adhatoda vasica*), Zebrawood (*Pistacia integerrima*), *Tecoma undulate*, and *Capparis decidua* on drier slopes. These are low branching small evergreen trees with varying densities. Some of these tree species are thorny. Most of these tree and shrub species produce substantial feed and fodder for wildlife and livestock.

These forests types have been subjected to heavy felling and lopping as well as excessive grazing in the past and are now found in degraded condition.

The detail of vegetative species of Islamabad region are given in **Table 4-21**.

Table 4-21: Trees / Shrubs & Herbs of Islamabad

Sr. No.	Common Name	Scientific Name	IUCN Status
1	Phulai	*Acacia modesta*	Least Concern
2	Wild Olive	*Olea ferruginea*	Vulnerable
3	Sanatha	*Dodonaea viscosa*	Least Concern
4	Dhak	*Butea frondosa*	Not Evaluated
5	Ana	*Punica granatum*	Least Concern
6	Pear	*Pyrus pasha*	Least Concern
7	Kachnar	*Bauhinia vareigate*	Least Concern
8	Amaltas	*Cassia fistula*	Least Concern
9	Woodfordia	*Woodfordia fruticose*	Not Evaluated
10	Jasmine	*Jasminum humile*	Not Evaluated

Sr. No.	Common Name	Scientific Name	IUCN Status
11	Holmskioldia	*Holmskiodia sanguine*	Not Evaluated
12	Beri	*Zizyphus mauritiana*	Vulnerable
13	Royle's Spike Thorn	*Gymnosporia royleana*	Endangered
14	Baikarh	*Adhatoda vasica*	Not Evaluated
15	Zebrawood	*Pistacia integerrima*	Not Evaluated
16	Poplar	*Populus sp.*	Varies by species
17	Devil Tree	*Alstonia scholaris*	Not Evaluated
18	Bougainvillea	*Bougainvillea spectabilis*	Not Evaluated
19	Sukh Chain	*Pongamia pinnata*	Not Evaluated
20	Dharek	*Melia azedarach*	Not Evaluated

4.6.2 Fauna / Wildlife

Different areas in Islamabad are home to various species of wildlife, including monkeys, exotic birds and carnivores such as the rare and presently Margalla Common Leopard.

a) Mammals

Islamabad is the only city in the country which has struck a perfect balance between civilized progress and maintaining its wild side too. Perhaps because the expansion and progress are relatively better organized and disciplined than elsewhere.

Margalla Hills is a habitat to all kinds of animals, exotic birds, Monkeys, Grey Gorals, Barking Deer, Jungle Cats, Porcupines, Cape Hares, Himalayan Palm Civets, Red Foxes, Asiatic Jackals, White Crested Kalij Pheasants, Golden Orioles, Paradise Flycatchers, Grey Shrikes, Spotted Doves and others.

However, the following **Table 4-22** shows the list of mammalian species present in Islamabad region. The Project area is to be considered highly degraded in terms of wild fauna.

Table 4-22: List of Mammals

Sr. No.	Mammals	Scientific Name	IUCN Status
1.	Golden Jackal	*Canis aureus*	Least Concern
2.	Barking Deer	*Muntiacus vaginalis*	Endangered*
3.	Common Leopard	*Panthera pardus*	Endangered*
4.	Red Fox	*Vulpes vulpes*	Least Concern
5.	Jungle Cat	*Felis chaus*	Least Concern
6.	Mongoose	*Herpestes auropunctatus*	Least Concern
7.	Indian Mole Rat	*Tachyoryctes splendens*	Least Concern
8.	Field Mouse	*Mus booduga* (likely)	Least Concern
9.	Porcupine	*Hystrix indica*	Least Concern
10	Rabbit	*Oryctolagus cuniculus*	Least Concern
11	Cape Hare	*Lepus capensis*	Least Concern
12	Masked Palm Civet	*Paguma larvata*	Least Concern
13	Wild Boar	*Sus scrofa*	Least Concern

Source: Sheikh and Molur, 2004

b) Amphibians

The amphibians that are found near or around the Project area are given in the **Table 4-23** below.

Table 4-23: Amphibians of the Study Area

Sr. No.	Local/ English Name	Scientific Name	IUCN Status
1.	Common Frog	*Rana tigrine*	Least Concern
2.	Common Toad	*Bufo bufo*	Least Concern
3.	Marble Frog	*Uperodon systoma*	Least Concern

c) Reptiles

Islamabad region supports a good variety of reptiles. In Islamabad, the most common reptile that is worth mentioning and is occasionally witnessed by the hikers is Monitor Lizard. These are generally large reptiles, although some can be as small as 12 centimeters in length. They have long necks, powerful tails and claws, and well-developed limbs.

The reptiles that are found near or around the Study Area are given in the **Table 4-24**.

Table 4-24: Reptiles of the Study Area

Sr. No.	Local/ English Name	Scientific Name	IUCN Status
1.	Fringed Toed Lizard	*Acanthodactylus cantoris*	Least Concern
2.	Spiny Tailed Lizard	*Uromastyx hardwickii*	Vulnerable
3.	Common Krait	*Bungarus caeruleus*	Least Concern
4.	King Cobra	*Ophiophagus Hannah*	Vulnerable
5.	Viper	*Vipera xanthina*	Least Concern

d) Birds

Many bird species have been reported in and around the study area. These include passage migrants, vagrant, resident, breeding and irregular visitors. The migratory birds descend from higher altitudes during the winter months. The common birds observed and reported in and around the study area are given in **Table 4-25.**

Table 4-25: Birds Found in Study Area

Sr. No.	Common Name	Scientific Name	IUCN Status
1.	Rock Pigeon	*Columba livia*	Least Concern
2.	Myna	*Acrido therestritis*	Least Concern
3.	Grey Partridge	*Perdix perdix*	Least Concern
4.	House Sparrow	*Passer domesticus*	Least Concern
5.	Red-Billed Chough	*Pyrrhocorax pyrrhocorax*	Least Concern
6.	Magpie	*Pica pica*	Least Concern
7.	Alpine Chough	*Pyrrhocorax graculus*	Least Concern
8.	Grey Shrikes	*Lanius excubitor*	Least Concern
9.	Spotted Doves	*Spilopelia chinensis*	Least Concern

Murree

4.6.3 Flora

Murree, a newly created district in 2022, now a part of Rawalpindi Civil Division, lies in the Himalayan region bordering Rawalpindi District, Azad Jammu Kashmir (AJK) and Khyber-Pakhtunkhwa (KPP). It is popular tourist resort due to its climate and scenic beauty. The district has an area of 738 km^2 with a population of 372,947 and lies between 33°54'15" N and 73°23'25" E. The elevation of district ranges from 2,500 ft to 7,516 ft. The area has both subtropical and temperate climates and ecological zones. These varying ecological zones support a high degree of plant diversity, including many species adapted to specific altitudes and microclimates. It has a mix of sub-Tropical Broad- Leaved Evergreen Forests, sub-Tropical Chir Pine and Himalayan Moist Temperate Coniferous Forests.

Murree area support a wide range of trees, shrubs, herbs, and climbers, many of which are either regionally endemic or hold ethnobotanical significance. In a floral biodiversity survey, a total of 248 species belonging to 56 families were recorded from the area, where Poaceae was the largest family with 48 grass species. This was followed by Papilionaceae with 15, Asteraceae with 10, and Euphorbiaceae with 7 species. Species diversity was quite high, which seemed to be highly influenced by topographic characteristics like altitude, slope and aspect. Many areas were invaded by exotic species like *Dodonaea viscosa*, which was the most dominant shrub at lower altitudes. *Carissa opaca* also dominated lower altitudes along with *D. viscosa. Themeda anathera* dominated higher altitudes and steeper slopes among grasses, whereas tussock grasses like *Chrysopogon serrulatus* and *Dichanthium foveolatum* were dominant at lower altitudes along with *Cymbopogon jwarancusa*. Among conifers, *Pinus roxburghii* was recorded from moderate heights, while *P. wallichiana* and *Cedrus deodara* from the highest peaks. Conservation status of many economically important species was overall very poor, which was ascribed to anthropogenic activities and habitat destruction[37]. The main forest types present in area with their characteristics is as follow:

Sub-Tropical Broad- Leaved Evergreen Forests: The sub-tropical broad-leaved evergreen forests are covering the low ranges of the district in foothills of Himalayas up to 3000-3500 ft. These are immensely important catchment areas of the Rawal and Simli Dams. These ecologically important forests are found in foothills from Islamabad territory upto Chattar village and up to River Jhelum to Muzaffarabad district. The mean annual rainfall is 250-750 mm and mean annual temperature is 18-30°C in this ecological region. Climate is characterized by winter and spring rains and dry hot summers.

Dominant tree species include Phulai (*Acacia modesta),* Wild Olive (*Olea ferruginea*), and Santha (*Dodonea viscosa*). Santha (*Dodonea viscosa*) is the predominant specie of the type, usually thriving on the southern aspects and over grazed areas near inhabitations. Olive stands grow in cooler and sheltered niches and sporadically on steep rocky slopes.

[37] *Floral Biodiversity and Conservation Status of the Himalayan Foothill Region, Punjab. Pak. J. Bot., 44: 143-149, Special Issue May 2012*

Dense stands of olive can be seen in less accessible areas because its leaves and branches are normally cut for fodder and firewood. The areas near the villages are comparatively less stocked due to browsing and illicit damage by the community. *Ziziphus numularia* and *Ziziphus sativa* are observed below an altitudinal zone of 1,306 m masl (3,400 ft) in sub-catchment area of Rawal and Simli Dams. These forest types have been subject to heavy felling and lopping as well as excessive grazing in the past and mostly are in degraded condition.

Commonly these are also known as scrub forest. The trees and shrubs are mostly thorny and evergreen but some are not thorny e.g. *Olea cuspidate*, *Pome granata,* etc. They produce small timber, fuelwood, and fodder, roof, Handicraft, Handles Tools and Rural cots. Conspicuous erosion, Gullies and deep ravines.

Distribution: Found in foothills of Tret, Bun, and Sherbagala sub-Division of Murree Forest Division and Guzara Forest area. The floristic species found in this forest are as follows:

Sr. No.	Specie Name	Local Name
1.	*Acacia modesta*	Phulai
2.	*Acacia catechu*	Khair Tree / Cutch Tree
3.	*Bauhinia verigata*	Kachnar
4.	*Cacia fistula*	Amaltas / Golden Shower Tree
5.	*Bombox ceiba*	Simal / Silk Cotton Tree
6.	*Zizypus mauritiana*	Ber / Indian Jujube
7.	*Sterculia villosa*	Wild Almond Tree / Bhurj
8.	*Terminalia beterica*	Bahera
9.	*Flecourtia indica*	Indian Plum / Governor's Plum
10.	*Punica granatum*	--
11.	*Ficus carica*	--
12.	*Dalbergia sissoo*	Sishma
13.	*Indigofera*	Neil
14.	*Dondonea viscosa*	Santh
15.	*Adhatoda*	Ber / Indian Jujube
16.	*Gymnosporia*	Wild Almond Tree / Bhurj
17.	*Carissa*	Karonda / Natal Plum

Sub-Tropical Chir Pine Forest: These are open inflammable pine forests sometimes with, but often without, a dry evergreen shrub layer and little or no underwood. This type consists of Chir pine (*Pinus roxburghii*) forests found between 900 m and 1700 m elevation in the Western Himalayas within the range of the south-west summer monsoon. It is the only pine of these forests though there is a small overlap with *Pinus wallichiana* (Kail, Biar) at the upper limit. There is heavy Needle fall in the May. Occurrence of forest fire is common feature in chir forests. The bark of this tree withstands normal fire hazard up to ground fire. The forest occurs on slopes of Rocky Mountains; hence its soils is well drained and often dry. The tree is mostly needle heaving high rate of transpiration. Some broad-leaved species are also associated. Chir form the top major parts of the top canopy. It normally attains the height of 120 feet, heaving girth of 7-8 feet. Pine canopy has an even-aged cover. Usually catch fire in summer. In depression, evergreen Quercus incana (oak) and some deciduous plants grow. Shrubs are few as a under growth. Herbs and greenness occur in monsoon.

Distribution: The Chir Pine stands are found in Tret sub-division of Murree and in Ghora Gali area below the Lawrance College in Samli area as well as in Gulera Gali and Bun sub-division of Murree Forest Division and Guzara Forest area. The floristic species found in this forest are as follows:

Sr. No.	Specie Name	Local Name
	Trees	
1.	*Pinus roxburgii*	Chir Pine
2.	*Quercus incana*	Grey Oak / Banj Oak
3.	*Pyrus pashia*	Wild Himalayan Pear
4.	*Pistacia integrima*	Kangar
5.	*Lyonia ovali*	Himalayan Lyonia
6.	*Rhododenron arboretum*	Tree Rhododendron / Burans
7.	*Zyzygium cummini*	Java Plum / Jamun
8.	*Xylosoma longifolium*	Xylosma
9.	*Quercus glauca*	Ring-Cupped Oak / Blue Japanese Oak
10.	*Mallotus philippinesis*	Kamala Tree / Red Kamala
11.	*Ficus spp*	Fig species (e.g., Peepal, Banyan)
12.	*Olea cuspidate*	Wild Olive
13.	*Grevea oppositifolia*	Dhaman / Phalsa
	Shrubs	
1.	*Myrsine Africana*	Khokhal / African Boxwood
2.	*Daphane*	Banaksha (local name varies)
3.	*Lonicera*	Jasmone / Honeysuckle
4.	*Rose*	Gulab / Rose
5.	*Crisa*	Rudanti / Cressa (a salt-tolerant herb)
6.	*Dodoneaviscosa*	Sanatha / Hopbush
7.	*Wood fordia*	Dhataki / Dhawe / Fire Flame Bush
8.	*Berberis lycium*	Sumblu / Indian Barberry
9.	*Indigofera*	Nil / Indigo Plant
10.	*Reinwardtria*	Basanti / Yellow flax
11.	*Rubus*	Rubus / Wild Raspberry / Hisalu (varies locally)
	Grasses	
1.	*Hetropogon contortous*	Tangle head Grass

Himalayan Moist Temperate Forests: The major distribution of this vegetation type is between 1,500 and 2,500 m masl. Variations occur in the crop due to aspect. This forest type is characterized by the extensive development of coniferous forests, which begin in sub-tropical pine zones and extend into dry temperate and sub-alpine regions. The flora and fauna exhibit wide diversity due to varied climatic conditions and elevation. Conifers form tall forests (80–150 ft), and many species reach a girth of over 15 ft. Evergreen oaks dominate the undergrowth, although the number of dominant species is small. Deciduous broad-leaved forests occur in moist depressions and cooler slopes.

Silviculturally, the forest floor consists of almost pure Kail crop with negligible percentage of scattered trees of Silver Fir and Spruce at the upper elevation and with Chir pine in the lower area. Normally, this forest includes a mix of high rainfall deciduous and coniferous forests, depending on the altitudes. Dominant trees includes Blue Pine (*Pinus wallichiana*) Silver Fir (*Abies pindrow*) and Spruce (*Picea smithiana*). The broad leaved associates of Walnut (*Juglans regia*), Amlok (*Diospyros lotus*), Oak (*Quercus dilatate* and *Quercus semicaprifolia*), Acer (*Acer caesium*), Common Yew (*Taxus wallichiana*), Horse Chest Nut

(*Aesculus indica*), *Prunus padus,* Ruthnol (*Rhododendron arboretum*), Pluch (*Populus ciliata*), Wild Pear (*Pyrus pashia*) , Sharol (*Alnus nitedae*)and with dense undergrowth of shrubs.

Distribution: Moist temperate forests extend along the Municipal and cantonment areas of Murree as well as in Patriata area adjacent to Nathiagalli, Dongagalli and Ayubia on the northern and western aspects. The floristic species found in this forest are as follows:

Sr. No.	Specie Name	Local Name
Coniferous Trees		
1.	Pinus wallichiana	Blue Pine or Himalayan Pine
2.	Cedrus deodara	Deodar Cedar
3.	Picea smithiana	Morinda Spruce or West Himalayan Spruce
4.	Abies pindrow	Pindrow Fir or Himalayan Silver Fir
5.	Taxus baccata	English Yew or Common Yew
Oak Species		
1.	Quercus incana	Gray Oak / Rin
2.	Quercus dilatate	White Oak / Burungi
3.	Quercus glauca	Ring-Cupped Oak / Barin
4.	Quercus ilex	Holm Oak / Bhin
5.	Quercus semecarpifolia	Brown Oak / Banchar
Deciduous Trees		
1.	Acer pictum	Painted Maple
2.	Aesculus indica	Indian Horse Chestnut / Ban Akhrot
3.	Prunus padus	Bird Cherry
4.	Ulmus wallichiana	Himalayan Elm / Kainth
5.	Fraxinus hookeri	Himalayan Ash
6.	Populus ciliata	Himalayan Poplar / Safeda
7.	Corylus colurna	Turkish Hazel
8.	Alnus nitida	Himalayan Alder / Lutsan

A) SHRUBS

The undergrowth is very scanty and consists of a thin sprinkling of low shrubs like *Berberis lyceum* (Sumble), *Mysineafricana* (Khukhal), *Gymnosporearoyaleana* (Pataki), *Adhatoda vassica* (Bhaikar) and *Olea cuspidate* (Sanatha).

B) GRASSES

Common grasses found in the tract include *Cynadon edactylon* (Khabbal), *Desmostachya bipinnate* (Dab) and Chrysopogon echnierlaus. A list of trees and shrubs found in the Project and surrounding area are given in Tables 4-26 and 4-27, respectively.

Table 4-26: List of Common Trees in the Project Area

Sr. No.	Common Name	Scientific Name	IUCN Status
1.	Blue Pine	*Pinus Walliciana*	Least Concern
2.	Chir Pine	*Pinusroxburghii*	Least Concern
3.	Ban Akhor	*Aesculusindica*	Least Concern
4.	Trekhan	*Acer caesium*	Least Concern
5.	Poplar	*Populusciliata*	Least Concern

Sr. No.	Common Name	Scientific Name	IUCN Status
6.	Toot	*Morus alba*	Not Evaluated
7.	Sirris	*Albizzialebbek*	Least Concern
8.	Willow	*Salix Spp*	Varies by species
9.	Kau	*Oleaferruginea*	Not Evaluated
10.	Batangi	*Pyruspassia*	Not Evaluated
11.	Dhaman	*Grewiaoppositifoa*	Not Evaluated
12.	Phagwari	*Ficus palmate*	Not Evaluated
13.	Drewa	*Ailanthus altisimma*	Not Evaluated

Table 4-27: List of Common Shrubs in the Project Area

Sr. No.	Common Name	Scientific Name	IUCN STATUS
1.	Pataki	Gymnosporearoyaleana	Endangered
2.	Sumblu	Berberis lyceum	Least Concern
3.	Khukhal	Mysine Africana	Not Evaluated
4.	Sanatha	Deodoniaviscosa	Least Concern
5.	Bhekar	Adhatodavasica	Least Concern
6.	Kaner	Neriumodorum	Least Concern
7.	Chambat	Viburnum contiifolium	Not Evaluated

4.6.4 Fauna

Fauna of the tract consists of mammals, reptiles, amphibians and birds. The details are given as under.

a) Mammals

List of mammals reported in the area are provided in **Table 4-28.**

Table 4-28: List of Mammals Reported in Vicinity of Project Area

Sr. No.	Mammals	Scientific Name	IUCN Status
1.	Golden Jackal	*Canis aureus*	Least Concern
2.	Kashmir Flying Squirrel	*Eoglaucomys fimbriatus*	Near Threatened
3.	Indian Crested Porcupine	*Hystrix indica*	Least Concern
4.	Indian Hare	*Lepus nigricollis*	Least Concern
5.	Rhesus Macaque	*Macaca mulatta*	Least Concern
6.	Indian Pangolin	*Manis crassicaudata*	Near Threatened
7.	Yellow-throated Marten	*Martes flavigula*	Least Concern
8.	Barking Deer	*Muntiacus vaginalis*	Least Concern
9.	Common Leopard	*Panthera pardus*	Vulnerable
10.	Brandt's Hedgehog	*Paraechinus hypomelas*	Least Concern
11.	Indian Flying Fox	*Pteropus giganteus*	Near Threatened
12.	Small Indian Civet	*Viverricula indica*	Least Concern
13.	Red Fox	*Vulpes vulpes*	Least Concern
14.	Jungle Cat	*Felis chaus*	Least Concern
15.	Northern Palm Squirrel	*Funambulus palmarum*	Least Concern
16.	Mongoose	*Herpestes auropunctatus*	Least Concern
17.	Indian Mole Rat	*Tachyoryctes splendens*	Least Concern

Sr. No.	Mammals	Scientific Name	IUCN Status
18.	Field Mouse	*Mus booduga* (likely)	Least Concern
19.	Porcupine	*Hystrix indica*	Least Concern
20.	Rabbit	*Oryctolagus cuniculus*	Least Concern
21.	Cape Hare	*Lepus capensis*	Least Concern
22.	Masked Palm Civet	*Paguma larvata*	Least Concern
23.	Wild Boar	*Sus scrofa*	Least Concern

b) Reptiles

Reptiles include snakes like Cobra (*Naja naja*), rattle snakes and rat eaters. Small and medium sized lizards (*Uromastyx hardwikkii*) and fringed toed lizards (*Acanthoandactylus contoris*) are also found in the area.

c) Amphibians

Amphibians found in the tract include common frog (*Rana tigrina*) and common toad (*Bufo bufo*).

d) Livestock

Livestock or Cattle in the area, mostly consist of goats and sheep, whereas some people also keep cows and buffaloes as milk animals. Donkeys and Mules are used for taking heavy articles of grocery and construction material to the hill tops.

e) Birds

Various bird species have been observed within the Project area. A comprehensive list of these species is provided in the **Table 4-29.**

Table 4-29: List of Common Birds Reported in the Project Area

Sr. No.	Common Name	Scientific Name	IUCN Status
1.	Black Partridge	*Melanoperdix niger*	Vulnerable
2.	White Wagtail	*Motacilla alba*	Least Concern
3.	Rufous-bellied Niltava	*Niltava sundara*	Least Concern
4.	Variable Wheatear	*Oenanthe picata*	Least Concern
5.	Common Tailorbird	*Orthotomus sutorius*	Least Concern
6.	House Sparrow	*Passer domesticus*	Least Concern
7.	Indian Peafowl	*Pavo cristatus*	Least Concern
8.	Grey Partridge	*Perdix perdix*	Least Concern
9.	Long-tailed Minivet	*Pericrocotus ethologus*	Least Concern
10.	Blue-throated Barbet	*Psilopogon asiaticus*	Least Concern
11.	Grey-hooded Warbler	*Phylloscopus xanthoschistos*	Least Concern
12.	Rusty-cheeked Scimitar Babbler	*Erythrogenys erythrogenys*	Least Concern
13.	Black-throated Accentor	*Prunella atrogularis*	Least Concern
14.	Slaty-headed Parakeet	*Psittacula himalayana*	Least Concern
15.	Red-vented Bulbul	*Pycnonotus cafer*	Least Concern
16.	Himalayan Bulbul	*Pycnonotus leucogenys*	Least Concern
17.	White-throated Fantail	*Rhipidura albicollis*	Least Concern
18.	Shikra	*Accipiter badius*	Least Concern
19.	Common Myna	*Acridotheres tristis*	Least Concern

Sr. No.	Common Name	Scientific Name	IUCN Status
20.	Black-throated Bushtit	*Aegithalos concinnus*	Least Concern
21.	Long-billed Pipit	*Anthus similis*	Least Concern
22.	Brown Rock Chat	*Oenanthe fusca*	Least Concern
23.	White-capped Redstart	*Phoenicurus leucocephalus*	Least Concern
24.	Large-billed Crow	*Corvus macrorhynchos*	Least Concern
25.	House Crow	*Corvus splendens*	Least Concern
26.	Common Quail	*Coturnix coturnix*	Least Concern
27.	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	Least Concern
28.	Rufous Treepie	*Dendrocitta vagabunda*	Least Concern
29.	Brahminy Starling	*Sturnia pagodarum*	Least Concern
30.	Jungle Babbler	*Turdoides striata*	Least Concern
31.	Eurasian Hoopoe	*Upupa epops*	Least Concern
32.	Grey Bush Chat	*Saxicola ferreus*	Least Concern
33.	Indian Robin	*Copsychus fulicatus*	Least Concern
34.	Grey-capped Pygmy Woodpecker	*Yungipicus canicapillus*	Least Concern
35.	Fulvous-breasted Woodpecker	*Dendrocopos macei*	Least Concern
36.	Black-rumped Flameback	*Dinopium benghalense*	Least Concern
37.	Rock Bunting	*Emberiza cia*	Least Concern
38.	Reed Bunting	*Emberiza schoeniclus*	Least Concern
39.	Asian Koel	*Eudynamys scolopaceus*	Least Concern
40.	Red-throated Flycatcher	*Ficedula albicilla*	Least Concern
41.	Asian Barred Owlet	*Glaucidium cuculoides*	Least Concern
42.	Himalayan Griffon Vulture	*Gyps himalayensis*	Near Threatened
43.	Barn Swallow	*Hirundo rustica*	Least Concern
44.	Brown-fronted Woodpecker	*Dendrocoptes auriceps*	Least Concern
45.	Red-billed Leiothrix	*Leiothrix lutea*	Least Concern
46.	Kalij Pheasant	*Lophura leucomelanos*	Least Concern
47.	Great Barbet	*Psilopogon virens*	Least Concern

4.6.5 Endangered Species

The common leopard found in tract is classified as “Endangered” in Pakistan (Sheikh and Molur, 2004). Pheasant species such as the Kalij and various partridges are also becoming increasingly rare in the region and are considered endangered as discussed above.

4.6.6 Protected Areas

a) Margalla Hills National Park (MHNP)

Margalla Hills National Park (MHNP), established in 1980 under the Islamabad Wildlife (Protection, Preservation, Conservation and Management) Ordinance of 1979, is located in the northern part of Islamabad Capital Territory, Pakistan. Covering an area of approximately 17,386 hectares, the park lies within the Himalayan foothills at elevations ranging from 600 to 1,600 meters above sea level. The climate of the region is subtropical, characterized by hot summers, mild winters, and an average annual rainfall of 850 to 1,200 millimeters, with the monsoon season lasting from July to September. The park’s terrain is predominantly limestone with loamy to clayey soils, supporting diverse vegetation types that include subtropical pine forests, scrub forests, and broad-leaved deciduous and evergreen woodlands.

The flora of MHNP is rich and diverse, comprising approximately 600 to 650 plant species. The dominant vegetation includes the subtropical pine forest primarily represented by *Pinus roxburghii* (Chir Pine). The scrub forest vegetation consists of species such as *Dodonaea viscosa*, *Acacia modesta* (Phulai), *Olea ferruginea* (Indian olive or Kahu), and *Ziziphus nummularia*. The broad-leaved forests are home to species like *Bauhinia variegata* (Kachnar), *Melia azedarach* (Dharek), and *Ficus carica* (wild fig). Additionally, the park harbors a variety of medicinal and aromatic plants, including *Withania somnifera* (Ashwagandha), *Berberis lyceum*, *Mentha longifolia*, and *Asparagus racemosus*, which hold significant ethnobotanical and pharmacological importance.

The faunal diversity of Margalla Hills is equally impressive, with over 600 documented species spanning mammals, birds, reptiles, amphibians, and insects. Mammalian fauna includes approximately 38 species, notable among them being the *Panthera pardus* (common leopard), which is an apex predator in the park and classified as vulnerable on the IUCN Red List. Other mammals such as the *Canis aureus* (golden jackal), *Muntiacus muntjak* (barking deer), *Macaca mulatta* (Rhesus macaque), and *Herpestes edwardsii* (Indian mongoose) are also commonly found. The avifauna is particularly rich, with around 250 bird species recorded, comprising both resident and migratory populations. Common species include *Milvus migrans* (black kite), *Accipiter badius* (shikra), *Psittacula krameri* (rose-ringed parakeet), and *Francolinus francolinus* (black francolin). Rare migratory birds, such as the *Ciconia episcopus* (woolly-necked stork), have been occasionally sighted in the park. Reptilian fauna includes species such as the *Varanus bengalensis* (monitor lizard), *Naja naja* (Indian cobra), and *Eublepharis macularius* (leopard gecko), while the park also supports a diverse community of butterflies and other insects, which are vital pollinators within this ecosystem.

Despite its ecological significance, Margalla Hills National Park faces multiple anthropogenic threats. Urban encroachment from the expanding Islamabad city has led to habitat fragmentation and increased human-wildlife conflicts, particularly involving leopards. Illegal logging and fuelwood collection have caused deforestation and degradation of key habitats, while invasive plant species like *Lantana camara* and *Parthenium hysterophorus* threaten native biodiversity by outcompeting indigenous flora. Additionally, recurrent wildfires, often caused by human negligence, pose serious risks to both flora and fauna. Increased recreational activities without proper waste management have contributed to pollution and littering in the park.

To address these challenges, comprehensive conservation measures have been implemented by the Islamabad Wildlife Management Board (IWMB) and other stakeholders. These measures include regular patrolling and monitoring of wildlife through camera trapping, community-led reforestation efforts, public awareness campaigns focused on eco-tourism and wildlife protection, and the establishment of fire management systems such as fire lines and early warning mechanisms. The park's legal protection under national legislation, combined with active management strategies, aims to conserve its unique biodiversity and maintain ecosystem services, including watershed protection for Rawal Lake and carbon sequestration.

In conclusion, Margalla Hills National Park represents a critical biodiversity hotspot within the Islamabad region, providing essential habitat for a wide range of plant and animal species. Effective management and sustained conservation efforts are vital to safeguarding its ecological integrity against increasing anthropogenic pressures, thereby ensuring the park continues to serve as a valuable natural resource for both wildlife and the local human population.

b) Murree, Kotli Sattian and Kahuta National Park and Forest Reserves

The Murree, Kotli Sattian, and Kahuta regions are ecologically significant forest reserves situated in the Himalayan foothills of Punjab, Pakistan, representing vital biodiversity hotspots within this landscape (Khan et al., 2015; IUCN Pakistan, 2020). Murree, a prominent hill station, is predominantly covered by temperate coniferous forests dominated by Chir Pine (*Pinus roxburghii*) and Blue Pine (*Pinus wallichiana*), which provide critical habitat for diverse wildlife, including apex predators such as the common leopard (*Panthera pardus*), primates like rhesus macaques (*Macaca mulatta*), and numerous avian species (Shah et al., 2018). The area also functions as an essential watershed, supplying freshwater to downstream communities, but faces increasing pressures from urbanization, tourism, deforestation, and soil erosion, leading to habitat fragmentation and biodiversity loss (Ahmad et al., 2017).

Murree, Kotli Sattian, and Kahuta National Park and adjacent forest reserves also contribute significantly to the regional biodiversity, containing mixed forests of Chir Pine and Oaks, and supporting populations of barking deer (*Muntiacus vaginalis*), porcupines (*Hystrix indica*), masked palm civets (*Paguma larvata*), and common leopards (IUCN Pakistan, 2020). Despite its protected status, it faces challenges from poaching, illegal timber extraction, and habitat degradation (WWF Pakistan, 2018).

Collectively, these forest reserves provide critical ecosystem services, including carbon sequestration, soil stabilization, and water regulation, and act as essential corridors for wildlife movement and genetic exchange (UNEP, 2019). To preserve regional biodiversity and maintain ecological balance, it is imperative to strengthen conservation enforcement, promote sustainable land use, and increase community awareness and involvement (Khan et al., 2021). These actions will help ensure the long-term environmental sustainability of Murree, Kotli Sattian, and Kahuta forest ecosystems for the benefit of both nature and local populations.

***Nandkot Reserved Forest**:* Nandkot Reserved Forest is situated at an approximate elevation of 1,028 meters near the locality of Phari in Punjab, falling under the administrative jurisdiction of the Murree Forest Division. Although comprehensive biodiversity assessments are limited, this forest contributes substantially to regional ecological balance by supporting a variety of indigenous flora and fauna typical of the lower Himalayan subtropical zone. Its preservation aids in watershed protection and serves as a green buffer against anthropogenic pressures.

Salkhetar Reserved Forest: Located near Managa Village, at approximately 808 meters elevation, the Salkhetar Reserved Forest is managed by the Murree Forest Division. As a designated reserved forest under the Punjab Forest Department, it plays an essential role in

maintaining local ecological integrity and biodiversity conservation. Although detailed species inventories are currently unavailable, the forest is part of the vital forested landscape that supports soil stabilization, hydrological regulation, and habitat connectivity within the region.

Seri Bari Reserved Forest: Seri Bari Reserved Forest is positioned near Kalran in the Murree district of Punjab. As part of the broader Murree Forest Division's protected areas, it sustains various native plant and animal populations, contributing to the environmental stability of the region. Its role in maintaining biodiversity and ecological services such as carbon sequestration and erosion control remains significant despite limited detailed biological data.

Guzara Forest in Murree: Guzara Forests are a unique classification of forests found in Pakistan, particularly in the hilly regions such as Murree, Kotli Sattian, and Kahuta. In the context of Murree, Guzara Forests are community-managed forest lands that are owned by the local right-holders but are regulated under the jurisdiction of the Punjab Forest Department. These forests were designated to meet the timber and firewood needs of local communities while ensuring conservation of forest ecosystems.
Guzara Forest were initially sanctioned under Forest Conservancy Rules to bring all the waste lands under the control of Deputy Commissioner of Rawalpindi. These rules empowered the Provincial Government to manage waste land, falling of trees, standing on such wastelands and to check breaking for cultivation in the hills. Considerable, wooded areas were set apart as Guzara Forests, primarily to meet grazing requirements of owners and other land owners in respect of timber, firewood, grazing and browsing of cattle, sheep's and goats and grass cutting. The Government, however asserted and established its rights to conservancy management and to share out of sale proceeds from this Guzara Forests.
In Murree, Guzara Forests are characterized by subtropical evergreen broad leaves forests, subtropical chir pine forests, Himalayan moist temperate forests, and broadleaf species. The dominant tree species include Kahu, Phulai, Sanatha, Chir Pine (*Pinus roxburghii*), Blue Pine (*Pinus wallichiana*), *Quercus incana* (Grey Oak), and *Aesculus indica* (Indian Horse Chestnut). These forests support a rich diversity of wildlife, including leopards, wild boars, porcupines, jackals, and various pheasants and bird species.

Guzara Forests play a significant ecological role by:

- Maintaining regional biodiversity;
- Supporting groundwater recharge and watershed protection;
- Providing habitat connectivity between protected areas (such as Murree Wildlife Park and Reserved Forests); and
- Acting as a carbon sink to mitigate climate change.

Despite their importance, Guzara Forests in Murree are under pressure due to population growth, encroachments, overharvesting, and unregulated tourism. Sustainable forest management practices and community-based conservation strategies are essential to preserve these valuable forest ecosystems.

c) Murree Wildlife Park

Murree Wildlife Park, located at Bansra Gali near Murree, spans an area of approximately 240 acres. Established in 1986 under the National Development Scheme 'Development of Wildlife Park,' it forms an integral component of the Ayubia National Park ecosystem. The park supports a wide range of fauna, including several mammal, bird, and reptile species, thus acting as a crucial sanctuary for wildlife conservation and biodiversity preservation in the region. The park also promotes eco-tourism and environmental education, serving as a recreational and research site for conservationists and visitors alike.

4.6.7 Crop Pattern

Main Kharif crop at the Project site is Maize, which is sown during May and June and cultivated in October and November. Rice is sown during April and May and cultivated in the month of October and November.

Wheat is grown during Rabi season, which is sown in the months of October and November and harvested in the months of April and May. In addition to Maize, some fodder crops and pulses are also raised during Kharif season.

4.6.8 Crop Yield and Income

Crop yield are usually low due to small land holdings and use of primitive mode of agriculture, as shown in **Table 4-30**.

Table 4-30: Crop Yield and Income

Sr. No.	Name of Crop	Yield Per Acre	Income Per Acre
1.	Maize	800 Kg	16,000
2.	Wheat	900 Kg	18,000
3.	Rice	1040 Kg	52,000
4.	Vegetables	-	75,000

***Source**: Agriculture Department, Murree*

4.6.9 Fruit Crops

There are no compact fruit gardens in the tract, but local people have raised fruit trees in small number on the boundaries of their agricultural fields and in the open land available near their houses.

Fruit trees normally raised are Apple, Walnut, Apricot, Pears and Peaches. Many of the fruit plants like walnut, amlok and pear grow naturally as well along the water streams. **Plates 4-6** and **4-7** shows pictorial view of flora and fauna observed in the Study Area.


PAPNA












































Plate 4-6: A Pictorial View of Flora in the Study Area



Plate 4-7: A Pictorial View of Fauna in the Study Area

4.7 SOCIO-ECONOMIC ENVIRONMENT

The socioeconomic environment has been studied with respect to human and economic development and quality of life values of the population residing in the vicinity of the Project site. The human and economic development will mainly focus on population and communities, industrial development, situation of infrastructure availability, institutions, transportation network, prevailing land use, power sources and agricultural pattern of the

Project Area. Quality of life will include socio-cultural values, situation of public health situation, recreational resources & development and archaeological/historical and cultural sites, etc.

In addition to this, consultations were held with major stakeholders of the Study Area in order to seek the public opinion on the implementation of the proposed Project. For the collection of data, both primary and secondary sources were used. During the desk/ office study, available reports/ documents were comprehensively studied. During the field survey, informal/formal meetings and interviews were held with different stakeholders using socio-economic performa and observations were recorded after giving due consideration during survey.

4.8 POLITICAL AND ADMINISTRATIVE SETUP

Islamabad

For an administrative system, with judicial and administrative control over the Islamabad Capital Territory (ICT), the District Administration was established in 1980. Accordingly, on January 01, 1981 administrative functions were resumed by the Federal Government with direct administration by the President and Islamabad Administration was assigned all the powers and functions of a Provincial Government. The local government institutions in ICT area therefore are slightly different from those of other districts in Pakistan.

The Capital Territory is spread over an area of 906 sq. km., and is divided into three segments; namely, (i) Islamabad Urban area including institutional and industrial area, covering 220 sq.km (ii) Islamabad Park occupying 220 sq.km, and (iii) Islamabad Rural area measuring 466 sq.km. The rural area of Islamabad encompasses 132 villages and administratively consists of 12 Union Councils.

Murree District is an administrative district of Rawalpindi Division in Punjab, Pakistan. It was created out of Rawalpindi District in 2022 and consists of two tehsils, Kotli Sattian and Murree.

Murree

Murree District, established in October 2022 after being carved out from Rawalpindi District, comprises two tehsils Murree and Kotli Sattian and is administratively overseen by a Deputy Commissioner. Politically, it is represented in the National Assembly through NA-51 (Murree-cum-Rawalpindi) and in the Provincial Assembly by PP-6 (Murree), with elected officials responsible for governance and development. The district's creation followed the 2022 Murree snowstorm tragedy, aiming to improve local administration and disaster management. Despite this upgrade, many administrative departments remain under Rawalpindi's control, limiting Murree's full autonomy.

4.9 HUMAN AND ECONOMIC DEVELOPMENT

a) Human Development

i. Population Composition and Demographics of the Project Area

Islamabad

According to the results of 2017 census report, the total population of Pakistan is estimated as 207,774,520 persons with annual growth rate of 2.40 percent and the total population of Islamabad District is 2,006,572, with urban population of 1,014,825 which is around 50.58 percent of the total population. The average annual growth rate of population in the district during this period was 4.91 percent. The total area of district is 906 kilometers which gives population density of 1,165 persons per square kilometer. The total population of Islamabad Capital Territory (ICT) was 8,05,235 as enumerated in March, 1998 with an intercensal percentage of 136.8 since March, 1981 when it was 3,40,286 souls. The average growth rate was 5.19 percent, which gives population density of 889 persons per square kilometer as against 375 persons observed in 1981 indicating a very fast growth rate of ICT.

Murree

As of the **2023 census,** Murree district has 66,187 households and a population of 372,947. Murree tehsil covers an area of 434 km² and has a population of 252,526. It exhibits a high population density of 581.86 people per km², indicating a significant urban concentration. The urban areas, including the town of Murree, are characterized by developed infrastructure, tourism facilities, and higher literacy rates.

ii. Religion

Islamabad

The population of district is predominantly Muslims i.e. 95.5 percent. The next higher percentage is of Christian with 4.1 percent, followed by Ahmadi as 3 percent. While other minorities like Hindu (jati), Scheduled castes, etc. are very small in number. The proportion of Muslims is higher in rural areas (98.8 percent), as compared to their counterparts in urban (93.8 percent). Christians are mostly living in urban areas representing 5.7 percent as compared to just 0.9 percent in rural areas. Similarly Ahmadis are more in urban area as compared to their proportion in rural areas.

Murree

According to the 2023 Census, Islam is the dominant religion in Murree, representing 99.61% of the population. Christianity makes up 0.33%, while other religions such as Hinduism, Sikhism, and others collectively constitute about 0.06% of the population.

iii. Ethnic Structure

Islamabad

For the study of ethnography Islamabad can be divided into two parts i.e. urban and rural. In Islamabad city people belonging to almost all possible races and tribes of Pakistan are living.

Regarding people living in rural area, they are mostly Rajput. The important sub-division are Bhatti, Rawal, Janjua and Chohan. Besides, Gujjar, Awan, Mughal, Qureshi, Syed and Satti are also living there. Some of the other minor tribes are the Jat, Malyar and Pathan and some Khattar.

Murree

Murree District is home to a diverse ethnic composition, primarily comprising the Dhund Abbasi, Dhanyal, Satti, Kethwal, and Jasgam tribes. The Dhund Abbasis, who speak dialects such as Pahari and Hindko, are the largest group in northern Murree and trace their ancestry to Abbas ibn Abd al-Muttalib. The Dhanyal, found in the western part of Murree, claim descent from Ali ibn Abi Talib, while the Satti tribe, predominant in Kotli Sattian, has Rajput origins. The Kethwal, located between Dhund and Dhanyal areas, are said to descend from Alexander the Great, and the Jasgam, the smallest group, also claim Abbasi Arab heritage. Together, these groups contribute to the rich cultural and social fabric of Murree, each with distinct languages, traditions, and customs.

iv. Mother Tongue

Islamabad

The mother tongue refers to the language used for communication between parents and their children in any household. Punjabi is the predominantly language being spoken in Islamabad Capital Territory, representing 71.6 percent of population followed by Urdu spoken by 10.1 percent, Pushto 9.5 percent and Siraiki 1.1 percent while others speak Sindhi, Balochi, Bravi, Dari, English, etc. The proportions of people speaking Urdu, Sindhi, Pushto, Siraiki and other languages except Punjabi are more in urban area than in rural areas.

Murree

The predominant mother tongues spoken in Murree District include Pahari, Hindko, and Urdu. Pahari and Hindko are the most widely used regional languages, reflecting the linguistic heritage of the main ethnic groups such as the Dhund Abbasi and Dhanyal. Urdu, being the national language of Pakistan, is commonly understood and used in formal education, administration, and communication. The coexistence of these languages highlights the district's cultural diversity and serves as a vital link between its rural and urban populations.

v. Sex Ratio

Islamabad

Sex ratio, i.e. proportion of males for every 100 females. According to the census of 2017, the sex ratio is 111.04, that is 108.41 in rural and 113.68 in urban area, which was 117 percent recorded in 1998 Census which had decreased from 119 in 1981. The ratio was 118 percent in rural area and 122 in urban area.

Murree

The district has a sex ratio of 101.18 males to 100 females and a literacy rate of 85.90%: 92.13% for males and 79.52% for females. 82,063 (22.19% of the surveyed population) are under 10 years of age. 48,729 (13.07%) live in urban areas.

vi. Migration

The total number of life time in-migrants in Islamabad Capital Territory was 3, 97,731 or 49.4 percent of population of the district. Of total life time in-migrants 312,640 persons were settled in Capital city. Of total district migrants 88.1 percent came from Punjab, Sindh, Baluchistan and KPK, 6.6 percent from Azad Kashmir and Northern areas while remaining 5.4 percent Pakistani repatriated from other countries. There is no single case of migrant whose birth place is not reported.

4.10 INDUSTRIAL AND COMMERICIAL DEVELOPMENT

Islamabad

In order to meet local requirement, CDA, has allotted 450 Industrial plots in I-9, I-10 Sectors of Islamabad and Kahuta Triangle. The city has 11 main markets in addition to Industrial and Trade Centre as well as Blue area. Fecto Cement Factory is also situated near the Margallah hills and 9 stone crusher units are also functioning within the limits of Islamabad.

Murree

Industrial and commercial development in Murree has traditionally been limited to small-scale industries such as sawmills, poultry farms, and cottage enterprises. However, recent initiatives have marked a shift toward enhancing the district's commercial and tourism infrastructure. The Punjab government has launched a PKR 4.5 Billion project to transform Murree into a world-class tourist destination by restoring historical buildings and modernizing commercial areas around the GPO and Mall Road. Additionally, the Capital Development Authority has proposed the "Jinnah Square Downtown" Project along Srinagar Highway and Murree Road, which includes the development of hotels, apartments, hospitals, and recreational facilities to attract investment. Real estate developments like the HSQ Tower on Murree Expressway are also contributing to the district's economic diversification. These projects collectively aim to blend Murree's natural charm with sustainable commercial growth, positioning it as a rising hub for tourism and business in the region.

4.11 TRANSPORTATION AND COMMUNICATION

Islamabad

The road network in the urban area of Islamabad is designed to provide an effective transportation system to servers of all sector of city. It consists of various specifications, such as highways, main roads and service roads. Islamabad is linked to the NWD /STD systems and gate-way exchange system for rapid and quick internal as well as external communication. The Project area is located around the well-connected road network of the Islamabad City.

Islamabad has also been linked by railway line at Margalla, situated between Sector I-9 and H-9. Islamabad has an international airport with good domestic and international connections. It is directly linked with Middle East, Europe and China.

Murree

Murree District has witnessed substantial improvements in transportation and communication infrastructure, enhancing accessibility for residents and tourists alike. The E-75 Murree Expressway and the recently completed Jinnah Square Underpass on Murree Road provide signal-free, efficient travel between Murree and Islamabad, while the rehabilitation of major local roads has further improved intra-district connectivity. Additionally, the proposed Kohsar Tourism Expressway will link Rawalpindi to Muzaffarabad via Murree, boosting regional tourism and economic integration.

In terms of communication, Murree enjoys widespread coverage of 2G, 3G, 4G, and emerging 5G networks by major telecom providers, with ongoing efforts by the Pakistan Telecommunication Authority to enhance service quality in Murree and adjoining areas. PTCL also provides internet services, strengthening the district's digital infrastructure. These developments collectively support Murree's socio-economic growth, particularly by fostering tourism and improving access to essential services.

4.12 EDUCATIONAL FACILITIES

Islamabad

Islamabad have various universities but not limited to: Quaid–e-Azam University, Allama Iqbal Open University, Air University, NUML University, Iqra University, The National University of Sciences & Technology (NUST) and International Islamic University. In addition to that there are 07 Degree Colleges, 13 Higher Secondary, 79 High Schools, 46 Middle and 216 Primary Schools. There are additional 14 Islamabad Model Colleges.

Murree

Murree District hosts a range of educational institutions, including public universities, private schools, colleges, and military academies, reflecting a strong commitment to academic development. Kohsar University Murree, established in 2020, is the district's main public university offering undergraduate and graduate programs across various disciplines. Prestigious institutions such as Lawrence College Ghora Gali, PAF College Lower Topa, and Cadet College Murree provide quality education with a focus on leadership and discipline. Historic private schools like the Convent of Jesus and Mary and Presentation Convent High School have long served the region, particularly in girls' education, under the Catholic Board of Education. Together, these institutions form a robust educational infrastructure that supports the district's socio-economic progress and provides diverse learning opportunities for students from Murree and beyond.

4.13 HEALTH FACILITIES

Islamabad

The major health facilities available in the ICT are Federal Government Services Hospital, Capital Hospital, Pakistan Institute of Medical Sciences (PIMS), Children Hospital, National Institute of Health and Shifa International Hospital. Besides, 35 (ICT) Dispensaries, Maternal Child Hospital (MCH), 03 Rural Health Centers and 13 Basic Health Units in rural area are functioning day and night. The health network of ICT seems to be satisfactory as compared with other areas of the country.

Murree

Murree provides a range of healthcare services through a combination of public and private facilities. The Tehsil Headquarters (THQ) Hospital Murree serves as the main public healthcare center, offering services such as emergency care, gynecology, pediatrics, radiology, and pathology. The district is also home to the 360-bed Samli Sanatorium, specializing in the treatment of tuberculosis and respiratory illnesses. Primary healthcare needs across rural areas are addressed through a network of Basic Health Units (BHUs) and Rural Health Centers (RHCs). In the private sector, facilities like Farooq Hospital, located on the Murree Expressway, offer specialized services including cardiology, neurology, orthopedics, and pediatrics. Collectively, these healthcare establishments contribute to the district's efforts in providing accessible and comprehensive medical care to its population.

4.14 ARCHEOLOGICAL AND CULTURAL PROPERTY/ PLACES OF INTEREST

Islamabad

The shrine of Syed Mehar Ali Shah of Golra Sharif is located in Sector E-11 of Islamabad, where devotees gather annually to celebrate his Urs. Another prominent shrine is that of Shah Abdul Latif Kazmi, popularly known as Bari Imam, whose death anniversary (Urs) is observed during the first week of May, from Monday to Thursday, featuring vibrant festivities that showcase Potohar culture and attract visitors from across the country.

Islamabad is also home to the stunning Shah Faisal Mosque, designed by renowned Turkish architect Vedat Dalokay and named in honor of the late King Faisal of Saudi Arabia. Other notable landmarks include the Lok Virsa Museum, which highlights Pakistan’s rich cultural heritage, and the ancient Shah Allah Ditta caves, reflecting the area's historical importance. These historical and cultural landmarks make Islamabad a significant destination for both heritage enthusiasts and tourists.

Murree

Murree is home to a variety of archaeological and cultural sites that highlight its rich historical and touristic appeal. The Riwat archaeological site, located near Murree, is significant for its evidence of early human occupation dating back approximately 45,000 years, making it one of the oldest known sites in South Asia. Colonial-era buildings such as the Holy Trinity Church (1857) and the Convent of Jesus and Mary (1876) reflect Murree's British-era architectural legacy. The area also offers numerous cultural and recreational attractions including the bustling Mall Road, scenic viewpoints like Kashmir Point and Pindi Point, and Patriata (New Murree), known for its chairlifts and cable cars through dense pine

forests. These historical and cultural landmarks make Murree a significant destination for both heritage enthusiasts and tourists.

4.15 SOCIO-ECONOMIC BASELINE SURVEY OF THE PROJECT AREA

The socio-economic survey was carried out in the month of April 2025. A sample size of 115 (103 Males & 12 Females) was taken by using random sample technique. During the socio-economic survey, respondents were informed about the Project objectives, its location and basic design features. To get the maximum information about the local community and proposed Project area, both primary and secondary sources were used for data collection. To assess the socioeconomic conditions, a series of questions were asked during the socio-economic survey (attached as **Annexure-I**)

4.16 SURVEY FINDINGS

Detailed findings of the survey comprising of different parameters are discussed in the following section.

A) Demographic Characteristic

Demography refers to the statistical study of population characteristics, including factors such as age, sex/gender, religion, ethnic composition, and mother tongue. Based on the survey, the demographic features of the sampled population are outlined below.

i. Gender Distribution of the Respondents

About 115 respondents, comprising 90% male and 10% female population in the Project Area was contacted to carry out socio-economic and impact assessment survey.

ii. Population and Family Size

A socio-economic survey of 115 households was carried out following the established methodology, revealing a total population of approximately 636 individuals. Of this population, males comprised 51% while females accounted for 49%. The average household size was found to be 5.6 persons, with the majority of families living in a nuclear family structure. The gender wise distribution of the 115 respondents families are given in **Table 4-31.**

Table 4-31: Population and Family Size of the Respondents

Total Respondents	Population				Total Population	%
	Male	%	Female	%		
115	324	51	312	49	636	100

Based on the social survey carried out in April 2025

iii. Age Composition

The demographic characteristics presented in **Table 4-32** indicate that 12% of the respondents were aged between 15 and 25 years, while approximately 14% fell within the 26

to 35-year age group. About 26% of respondents were between 36 and 45 years old, and the remaining 48% were aged 46 years and above. These age distributions suggest that the majority of respondents were sufficiently mature to provide informed opinions and express concerns regarding the proposed Project and its potential impacts.

Table 4-32: Age Composition of the Respondents

Sr. No.	Age Composition	Number of Respondent	Percentage (%)
1	15 – 25	14	12
2	26 – 35	16	14
3	36 – 45	30	26
4	46 and above	55	48
Total		**115**	**100**

iv. Educational Level

The educational distribution of the respondents is detailed in **Table 4-33** According to the data, 14% of respondents were illiterate, while 12% had completed primary education. About 20% had attained middle school education, and 24% were matriculate. Additionally, 14% reported having an intermediate level of education, and the remaining 16% were graduates or held master's degrees and higher qualifications.

Table 4-33: Educational Level of the Respondents

Sr. No.	Educational Level	Number of Respondent	Percentage (%)
1	Illiterate	16	14
2	Primary	14	12
3	Middle	23	20
4	Matric	28	24
5	Intermediate	16	14
6	Graduation & Above	18	16
Total		**115**	**100**

v. Occupation

The socio-economic conditions of the respondents were also examined during the field survey. The majority, 24%, were engaged in running their own businesses or shops, while 20% were employed in private sector jobs and 17% held government positions. Additionally, 15% worked as laborers in various fields, including industrial and general labor, and 9% identified as drivers of buses, vans, autos, or taxis. Mechanics comprised 6% of the respondents, followed by hotel operators at 4%, farmers at 3%, and students at 2%. Detailed statistics on the occupational status of respondents are provided in **Table 4-34** below.

Table 4-34: Occupation of the Respondents

Sr. No.	Profession	Number of Respondent	Percentage (%)
1	Business/Shopkeepers	27	24
2	Private Service	23	20
3	Govt. Employee/ Retired	19	17
4	Labor Workers	18	15
5	Driver	10	9
6	Mechanic	7	6
7	Hotel	5	4
8	Farmers	4	3
9	Students	2	2
Total		**115**	**100**

vi. Religion

During the survey, respondents were asked about their religious affiliation, and all of them (100%) reported Islam as their religion.

vii. Ethnic Structure

The area is home to a variety of castes and sub-castes, with the main ones in the Project Area including Abbasi, Awan, Raja, Chaudhary, Malik, Arain, Sakt, Syed, Qureshi, Mughal, Gakhar, and Lodhi.

viii. Languages

The data indicates (**Table 4-35**) that 34% of respondents speak Hindko, while 21% speak Pothwari. Additionally, 18% speak Urdu, 14% Punjabi, 8% Pashto, and 3% Kashmiri. The remaining 2% communicate in various other languages.

Table 4-35: Languages Spoken in Project Area

Sr. No.	Language	Number of Respondent	Percentage (%)
1	Hindko	39	34
2	Pothwari	24	21
3	Urdu	21	18
4	Punjabi	16	14
5	Pashto	9	8
6	Kashmiri	4	3
7	Other	2	2
Total		**115**	**100**

ix. Family System

Approximately 28% of the sampled population lived in joint family systems, where grandparents reside under the same roof, while the majority 72% reported living in nuclear family setups. Detailed information is provided in **Table 4-36** below.

Table 4-36: Family Structure

Sr. No.	Family Structure	Number of Respondent	Percentage (%)
1	Joint	32	28
2	Nuclear	83	72
Total		**115**	**100**

B) Socio- Economic Characteristics

a) Monthly Income of the Respondents

Table 4-37 shows that 24% of respondents belong to the low-income group, earning up to PKR 37,000 per month. Thirty percent fall within the income range of PKR 37,001 to PKR 47,000, while 14% earn between PKR 47,001 to PKR 57,000 monthly. Additionally, 10% reported incomes ranging from PKR 57,001 to PKR 67,000, and 22% earn above PKR 67,000 per month.

Table 4-37: Average Monthly Income of the Respondents

Sr. No.	Average Monthly Income	Number of Respondent	Percentage (%)
1	Up to 37,000	28	24
2	37,001 – 47,000	34	30
3	47,001 – 57,000	16	14
4	57,001-67,000	12	10
5	Above 67,000	25	22
Total		**115**	**100**

b) Expenditure of the Respondents

Household expenditure is closely linked to income, with about 26% of respondents reporting monthly expenses of up to PKR 37,000. Thirty percent indicated their expenditures fall within the range of PKR 37,001 to PKR 47,000 per month. Fourteen percent reported spending between PKR 47,001 and PKR 57,000, while 11% had monthly expenses ranging from PKR 57,001 to PKR 67,000. Additionally, 19% of respondents reported monthly expenditures exceeding PKR 67,000. The average monthly expenditures is provided in **Table 4-38.**

Table 4-38: Range of Monthly Expenditures of the Respondents

Sr. No.	Average Monthly Expenditures	Number of Respondent	Percentage (%)
1	Up to 37,000	26	26
2	37,001 – 47,000	30	30
3	47,001 – 57,000	14	14
4	57,001-67,000	11	11
5	Above 67,000	19	19
Total		**115**	**100**

c) Ownership Status of the Houses

The sampled respondents were asked about their housing ownership status to assess their living standards, as shown in **Table 4-39**. The majority, 66%, lived in their own homes, 18% resided in rented houses, and the remaining 16% had built their homes on landlord-owned land or were living as encroachers

Table 4-39: Ownership Status of Houses

Sr. No.	Ownership Status	Number of Respondent	Percentage (%)
1	Owner	76	66
2	Rented	21	18
3	Other	18	16
Total		**115**	**100**

d) Housing Construction Pattern

A mixed housing pattern is observed in the Project area, with 80% of respondents residing in pacca houses constructed using high-quality materials and workmanship, while 20% live in semi-pacca houses, which are built with brick masonry and mud mortar. **Table 4-40** presents the housing construction patterns in the project area.

Table 4-40: Housing Construction Pattern

Sr. No.	Type of House	Number of Respondent	Percentage (%)
1	Pacca	92	80
2	Semi Pacca	23	20
Total		**115**	**100**

e) Mode of Transport

Table 5-41 outlines the modes of transport used by respondents surveyed during the social impact assessment. Due to the limited availability of public transport in the Project area, around 46% of respondents reported relying on their own private vehicles. Only 22% used public transportation exclusively, while 32% utilized a combination of both public and private transport for their travel needs.

Table 4-41: Mode of Transport

Sr. No.	Mode of Transport	Number of Respondents	Percentage (%)
1	Personal	53	46
2	Public	25	22
3	Public & Person (both)	37	32
Total		**115**	**100**

C) Civic Amenities

a) Basic Amenities in the Project Area

Social infrastructure and basic amenities are essential for fostering sustainable communities. This assessment evaluates living standards based on factors such as the size of household dwellings, access to electricity and modern appliances, sources of water, type of cooking fuel (particularly considering the burden on women), and the availability of sanitation facilities.

Survey results indicate that 97% of households have access to electricity, while only 30% reported access to a water supply. Sui gas was available to 20% of respondents within the Project corridor. Additionally, 63% mentioned having a proper sewerage system. Mobile network services are generally available and satisfactory in the Project area and surrounding regions. Details regarding access to social amenities and service quality are presented in **Table 4-42.**

Table 4-42: Access to Social Amenities in the Project Area

Sr. No.	Social Amenities	Number of Respondents	Available (%)
1	Electricity	84	97
2	Water Supply	26	30
3	Gas	17	20
4	Sewerage	72	63

Source: field survey

Educational and health facilities are primarily available in larger settlements and urban centers, where residents from surrounding areas access these services.

b) Source of Drinking Water in the Project Area

Access to safe drinking water is not only a fundamental need and essential for a healthy life, but also a basic human right. Water quality is closely tied to public health. As shown in **Table 4-43,** the study reveals that only 12% of respondents have access to a piped water supply, while 40% rely on groundwater and 34% and 14% obtain drinking water from springs and wells respectively.

Table 4-43: Sources of Drinking Water

Sr. No.	Source of Water	Number of Respondent	Percentage (%)
1	Public Water	14	12
2	Bore Hole	46	40
3	Spring (Chashma)	39	34
4	Well	26	14
Total		**115**	**100**

c) Satisfaction about Quality of Water

Table 4-44 presents the current status of water quality in the Project area. The majority of respondents (82%) expressed satisfaction with the available water quality, while 18% reported dissatisfaction, primarily due to issues such as brackish and contaminated groundwater.

Table 4-44: Satisfaction about Quality of Water

Sr. No.	Satisfaction about Quality of Water	Number of Respondent	Percentage (%)
1	Yes	94	82
2	No	21	18
Total		**115**	**100**

d) Common Diseases in the Project Area

In Murree District, the most commonly reported diseases include Acute Diarrhea (Non-Cholera), Malaria, Influenza-Like Illness (ILI), and Acute Lower Respiratory Infections (ALRI) among children under five. Other frequently observed health conditions are Severe Acute Respiratory Infections (SARI), Typhoid, and Viral Hepatitis.

In Islamabad, prevalent illnesses include respiratory infections such as ILI and ALRI, along with diarrheal diseases and malaria. Acute Diarrhea (Non-Cholera), ALRI in young children, and Malaria remain among the most reported health concerns.

D) Awareness Regarding the Proposed Project

Approximately 52% of the respondents had no prior knowledge of the Project, while 48% were already aware of it, as indicated in **Table 4-45**. All participants were subsequently informed about the key features of the proposed Project.

Table 4-45: Awareness about the Project

Sr. No.	Awareness of the Project	Number of Respondent	Percentage (%)
1	Yes	40	48
2	No	60	52
Total		**115**	**100**

E) Pressing Needs of the Area

A pressing need refers to an urgent requirement that demands immediate attention, often arising from a critical issue. In Murree City, vehicle parking has emerged as a major concern, with local residents emphasizing the need for dedicated parking facilities to accommodate the influx of tourists. Additionally, the community expressed strong demands for improved access to clean drinking water, Sui gas supply, and enhanced transportation services.

F) Perceived Impacts of the Project During and After Construction

The anticipated impacts identified by respondents during and after the construction of the Glass Train are outlined in the following sub-sections.

a) Perceived Impacts of the Project during Construction

Respondents expressed multiple concerns regarding the construction of the Glass Train Project. Key issues included the potential demolition of residential structures, the acquisition of private land, and the cutting down of trees, all of which could have significant social and environmental impacts.

Traffic management was also highlighted as a major challenge, with worries about increased congestion and disruption during the construction phase. On a positive note, many respondents recognized that the Project could generate employment opportunities for local residents, providing a much-needed boost to the local economy. However, they also raised concerns about environmental and health-related impacts, particularly dust and noise pollution, which could adversely affect the well-being of nearby communities if not properly controlled. Consequently, respondents stressed the importance of implementing effective mitigation measures to minimize these negative effects and ensure that construction activities proceed in a responsible and sustainable manner.

b) Perceived Impacts of the Project during Operational Phase

When questioned about the anticipated impacts following the completion of the construction phase, the majority of respondents expressed optimism about the Project's potential to significantly boost tourism and enhance overall mobility in the region. They believe that the introduction of the glass train will provide tourists with a more efficient, comfortable, and attractive mode of transportation, thereby improving their travel experience. Moreover, respondents expect that the glass train service will contribute to a reduction in road traffic accidents by offering a safer alternative to traditional road travel, which is often hampered by congestion and challenging terrain. Beyond transportation benefits, many respondents also pointed out the likelihood of increased income-generating activities emerging as a result of the Project. These could include new business opportunities related to tourism, hospitality,

and local services, ultimately contributing to economic growth and improved livelihoods for the community. Overall, the respondents view the Project as a catalyst for positive social and economic development in the area.

5 PUBLIC CONSULTATIONS

5.1 GENERAL

Timely and broad-based stakeholder involvement is an essential element for an effective environmental assessment, as it is linked with project Planning, appraisal and development in general. Public involvement during EIA has a tendency to improve project design environmental soundness and social acceptability.

Public involvement, undertaken in a positive manner and supported by a real desire to use the information gained to improve the project design, will lead to better outcomes and lay the basis for on-going positive relationships between the stakeholders. It gives the feeling of an ownership to the local population. Public involvement is necessary for smooth implementation of the project and especially the local community whose support is also required for the success of the project.

The project management and implementation authorities are committed for undertaking public consultation at Provincial and local levels as a part of project planning/design for getting necessary environmental permissions.

This Chapter presents the objectives, process, and outcome of the consultations carried out with the key stakeholders of the project during the present IEE study. A consultation framework, describing the consultations to be carried out during the subsequent phases of the project implementation ensuring ongoing and inclusive dialogues with key stakeholder is also provided in this chapter.

5.2 OBJECTIVES

The objectives of stakeholder consultation were to contribute to the openness, transparency and dialogue. Special efforts were made to ensure that the communication with the public should be efficient and well balanced. The concerned stakeholder groups were identified to participate in the assessment process. Specific tasks and purposes of consultations with stakeholders have been given in the **Table 5.1**.

Table 5.1: Tasks and Purposes of Consultations

Task	Purpose of Consultation with Stakeholders
Why consultation with the stakeholders?	• To build trust to ensure sustained support for the project and build resilience for times of crisis. • To learn about public concerns that need to be addressed and taken into account in designing of the project concept and preparation mitigation measures and programs. • To learn about the strengths, skills and organizations that the stakeholders can bring to support project planning and implementation.
Modes and benefits of consultation	• Listening and dialogue with stakeholders to keep the project at tuned to public concerns early, to pre-empt breakdowns in public confidence. • Engaging the public as advocates for the project construction and to support the implementation of social, resettlement, and environment and health programs.

Other objectives of public involvement include:

- Informing the stakeholders about the proposed project;
- Providing an opportunity to those who remained unable to present their views and values, therefore allowing more sensitive consideration of mitigation measures and trade-offs;
- Providing those involved with planning the proposal with an opportunity to ensure that the benefits of the proposal are maximized and that no major impacts have been overlooked;
- Providing an opportunity for the public to influence the project design in a positive manner;
- Increasing public confidence in front of proponent, reviewers and decision makers;
- Providing better transparency and accountability in decision making;
- Reducing conflict through the early identification of contentious issues, and working through these to find acceptable solutions;
- Creating a sense of ownership of the proposal in the minds of the stakeholders; and
- Developing the project which is truly sustainable.

5.3 IDENTIFICATION OF STAKEHOLDERS

Identification of stakeholder is an important step which ensures that all the concerned stakeholders are identified for the following:

- Sharing of information with stakeholders about the proposed project activities and potential impacts of proposed project on the physical, ecological and socio-economic conditions in the AoI; and
- To address the most relevant concerns of the stakeholders on project and its activities including the upfront negative impacts.

5.3.1 Primary Stakeholders

Primary stakeholders are those who are directly concerned with the project or directly affected both positively and negatively by the project interventions. The primary stakeholders of this project include land owner, local residents and the proposed Project Affected Persons (PAPs). Apart from this, the beneficiaries of the project and the implementing agency are also primary stakeholders for the proposed project.

5.3.2 Secondary Stakeholders

Secondary stakeholders are people or groups that are indirectly affected from the Project activities or have their interest in the proposed Project such as Pak-EPA, Punjab-EP&CCD, TMA Murree, Punjab Tourism Development Cooperation of Punjab (TDCP), Forest Department, Wildlife Department, CDA, Islamabad Wildlife Management Board and other line agencies / departments of Government of Pakistan and Government of Punjab.

Details regarding roles and responsibilities of the concerned agencies and departments are given below Table 5.2.

Table 5.2: Role of Concerned Agencies/Departments

Project Stakeholders	Roles and Responsibilities
Pakistan Environmental Protection Agency	• The Pakistan Environmental Protection Agency (Pak-EPA), operating under the Ministry of Climate Change, is the federal authority responsible for implementing environmental policies and regulations as outlined in the Pakistan Environmental Protection Act, 1997. • Its key functions include reviewing and approving Environmental Impact Assessments (EIA) and Initial Environmental Examinations (IEE), enforcing National Environmental Quality Standards (NEQS), issuing environmental approvals and No Objection Certificates (NOCs), and monitoring compliance with environmental laws. • Pak-EPA also plays a central role in raising public awareness, supporting capacity building, coordinating with provincial EPAs, and representing Pakistan in international environmental conventions. • Through inspections, enforcement actions, and ongoing research, the agency ensures environmental protection and sustainable development across the country. • Pak-EPA is responsible for the issuance of NOC of the proposed Project. • Pak-EPA is responsible for the compliance of EMP and NOC provision during the construction and operation stages of the Project.
Punjab Environmental Protection and Climate Change Department	• Punjab-EP&CCD is the regulatory authority and mainly responsible for the development and implementation of the environmental policies and strategies in order to integrate the environmental issues and sustainable development approaches into the legal and regulatory frameworks as per Punjab Environmental Protection Act, 2012 (Amended 2017). • Punjab-EP&CCD is responsible for the issuance of NOC of the proposed Project. • EP&CCD is responsible for the compliance of EMP and NOC provision during the construction and operation stages of the Project.
Capital Development Authority (CDA)	• The Capital Development Authority (CDA) is the principal civic body responsible for the planning, development, and management of the Islamabad Capital Territory. Its key responsibilities include urban planning, infrastructure development, provision of municipal services, land use regulation, and enforcement of building codes and zoning laws. • The Environmental Wing of the Capital Development Authority (CDA) is responsible for ensuring environmentally sustainable urban development within the Islamabad Capital Territory. • Its core functions include the planning, implementation, and monitoring of environmental conservation and beautification projects, such as plantation drives, green belt development, and landscape enhancement. • The wing also plays a key role in conducting environmental assessments of CDA development projects, ensuring compliance with environmental regulations and standards, and coordinating with Pak-EPA and other relevant agencies. Additionally, it is tasked with managing solid waste disposal, controlling air and noise pollution, and promoting public environmental awareness to maintain and enhance Islamabad's ecological balance and aesthetic character.
Tehsil Municipal Administration (TMA) Murree	• The Tehsil Municipal Administration (TMA) Murree is responsible for the municipal governance and urban management of Murree Tehsil. • Its core functions include the provision and maintenance of essential municipal services such as water supply, sanitation, solid waste management, street lighting, and road maintenance. • TMA Murree plays a key role in regulating construction activities by

Project Stakeholders	Roles and Responsibilities
	enforcing building by-laws and zoning regulations, issuing construction permits, and ensuring compliance with environmental and safety standards. • Additionally, the TMA oversees urban planning, public health services, revenue collection, and beautification projects, working to preserve the ecological and scenic character of Murree as a prominent tourist destination.
Forest Department, Punjab	• The Forest Department, Punjab is primarily responsible for the protection, conservation, and sustainable management of forest resources across the province. Its core roles include enforcing the Punjab Forest Act (amended) and related forestry laws, managing reserved and protected forests, implementing afforestation and reforestation programs, and promoting biodiversity conservation. • The department also oversees the regulation of timber harvesting, prevention of illegal logging, and control of forest fires. • Additionally, it plays a key role in ecotourism development, watershed management, and ensuring community participation through social forestry initiatives. • The Forest Department supports climate resilience efforts and contributes to national and provincial targets for carbon sequestration and environmental sustainability.
Wildlife Department, Punjab	• The Wildlife Department, Punjab is responsible for the conservation, protection, and management of wildlife and their habitats across the province. • Operating under the Punjab Wildlife (Protection, Preservation, Conservation and Management) Act, 1974 (amended), the department manages protected areas, including national parks, wildlife sanctuaries, and game reserves, and regulates the hunting and trade of wild species. • It is also engaged in biodiversity conservation, species protection programs, captive breeding, and rehabilitation of endangered species. • In addition, the department conducts research and awareness campaigns to promote public involvement in wildlife protection and supports eco-tourism in wildlife-rich regions like Murree. The department plays a vital role in ensuring compliance with national and international conservation agreements, including CITES.
Islamabad Wildlife Management Board (IWMB	• The Islamabad Wildlife Management Board (IWMB) is a statutory body established under the Islamabad Nature Conservation and Wildlife Management Act, 2023, tasked with the conservation, protection, and sustainable management of wildlife and natural habitats within the Islamabad Capital Territory (ICT). • The IWMB is responsible for overseeing the Margalla Hills National Park (MHNP) and other designated protected areas, ensuring the implementation of conservation policies, and regulating human activity to prevent environmental degradation. • Its roles include monitoring wildlife populations, preventing illegal hunting and poaching, conducting ecological research, and engaging communities and stakeholders in nature conservation. • The IWMB also promotes eco-tourism, environmental education, and enforcement of environmental laws, contributing to the preservation of biodiversity and natural heritage in the region.
Tourism Development Corporation of Punjab (TDCP)	The Tourism Development Corporation of Punjab (TDCP) is an autonomous organization established to promote and develop tourism within Punjab province. Its primary roles encompass: • It actively promotes Punjab's diverse cultural, historical, and natural attractions through various marketing strategies, including participation

Project Stakeholders	Roles and Responsibilities
	in domestic and international tourism exhibitions and events; • Involved in developing and maintaining tourism infrastructure such as resorts, motels, recreational facilities, and tourist information centers to enhance visitor experiences; • Through its Institute of Tourism and Hotel Management (ITHM), TDCP offers educational programs and training to build capacity in the tourism and hospitality sectors. • It encourages private sector participation in tourism development projects, fostering economic growth and employment opportunities within the province; • Organizes cultural and recreational events, such as the Cholistan Jeep Rally and various festivals, to attract tourists and showcase Punjab's rich heritage; and • Committed to promoting eco-tourism and implementing sustainable practices to preserve the natural environment and cultural heritage of Punjab. Through these initiatives, TDCP plays a pivotal role in positioning Punjab as a leading tourist destination, contributing to the province's socio-economic development.

Given the significance of the Project, consultations were conducted at multiple levels, including both departmental and local stakeholders. This consultation process is continuous and will persist throughout the Project's lifecycle, extending beyond the submission of this report. Stakeholders were systematically identified, categorized, and engaged at both institutional/departmental and community levels. During the field survey, considerable efforts were made to recognize the various stakeholder groups and understand their interests.

The feedback and concerns raised during the consultations were carefully recorded and documented to inform the development of the Project strategy. Consultations with government departments primarily focused on the legal requirements of the proposed Tourist Glass Train Project, potential environmental and social impacts, availability of necessary baseline data, specific regulatory obligations, information on any planned future developments, and coordination among the relevant agencies.

5.4 APPROACH FOR THE CONSULTATION AND INFORMATION DISSEMINATION

A series of consultations were conducted to gather feedback and concerns from various stakeholder groups, including provincial and district-level departments, potential Project Affected Persons (PAPs), local communities, and the general public residing within the Project area.

The consultation process involved meetings with identified PAPs, community gatherings, semi-structured interviews, and one-on-one discussions with representatives from government bodies, private sector, and civil society organizations. Throughout these consultations, stakeholders were informed about the Project's objectives and scope, and their concerns, fears, and suggestions were carefully documented.

Consultations were conducted at two levels:

- Departments Level
- Institutions Level

5.4.1 Consultations with Stakeholders at Departments Level

The stakeholder consultations were held with officials of the relevant departments. Details of department officials contacted are given in Table 5.3.

Table 5.3: List of Government Officials Consulted

Sr. No.	Department/Venue	Name/Designation	Date
1.	Pakistan Environmental Protection Agency, Islamabad	Mr. Aashiq Nawaz, Director EIA/Monitoring	17-04-2025
2.	Punjab Environmental Protection and Climate Change Department-District Office Murree	Ms. Romaisa Babar, Assistant Director (Field)	19-04-2025
3.	Capital Development Authority (CDA)-Environmental Wing	Mr. Irfan Khan Niazi, Deputy Director Environment-I Mr. Altaf, Assistant Director, Forestor	17-04-2025
4.	Tehsil Municipal Administration (TMA), Murree	Mr. Muhammad Khalid Khan, TMO	18-04-2025
5.	Forest Department, Punjab – DFO Office Murree	Mr. Sadheer Ahmed Mughal, DFO Murree	18-04-2025
6.	Wildlife Department, Punjab-Wildlife Office Murree	Mr. Ibrar Shah, Assistant Director, Wildlife	18-04-2025
7.	Islamabad Wildlife Management Board (IWMB)	Mr. Jibran Haider, Director Wildlife	17-04-2025
8.	Tourism Development Corporation of Punjab (TDCP) – Regional Office Murree	Mr. Mozzam Nazir, Regional Manager, Murree	18-04-2025

The **Table 5.4** indicates the detail of issues raised/discussed and suggestions given during the consultation:

Table 5.4: Detail of Issues/Points Raised/Discussed during Departmental Consultations

Sr. No.	Department/ Organization	Concerns/Suggestions
1.	Pakistan Environmental Protection Agency, Islamabad	• The proposed alignment traverses Zone-3 of Islamabad, designated as a protected area due to the presence of the Margalla Hills National Park (MHNP). This region holds ecological significance and is subject to stringent environmental regulations. • Efforts must be made to minimize the cutting of trees, particularly mature and sub-mature species. • Prior to commencing construction, a No Objection Certificate (NOC) must be secured from the Islamabad Wildlife Management Board (IWMB). This is essential due to the Project's impact on ecological biodiversity within the MHNP. • A comprehensive Tree Management Plan should be developed, detailing the number of trees to be felled and replanted. Each tree designated for removal or replantation must be appropriately

Sr. No.	Department/ Organization	Concerns/Suggestions
		tagged to ensure transparency and accountability. • The Project must adhere to all pertinent environmental legislation, including the Pakistan Environmental Protection Act, 1997. This entails the preparation and submission of an Environmental Impact Assessment (EIA) report, aligning with the guidelines established by the Pakistan Environmental Protection Agency (Pak-EPA). • Comprehensive consultations with all relevant stakeholders and governmental departments should be conducted to address potential environmental and social impacts, ensuring collaborative decision-making and compliance with regulatory requirements. • Environmental monitoring should be carried out, particularly in ecologically sensitive areas within the Project vicinity. This will facilitate the early detection of adverse impacts and the implementation of necessary mitigation measures. • Recommended to explore alternative alignments that circumvent densely forested areas near Islamabad and Murree. Constructing the proposed alignment at an elevated level should be considered to minimize disturbances to local flora and fauna. This approach aims to reduce habitat fragmentation and preserve the ecological integrity of the area.
2.	Punjab Environmental Protection and Climate Change Department-District Office Murree	• The proposed alignment traverses the Murree-Kotli Sattian-Kahuta National Park, designated under the Punjab Wildlife (Protection, Preservation, Conservation and Management) Act. This area holds significant ecological value and is subject to stringent environmental regulations aimed at preserving its natural biodiversity. • Prior to the commencement of construction activities, it is imperative to obtain No Objection Certificates (NOCs) from both the Punjab Wildlife Department and the Forest Department. These approvals are essential due to the Project's potential impact on the region's ecological biodiversity. • A comprehensive Tree Management Plan should be formulated, detailing the specific number of trees proposed for removal and replantation. Each tree identified for such actions must be appropriately tagged to ensure transparency and facilitate monitoring throughout the Project lifecycle. • The Project must adhere to all relevant environmental legislation, including the Punjab Environmental Protection Act, 2017. This entails the preparation and submission of an Environmental Impact Assessment (EIA) report, in accordance with the guidelines established by the Punjab Environmental Protection & Climate Change Department (EP&CCD). • Comprehensive consultations with all pertinent stakeholders and governmental departments should be conducted to address potential environmental and social impacts. This collaborative approach ensures informed decision-making and compliance with regulatory requirements. • To mitigate environmental impacts, it is recommended to explore alternative alignments that circumvent densely forested regions near Murree. Additionally, constructing the proposed alignment at an elevated level, or through tunnels should be considered to minimize disturbances to local flora and fauna.
3.	Capital Development	• The proposed alignment passes through Zone-3 of Islamabad,

Sr. No.	Department/ Organization	Concerns/Suggestions
	Authority (CDA)- Environmental Wing	which is designated as a protected area due to its inclusion in the Margalla Hills National Park, specifically intersecting Margalla Reserve Forest Compartment No. 8. This region holds ecological significance and is subject to stringent environmental regulations. • Efforts must be made to minimize the cutting of trees, particularly mature and sub-mature specimens in city area. Given the alignment's passage through protected zones, obtaining permission from the Cabinet is mandatory for any tree removal activities and construction activities within the reserved areas. • Prior to commencing construction, a No Objection Certificate (NOC) must be secured from the Islamabad Wildlife Management Board (IWMB). This is essential due to the Project's impact on ecological biodiversity within the MHNP. • A comprehensive Tree Management Plan should be developed, detailing the number of trees to be felled and replanted. Each tree designated for removal or replantation must be appropriately tagged to ensure transparency and accountability as per CDA bylaws. • Comprehensive consultations with all relevant stakeholders and governmental departments should be conducted to address potential environmental and social impacts, ensuring collaborative decision-making and compliance with regulatory requirements. • To mitigate environmental impacts, it is recommended to explore alternative alignments that circumvent Margalla Reserve Forest Compartment No. 8. Additionally, constructing the proposed alignment at an elevated level such as on stilts, viaducts, or through tunnels should be considered to minimize disturbances to local flora and fauna.
4.	Tehsil Municipal Administration (TMA), Murree	• TMA Murree expressed appreciation for the proposed Murree Glass Train Project, acknowledging its potential to enhance sustainable tourism and provide eco-friendly transportation within the region. The Project is anticipated to help alleviate persistent traffic congestion while also creating employment opportunities for both skilled and unskilled labor, thereby contributing to the local economy. • TMA Murree also emphasized the importance of integrating environmental conservation measures to protect the area's unique ecological character. Key recommendations provided includes: ▪ Preventing fragmentation of forest habitats. ▪ Tree removal should be minimized and compensated through a structured reforestation program in consultation with the Forest Department. ▪ Measures should be taken during construction and operation to minimize noise and vibration, particularly in sensitive wildlife zones, to prevent disturbance to native species. ▪ The design of the glass train and associated infrastructure should blend with the natural landscape to preserve the scenic beauty of Murree, a key asset for tourism.
5.	Forest Department, Punjab – DFO Office Murree	• The proposed alignment traverses the Murree-Kotli Sattian-Kahuta National Park, designated under the Punjab Wildlife (Protection, Preservation, Conservation and Management) Act. This area holds highly significant ecological value and is subject to stringent environmental regulations aimed at preserving its natural biodiversity.

Sr. No.	Department/ Organization	Concerns/Suggestions
		• The alignment passes through twenty (20) compartments within the different reserved forests of Murree Forest Division. Therefore, alternatives routes shall be considered. • Prior to initiating construction, it is mandatory to obtain a No Objection Certificate (NOC) from the Forest Department, in accordance with applicable environmental and forestry regulations. • A formal letter should be submitted to the Secretary Forest to initiate further discussions. This correspondence should seek guidance on necessary approvals and propose detailed ground surveys to assess site-specific ecological sensitivities, if required.
6.	Wildlife Department, Punjab-Wildlife Office Murree	• The proposed alignment traverses the Murree-Kotli Sattian-Kahuta National Park, designated under the Punjab Wildlife (Protection, Preservation, Conservation and Management) Act. This designation reflects the area's high ecological significance and subjects it to strict environmental protection measures aimed at conserving its native biodiversity. • Prior to the commencement of any construction activities, it is essential to obtain a No Objection Certificate (NOC) from the Wildlife Department, in compliance with applicable environmental regulations. • To reduce potential environmental impacts, it is strongly recommended to evaluate alternative alignments that avoid densely forested zones. • A detailed Tree plantation and Management Plan must be prepared, specifying the exact number of trees to be removed and replanted. Each tree identified for removal or replantation must be clearly tagged to ensure accountability and transparency in monitoring in consultation with concerned department.
7.	Islamabad Wildlife Management Board (IWMB)	• The proposed alignment traverses the Margalla Hills National Park (MHNP), a protected area established in 1980, encompassing approximately 17,386 hectares. MHNP holds significant ecological value, serving as a vital habitat for diverse flora and fauna, including several endangered species. The park is managed by the Islamabad Wildlife Management Board (IWMB), which enforces stringent environmental regulations to preserve its natural biodiversity. Trail 5 and 6 hosts Common Leopard (Panthera pardus), which is endangered species. • Prior to the commencement of construction activities, it is imperative to obtain a No Objection Certificate (NOC) from the IWMB. This approval is essential due to the Project's potential impact on the region's ecological biodiversity. • Efforts must be made to minimize the cutting of trees, particularly mature and sub-mature specimens within the city area. A comprehensive Tree Management Plan should be developed, detailing the specific number of trees proposed for removal and replantation. Each tree identified for such actions must be appropriately tagged to ensure transparency and facilitate monitoring throughout the Project lifecycle. • Comprehensive consultations with all pertinent stakeholders and governmental departments should be conducted to address potential environmental and social impacts. This collaborative approach ensures informed decision-making and compliance with regulatory requirements. • It is recommended to explore alternative alignments that

Sr. No.	Department/ Organization	Concerns/Suggestions
		circumvent densely forested regions near Islamabad. Additionally, constructing the proposed alignment at an elevated level—such as on stilts, viaducts, or through tunnels—should be considered to minimize disturbances to local flora and fauna.
8.	Tourism Development Corporation of Punjab (TDCP) – Regional Office Murree	• The entire Murree region has been officially designated as a National Park under the Punjab Wildlife (Protection, Preservation, Conservation, and Management) Act. This status highlights the region's ecological sensitivity and requires adherence to stringent environmental regulations to conserve biodiversity and natural habitats. • As the current alignment traverses through reserved forest areas, it is strongly recommended that the route should be re-aligned. A more viable alternative is to align the route along the Murree-Islamabad Expressway, constructed at an elevated level along the median. The alignment should conclude at Patriata, thereby avoiding habitat fragmentation and reducing adverse impacts on native flora and fauna. • The proposed route is presently underutilized by tourists due to frequent traffic congestion and the impacts of over-tourism, particularly around the Mall Road area. These issues significantly diminish the route's appeal and operational efficiency. • The current alignment poses notable challenges related to landslides and slope stability, increasing the risk to infrastructure integrity and public safety. Addressing these risks would require substantial engineering interventions, leading to significantly higher construction and maintenance costs.



Consultation with Director EIA/Monitoring, Pak-EPA



Consultation with Deputy Director Environment-I, CDA-Environmental Wing



Consultation with Director Wildlife, IWMB



Consultation with the Assistant Director Wildlife Murree



Consultation with Assistant Director (Field), Murree-Punjab EP&CCD



Consultation with Regional Manager, Murree-TDCP



Consultation with DFO Murree



Consultation with TMO Murree

Plate 5.1: Pictorial View of the Departmental Consultations

5.4.2 Consultations with Stakeholders at Institutional Level

Stakeholder consultations were also conducted at the institutional level. The details of the officials engaged are provided in **Table 5-5.**

Table 5-5: List of Institutes Officials Consulted

Sr. No.	Date	Name of Person	Designation	Name of Institutes / Office
1.	16-04-2025	Mr. Hakim Khan	Head of Institute	IMSB (T-V Model School for Boy) Malpur (FA), Islamabad
2.	16-04-2025	Mr. Prof. Dr. Nisar Ahmed	Director Academics	Karlot Residential Collage, Islamabad
3.	18-04-2025	Mr. Asif Mehmood Jasra	Deputy Registrar	Iqra University (IU), Islamabad
4.	18-04-2025	Mr. Aqib Afraz	Principal	Trimna Model High School, Murree
5.	19-04-2025	Mr. Qazim Riaz	Manager Admin and Finance	Ittehad Steel Industry, Islamabad

The **Table 5-6** indicates the detail of issues raised/discussed and suggestions given during the consultation.

Table 5-6: Summary of Consultation Meeting at Institutional Level

Sr. No.	Name of Institute / Office	Stakeholder Views/Concerns
1.	IMSB (T-V Model School for Boy) Malpur (FA), Islamabad	• The Project is good initiative as it will enhance the transportation infrastructure, which will benefit both tourists and local residents. Easier and more efficient travel will not only promote tourism but also improve access to essential services and economic opportunities for the local population. • To minimize disruptions to students and maintain a conducive learning environment, construction activities should be strictly avoided during school hours, particularly near educational institutions. • The construction phase is likely to generate dust and noise, which can adversely affect nearby communities. Appropriate mitigation measures—such as regular water sprinkling to control dust, use of noise barriers, and scheduling high-noise activities during off-peak hours—should be implemented to minimize the impact on public health and comfort.
2.	Karlot Residential Collage, Islamabad	• The Project is good initiative as it will enhance the transportation infrastructure, which will benefit both tourists and local residents. Easier and more efficient travel will not only promote tourism but also improve access to essential services and economic opportunities for the local population. • Tourists will particularly benefit from the opportunity to experience scenic landscapes and explore natural heritage along the route, enriching their travel experience with elements of environmental and natural sciences. • To support inclusive access, it is recommended that special fare discounts be offered to students. This initiative would encourage greater use of public transport among the youth and support educational mobility at reduced costs. • To minimize disruptions to students and maintain a conducive learning environment, construction activities should be strictly avoided during school hours, particularly near educational institutions.

Sr. No.	Name of Institute / Office	Stakeholder Views/Concerns
		• The construction phase is likely to generate dust and noise, which can adversely affect nearby communities. Appropriate mitigation measures—such as regular water sprinkling to control dust, use of noise barriers, and scheduling high-noise activities during off-peak hours—should be implemented to minimize the impact on public health and comfort.
3.	Iqra University (IU), Islamabad	• The Project is good initiative as it will enhance the transportation infrastructure, which will benefit both tourists and local residents. Easier and more efficient travel will not only promote tourism but also improve access to essential services and economic opportunities for the local population. • To minimize disruptions to students and maintain a conducive learning environment, construction activities should be strictly avoided during school hours, particularly near educational institutions. • To support inclusive access, it is recommended that special fare discounts be offered to students. This initiative would encourage greater use of public transport among the youth and support educational mobility at reduced costs • The construction phase is likely to generate dust and noise, which can adversely affect nearby communities. Appropriate mitigation measures—such as regular water sprinkling to control dust, use of noise barriers, and scheduling high-noise activities during off-peak hours—should be implemented to minimize the impact on public health and comfort. • During the construction phase, appropriate temporary parking facilities should be arranged to accommodate both construction vehicles and local traffic near educational institutes to prevent congestion on nearby roads, ensure smooth traffic flow, and reduce inconvenience for the students.
4.	Trimna Model High School, Murree	• The Project is good initiative as it will enhance the transportation infrastructure, which will benefit both tourists and local residents. • Tourists will particularly benefit from the opportunity to experience scenic landscapes and explore natural heritage along the route, enriching their travel experience with elements of environmental and natural sciences. • To support inclusive access, it is recommended that special fare discounts be offered to students. This initiative would encourage greater use of public transport among the youth and support educational mobility at reduced costs. • To minimize disruptions to students and maintain a conducive learning environment, construction activities should be strictly avoided during school hours, particularly near educational institutions. • The construction phase is likely to generate dust and noise, which can adversely affect nearby communities. Appropriate mitigation measures—such as regular water sprinkling to control dust, use of noise barriers, and scheduling high-noise activities during off-peak hours—should be implemented to minimize the impact on public health and comfort. • During the construction phase, appropriate temporary parking facilities should be arranged to accommodate both construction vehicles and local traffic near educational institutes to prevent congestion on nearby roads, ensure

Sr. No.	Name of Institute / Office	Stakeholder Views/Concerns
		smooth traffic flow, and reduce inconvenience for the students.
5.	Ittehad Steel Industry, Islamabad	• The Project is good initiative as it will enhance the transportation infrastructure, which will benefit both tourists and local residents. Easier and more efficient travel will not only promote tourism but also improve access to essential services and economic opportunities for the local population. • Tourists will particularly benefit from the opportunity to experience scenic landscapes and explore natural heritage along the route, enriching their travel experience with elements of environmental and natural sciences. • Construction activities should be carefully planned to avoid any adverse impact on nearby industrial operations. • Service lanes adjacent to industrial areas must remain open and unobstructed to ensure uninterrupted access for vehicles and personnel. • To minimize disruption to business activities, construction work near industrial zones should be carried out during nighttime hours when industrial operations are typically reduced. • Coordination with industrial stakeholders is recommended to schedule construction in a manner that aligns with their operational requirements.

In general, the stakeholders expressed a positive outlook regarding the proposed Project, noting its potential to contribute to the local economy. They anticipated that the Project would lead to an increase in tourist activity, improved transportation facilities, greater attention to visitor needs, and significant time savings for travelers. In addition to their support, the following key suggestions were provided:

- Stations should be strategically located near settlements to ensure accessibility for local communities.
- Construction activities in the vicinity of educational institutions should be avoided during peak school hours to minimize disruption.
- Adequate parking facilities should be established at transit stations and within Murree City to manage increased traffic and enhance commuter convenience.
- Active involvement of the local community in Project planning and implementation shall be ensured to foster ownership and address community concerns effectively.



Consultation with Director Karlot Residential Collage



Consultation with Deputy Registrar Iqra University (IU)



Consultation with Representatives of Ittehad Steel Industry



Consultation at IMSB (T-V Model School for Boy) Malpur (FA)

Plate 5-2: Pictorial View of the Institutional Consultations

5.5 COMMUNITY CONSULTATION AND PARTICIPATION PROCESS

For ascertaining the perceptions of different stakeholders about the Project (during/after construction) meetings were held with local communities and anticipated Project Affected Persons (PAPs) within the Project area COI. These sessions were held in an open and transparent environment, allowing participants to freely share their opinions. Additionally, informal group discussions were organized to further assess stakeholder views on the Project and its potential positive and negative impacts. The feedback from local residents and the general public was formally documented, with efforts made to incorporate their insights to benefit the Project.

5.5.1 Methods of Public Consultation

The following methods were used for public consultations with Project stakeholders in order to ascertain their stakes regarding Project implementation:

- Community/Public Consultations
- Individual meetings with Locals/PAPs

The views of the beneficiaries were formally recorded. People of surrounding communities (males and females) were also consulted along with general public (randomly selected) who were residing or working in the surroundings (COI) of the proposed Project.

5.5.2 Categories of Stakeholders Contacted

Different categories of stakeholders contacted during consultation are given in **Table 5-6.**

Table 5.6: Stakeholders Contacted in the Project Area

Sr. No.	Stakeholder Category
1	Tourists
2	People of the surrounding communities
3	Local Residents
4	Business/ shop owners
5	Government and private Servants

5.5.3 Consultations with Local Communities

Extensive consultations were conducted with the local communities in the Project area to record their views and incorporating in the Project planning. The major categories participated in these meetings were local residents, tourists and landowners.

The participants were briefed about the proposed Project site with the help of design maps. During the consultations, participants were informed/briefed about the Project objectives and extensive question and answer sessions were conducted to clarify the Project related works and activities to resolve the environmental and social issues. They were briefed that the purpose of the consultations and discussions is to find out the possible solutions to the issues, which may be faced before and during the construction of the proposed Project. The concerns and their possible solutions presented by the participants regarding the proposed Project were recorded to make further possible recommendations.

The detail of the locations of consultations is provided in **Table 5-7** and the summary findings of the consultations are presented in an annotated form given in **Table 5-8**.

Table 5-7: Locations of Consultations

Sr. No.	Venue	Date	No. of Participants
1	Saneoh Murree	29-01-2025	8
2	Phulgran	29-01-2025	10
3	Nambal Blach	30-01-2025	6
4	Ghora Gali	30-01-2025	10
5	Murree Bus Strand	30-01-2025	9
6	Barhoa	31-01-2025	9
7	Nadkot	01-02-2025	6
9	Bara Kahu	01-02-2025	8
10	Malpur	16-04-2025	15

Sr. No.	Venue	Date	No. of Participants
11	Trimna	17-04-2025	16
12	Along the Proposed Route	17-04-2025	19
13	Jhika Gali	18-04-2025	25
14	Iqra University	18-04-2025	12
Total Participants			**153**

Table 5-8: Summary of Findings of the Consultations

Sr. No.	Concerns Raised by Participants	Mitigation Proposed by Participants	Action to be taken by Project Executors
1.	Loss of livelihood due to the clearance of land for the construction activities.	Proper compensation shall be paid for the acquired land as per prevailing market rates prior to initiate civil works.	Land must be acquired from the landowners in accordance with the agreement before the commencement of construction activities.
2.	Due to construction of the proposed Project, local community will face mobility issues to their residents.	Alternate route should be provided to the local communities for convenience in mobility to their settlements. Construction activities should be halted during peak hours.	Possible alternate route will be provided before the commencement of the civil work on the proposed Project.
3.	Health and safety and noise issues will arise for residents and students due to the construction activities.	Labour will bound to work and stay in the designated area or camp sites to ensure safety and privacy of female residents. Ensure minimum transportation of construction material and use of construction machinery during peak working hours and at night.	Contractor should be bound to take all protective and precautionary measures to keep safe the health of the local people.
4.	Disturbance of the social amenities.	Participants were of the view that due to construction of the proposed Project, several social amenities will be disturbed. These social amenities should be restored before commencement of the construction work to avoid any inconvenience for the local community.	Social amenities should be restored before execution of the civil work.
5.	Due to the construction machinery and movement of loaded trucks carrying construction material during the construction period, congestion on the access road will increase.	The appropriate diversion plan will be developed to avoid traffic blockage/disruption due to the use of heavy machinery especially near sensitive receptors such as schools and mosques.	The contractor should be bound to make a site-specific traffic management plan in consultation with the traffic police during the construction phase.
6.	Due to construction activities as well as the influx of labor, the movement of the citizens particularly females, residing in the area will	In order to tackle this situation, construction will be carried out in scheduled hours. So that after construction hours, the local community, particularly females can easily move in the area.	People should be aware of complete construction activity plans so that they can move in the area freely and safely.

Sr. No.	Concerns Raised by Participants	Mitigation Proposed by Participants	Action to be taken by Project Executors
	be restricted.		
7.	Dust emissions due to construction activities such as deep excavations, transportation of construction materials and use of construction machinery.	Dust pollution will be controlled by water sprinkling on a regular basis.	The contractor should be bound to take all protective and precautionary measures to keep safe the health and properties of the local people.
8.	Job and labor opportunities for local people.	Skilled and unskilled workforce should be hired from the local community. It will enhance the acceptability of the proposed Project among local people.	The contractor should be bound to hire skilled and unskilled workers from the local community as priority.

During the stakeholder consultations, participants put forward several important recommendations aimed at enhancing the success and effectiveness of the Project. These key suggestions include:

- Ensuring that the transport services remain affordable and accessible to the local communities.
- Implementing reasonable and fair fare structures to encourage widespread usage.
- Creating employment opportunities for residents within the Project area to promote local economic benefits.
- Introducing small-scale restaurants or refreshment facilities aboard the train to improve passenger comfort.
- Providing sufficient and well-organized parking facilities at all train stations to accommodate commuters.
- Upgrading onboard travel amenities to offer a comfortable and enjoyable experience for tourists.
- Resolving existing parking congestion issues within Murree City to facilitate smoother traffic flow and accessibility.







Plate 5.3: Pictorial View of the Community Consultations

5.5.4 Gender Consultations

Recognizing the significant role of women both within households and society, gender-specific consultations were conducted at three locations to capture the perspectives and concerns of female stakeholders related to the Project's implementation. During these sessions, participants were informed about the proposed Project, and women actively engaged in the discussions, expressing their support. However, it was noted that most

women were initially unaware of the Project details. A summary of the participants is provided in **Table 5-9.**

Table 5-9: Summary Consultation with Females

Sr. No.	Venue	Date	Participants
1	Malpur	16-04-2025	13
2	Trimna	16-04-2025	10
3	Mall Road & Traith	17-04-2025	14
Total			**37**

5.6

The concerns/suggestions raised by the participants along with the responses are provided in **Table 5-10** whereas the pictorial view is provided in **Plate 5-3.**

Table 5-10: Gender Concerns and their Responses

Sr. No.	Concerns/Suggestions	Response
1.	The construction activities will cause inconvenience to the mobility of the women	The contractor will ensure that construction work does not disrupt local women's access to local routes or their daily activities. In this regard, an alternate route will be established, as per the provisions of the detailed design, before the commencement of civil works.
2.	Privacy issues for local females and school/college students during construction work due to outside labour in the Project area.	Laborers will be required to work and reside within designated areas or campsites, and contractors will be instructed to prioritize hiring the majority of the workforce from local communities. Special privacy measures, such as protective barriers, will be implemented around educational institutions to safeguard women's privacy. Additionally, contractors will conduct comprehensive GBV (Gender-Based Violence) prevention training for all Project workers.
3.	Women and children may have health issues due to poor air quality, dust and noise.	Water will be regularly sprinkled to control dust emissions, and construction activities will be limited during peak hours to minimize noise-related disturbances.
4.	Job and labour opportunities for local females.	The provision of special jobs for female will be ensured during the implementation stage and duly incorporated in E&S documents and bidding/tender documents accordingly.
5.	Separate waiting areas for men and women should be established at all stations, along with the construction of adequate lavatory facilities. Special attention must be given to ensuring these amenities fully address the needs and comfort of female passengers.	Based on the prevailing circumstances and design requirements, the requested facilities will be incorporated into the Project's design and budget accordingly.

Participants also provided valuable feedback during the consultations, with key suggestions summarized as follows:

- The train fare should be set lower than that of local transport to ensure affordability.
- Parking facilities should be established at stations, with special consideration for daily workers.
- The train route should be extended to Muzaffarabad to enhance connectivity.
- Dedicated cabins should be allocated exclusively for female passengers to ensure their comfort and safety.



Plate 5-4: Pictorial View of the Gender Consultations

5.7 PROPOSED CONSULTATIONS PROGRAM

The stakeholder consultation and engagement are an ongoing process and will continue throughout the Project's construction as well as operation and maintenance phases. The ongoing consultation process could be scheduled on need basis with the stakeholders including but not limited to the concerned government departments, local administration, community representatives and PAPs from the proposed Project area.

The overarching goal of consultations and community engagement is to support and facilitate the Project's design and implementation, to reduce conflicts and Project opposition, and to increase Project's acceptability.

The consultations will be carried out during the construction and operation phases of Project. Consultations will be undertaken in all the communities twice or more time in a year, depending on the number of concerns raised under each consultation. Ongoing stakeholders' engagement activities include:

- Ongoing reporting on progress on the implementation of environmental and social management measures identified during the EIA process and recording of comments on the effectiveness of these measures;
- Updating communities and other stakeholders about Project developments and recording comments on these; and
- Ongoing action of the grievance mechanism.

Efforts will be made to maximize the consultations during the Project implementation. The consultations will be carried out with the objectives to develop and maintain communication linkages between the Project promoters and stakeholders, provide key Project information to the stakeholders, and to solicit their views on the Project and its potential or perceived impacts, and ensure that views and concerns of the stakeholders are incorporated during the implementation with the objectives of reducing or offsetting negative impacts and enhancing benefits of the proposed Project. The framework for the future consultations is elaborated in **Table 5-11**, but not limited to the following.

Table 5-11: Proposed Consultations Framework

Sr. No.	Stakeholders	Project Phase	Frequency of Consultation
1.	Institutions/Departments	• Pre-Implementation • During the Project Implementation • At Closure period	• One round of consultation before the implementation of the Project. • Bi-annually during operation phase. • Once before the closure of the Project.
2.	Local Communities/ Key Persons	• Pre-Implementation • During the Project Implementation • At Closure period	• Consultation at different stages i.e., before implementation, periodic meetings during the construction phase and at the time of Project completion.
3.	NGOs/CBOs	• Pre-Implementation	• Periodic meetings will be

Sr. No.	Stakeholders	Project Phase	Frequency of Consultation
		• During the Project Implementation • At Closure period	conducted as per requirement of the Project.

During the operational phase of the Project, consultations with stakeholders are important to assess the benefits of the Project and impacts on the local communities.

A comprehensive stakeholder consultation plan shall be prepared by the contractor(s) to get feedback from the stakeholders and to resolve the issues during the construction and operational phases of the Project.

6 ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

6.1 GENERAL

This chapter identifies the beneficial as well as the potentially significant adverse environmental and social impacts during design/pre-construction, construction and operation phases of the proposed Project on the physical, ecological and socio-economic domains of the environment. The appropriate mitigation and remedial measures are proposed in this chapter. A project impact evaluation matrix has been developed to evaluate the potential impacts of the proposed Project. A brief qualitative description of each aspect and the affected environment in Study Area / AOI is presented below.

6.2 NOTION OF SIGNIFICANCE

The term ***"Environmental Impact"*** or simply *"**Impact**"* covers the negative, adverse or harmful as well as positive, desirable or beneficial impacts of the project on environmental settings. Prediction of impacts of the proposed activity is based on factual data; however, the significance of these impacts involves a value judgment technique. The nature of the impacts may be categorised in terms of:

Direction - Positive or Negative
Duration - Long or Short Term
Effect - Direct or Indirect
Extent - Wide or Local

Impact significance depends on both the nature of the impact and on the sensitivity of the receptor. The more sensitive the receptor the greater will be the significance of impact from that proposed activity. For this EIA, activities and nature of impact are combined with the sensitivity of the receptor to evaluate the significance of the impact. The significance of impact is characterized as very low, low, moderate, high and very high. Environmental issues having "moderate", "high" and "very high" significance is provided with mitigation measures.

Following the assessment of magnitude, the quality and sensitivity of the receiving environment or potential receptor has been determined and the significance of each potential impact established using the impact significance criteria matrix as shown below. Most of the potential impacts can be mitigated by implementation of various types of mitigation measures; however, some residual environmental impacts may remain after mitigation.

6.3 METHODOLOGY FOR IMPACT EVALUATION

The methodology adopted for the evaluation of the impacts included the following assessment tools, (i) project impact evaluation matrix and (ii) overlays. These tools were

used to identify the significance and magnitude of the impact as well as the nature, reversibility, extent, etc.

6.3.1 Project Impact Evaluation Matrix

The Impact Evaluation Matrix was developed by placing project activities along one axis (i.e. Y-axis), and on the other axis (i.e. X-axis) the different environmental parameters likely to be affected by the proposed Project actions grouped into categories i.e. physical, ecological and socio-economic environment. For the impact assessment, project impact evaluation matrix was used by dividing the project action into different phases (construction and operational phases). A Project Impact Evaluation Matrix is given as **Table 6.1**.

6.3.2 Overlays

In order to identify spatial based impacts, overlays were used. An overlay is based on a set of transparent maps, each of which represents the spatial distribution of an environmental characteristic (for example, land acquisition). Information for an array of variables such as land use, infrastructure, vegetation etc. was collected for the standard geographical units within the project's AOI, recorded on a series of maps, typically one for each variable. These maps were overlaid to produce a composite map. The resulting composite maps characterize the Project area's land use, physical, social, ecological and other relevant parameters related to proposed intervention. The overlays maps used in this EIA for the quantification of the landuse categories is given in Chapter 4: Description of Environment.

6.4 DELINEATION OF STUDY AREA / AOI

For an EIA Study, a clear delineation of the Study Area / AOI is required. Study Area / AOI is the area within which the potentially significant impacts of the proposed Project activities (direct or indirect) are envisaged. In this report, the Study Area / AOI of the proposed project is considered as 25m from project boundary where the impacts on the environment due to the proposed Project activities are assessed. Based on the available Google Earth Imagery and ARC GIS software, Project footprints were overlaid on the existing Project Area Imagery. Utilizing the information collected through the detailed site visit, consultations with the locals and concerned departments and foreseen impacts of the proposed Project, a tentative AOI was delineated. Map of the Study Area / AOI is shown as **Figure 1.2**.

Table 6.1: Environmental Impacts Matrix for Construction Phase

Project Impact Matrix

Environmental Component / Project Component	Physical Environment								Ecological Environment					Socio Economic Environment										
	Soil (Erosion / Stability / Contamination)	Air Quality	Noise Level	Surface & Ground Water Quality	Solid Waste Generation	Wastewater Generation	Emission of GHGs	Traffic Issues	Aquatic Ecosystem	Terrestrial Ecosystem	Endangered Species	Loss of Trees	Loss of Crops/Orchards	Conflict over Resources	Public Utilities	Accessibility	Community Stability	Gender Issues	Cultural & Social Issues	Health& Safety	Aesthetic	Security Situation	Living Standards	Employment Opportunities
A. Planning & Design Phase																								
Topographic Survey of Project	2	2	o	o	o		o	o	o	0	o	o	o	o	o	o	o	o	o	0	o	o	o	o
Geotechnical Investigation	o	o	2	o	o		o	o	o	o	o	2	0	o	o	o	o	o	0	2	o	o	o	o
Socio-Economic Surveys	2	2	o	o	o		o	o	o	0	o	o	o	o	o	o	o	o	o	0	o	o	o	o
B. Construction Phase																								
Site Clearance	9	9	9	2	8	4	2	2	o	12	o	10	0	6	10	3	o	2	2	9	4	2	o	6
Earthwork and Excavation	9	9	9	2	8	8	4	4	o	12	o	8	o	6	2	3	2	o	2	9	4	2	o	6
Establishment of Construction Camps & Workshop	2	2	4	o	8	8	o	2	o	4	o	4	0	8	o	o	4	4	4	8	4	2	o	6
Transportation & Storage of Construction Materials	4	6	6	4	4	2	o	4	o	2	o	o	0	o	o	o	4	o	2	6	4	o	o	4
Use of Construction Material and Heavy Machinery	3	8	9	o	4	o	o	2	o	4	o	o	o	o	2	2	o	o	2	8	o	4	o	4
Installation and operation of Batching and Asphalt Plants	4	8	8	2	4	2	2	o	o	2	o	o	o	2	o	o	o	o	o	6	4	o	4	4
Spoil Disposal	3	3	o	2	6	o	o	o	o	6	o	4	o	o	o	o	2	o	4	4	6	o	o	2
Structural & Civil Work	8	8	8	2	7	2	2	2	o	6	o	o	o	2	2	o	2	4	4	9	4	3	o	8
Drainage, Water Supply & sewerage works	4	6	6	2	6	4	2	2	o	6	o	o	o	2	2	o	2	4	4	9	4	4	o	8
Construction of residential/commercial units	o	2	4	4	6	4	2	2	o	2	o	o	o	o	o	o	o	2	o	4	o	o	o	8
C. Operational Phase																								
Movement of Residents, Employees & Visitors	2	4	4	4	9	10	4	4	o	4	o	6	o	o	0	0	4	o	o	2	6	6	6	6
Consumption of water	o	o	o	4	o	o	o	o	o	o	o	o	o	o	0	0	o	o	o	o	o	o	o	o
Municipal solid waste and wastewater generation	o	o	o	o	6	o	6	6	o	o	o	o	o	o	0	0	o	o	2	6	4	o	o	2
Maintenance of Area Facilities	o	2	2	2	6	2	o	o	o	o	o	o	o	o	0	0	o	o	o	6	o	o	o	2
Landscaping/ Maintenance of Green areas	o	2	2	o	2	o	o	o	o	o	o	o	o	o	0	0	o	o	o	4	4	o	o	2

Positive Impact Score
0
2 to 4
5 to 8
9 to 12
>12

act Significa	
Negligible	
Low	
Medium	
High	
Very High	

6.5 POTENTIAL ENVIRONMENTAL IMPACTS AND MINTIGATION MEASURES

There are some potential significant adverse environmental impacts on the local environment. The proposed Project is divided into three (03) phases i.e. Pre-construction / Planning and Design Phase, Construction Phase and Operation and Maintenance (O&M) Phase. The Pre-Construction Phase includes all stages before the Construction Phase (i.e. site investigation work i.e. topographical, seismic studies etc.); Construction Phase includes all stages from mobilization of Contractor to the completion of Project; and Operation Phase starts after the Construction Phase which includes the inspection and repair works.

Adverse impacts envisaged at these three (03) phases of the proposed Project along with their proposed remedial or mitigation measures are detailed below:

6.5.1 Potential Environmental Impacts during Pre-Construction / Design Phase

Following is the brief description of impacts envisaged and the recommended mitigation measures during Pre-construction / Design phase.

6.5.1.1 Topography

The construction and operation of the Murree train project are likely to induce substantial alterations to the natural topography of the region. Murree's terrain is characterized by steep slopes, rugged hills, and narrow valleys, making large-scale infrastructure development particularly challenging. Key topographical impacts include:

- To accommodate railway tracks and related infrastructure, extensive cutting of hillsides and filling of valleys may be required. This process alters the natural landform, potentially leading to slope instability and increased susceptibility to landslides and erosion.
- The alignment of the railway through hilly terrain may necessitate the construction of multiple tunnels and deep cuttings. While tunnels reduce surface disruption, their construction involves heavy excavation, blasting, and spoil generation, which can disturb the underlying geology and hydrology.
- Modifying the topography through embankments, culverts, and bridges can interfere with natural drainage networks. This may result in waterlogging in some areas and reduced water flow in others, potentially impacting both ecosystems and nearby human settlements.
- The modification of natural landforms can degrade the scenic beauty of Murree, a major tourist destination known for its landscape. Rail embankments, retaining walls, and cut slopes can significantly alter the visual character of the region.
- Disturbance of slopes and vegetation cover during construction increases soil erosion risks, particularly during the monsoon season. This can lead to sedimentation in downstream rivers and streams, affecting water quality and aquatic habitats.
- The establishment of permanent infrastructure tracks, stations, access roads will result in irreversible changes to the natural terrain. These alterations may affect land use patterns and restrict future development options.

Visual changes to the topography will be of permanent and moderate negative in nature.

Mitigation Measures:

- The project design would consider aesthetic concerns such as the tree plantation which is already recommended in the EIA Report;
- Use of tunnel-boring machines to minimize open cutting;
- Construction of retaining walls and slope stabilization structures;
- Landscape integration to preserve visual harmony with the environment;
- Erosion control through proper drainage and sediment management systems;
- Retaining structures such as gabions, cribs grids of wood or concrete beams filled with earth or rock), or other types of wooden barricades and grid works, usually battered back against the slope;
- Best engineering design measures should be adopted keeping in view the aesthetics of the project area; and
- Ground disturbances should be limited to only the areas necessary for project related construction activities.

6.5.1.2 Route (Alignment) Optimization

Improper route selection of proposed glass train will lead to disturbance to ecological sensitive areas and social issues of resettlement and displacement of people. This impact would be of moderate significance.

Mitigation Measures:

Most of the significant environmental, ecological and social impacts of the project have been addressed at the design phase. Environment team has closely worked with design team for the route optimization. In order to minimize environmental, ecological and social issues at the design stage, various features have been considered. The train route alignment has been finalized by considering features (maximum avoidance to settlements, ecologically sensitive areas, mosques, Graveyards, major water resources, etc.) and efforts have been made to avoid or minimize impacts on ecological and social components of the environment.

6.5.1.3 Environmentally Responsive Design Considerations

Designing of the project components without considering the prospective and futuristic needs can result in structures with low social acceptability and functionality. Improper designed infrastructure may lead to technical, environmental and financial problems. This includes railway track, station, tunnels, culverts, bridges, etc. If not properly planned and designed, it may lead to both social and environmental concerns. Moreover, utilization of the available spaces and designing the layout without considering the prospective and futuristic needs may result in design with low social acceptability and functionality.

This impact is permanent and moderate negative in nature.

Mitigation Measures:

- Focus design work on minimizing use of natural resources, intrusion into natural waters, avoiding forests, scheduling of work to minimize wildlife interference, maintenance of surface runoff and planning location of work camps that minimizes short and long term negative effects.
- All structural, layout and engineering designing should be in strict considerations with the applicable national and international by-laws and engineering parameters.

6.5.1.4 Infrastructure Design of Stations and Buildings

Inadequate provisions for water supply, sewerage, drainage and solid waste management at station and buildings may lead to health issues, odor and nuisance problem for public. This is a medium adverse impact

Mitigation Measures:

- All structural, layout and engineering designing should be in strict accordance with the applicable by-laws and engineering parameters;
- A solid waste management plan for onsite storage, collection and disposal of garbage will be prepared;
- Storm-water drainage system for the railway bridges should be carefully designed; and
- Provision of culverts and plan for rehabilitation of the existing ones in the design at regular intervals to channel away the water from the elevated tracks to the lowest point.

6.5.1.5 Design of Level Crossings

Level crossings provide a means for vehicles, pedestrians and animals to cross over railway lines. Poorly designed level crossings can lead to serious injuries or accidents. Risks that arise at level crossings include user slips/trips/falls (including cyclists), trespass along the railway line itself, equipment damage due to vandalism, electric shock from overhead wires and vehicle collisions with barriers, pedestrians or other vehicles.

The layout, configuration and use of level crossings vary from location to location, so each one is essentially unique. To minimize the risk of trains striking crossing users, the following features and provisions could be incorporated in their design.

Mitigation Measures:

- Barriers or gates at public vehicular crossings to physically prevent vehicle or pedestrian users from crossing the railway. These may be operated:
  - Automatically upon detection of an approaching train, or
  - Manually by railway staff present at the crossing (or from an adjacent signal box) or via remote control from the signal box controlling the area
- Colored lights which provide a visual indication to the user of whether, or not, it is safe to cross; this may also be combined with an audible alarm.
- Telephones for the user to request permission from the signaller to cross.

- Gates or stiles to highlight to the user where the boundary with the railway begins and ends. These can also prevent inadvertent trespass of children or animals onto the crossing or, in the case of locked gates, unauthorized use.
- Signage to explain the safe method of using the crossing or to bring the user's attention to specific dangers.
- Railway signs that signify trains to stop on the approach to crossings which are crossed over when identified as safe to cross by the train crew.

6.5.1.6 Hydrology and Drainage pattern

The project can affect the natural surface and subsurface drainage pattern in the project area. The presence of excess water or moisture within the rail track will adversely affect the engineering properties of the materials used in its construction. Poor drainage can cause cut or fill failures, road surface erosion, and weakened subgrade followed by a mass failure. Improper drainage can modify surface water flow by concentrating flows at certain points and, in many cases, increasing the speed of flow.

The potential effects of poor drainage include; deterioration of vegetation, increased susceptibility to erosion, loss of water for drinking as well as agricultural use. It can also lead to water quality degradation (surface and groundwater).

Mitigation Measures:

- Water must not be allowed to develop sufficient volume or velocity so as to cause excessive wear along ditches, below culverts, or along exposed running surfaces, cuts, or fills.
- Natural drainage characteristics of a hill slope, as a rule, should not be changed.
- Culverts should be placed at grade and in line with the centerline of the channel to avoid excessive erosion of soils above and below the culvert.
- Culverts should be designed based on the flood history of the project area.

6.5.1.7 Seismic Hazard

As per Building Code of Pakistan, Seismic Provisions, 2007, the project area is located in Seismic Zone 2B & 3 (moderate to high hazard), where peak horizontal ground acceleration from 0.16g to 0.32g. In this Zone, designing of various types of structures should be done on the basis of PGA. A high intensity earthquake impacting the project site can adversely impact the development. This factor requires special consideration of the designers keeping in view of the recent earthquake of October 08, 2005. This will be a local and high adverse impact.

Mitigation Measures:

- The proposed structures should be designed and constructed to withstand high intensity earthquakes. For seismic hazard analysis, updated structural, geotechnical and seismic studies should be conducted; and
- To mitigate the seismic hazard, Seismic Building Code of Pakistan 2007 (SBC-07) should be adopted. This code specifies minimum requirements for seismic safety of

buildings and has to be applied and used by engineers in conjunction with the necessary understanding of the concepts of structural, geotechnical and earthquake engineering.

6.5.1.8 Site Selection of Construction Camps

Improper site selection and location of construction camp(s) may lead to various social and environmental impacts which include loss of vegetation due to setting up construction camps, indiscriminate generation of solid waste, and discharge of sanitary effluent, water pollution and health & safety issues in the surrounding settlements. This impact is low negative and short term.

Mitigation Measures:

- Construction camps should be designed to be self-contained to reduce demand on infrastructure and services of nearby communities and to minimize the removal of existing macro-plants;
- There should be no resettlement issue for the location of the camps;
- Camp site should be away from the residential areas and sensitive receptors;
- Selection of sites for construction camps shall be near the project area having proper access to the nearby main/link road;
- The camps must be located in a place where the drainage from and through the camps will not threaten any domestic or public water supply;
- Camp site must be adequate in size to prevent overcrowding of necessary structures;
- The camp site should consider avoiding any damage of property, vegetation, irrigation, and drinking water supply systems;
- The camp site must not be subject to periodic flooding; and
- There should not be any ecological sensitive areas e.g. wildlife sanctuaries, game reserves, national parks, forest areas, etc. near to the construction camp site.

6.5.1.9 Transportation of Construction Material

The project construction will require transportation of construction material. This will cause unnecessary degradation of roads and areas surrounding along haul routes resulting in generation of dust, noise, traffic congestion and safety issues. This impact is temporary and medium adverse in nature.

Mitigation Measures

- A checklist and guideline for handling of all construction materials and the designation of roads not suited for hauling materials should be prepared by PR in consultation with local police and enforced.

6.5.1.10 Noise and vibration

Vibration as well as noise, is an environmental and human health concern; Both factors significantly impact comfort and quality of life. While vibrations from passing electric trains

are generally too weak to damage buildings, they can still cause considerable annoyance and discomfort for people living near railway lines.

Mitigation Measures:

- Some technical solutions consist of replacing the cast iron brake blocks with composite brake blocks or disc brakes, which reduce the pass-by noise level, as they do not increase the wheel roughness as much as the cast iron blocks.
- Noise abatement measures such as fitting barriers along railway tracks, fitting noise dampeners and acoustic rail grinding should be carried out.
- The composite brake blocks must be acoustically certified through the procedure set out in the TSI and meet well-defined limits.

6.5.1.11 Public Utilities

Due to the proposed project, public utilities (electric poles, water pipes, power/ telephone lines, etc.) may be affected creating disruption of public services and inconvenience to the local residents. This impact is temporary and may be considered as moderately negative in nature.

Mitigation Measures:

- The provision in the design and budget for the relocation of the existing utility infrastructure wherever required and shall be finalized in consultation with the concerned department; and
- All public utilities (e.g. electric lines, water pipes, power/ telephone lines, etc.) likely to be affected by the proposed project shall be relocated well ahead of time before the actual commencement of the construction work.

6.5.1.12 Emergency Management

Emergency management in case of natural and man-made disaster is a major concern. Increased incidents of disasters especially act of terror, fire, earthquakes etc. demand proper planning. The impact is considered to be high negative, and long-term. An inefficient firefighting system and insufficient storage of fire water may pose a sever e threat to human life and to the proposed Project.

Mitigation Measure:

- A separate building for fire brigade, emergency response equipment and staff may be considered in the design;
- Emergency Response Plan is attached as **Annex-III**.

6.5.1.13 Flora

During the pre-construction phase, activities such as installation of construction camps, construction of temporary facilities & mobility of construction staff may damage the local vegetation/trees. As the heavy machinery and camps will be moved and installed, which

require significant space due to which available vegetation is expected to be removed. This impact is site-specific, permanent, medium significant and needs to be encountered prior to the start of construction stage.

Mitigation Measures

Construction of proposed glass train in the Margalla Hill National Park, Murree-Kotli Sattian-Kahuta National Park and reserve forests and for removal of trees NOC from the concerned forest department will be required prior to the start of construction of the train route to make the work carried on through a proper channel.

It is suggested that the trees falling within the boundaries of the national park and reserve forest will be marked by the Forest Department before the start of the work. A joint visit by the employer, consultants and concerned forest department will be carried out. A document containing details of the total trees to be felled having details of mitigation measures to be adopted during the construction phase of the project in the Reserve forests and details of the developments in the said forest will be provided to the concerned department for the issuance of NOC for the construction work to be carried out.

Other mitigation measures include:

- The camps, mobility of machinery and construction of temporary facilities should be proper planned and well designed to avoid any loss to local green cover;
- It is recommended to establish the construction camps where minimum or no vegetation exists;
- Similarly, the alternate routes for roads and points for camps are recommended where no loss of vegetation is expected; and
- The location of construction camp should be selected so, as to have limited environmental impact during construction phase and to reduce the cost and land requirement.

6.5.1.14 Fauna

As movement and installations of machinery and vehicles will take place, so noise and habitat loss is expected. The routes of the available wildlife and other habitats may be affected due to camps set-up and machinery movements and installations. This impact is site-specific, temporary and low significant.

Mitigation Measures

- The standard measures must be adopted to minimize noise due to machinery movements and installations;
- Wildlife movements and routes must be considered during activities and should be avoided to their maximum level;
- The alternate routes and points are recommended to avoid any damage to locally available fauna;
- The camps shall be designed as properly fenced and gated to check the entry of animals in search of eatable goods; and

- A waste management plan so that the wastes of the camps shall be properly disposed of to prevent it being eaten by animals, as it may be hazardous to them.

6.5.1.15 Nature Conservation and Biodiversity

The development of transport infrastructure usually increases pressure on the local environment. The impacts of rails on biodiversity includes Wildlife mortality, Habitat loss and the exclusion of species from their habitats, Exotic species invasions and barriers to them, Impacts of other environmental disturbances related to railway activities.

Wildlife mortality is most often due to collisions with trains, followed by electrocution, wire strikes and rail entrapment. The mortality of mammals due to train collisions is significant and can have a major impact especially on endangered species, species with large home ranges and low-density populations, and species with a low reproductive rate. Other animals, such as birds, amphibians and reptiles, are also killed in train collisions.

When it comes to habitat fragmentation, railway tracks also create barriers by dividing the natural environment into smaller areas. Items such as fences used to protect the transport network can isolate some species and increase their vulnerability. Some countries have worked on improving the situation by creating wildlife crossings, such as tunnels or bridges, to reduce the impact of transport infrastructure on wildlife.

According to the literature, there are four types of barriers to biodiversity conservation.

- **Physical and behavioral barriers:** Physical barriers are structures preventing species from crossing the railway, whereas behavioral barriers occur when species could cross but do not because of unfavorable environmental conditions or risk.
- **Disturbance:** Traffic noise, vibration, chemical pollution and human presence can affect animals living close to railways. The impacts are divided into those related to siting and construction and those related to the operation of the railway line.
- **Mortality:** This is considered a barrier, as it can directly prevent connectivity among subpopulations or reduce their reproductive success.
- **Habitat loss and fragmentation**: Railway construction can result in habitat loss, as the railway bed is not a suitable habitat for many species. Habitat loss can also happen, for example, when a population's territory is bisected by a railway. Habitat changes can occur in railway corridors, as their verges differ from the surrounding landscapes. These changes can also lead to colonization by invasive species.

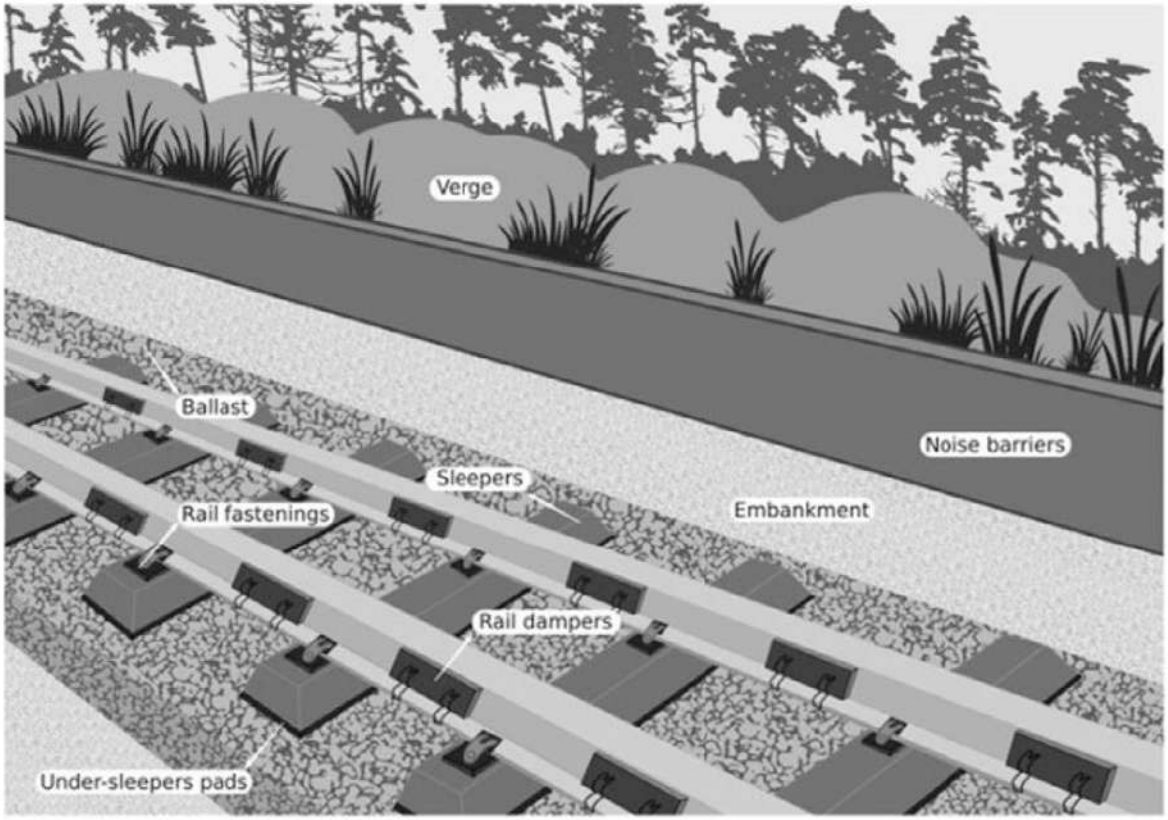
There are following adverse impacts associated with the proposed project:

- Establishment of Muree Train Project will result in the direct destruction/alteration of natural habitats.
- Wildlife may be struck by trains (rolling stock) or collide with infrastructure elements like overhead cables and windows.
- Small animals are at risk of getting trapped between tracks or other parts of railway infrastructure.

- Without proper management, created or restored habitats may degrade, reducing their ecological value.
- Light, noise, and vibration from trains and infrastructure can disturb local wildlife, affecting behavior and reproduction.
- Continuous natural areas may become divided by railway lines, isolating wildlife populations and limiting genetic exchange.
- Depending on train frequency, railways can act as physical or behavioral barriers, preventing animals from moving freely across the landscape.
- Negative effects of noise, light and vibration on insects, amphibians and birds.

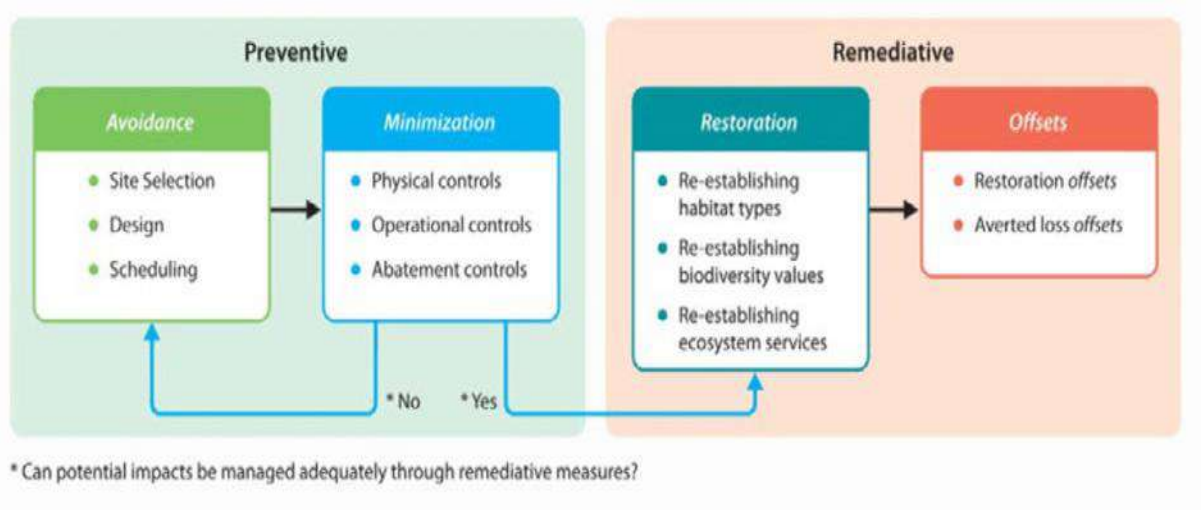
Mitigation Measures:

- Noise reduction measures should be implemented by lowering the speed of rail vehicles and minimizing radiated sound through regular maintenance.
- Other measures to decrease noise and vibration are rail fastenings, rail dampers, under-sleeper pads and noise barriers should be considered during design.
- It is also important to consider that reducing noise may impair wildlife's ability to detect approaching trains, potentially increasing the risk of collisions.
- The establishment of management plans and collective action are key to protecting and enhancing biodiversity.
- Different solutions can be implemented to allow animals to cross. Considering wildlife tunnels when building new railway infrastructure can also play a role.



Source: UIC (2022), *European Railways: Strategy and actions for biodiversity*, Paris.

According to a UIC report, there are four aspects of mitigating the impacts of railways on biodiversity that should be considered when planning any work.[38]



Source: UIC (2022), *European Railways: Strategy and actions for biodiversity*, Paris.

6.5.1.16 Impacts on Socio-economic Environment

Fast-moving trains at rail-road crossings pose a significant safety hazard, with the potential to cause major accidents, severe injuries, and fatalities. This concern is particularly critical in areas like Murree, where road infrastructure is often constrained by hilly terrain, and visibility at crossings may be limited.

At-grade rail-road crossings not only increase the risk of collisions but also contribute to severe traffic congestion, especially in peak tourist seasons. In such regions, the combination of high-speed rail traffic and inadequate crossing infrastructure underscores the urgent need for safety upgrades such as barriers, signals, overpasses, or underpasses to minimize risks to both motorists and pedestrians. This impact is permanent and highly adverse in nature

Mitigation Measures:

- Grade separations should be built at problematic crossings.
- Vehicular traffic management systems at level crossings should also be upgraded.
- Warning signs and gate lights need to be installed and warning bell should be operated by approaching train. Warning sign and disclaimers should be posted at all at-grade crossings.
- Level crossings should be provided with round the clock manned/ automatic barriers to improve the safety at these locations.
- Overhead pedestrian crossings should be provided where the alignment passes through major settlements.
- Noise barriers in form of tree plantation should be planned at sensitive receptors.

[38] https://uic.org/IMG/pdf/uic_reverse_strategy_and_actions_for_biodiversity.pdf.

- Heavy fines strategy should be integrated in rail traffic safety regulations for violators.

6.5.1.17 Impacts on Socio-economic Environment

a) Traffic Management

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- Noise barriers in form of tree plantation should be planned at sensitive receptors.
- Heavy fines strategy should be integrated in rail traffic safety regulations for violators.

b) Land Acquisition and Resettlement

Private land acquisition is involved in the construction of proposed project, which is multiple type of land. This impact will be permanent and major negative in nature. The land required for the construction of the proposed Murree Glass Train.

Mitigation Measures:

Mitigation measures will involve careful site selection by the design team to minimize the impacts by avoiding the residences of affected families. The Land Acquisition Act (LAA) of 1894 is the main law regulating land acquisition for public purpose. This impact can be mitigated by ensuring compliance of Land Acquisition Act, 1894, addressing community grievances on priority basis and timely compensation to affectees.

The process of land acquisition and compensation should be followed in a transparent manner to minimize the impacts to provide judicious compensation to the affected persons by providing sufficient budget in the project cost. According to Land Acquisition Act 1894, the following points needs to be considered while determining compensation for the project affectees:

- Due consideration should be given to minimum land acquisition in design phase by selecting careful site for the construction of proposed project;
- The market value of land at the date of publication of notification under section 4 sub section (1);
- The market value of land and 15% compulsory land acquisition surcharge, should be given;

- The damage if any sustained by the person interested at the time of the collector's taking possession of the land by reason of acquisition injuriously affecting his other property, moveable, or immoveable, in any other manner, or his earning; and
- As a consequence of the acquisition of the land by the collector, the person affected is compelled to change his residence or place of business, the reasonable expenses incidental to such change.

Therefore, compensation should be made to the affected people as per Land Acquisition Act, 1894 and market value for the loss of assets. Adequate budget will be provided in the Project cost for this compensation.

c) Temporary Acquisition of Land

The Contractors will require temporary land acquisition for:

- The development of Contractor camps and facilities i.e. storage, workshops, equipment parking and washing areas;
- Aggregate quarries; and
- Access roads/tracks for haulage, transportation etc.

The approximate area required for the establishment of one Contractor's camp facilities will be 1500m^2 at the different locations. Land utilization for Project activities and subsequent operation of Project may induce temporary as well as permanent changes in the existing land use pattern. Moreover, the contractor will provide the estimated quantity of excavation material during the construction phase. This impact can be categorized as direct, low, site-specific, short term, temporary, medium probability and reversible.

Mitigation Measures

It is the foremost option to establish the construction camps at the acquired land to eliminate the issues of land leased etc. however, if this option is not feasible than the land for above mentioned facilities should be selected and leased prior to the start of construction phase.

Land for above mentioned facilities will be directly rented from the private landowners by the Contractors. The provisions of the Land Acquisition Act (LAA), 1894 will not be involved as the acquisition of the land will be temporary and will be covered by short-term lease agreements between the landowners and Contractor. Rental terms should be negotiated to the satisfaction of the concerned landowners and the agreement should be in local language to make the process clear.

In addition, these project facilities should be located at a minimum distance of 500 meter from the existing settlements, built-up areas, archaeological and cultural monuments (if any) as the case may be. Prior to the commencement of the construction activities, the Contractor should submit a construction camp development/management plan to the Engineer-in-charge and the PEPA (if required) for its scrutiny and approval. As far as possible, waste/barren land i.e. areas not under agricultural or residential use and natural areas located at high elevation should be used for setting up the contractor camps.

d) Agriculture

The Proposed railway tack will be constructed on the new alignment and land under the required ROW will be acquired. During the survey it has been observed that the proposed RoW is also passing through the agricultural land which is being cultivated. The clearance of RoW will affect standing crops, which will cause loss of income to affectees. The impact on agriculture in the project area is major high and permanent.

Mitigation Measures

- The budget for the proposed project will include provision for payment of compensation to farmers for the loss of any standing crops, or crops already sowed. Will be applicable for all crops standing on land within the acquisition area at the time of dispossession;
- The compensation value shall be calculated based on market value of the crops and average yields in the project area;
- Removal of all contractors' facilities from the project area shall be a contractual requirement, and as such the land used for the construction camps can be restored to facilitate agriculture and the land used for the construction camp shall become cultivatable.
- Compensation for the loss of crops and orchards to the land owners and cultivators as the case may be will be paid, in accordance with the prevailing market prices and uniformity in rates will be ensured within the local areas; and
- As far as possible, land within the RoW (which will be acquired) or otherwise barren land without any crop outside the RoW will be selected for the camp sites and disturbance to the crops and natural vegetation will be avoided as much as possible.

e) Impact on Structures

Impact on Residential Commercial Structures

In the RoW & CoI housing and commercial structures of different categories will be affected fully and partially due to project intervention. These structures exist in the ROW of the proposed road at different locations. In addition to these structures, hand pumps, boundary walls and other related structures are also under the impact. These households are losing their residences permanent temporary and their relocation is involved. This impact will be temporary and medium to low adverse in nature.

Mitigation Measures

The inventory and detailed measurement of structures and the number of Affected Household to be affected for clearing of RoW for the proposed Project and detailed measurement survey should be carried out for preparing the compensation.

Following measures shall be adopted to mitigate the adverse impacts:

- Compensation of the structures should be evaluated and provided as per market rates;
- Affected Persons should be compensated on full replacement cost of each category to construct a new structure of the same type;
- Compensation of livelihood disturbance should be provided for the period of instruction of commercial activities;
- Proper consultations and coordination's with APs during resettlement process.
- Compensation for affected structures should be evaluated and provided as per market rates.
- Affected Persons should be compensated on full replacement cost of each category to construct a new structure of the same type; and
- Proper consultations and coordination's with PAPs during resettlement process.

Impact on Community and Religious Structures

The community and religious structures are very sensitive to impact and need special care during execution of the project; because people think that these structures might not be rebuilt if once demolished. Mosque, Graveyard fall in the RoW of the proposed track. Shifting and demolishing of these structures may cause serious social issues.

Mitigation Measures

Following measures shall be adopted to mitigate the adverse impacts:

- The effort will be made by making changes in design to avoid the sensitive and religious structures and to minimize the issues at possible extend. If needs demolishing, a mechanism will be developed for the restoration of these structures during the detailed design and during construction with the community consultation, and

- Proper consultations and coordination's with the communities

6.5.2 Potential Environmental Impacts during Construction Phase

Following is the brief description of impacts envisaged and the recommended mitigation measures during construction phase.

6.5.2.1 Topography

Construction activities is expected to impact the topography of the area significantly except for those areas where physical activities including digging and excavation areas, storing or dumping sites for excessive material, storing areas and movement of heavy construction machinery will be carried out. The excavated material will be generated due to the construction of various infrastructure components of the project like Roads & Walkways and paved areas, stations, tunnels, drainage network, electrification system, and parking facilities. The area where excavated material is to be dumped will also be negatively impacted. This impact is Site-specific, Temporary and medium significant in nature.

Mitigation Measures:

The excavated material will require safe disposal by the Contractor. Most of the excavated material could be used in back filling process and concrete aggregate to be used in construction. A detailed development and operation plan for borrow areas must be prepared by the contractor at the pre-development phase (before the starts of extraction of material from each borrow area). Contractor should strictly follow the provisions of approved plan in order to minimize any adverse impact associated with the borrow areas. Likewise, excavated material should be dumped at suitable and approved disposal sites.

6.5.2.2 Soil Erosion and Contamination

Impact on topsoil and soil stability is mainly expected during the preparatory and construction works, which will be caused by the arrangement of the construction camp, construction site, replacement of the equipment, earthworks, arrangement of temporary and permanent infrastructures, etc.

The soil would be exposed to erosion due to removal of vegetation, establishing construction camps / workshops and excavation etc. The most significant aspects in the construction phase of are excavation works and track works. These will expose soils in the affected project area leaving them vulnerable to erosion by surface run-off and wind. The overall threat could exist for the durations of construction works in the monsoon season.

Besides, there is high possibility for soil pollution with substances due to leakages of fuels and oils from the heavy vehicles and machinery used for construction and due to applied chemicals during this phase.

Mitigation Measures:

- In order to prevent the damage and contamination of soil at the project site, surface layer of the soil should be removed and stored temporarily in pre-selected locations. The soil should be stockpiled separately. Stockpiles should be protected

from wind and atmospheric precipitation and should be at least 50 meters away from surface water body;

- Stored excavated material shall be covered and preferably reused, e.g. in construction of dykes etc.;
- Sprinkling of water may help in reducing the erosion soil;
- Use of heavy machinery should be restricted as far as possible to work sites only to avoid the destruction of soil structure;
- Vehicles and equipment should be checked regularly. In case of damage and fuel / oil leakage, it should be repaired immediately. Damaged Vehicles should not be allowed on the construction sites;
- In case of spillage of pollutants, spilled material should be localized and contaminated site should be immediately cleaned; Staff should be provided with appropriate means (adsorbents, shovels, etc.) and with personal protective equipment as well;
- All spoils should be disposed of at site designated by RWMC and the site should be restored back to its original conditions;
- Non-bituminous wastes from construction activities will be dumped in approved sites, in line with the guidelines for dump sites, and shall be covered;
- Washing yards shall be paved to avoid seepage of runoff from the yard;
- After completion of construction works, all kind of waste (including hazardous waste) will be collected and removed from the area. Hazardous waste should be removed for further management by the licensed contractor;
- Minimize major earthworks during the rainy season, to the extent feasible; and
- At the end of the construction phase, re-vegetate cut slopes where ever is feasible.

6.5.2.3 Geo-Hazards

Construction of proposed project in mountainous region leads to wide spread environmental problems. It is clear that engineering works associated with the subgrades, bridges, and tunnels are the main factors influencing the degradation of the mountain environment. The critical areas are the geological hazards such as debris flows, landslides and slope instability.

Newly built railways in the mountain areas are bound to lead to changes in the geomorphic features, destruction of vegetation and the arbitrary placing of immense quantities of spoils. These impacts will aggravate the degradation of the mountain environment if appropriate treatment measures are not introduced.

Mitigation Measures:

- Comprehensive investigations should be conducted for spatial distribution and current stage of development of landslides, debris flows, and other mass-wasting processes in the project area for assessing geohazards and safe infrastructure design;
- Damage to the mountain environment shall be reduced as far as possible during the cutting & filling and other engineering works and control measures should be introduced to maintain the stability of unstable cutting slopes. Slope cutting at tunnel portals should be avoided as far as possible.

6.5.2.4 Water Quality

The potential sources of water pollution associated with the construction of proposed Project are runoff from the construction works area that may contain increased loads of sediments, suspended solids and other contaminants. Potential sources of pollution from the site include:

- Runoff and erosion from exposed soil surfaces, earth work areas and stockpiles e.g. grouting and cement material with the rain;
- Wash water from dust suppression sprays;
- Fuel and lubricants from maintenance of construction vehicles and mechanical equipment;
- Spillage of liquids stored on-site such as oil, diesel, and solvents etc. are likely to result in water pollution; and
- Uncontrolled discharge of debris and rubbish such as packaging, construction material and refuse.

The groundwater may get contaminated from the wastewater generation from the construction camps, leachate from improper dumping of solid waste. The impact is medium adverse in nature.

Mitigation Measures:

As a mandatory step, all the effluents will be disposed as per the requirements of PEQS. Moreover, to reduce the risk of surface and groundwater contamination, good management practices will be adopted to ensure that fuels, chemicals, raw sewage and wastewater effluent are disposed of in a controlled manner. These measures are described below:

- Construction camp will be established in area with adequate natural drainage channels in order to facilitate the flow of the treated effluents after ensuring that PEQS are met;
- The proponent will ensure that the construction work is confined within the project boundary and water bodies are prevented from pollution during construction;
- The solid waste will be disposed of in designated landfill sites to sustain the water quality for domestic requirements;
- Regular water quality monitoring according to determined sampling schedule;
- Water required for construction shall be obtained in such a way that the water availability and supply to nearby communities remain unaffected;
- The contractor will ensure that construction debris do not find their way into the drainage which may get clogged;
- To maintain the surface water flow/drainage, proper mitigation measures will be taken for the proposed project, like drainage structures;
- Wastes will be collected, stored and taken to approve disposal site;
- Wastewater effluent from the Contractors' workshops and equipment washing-yards will be passed through gravel/sand beds to remove oil/grease contaminants before discharging into the natural streams. According to the PEQS, the BOD concentration in sewage must be brought down to less or equal to 80 mg/l before being discharged into a natural stream having capacity to dilute the effluent. For wastewater apart from BOD, COD of 150 mg/l will also be checked; and

- Similarly, if the sewage after treatment is to be discharged in to the land it will meet the requirements of the PEQS for disposal of wastewater.

6.5.2.5 Deterioration of Ambient Air Quality

Air quality will be affected by fugitive dust emissions from construction machinery; dust from the unpaved surface and construction vehicles. Emissions may be carried over longer distances depending upon the wind speed, direction, temperature of surrounding air and atmospheric stability. Besides, multifarious construction activities and increased vehicular traffic (construction vehicles) would also contribute to the localized airborne dust. The larger sized particles, under influence of gravity, tend to settle down in the immediate vicinity of the source. The Suspended Particulate Matter (SPM) tends to remain suspended in the environment for much longer and persistent time and is an environmental hazard. The objectionable impacts of settling of the suspended dust would be its dry deposition on vegetation, motor vehicles, structures, and other exposed surfaces. Exhausts from fossil fuel burning in the construction machinery will also deteriorate local air quality. Similarly, exhausts from generators can also have impacts on air quality in the vicinity. The deteriorated ambient air quality may cause health hazards to the residents of nearby localities.

The overall impact on the quality of air during the construction phase will be high adverse, however, it will be temporary and limited to the project's implementation phase only.

Mitigation Measures:

The construction phase impacts of the proposed Project could be effectively mitigated by the implementation of simple procedures by the Contractor including but not limited to the following:

- All vehicles, machinery, equipment and generators used during construction activities should be kept in good working condition and be properly tuned and maintained in order to minimize the exhaust emissions;
- Open burning of solid waste from the Contractor's camps and at construction site should be strictly banned;
- Preventive measures against dust should be adopted for on-site mixing and unloading operations;
- Construction materials (sand, gravel, and rocks) and spoil materials will be transported through trucks covered with tarpaulins and all vehicles (e.g., trucks, equipment, and other vehicles that support construction works) will comply with the PEQS for carbon emissions and noise;
- Regular water sprinkling of the site should be carried out to suppress excessive dust emission(s);
- Emissions from power generators and construction machinery are important point sources at the construction sites. Proper maintenance and repair is needed to minimize the hazardous emissions;
- Emissions from batching / asphalt plants can be controlled efficiently by the installation of cyclone / scrubbers. Diesel operated equipment should be equipped with well-maintained fuel filter and may be replaced timely (if required). In addition

to that, regular maintenance activities comprising changing of lubricating oil, changing the air and fuel filter, cleaning the fuel system, draining the water separators and proper tuning may also help in reducing the emissions from diesel generators;

- Construction equipment is generally left idling while the operators are on break or waiting for the completion of another task. Emissions from idling equipment tend to be high. Existing idling control technologies, which automatically shut the engine off after a preset time can reduce emissions without intervention of the operators;
- PEQS applicable to gaseous emissions generated by construction vehicles, equipment and machinery should be enforced during construction works;
- Service roads (used for earthmoving equipment and general transport) should be regularly sprayed with water during dry weather;
- All excavation work should be sprinkled with water;
- Construction workers should be provided with masks for protection against the inhalation of dust;
- Vehicles used for construction should be tuned properly and regularly to control emission of exhaust gases;
- Ensure precautions to reduce the level of dust emissions from hot mix plants, crushers and batching plants should be taken up; e.g. providing them as applicable, with protection canvasses and dust extraction units. Mixing equipment should be well sealed and equipped as per existing standards; and
- Regular monitoring of air quality in accordance with the formulated environmental monitoring plan (given in EMP).

6.5.2.6 Noise and Vibration

The noise and vibration will be produced due to the operation of construction machinery, equipment and construction activities i.e. drilling, blasting, excavation, etc. Sources of noise and vibration during construction due to heavy machinery such as bulldozers, excavators, stabilizers, concrete mixing plant, pneumatic drills, stone crushers, asphalt plants and other equipment. Other sources of noise will be the use of explosives for blasting purposes for construction activities, drilling machines and quarrying and crushing activities.

Noise and vibration are perceived as one of the most undesirable consequences of construction activity. The above activities is expected to generate noise levels that would be severe in the Project Area. The noise and vibration may cause health hazards to the residents of nearby settlements.

The likely impacts due to noise are:

- Psychological effects of distraction of attention, irritation and short temperedness in the exposed persons due to persistently higher noise levels;
- Noisy settings and higher background levels can cause temporary threshold shift and the consequent habit of speaking loud, which may cause damage to vocal cords in the persons exposed;
- Potential impact from vibration during the construction period consists of damage to buildings from heavy earthmoving equipment; and
- Moreover, vibrations from machinery and equipment such as hand held compactors and concrete vibrators can produce easy fatigability and generalized aches in the persons operating these machines.

This impact is medium negative, local and short term.

Mitigation Measures:

There are a variety of ways by which construction equipment and worksite noise can be controlled. The following is a list of ways to control noise level at the worksite of the proposed Project:

Quieter Equipment: A cost-effective way to reduce noise at a construction worksite is to buy quiet equipment. In addition, equipment in use should be the most suitable for the job. Avoid using equipment that is over-powered and, conversely, avoid using under powered equipment. Whenever possible the quietest equipment alternative should be used. In general, electronic powered equipment is quieter than diesel powered equipment and hydraulically powered equipment is quieter than pneumatic power.

Modifying Existing Old Equipment: The most common way to reduce the noise levels of common construction equipment is through worksite modifications. Some common worksite modifications consist of retro-fitting existing equipment with damping materials and mufflers.

Barrier Protection: An effective way of reducing noise is to locate noisy equipment behind purpose-built barriers. The barriers can be constructed on the work site from common construction building material (plywood, block, stacks or spoils) or the barriers can be constructed from commercial panels which are lined with sound absorbing material to achieve the maximum shielding effect possible. To be effective, the length of the barrier should be greater than its height. The noise source should not be visible and barrier should be located as close as possible to either the noise source or the receiver.

Work Activity Scheduling: Work activity scheduling are administrative means to control noise exposure. Planning how noise sources are sited and organized on a work site can reduce noise hazards. Jobs can be rotated so that exposure time is limited. Transferring workers from a high exposure task to a lower exposure task could make the employee's daily noise exposure acceptable. Administrative controls include activity planning, for example, scheduling pavement breaking operations so as to reduce the number of work site workers exposed. In addition, noisy equipment should not be run for periods longer than necessary and should be switched off when not in use.

Maintenance: Increased attention to maintenance of tools and equipment will reduce worksite noise levels. Maintaining plant and equipment in good order not only increases its life, but makes it safer to use and quieter. Loose and worn parts should be fixed as soon as possible. Ideally, the worksite should have a system in place for checking and servicing the various machines and power tools.

Noise Perimeter Zones (NPZs): The NPZs are another administrative control to limit exposure to noisy processes or equipment to as few workers as possible. NPZs are areas where noise levels of 90 dB (A) or more are roped off and marked to keep out all workers

who don't have to be there. NPZs can be set up using a sound level meter to find the safe distance from the source (90 dB (A)) and the NPZs can be set up at that distance. Noise does not radiate from the source at the same level in all directions. Noise from machinery can be higher in one direction than another because the noise can also be either absorbed or reflected from surfaces it contacts, such as the ground or a wall. Therefore, measurements should be taken at several points in an area where people might be working. Once noise levels that are 90 dB (A) or more are determined, rope off this area as the Noise Perimeter Zone. Exclude all workers who do not need to be in that zone. All workers who need to work within the zone must wear hearing protection.

Other mitigation measure includes:

- contractors should comply with submitted work schedule, keeping noisy operations away from sensitive points; implement regular maintenance and repairs and employ strict implementation of operation procedures;
- Noise barriers in sensitive areas in the form of high boundary walls (concrete or wood), earth berms, etc. in front of schools, hospitals and mosques;
- Within 200 m of the nearest habitation, construction work such as crushing, concrete mixing and batching, mechanical compaction, etc., shall be stopped between 2200 and 0600 hours;
- Inform people of the possible vibration before using Vibrating Rollers near settled areas.
- Blasting shall be carried out according to relevant safety standards. Blasting schedules shall be publicly posted in areas where residences could be affected by the blasting noise; and
- Public hearings to discuss appropriate solutions and materials to control noise (e.g. mud or brick walls, bushes, etc.)

6.5.2.7 Borrow Areas/ Open Pits

Borrow / open pits and its excavation activities may result in land disputes, soil erosion, loss of potential cropland, loss of vegetation, landscape degradation, and damage to road embankments.

Borrow/ open pits may also result in potential sources of mosquito breeding and may prove hazardous to human beings, livestock and wildlife. This will also degrade hygienic condition of the Project Area. This impact is permanent and high adverse in nature.

Mitigation Measures:

- Necessary permits will be obtained for any borrow pits from the competent authorities;
- In borrow pits, the depth of the pit shall be restricted upto 5’ and the sides of the excavation will have a slope not steeper than 1:4;
- Soil erosion along the borrow pit shall be regularly checked to prevent/mitigate impacts on adjacent lands;
- In case borrow pits fill with water, measures have to be taken to prevent the creation of mosquito-breeding sites; and
- The Guideline Quarry Management Plan is attached as **Annex-IV**.

6.5.2.8 Operation of Construction Camps / Camp Sites

Mismanagement of construction camp activities can lead to various social and environmental impacts which include health and safety, traffic problems, soil degradation, loss of vegetation and assets on the selected land, solid waste and water pollution in the vicinity settlements. Furthermore, cultural differences, behavior of construction workers, potential disregard for local cultural norms can lead to increased tension between local communities and workers residing in the construction camps. This impact is temporary and moderate negative in nature.

Mitigation Measures:

- The project will seek to avoid sitting camps where their presence might contribute to any conflicts with locals;
- Employment policies which aim to maximize job opportunities for local people will help to minimize tensions caused by different socio-cultural values;
- Camps will be designed to be self-contained to reduce demand on infrastructure and services of nearby communities;
- A comprehensive safety and security plan for the camp will be prepared which will comprise of a training manual, use of safety equipment and emergency preparedness;
- Training will be provided to all staff on camp management rules and overall discipline and cultural awareness;
- Waste Management Plan (**Annex-V)** will be implemented to ensure safe handling, storage, collection and disposal of construction wastes and the training of employees who handle waste;
- Site for construction camp will be selected to minimize the removal of existing macro-plants at camp sites;
- Photographical and botanical inventory of vegetation before clearing the site;
- Compensatory plantation to be done when construction work near ends; and
- The contractor(s) shall ensure removal and rehabilitation of site upon completion.

6.5.2.9 Wastewater Generation at Construction Camps

Wastewater will be generated at the construction camps by the workers. If the generated wastewater is not properly treated or disposed of, this may contaminate the surface water sources such as nullahs, drains, water channels etc. apart from soil contamination. The wastewater generation is estimated to be 6,600 liters/day[39] for 200 construction workers during construction phase of the proposed Project. This impact can be categorized as moderate adverse, site-specific and temporary.

Mitigation Measures:

To dispose the liquid waste generated from the construction activities, the following steps should be taken by the Contractor:

[39] Design Criteria of Public Health Engineering for Water Supply, Sewerage and Storm Water Drain (Domestic sewage generation = 80% of water consumed/day)

- Domestic and chemical effluents from the construction camp will be disposed by the development of on-site sanitation systems i.e. septic tanks (as shown in **Figure 6.1**);
- Proper monitoring to check the compliance of PEQS will be carried out;
- Sewage from construction camps will be disposed of after proper pre-treatment and processes such as soakage pit; and
- The Contractor(s) will be responsible to submit details of site-specific wastewater management plan along with details of wastewater collection, transportation and its disposal.

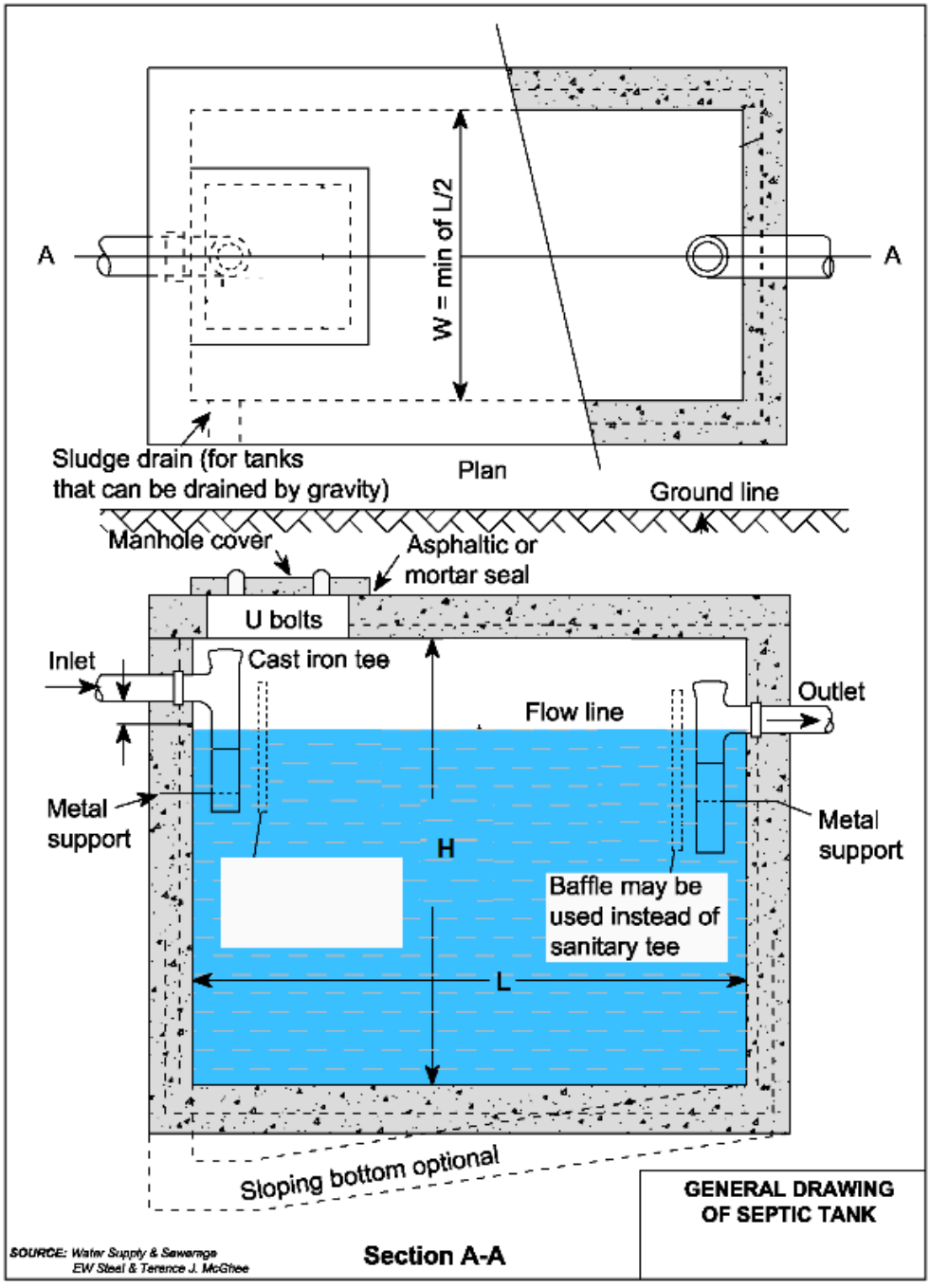


Figure 6.1: General Drawing of Septic Tank

6.5.2.10 Solid Waste Generation at Construction Camps

The solid waste generation is estimated to be 120 kg/day[40] for 200 construction workers during construction phase of the proposed Project. Different type of waste is likely to be generated during the construction phase of the proposed Project. The municipal waste will be in the form of food, cans, paper and wastewater from construction camps toilets and washing yards. Construction waste will include excavated soil, sand, gravel, rocks, asphalt, pieces of concrete, bricks, wood, metal pieces and electrical wires. Whereas, hazardous waste can be comprised of paints and construction chemicals. All these, if left unattended, can become a source of nuisance and environmental pollution in the Project Area.

Insecure and unhygienic disposal of the solid wastes particularly garbage and trash may cause degradation of soil and land. Insecurely disposed off heaps of wastes containing kitchen garbage and food waste can serve as breeding grounds for the disease spreading vectors and rodents. Throwing away of solid wastes into water channels and the wastewater network can result into choking of the latter. These impacts are temporary and minor negative in nature.

Mitigation Measures:

- Solid Waste generated during construction and camp sites will be safely disposed in demarcated waste disposal sites and the contractor will provide a proper waste management plan;
- Training of work force in the storage and handling of hazardous materials and chemicals Construction workers and supervisory staff should be encouraged and educated to practice waste minimization, reuse and recycling to reduce quantity of the waste; proper labeling of containers, including the identification and quantity of the contents, hazard contact information, etc.;
- Waste disposal plan must be reviewed during the entire construction phase in the light of changing weather conditions;
- Emergency response plan shall be prepared to address the accidental spillage of fuels and hazardous goods;
- Immediate collection of spilled oils/fuels/lubricants by collection of contaminated soils and skipping oils from surface water by applying appropriate technologies;
- Reusing bitumen spillage; and disposing non-usable bitumen spills in a deep trench providing clay linings at bottom and filled with soil at the top (for at-least 0.5 m);
- Used oil shall be collected in separate containers stored on impervious platform with restricted access and shall be sold to licensed contractor and the burning of waste oil shall be strictly restricted;
- Segregating and stockpiling scarified/ milled bituminous material and reusing this material in sub grade/shoulders;
- Construction waste such as waste wood can be recovered and recycled into wood for new building projects, and cement, bricks, and plaster can be crushed and reused in other construction and building projects; and

[40] Source: Estimated solid waste generation rate in the study area is about 0.6 kg/person/day (https://www.lwmc.com.pk/uc-plan.php).

- The contractor should ensure implementation of proposed Construction Waste Management Plan and it must be reviewed during the entire construction phase in the light of changing weather conditions.

6.5.2.11 Traffic Management

Due to the proposed project construction activities and movement of heavy project vehicles for construction material supply, traffic problems may arise for the commuters and transporters travelling especially through Ring Road and other Project Area access roads. The problems will include traffic jams and inconvenience to the public passing through the Project Area. It will also increase traffic load on the existing road network or access roads ultimately deteriorating the existing condition of the roads. The movement of vehicles along the haulage routes will cause soil erosion, dust emissions, noise related impacts, etc. Considering these consequences, this impact can be categorized as site-specific, medium negative and temporary.

Mitigation Measures:

To minimize traffic problems in the proposed Project Area, following measures will be considered:

- Movement of vehicles carrying construction materials and equipment/machinery will be restricted during the daytime to reduce traffic load and inconvenience to the local population;
- Construction vehicles, machinery and equipment will be parked at designated areas (at construction camps site) to avoid un-necessary congestions along the major roads;
- Damages of roads due to construction vehicles will be instantly repaired and/or compensated after the completion of work;
- Proper sign boards will be provided for smooth flow of traffic;
- Period of construction and area / location of construction site shall be informed to public in general and specifically to local residents;
- Any closure of the roads (especially main roads) and deviations / diversions proposed should be informed to the riders through standard signs and displays; and
- In the light of Guideline Traffic Management Plan **(Annex-VI)** a site specific TMP will be prepared by the contractor and implemented to avoid traffic accidents, jams/public inconvenience.

6.5.2.12 Climate Change and Green House Gas Abatement

The main sources of greenhouse gases (CO_2, CH_4, NO_x etc.) during the construction activities of the proposed Project will include both mobile and stationary sources. The mobile sources will be the construction and transportation vehicles while the stationary source will be the batching and asphalt plants. Emission of greenhouse gases cause global warming and other climatic changes on regional and global scale. The climate change due to global warming, may result in following impacts over a period of time:

- Extended summer season;
- Higher temperatures may result in more precipitation falling as rain rather than snow, hence earlier and greater runoffs, increased runoff may pose greater challenges for water management;
- Increased natural hazards such as landslides and debris flows, extreme/unpredictable rainfall events, wind storms, droughts and wildfire:
- Due to shift in temperatures and precipitation patterns runoff, stream/lake temperatures, suitable habitats may move upland, thereby declining in size, ecosystems become fragmented, number and composition of species will change with particular threats to sensitive species; and
- Increased damages to transportation infrastructure from extreme events, causing difficulties for access and emergency evacuation, and involves higher maintenance costs.

Mitigation Measures:

- Regular motioning of the vehicles for engine efficiency;
- All stakeholders (PMA, consultants, contractors, concessionaires) need to become aware that their actions at all stages of a project can contribute to reducing the CO2 burden;
- Elimination of unnecessary idling can save fuel, prolong engine life, and reduce emissions. It can also help reduce the noise levels associated with construction. Unnecessary idling occurs when trucks wait for extended periods of time to load or unload materials or supplies, or when equipment is left on when it is not being used. Constructions workers may take breaks and leave equipment running unnecessarily or may idle equipment because it is an ingrained habit;
- Managing equipment operations and training workers to reduce unnecessary idling is a relatively easy way to lower operating costs and help reduce the environmental impact of construction;
- A preventive maintenance program by the contractor seeks to maintain engines at their original level of performance and eliminate the high cost of catastrophic engine failure. Preventive maintenance is the systematic inspection, detection, and correction of potential construction equipment failures. It significantly reduces fuel consumption and emissions; and
- Use of low sulfur and good quality fuel in the construction vehicles or operating equipments that will reduce maintenance costs and harmful emissions.
- Alternative energy resources shall be considered where possible; and
- PEQS applicable to gaseous emissions generated by construction vehicles, equipment and machinery shall be enforced during construction works.

6.5.2.13 Natural and Man-Made Disasters

Natural disasters (earthquakes) and accidents such as fire, falls, slips and trips may result in injuries, financial losses and may even lead to deaths. The workers shall be trained and facilitated to cope with such disasters.

Mitigation Measures:

Mitigation measures include the following:

- An Emergency Response Plan (ERP) for earthquakes and manmade disasters should be developed by contractor in coordination with Supervision Consultant and PMA and should be implemented in close consultation with the RESCUE Services and other concerned departments;
- Training of the Contractor and PMA staff and employees regarding the emergency procedures and plans should be regularly conducted;
- Emergency numbers should be clearly posted at active construction sites; and
- Minor incidents and near misses should be reported by the contractor, and preventive measures should be formulated accordingly by the PMA management.

6.5.2.14 Occupational Health and Safety

Occupational Health and Safety (OHS) related impacts will arise during construction phase activities including clearing of earth, levelling, compaction, carpeting, pavement finishing and testing & commissioning. Eye injury can be caused by stone or metal particles. Hazard of being hit by falling objects, major hand-arm and whole body vibration hazards, skin and respiratory tract irritation from exposure to cement dust, overexertion and awkward postures etc. will be another impact. Welding hazards include electric shock, fumes and gases, fire and explosions, falls from height, eye and head injuries etc.

Other impacts will be fall from height, contact with heavy electrical and mechanical equipment, equipment failure, uncontrolled movement, unguarded moving mechanical equipment parts, fatigue, unbalanced load, falling objects, hand injury, slip and trip hazards, wind / storm activity, injury from releasing load too soon etc. Operating mechanical and electrical equipment will trigger the OHS related issues e.g. struck by moving vehicles or other equipment, slips or trips, struck by flying objects, such as dirt or splashed fluids, caught in pinch points, shear points, crush points, falling from machine etc. The proposed project area is also sensitive from the law and order point of view and the security as well as the safety of the Contractor and Consultant staff will be a major issue. Considering these consequences, this impact can be categorized as direct, moderate, site-specific, medium term, temporary, medium probability and irreversible.

Mitigation Measures:

Following mitigation is given to avoid the accidental risks:

- Providing basic medical training to specified work staff and basic medical service and supplies to workers;
- Complying with the safety precautions for the construction workers as per International Labour Organization (ILO) Convention No. 62, as far as applicable to the Project Contract;
- Training of workers in construction safety procedures, environmental awareness, equipping all construction workers with safety boots, helmets, gloves and protective masks, goggles, shields and monitoring their proper and sustained usage;
- Contractor will ensure the provision of medicines, first aid kits, ambulance etc. at the camp site;
- Work areas will be cordoned off where necessary;

- Contractors will instruct their staff to use Personnel Protective Equipment (PPE) (e.g., wire containment, displaying warning signs along the work site, communicating advance warnings to mats) to enhance the safety; and
- Safety lookouts will be built to prevent people and vehicles from passing at the time of hot or cold work; and
- An emergency management plan must be devised by the contactor in close coordination with the provincial emergency services.

The Occupational Health and Safety Plan is attached as **Annex-VII**.

6.5.2.15 Community Health and Safety

The construction activities and vehicular movement at construction sites may result in roadside accidents particularly inflicting local communities who are not familiar with presence of heavy equipment. Quality of groundwater and surface water resources available in the nearby local communities may be affected due to the construction activities, oil spillage and leakage, etc. The proposed Project will also have potential of air (dust pollution), noise and vibrational impacts on nearby community. The labour works with different transmittable diseases may cause spread out of those diseases in the local residents. The construction areas located near the residential, settlements, may cause accident for the people moving near to those areas. Conflicts may arise between the local community and the construction workers, which may be related to religious, cultural or ethnic differences, or based on competition for local resources. Tensions may also arise between different groups within the labor force, and pre-existing conflicts in the local community may be exacerbated. Ethnic and regional conflicts may also be aggravated if workers from one group are moving into the territory of the other. Considering these consequences, this impact can be categorized as site-specific, medium term, temporary and irreversible.

Mitigation Measures:

- Providing basic medical training to specified work staff and basic medical service and supplies to workers;
- There will be proper control on construction activities and oil spillage leakage of vehicles;
- The labourers with different transmittable diseases will be restricted within the construction site;
- Ensure that the site is restricted for the entry of irrelevant people particularly children;
- Efforts will be made to create awareness about road safety among the drivers operating construction vehicles;
- Timely public notification on planned construction works;
- Close consultation with local communities to identify optimal solutions for diversions to maintain community integrity and social links;
- Provision of proper safety and diversion signage at sensitive/accident-prone spots;
- Setting up speed limits in close consultation with the local stakeholders;
- The mitigation measures provided in the following sub-sections for air and noise shall be adopted to reduce the air pollution, noise pollution and vibrational impacts on nearby community;

- The communicable disease of most concern during construction phase, like Sexually-Transmitted Disease (STDs) such as HIV/AIDS, will be prevented by successful initiative typically involving health awareness; education initiatives; training heath workers in disease treatment; immunization program and providing health service;
- Reducing the impacts of vector borne diseases will be accomplished through implementation of diverse interventions aimed at eliminating the factors that lead to disease, which include prevention of larval and adult propagation of vectors through sanitary improvements and elimination of breeding habitat close to human settlements and by eliminating any unusable impounding of water;
- The Contractor will prepare the construction camp management plan which, in addition to other components, will include the labor influx management plan. This will be reviewed and approved by PMA; and
- Contractor will take due care of the local community and observe sanctity of local customs and traditions by his staff. Contractor will warn the staff strictly not to involve in any unethical activities and to obey the local norms and cultural restrictions.

6.5.2.16 Communicable Diseases

The laborers in the Contractor Camp, truck drivers and like personnel who interact with each other have the potential for the spread of communicable diseases like COVID-19 and HIV/AIDS. Majority of the people living in the surrounding of the Project, and potential labor are not aware of the source, mode of communication or consequences of HIV/AIDS. Although their religious and cultural value system, to a large extent excludes the outbreak or rapid communication of COVID-19 and HIV/AIDS, yet its occurrence in such a situation cannot be precluded. It is necessary that awareness and preventive campaigns are run from time to time in the labor camps and the field offices of the Project to prevent the communicable diseases.

There is a chance of spreading of an epidemic of Coronavirus disease (COVID-19) due to close interaction of the labor force during construction not only among the workers but also in the area. This impact can be categorized as medium, site-specific, temporary and reversible.

Mitigation Measures:

The Contractor shall:

- Arrange to run an active campaign, in the labor camp, to make people aware of the cause, mode of transmission and consequences of HIV/AIDS;
- SOPs related to the construction industry advised by National Action Plan for COVID-19 Pakistan to control spreading of COVID-19, shall be implemented by the contractor and should be strictly monitored. Guideline for COVID-19 are attached as **Annex-VIII**;
- Strengthen the existing local health and medical services for the benefit of labor as well as the surrounding villages;

- Ensure cleanliness and hygienic conditions at the labor camp by ensuring proper drainage and suitable disposal of solid waste. Inoculation against Cholera will be arranged at intervals recommended by the Health Department; and
- Keep all the camps, offices, material depots, machinery yards and work sites open for the inspection of health and safety measures and related documents.

6.5.2.17 Gender Based Violence (GBV)

In the society, female plays important role in managing household as well as in income earning activities, but they face various challenges to get access to educational institutions and employment opportunities due to cultural bindings, economic vulnerability and lack of facilities. Issues of gender violence may arise in the project area due to labour influx. This impact high negative in nature.

Mitigation Measures

With the effective measures and monitoring, the risk of gender violence could be minimized by adopting the following mitigation measures:

- Awareness should be created among the females at individual and community levels about the constructions sites;
- During the timing of educational institutions workers should not be allowed to crowd in the surroundings;
- Alternative routes for pedestrian should be provided to avoid mixing of women with workers;
- Gender protection act should strictly be enforced during the construction activities in the Project Area, and monitor the implementation through field staff;
- Raise awareness among the communities of the potential risks of GBV, and establish response services in the communities that can respond to instances of GBV (particularly those related to issues of labor influx);
- The Contractor should make sure that no discrimination is made on the basis of gender while hiring of workers. Complete SOPs should be formed and implemented by the contactor regarding working women at site. Implementation on these SOPs should be monitored by the implementation Consultants.
- Provisions of gender disaggregate bathing, changing, and sanitation facilities; and
- Contractor should take proper measures to address and resolve issues relating to harassment, intimidation, and exploitation, especially in relation to women.

6.5.2.18 Child Labor

There are two basic conventions on child labor adopted by the ILO, and one adopted by the United Nations. The ILO Minimum Age Convention, 1973 (No. 138) and its accompanying Recommendation (No. 146) set the goal of elimination of child labor, and the basic minimum age for employment or work (in developing countries at 14 years of age or the end of compulsory schooling, whichever is higher; and 15 or the end of compulsory schooling for developed countries). The Convention sets a minimum age of 2 years younger for “light work,” i.e., 12 and 13 years, respectively; and a higher minimum age for dangerous or hazardous work (basically 18 years of age, but 16 in certain circumstances). The Convention also has various other flexibility clauses.

Mitigation Measures

The chance of hiring of underage worker for the Project activities will be minimized by adopting the following mitigation measures:

- Awareness should be created among the local communities about the adverse impacts of child labor. For the public awareness, meetings should be held in the Project Area, and announcements should be made using the available local platforms with the involvement of all sectors of the society;
- Contractor through contractual agreement should be bound to follow the labor standards, rules and regulations during hiring the labor force and all activities should be monitored by the social and environmental staff of the implementing agency;
- Client and Supervision consultant should ensure that contractor shall have its employment policy in accordance with relevant act and labor policies in Punjab and Pakistan; and
- Contractor should ensure the presence of all persons at site are adults and have their proper identity cards with them.
- Reduce or eliminate the worst forms of child labor and rescue and rehabilitate the children in the worst forms of child labor.
- Penalize contractors/employees using the worst forms of child labor and penalize adults who violate children's rights and who force children to enter child labor, especially in its worst forms.
- Reduce the health hazards and dangers to young persons in the workplace.

6.5.2.19 Resource Conservation

The materials used in construction of proposed project would include coarse aggregates (crush), fine aggregates (sand), steel, water, asphalt, reinforcement and cement. Almost all the materials to be used in the construction of proposed Project are non-renewable and therefore their sustainable use is necessary for the future use.

Fuel will be used to operate construction machinery and asphalt and batching plants. Sustainable use of energy resources is very important not only to continue future use but also to help to reduce air emissions. For conservation of energy, efficiency of the engines and burning processes is very important. The impact is negative and long term in nature.

Mitigation Measures:

Following practices shall be adopted to conserve these natural resources:

- Diesel and fuels with low sulphur content should be used to operate construction machinery and equipment's;
- The efficient and well maintained equipment's and machinery should be used;
- The equipment and machinery should be turned off when not in use;
- Regular maintenance of machinery to avoid fuel leakages;
- Reduction of wastage of water through training of workers involved in water use should be planned;
- Plan for reuse of construction waste materials may be formulated;

- A good camp design and an efficient worksite management plan should be prepared that may help the contractor to reduce the water demand, and wastewater and solid waste volumes to the lowest levels; and
- Use of solar panels at camp sites to conserve energy.

The Resources Conservation Plan is attached as **Annex-IX**.

6.5.2.20 Discovery of Heritage Sites/ Structures during Excavation

During excavation, there is a chance of finding artifacts. In case of finding any artifact, the contractor shall immediately report through Supervision Consultant to Directorate General (DG) of Archeology, Government of Punjab to take further suitable action to preserve those antiques or sensitive remains. Chance finds procedure (given in **Annex-X**) shall be adopted in case of any accidental discovery of cultural heritage.

6.5.2.21 Flora

The Transmission line passes through the vegetation/habitats types of Sub-tropical Chir pine forest, sub-tropical broad leaved scrub forest, and agriculture fields. The construction of Transmission line will involve clearance of vegetation and trees of different habitats will be disturbed. Although it is likely to affect the fauna species, however this effect will be minor and localized.

Moreover, exhaust of noxious gases from movement of heavy machinery and dust will pollute air which will adversely affect health and vigor of plants. During construction activities the Contractor's workers may damage the vegetation and trees (for use as fire-wood to fulfill the camps requirements). Overall, it can be stated that the large number of trees may be damaged in the proposed project activities.

This impact is site-specific, medium negative and high significant.

Mitigation Measures:

To mitigate the impacts of the glass train on the flora and fauna during construction phase, following components should be taken into consideration to adopt all the possible measures to mitigate up-to the maximum level, the impacts on the floral and faunal species. Those components are as follows;

- ***Avoidance/Prevention:*** Avoidance/prevention means essentially keeping away from sensitive areas by locating or reducing the size of activity.
- ***Modification:*** In some case modification of activity or its implementation under special conditions (e.g., timing of activities, buffers around nesting areas) will greatly reduce the adverse impacts.
- ***Control/Mitigation:*** It is not possible or even practical to avoid all impacts. Following proper control/mitigation measures will reduce (i.e. control) the extent of impact on

the environment. The best construction practices also help in reducing the extent of impact.

If the impacts are not avoidable, then the following measures will be adopted;

- ***Protection:*** Protection/insulation of receptors from impacts will reduce the impacts that remain after control measures have been used.
- ***Relocation/Compensation***: Compensation refers to the provision of "equivalent" environmental features.
- ***Enhancement:*** Enhancement refers to the provision of features that are an improvement over previous environmental condition.

Some specific measures will include:

- Cutting of trees and disturbance of trees shall be avoided as far as possible and select the alternate route for the proposed project as the impact on local ecosystem (especially trees) is expected as high. So, that negative effects on the process of natural regeneration of species are minimized and if possible an alternate area may be considered for proposed project, in which minimum ecological and environmental losses are expected;
- Trees should be replanted or transplanted wherever possible, instead of cutting;
- Tree plantation plan/ Afforestation Plan should be implemented preferably in the project area or nearby blank spaces within 500m radius possibly;
- A tree plantation program shall be formulated with the recommendations and technical support of Forest Department;
- NOC for tree cutting from the concerned authority is mandatory;
- As a principal of 1:10, ten trees shall be planted in place of felling of one tree in consideration of mortality;
- The proponent shall implement the program with the help of CDA and Forest Department and in consultation with concerned consultant ecologist;
- Open fires should be banned in the area to avoid hazards of fire in the area;
- Clearing of vegetation cannot be avoided at the areas specified for project structures, but damage to the natural vegetation may be minimized by establishing camp sites, workshops and batching plants on waste / barren land rather than on forested or green land;
- However, if such type of land is not available, it shall be ensured that minimum clearing of the vegetation is carried out and minimum damage is caused to trees and undergrowth;
- Construction vehicles, machinery and equipment will remain confined within their designated areas of movement;
- The Contractor's staff and labor shall be strictly directed not to damage any vegetation such as trees or bushes; and
- Contractor shall provide gas cylinders at the camps for cooking purposes and cutting of trees/bushes for fuel shall not be allowed.

6.5.2.22 Fauna

During construction phase the existing population of birds, mammals and reptiles of the construction areas will be affected due to disturbance arising from construction activities

involving excavation, movement of machinery and vehicular traffic, movement of labor, camping, etc. The existing fauna will leave the directly affected areas due to construction activities and human intervention. Some animals particularly reptiles may get killed during the earthworks operations. Moreover, the movements of the mammals and reptiles will be restricted during the construction phase.
Birds as well will tend to move away from the construction areas and find shelter and food elsewhere due to the activities mentioned above for fear of being hunted / trapped.

Noise generated from machinery particularly during the night hours will even scare the wildlife residing in habitats located at some distance from the construction areas. Uncontrolled blasting may even disturb the fauna of the Project Area. Food and refuse at the Contractor's camps may attract animals that might in turn be hunted by the workers. This impact is indirect, site-specific, temporary, reversible and medium significant.

Mitigation Measures:

- Care shall be taken during construction activities for avoiding purposely or chance killing of animals;
- If any wild species and habitat is found during construction, it must be dealt carefully and local wildlife department officials should be informed;
- Hunting, poaching and harassing of animals shall be strictly prohibited, and Contractor shall be required to instruct and supervise its labor force accordingly and clear orders should be given in this regard;
- The Contractor must be held responsible for instructing his work force accordingly and for enforcing this restriction. In addition, this shall have to be controlled by the Wildlife Department;
- Special measures shall be adopted to minimize impacts on the wild birds, such as avoiding noise generating activities during the critical periods of breeding;
- Noise generating activities shall not be carried out during the night by the work force;
- Wastes of the camps shall be properly disposed of to prevent it being eaten by animals, as it may be hazardous to them; and
- Noise produced due to construction activities may be kept to acceptable level.

6.5.2.23 Loss of Habitat

Loss of wildlife and wildlife habitat is occurred both from direct and indirect activities associated with the proposed development. Alteration, fragmentation, or destruction of wildlife habitat can result in the direct loss or displacement of species and the ability of the ecosystem to support other biological resources such as the plant communities upon which the wildlife relied for survival. The Muree forests are already under pressure and further development will definitely aggravate the pressure on it. Loss of natural resources such as quality water supply, clean air, forests, rare-species and recreation opportunities can impact a community's ability to sustain itself over the long term.

There is a direct loss of habitat during establishment and maintenance of proposed project. This may happen due to clearing of vegetation, dumping of excavated earth and material movement of heavy vehicles and earth movers, creation of labour camps etc. the effect of

these disturbances may persist in the landscape for years. The effect of infrastructure on bird populations extended over distances up to 1 km and for mammal's population up to about 5 km.

Mammals and birds seemed to avoid infrastructure in open areas over larger distances compared to forested areas. The construction work gives raise to landslides and other forms of erosion in steep forested landscapes. During the construction period, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the vicinity of project area. The operation of equipment will generate significant noise, especially during blasting which will have adverse impact on wildlife of the area. The noise may scare the fauna and force them to migrate to other areas. Likewise siting of construction plants, workshops, stores, labour camps etc. could also lead to adverse impact on the wildlife habitat of the area. During the construction phase, accessibility to area will lead to influx of workers and the people associated with the allied activities from outside will also increase. Increase in human interference could have an impact on terrestrial ecosystem. The other major impact could be the blasting to be carried out during construction phase. This impact needs to be mitigated by adopting controlled blasting and strict surveillance regime and the same is proposed to be used in the project. This will reduce the noise level and vibrations due to blasting to a great extent. The impacts caused by the construction activity can be easily mitigated.

Mitigation Measures

- It is highly recommended to avoid tree cutting in all the protected areas, Limit clearance of vegetation only to unavoidable areas. If it is unavoidable to cut trees in protected areas, then protected areas clearance procedure should be adopted.
- Avoid blasting/construction activities during the breeding season of resident birds from May to June after ensuring the presence of nests in the area. In the absence of nests (Ground or Tree nests) construction activities can be continued.
- Afforestation plan must be implemented in true sense to restore the habitats of avifauna;
- Carryout extensive reforestation and afforestation plan of the disturbed areas after construction activities;
- Afforestation will be done in those areas in which there is low forest cover or in areas which have been clearly felled and leave barren.
- Afforestation is highly important to maintain the biodiversity and ecological balances.
- Avoidance of unnecessary revolving of engines and switch off equipment when not required.
- Using enclosures for noisy equipment such as pumps or generators.
- Minimizing the drop height of materials.
- Special measures need to be adopted to minimize impacts on important resources, such as activities during critical periods of migration, breeding and feeding of birds and other wild animals.
- Ecological expert from consultant should accompany with the contractor during construction phase in order to identify trees of high value regarding trees of large foliage which is suitable for wildlife and avifauna habitat.

6.5.2.24 Social/ Cultural Conflicts

During the construction phase of the project, conflicts may arise between labor force and Local communities that exists near the Project Area. Use of local resources (existing infrastructure and utilities) by the construction workers can generate stress on the local residents. Furthermore, difference in cultural values may also cause discomfort to local residents. This impact is temporary and moderate adverse in nature.

Mitigation Measures

- Local labor should be preferably employed for the construction works;
- Careful planning and training of work force to minimize disturbance to the local people; and
- Public notification through print or electronic media during the entire construction phase to avoid any inconvenience in accessibility to the locals.

6.5.2.25 Economic Activity

Due to the construction of the proposed Project, economic activity will be generated in the project area as the laborers and semi-skilled staff will have an opportunity to work for the construction of the proposed project. This will help in developing their skills and capacities. Further, it will also increase commercial activity in the project area as the laborers and contractor staff will be buying their daily goods from local market. This is a moderate positive impact

6.5.3 Potential Environmental Impacts during Operational Phase

The anticipated environmental impacts related to the proposed Project have been studied for the operational phase of the project as discussed hereunder.

6.5.3.1 Surface Water

Surface water pollution during the operating period comes primarily from untreated sewage effluent discharged by passing train, which then washes into local surface waters.

Mitigation Measures:

- A spill contingency plan and good maintenance of track and rolling stock will help reduce the risk of accidental spills, and permit rapid action if an accident does occur.
- All wastewater should be treated until it conforms to applicable discharge standards. Treatment may include septic tanks, oil separators, or connection to an existing municipal system.

6.5.3.2 Drinking Water/ Internal Water Supply System Contamination

Water pollution can originate in the internal water network of freight stations. If the pipes and the overhead storage tanks are not cleaned properly, it may lead to bacteriological contamination of the potable/ drinking water and thus will lead to infectious diseases or other health problems to the railway employees. This is a moderate negative impact.

Mitigation Measures:

- PMA management should install water filtration units of required capacity to avoid any bacteriological contamination in the drinking water;
- Overhead water storage tanks should be regularly cleaned on quarterly basis; and
- Water quality monitoring should be conducted on quarterly basis by the PR management in accordance with the drinking water standards specified in PEQS/NEQS.

6.5.3.3 Waste Generation

Solid wastes would generate from stations and maintenance facilities. The solid waste during operational phase will consist of food remains, plastics, metal and organic wastes littered by railway service users. Such wastes can cause blockage to drainage systems, chocking of water bodies and negative impacts on animal health. Some of these waste materials especially plastics/ polythene which are not biodegradable may cause long term injuries effects on the environment. Hazardous wastes could be generated during operation of the project due to accidental spillages impacting soil, groundwater, and adjacent water bodies.

Mitigation Measures:

- A comprehensive solid waste management system should be formulated for the operation phase; Waste storage containers with color coding should be placed at designated locations;
- PMA should employee sanitary workers or hire contractor for waste collection and allocate budget for it;
- Waste segregation should be done at source and requisite planning needs to be done to implement the segregation techniques through residents and commercial building users;
- The biodegradable waste may be processed, treated and disposed of through composting as far as possible. The residual waste should be given to waste collectors or a certified third party contractor for final disposal at the designated landfill site;
- Daily housekeeping of stations, roads and parks should be carried out to minimize the generation of waste.
- Schedule inspection of the railway tracks to keep it clean and to identify any hazardous material.

6.5.3.4 Emergency Preparedness and Disaster Management Plan

During the operation phase, emergencies like fire and disasters such as earthquakes and flooding may occur. Other common emergencies are derailing of wagons, brake failures, oil

spillages, fires, damages due to flood and terrorism. This impact is negative, temporary and moderate in nature.

Mitigations Measures:

- In the light of National Disaster Response Plan (NDRP), PMA should formulate an emergency preparedness and disaster management plan for its glass train operations in close coordination with the National Disaster Management Authority (NDMA).
- Training of management staff and employees regarding the emergency procedures and plans should be regularly conducted;
- Responsible person to implement the Emergency Response Plan should be clearly designated;
- Emergency numbers should be clearly posted at stations, so that a quick action is taken when an emergency arises;
- Firefighting machinery and vehicles should be maintained regularly; and
- Regular drills for fire emergencies should be carried out.

6.5.3.5 Air Quality

The operational phase is expected to help in reducing air emissions by reducing the number of private vehicles on roads and easing traffic congestion. Rail is the most efficient transport mode in terms of GHG emissions per passenger-kilometre (Figure 6.2). By shifting tourists and local commuters from cars to rail, Murree can drastically lower transport-related emissions i.e. CO, NOx, SOx. It supports national and provincial climate commitments while making Murree more livable and resilient to future challenges.

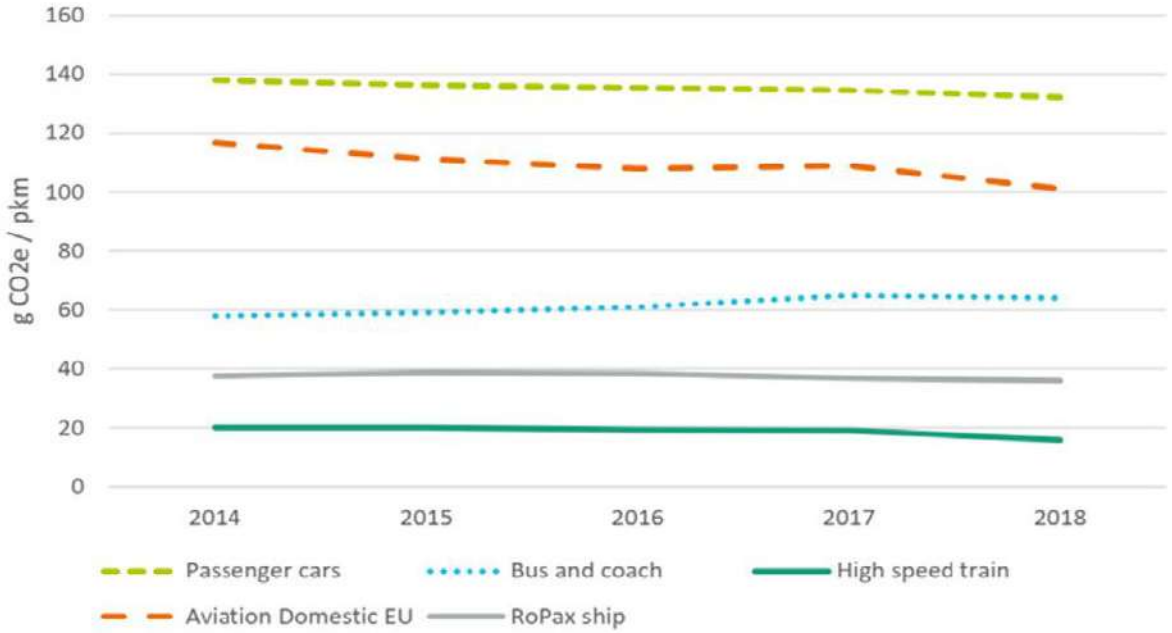


Figure 6.2: GHG emissions per passenger-kilometre by mode of transport[41]

[41] *Source:* CE Delft (2020), *Methodology for GHG Efficiency of Transport Modes*, Karlsruhe.

6.5.3.6 Impact on Ecology

During the operational phase of the proposed project, no significant impacts are envisaged or release of any significant pressure detrimental to flora. A reduced number of vehicles on the roads will lead to lower emissions of flue gases from both private and public transport passing through the project area, thereby contributing to improved air quality.

Mitigations Measures:

- The implementation of afforestation/plantation plan recommend in compensation for cutting of trees should start during operational stage, to ensure the ecological balance and to avoid any impact on local Environment;
- Compensation to the forest department will be made according to the standard markets rate of standing volume for each tree.
- The Forest and Wildlife Departments should implement afforestation and habitat enhancement programs in collaboration with local communities, developing nurseries, propagating plant stock, supervising planting programs and undertaking aftercare/maintenance programs.
- Hunting of wild animals and birds will be strictly prohibited;
- It is highly recommended to avoid the reserve, protected forests, national park areas, critical sensitive habitats and the legally notified and ecologically important zones.
- Proper check and balance of above mentioned activities is highly recommended.
- Maintenance and security of the plantation should be done for at-least five years.

6.5.3.7 Socio-economic Impacts

Improved Economy

Better communication and building infrastructure will facilitate the locals and will provide better business, trade and development opportunities to the locals resulting in uplift in economy. The proposed Project will also generate new job opportunities in different sectors. This is positive impact.

Tourism

The proposed project valuable for the tourists, community as well for the employees who daily travel from twin cities to Murree. Due to the implementation of this project, tourism and mobility will increase. Tourists will enjoy better transport facility and due to glass train facility road accidents will reduce. The respondents pointed out that increase in income generating activities.

7 ENVIRONMENTAL MANAGEMENT PLAN

7.1 GENERAL

Environmental Management Plan (EMP) is a tool for the implementation of the all the suggested measures to make the project environmentally sustainable. It provides an overall approach for managing and monitoring the environmental, ecological and socio-economic issues of the proposed Project, and describes the institutional framework and reporting mechanism to implement EMP for the proposed Project.

This section provides brief description of environmental issues, mitigation measures to eliminate or reduce environmental and social impacts to an acceptable level, institutional framework for the implementation of the mitigation measures and environmental monitoring plan for air quality, water quality, and noise pollution parameters during construction and operational phase. A budgetary plan is also developed, indicating estimated costs to be incurred to mitigate potential adverse impacts of the proposed Project.

7.2 EMP COMPONENTS

The EMP comprises following main components:

- EMP Objectives;
- Scope of the EMP;
- Environmental Policy, Legislation and Framework;
- Institutional Requirements;
- Environmental Mitigation and Management Matrix;
- Environmental Monitoring Plan;
- Planning for EMP Implementation;
- Training and Capacity Building;
- Communication & Documentation;
- Management Plans;
- Chance Find Procedure;
- Public Disclosure;
- EMP Cost; and
- Summary of Environmental Cost.

7.3 OBJECTIVES OF EMP

The main objectives of the EMP are to:

- Provide the details of the Project impacts along with the proposed mitigation measures, and the corresponding implementation activities;
- To ensure that all necessary corrective actions are carried out and monitored in time to counter any adverse environmental impact under a systematic monitoring approach;

- Provide a procedure for timely action in the face of unanticipated environmental situation;
- Define the role and responsibilities of the Project Proponent (PMA), Contractor(s), Supervisory Consultant(s) and other key players in order to effectively communicate environmental and social issues among them;
- Define a monitoring mechanism, reporting frequency and identify monitoring parameters to ensure that all the mitigation measures are completely and effectively implemented;
- Design the training and capacity building plan for enhancing the capacities of the Project Proponent (PMA), Contractor(s), Supervisory Consultant(s) on environmental and social management;
- Identify the resources required to implement the EMP and outline the corresponding financing arrangements; and
- Define the requirements necessary for documenting compliance with EMP and communicating it to all the concerned regulatory agencies.

7.4 INSTITUTIONAL REQUIREMENTS

The institutional requirements for the Construction and Operation & Maintenance (O&M) phases of the proposed Project are provided in below sections.

7.4.1 Institutional Setup for Implementation and Management of EMP

The key players involved during construction phase of the proposed Project are the PMA as employer/proponent, PEPA, the Supervisory Consultant (SC) and the Contractor. The roles and responsibilities of these organizations are outlined below.
The following staff will be involved in the implementation of EMP:

- PMA/Proponent/Employer;
- SC's; and
- Contractor's Environmental Manager.

The employer/ proponent (PMA) will make Contractor bond through contract documents to implement the EIA including EMP and other terms and conditions of the Environmental Permit. The EMP will be included as a clause of the contract documents. Construction camps will be established after necessary approvals and submission of Site-Specific EMPs to be developed in the light of the relevant agencies requirements, before commencement of construction works. The organizational setup for implementation of EMP during construction phase is provided in **Figure 7.1**.

7.4.2 Overall Oversight Arrangements

A Project Steering Committee comprising of Chairman PMA, Project Director PMA and Deputy Director, PMA will provide overall guidance and oversight and will be responsible for ensuring effective implementation of the project.

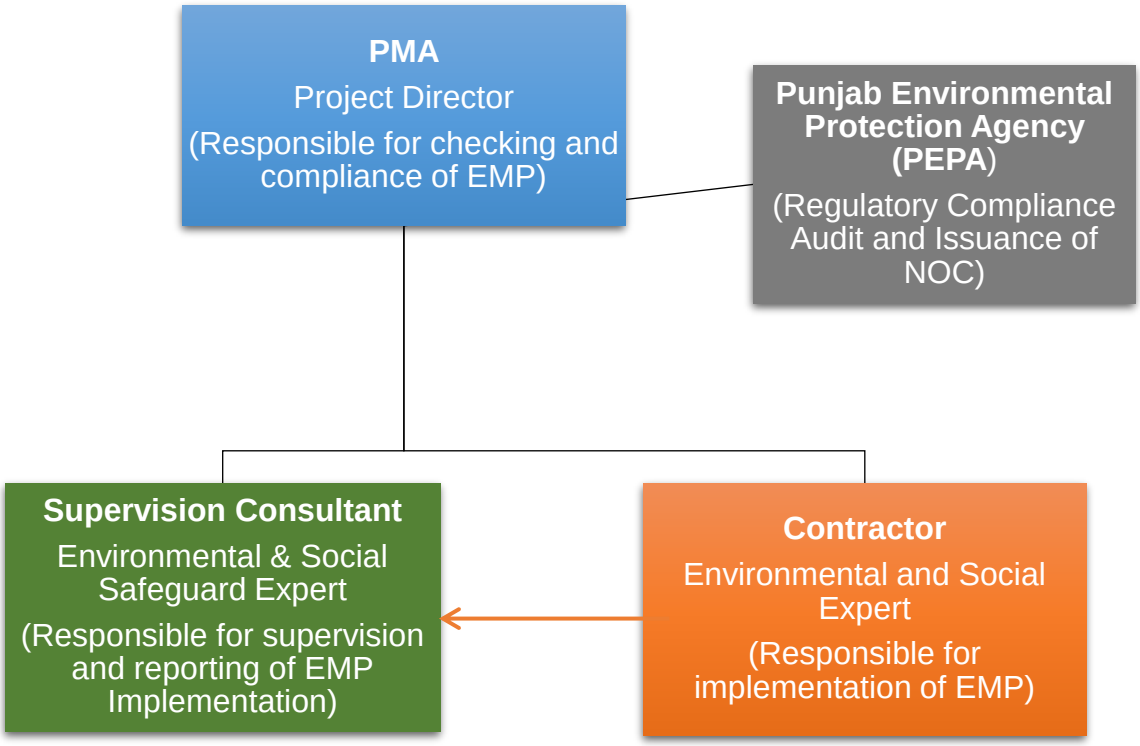


Figure 7.1: Organizational Setup for the Implementation of EMP at Construction Stage

7.4.3 Roles and Responsibilities for EMP Implementation during construction Phase

a. PMA/ Employer Concerned Staff

The specific responsibilities are as follows:

- Setting up systems for environmental management;
- Ensuring that the Contractor(s) develop and carry out environmental implementation plans that are consistent with the EMP;
- Liaising between the Project staff and the Supervisory Consultant‘s staff to monitor environmental and social compliance during construction phase;
- Ensuring that the required environmental and social training is provided to the concerned staff;
- Responsible for carrying out random site visits to the construction sites to review the environmental performance of the contractors;
- Monitoring the progress of environment and social related activities;
- Make sure that the contractor is implementing the additional measures, suggested by the Supervisory Consultant in monthly environmental monitoring reports;
- Assessment of the crops, trees, valuation of property (if any), public utilities and negotiation with the affectees for fixation of compensation to be paid for temporary as well as permanent acquisition of the land;
- Assist in checking genuine ownerships of the claimants, in consultation with the Revenue staff for prompt payment to the affectees;

- To assist Contractor for obtaining necessary approvals from the concerned departments;
- Maintaining interface with the other lined departments/stakeholders; and
- Reporting to the EPA-Punjab on status of EMP implementation.

b. Supervision Consultant (SC)

A professional consulting firm will be hired by PMA and responsible for Contract Administration and Construction Supervision. The firm will be fully empowered as the 'Engineer' in accordance with International Federation of Consulting Engineers (FIDIC) stipulations. The Consultant will administer the civil work's contracts, make engineering decisions, be responsible for quality assurance, provide general guidance and furnish timely responses to the Contractors in all matters relating to the civil works, and ensure that all clauses of the Contract Agreement including environmental and social clauses between the civil works Contractors' and PMA are respected. The Project Engineer will have a full-time field based environmental and social specialist to ensure the implementation of EMP. Two separate experts, one for environment and one for social aspects, will be hired. The environmental and social specialist of SC will also develop training modules, conduct environmental and social trainings for the contractor's staff, and ensure social issues are properly addressed and mitigated during the project life.

Environmental and Social Experts (ESEs) of SC will oversee the performance of contractor to make sure that the contractor is carrying out the work in accordance with EMP as mentioned in the contract documents. He will provide guidance to the contractor's ESE for implementing each of the activity as given in EMP. ESEs will be responsible for record keeping, providing instruction through the Resident Engineer (RE) for corrective actions and will ensure the compliance of various statutory and legislative requirements.

However, overall responsibilities of ESEs are as follows:

- To oversee the performance of the Contractor to make sure that the Contractor is complying with EMP;
- Discussing various environmental and social issues and environmental mitigation, enhancement and monitoring actions with all concerned personnel's;
- Inspect, supervise and monitor all the construction and allied activities related to the EMP for the project and oversee the performance of the Contractor to make sure that the Contractor is complying with EMP;
- Visiting construction sites including incomplete construction work sites, where there is no contractor's activities, active construction work sites, completed areas of work sites as well as ancillary sites such as borrow areas, quarries, asphalt and crusher sites, hot mix plant sites, construction camps and work shop areas to ensure contractors compliance with EMP stipulations and conditions of statutory bodies;
- Assisting contractor in all matters related to public contacts including public consultation pertaining to environmental and community issues;
- To organize periodic environmental training programs and workshops for the consultant's and contractor's staff;
- Periodic reporting as mentioned in EMP; and
- Suggest any additional mitigation measures (if required).

c. Responsibilities of Contractor

Site Environmental and Social Expert of contractor will carry out the implementation of the mitigation measures at construction site. Contractor will be bound through contract documents to appoint the Site Environmental and Social Expert with relevant educational background and experience. The responsibilities of ESE of Contractor are as follows:

- Responsible for Implementation of the mitigation measures at construction site;
- Preparation of Site Specific Environmental and Management Plan (SSEMP) including Evacuation Plan, HSE Management Plan, Material Transportation Plan, Traffic Management Plan, Emergency Response Plan, Monitoring Plan, and asphalt and batching plant area plans, and will submit all the plans to the SC.
- ESE of contractor will be responsible for the implementation of EMP and to take effective measures against corrective actions plan;
- ESE will prepare the monthly compliance and monitoring reports as per schedule and will submit it to the SC;
- Provision of proper Personal Protective Equipment's (PPEs) to the workers and train them for their proper use;
- ESE will conduct the environmental, health and safety trainings for the staff and labors; and
- The Contractor shall submit the Code of Conduct that will apply to all of the contractor's staff. The contractor shall submit an outline of how the Code of Conduct will be implemented. The aspects to be addressed include:

    - Ensure compliance with applicable environment, health and safety standards and procedures associated with risks of Project activities;
    - Ensure compliance with all acquired approvals, applicable to the proposed Project;
    - Ensure protection of local community (including vulnerable and disable assemblies), and the Contractor's staff, sub-contractors and daily wage workers;
    - Ensure employment of fulltime security guards, and necessary security measures and instruments (CCTV) at site;
    - Ensure provision of adequately stocked first aid kit at site for dealing with accidental injuries, and natural hazards;
    - Prohibit use of illegal items such as weapons, alcohol and drugs at site;
    - Ensure that Project property is protected against vandalism, theft, and noxious activity;
    - Ensure that positive attitude of respect and warmth is given to staff and community members;
    - Ensure good housekeeping practices shall be adopted at site;
    - Ensure that employment decisions are not made on the basis of personal characteristics unrelated to inherent job requirements, including race, gender, nationality, religion or belief, disability, age, sexual orientation, or ethnic, social and indigenous origin;
    - Ensure establishment and strictly enforcement of "No Sexual Harassment Policy";
    - Ensure provision of necessary sanitation requirements for site workers (both for men and women);
    - Ensure workers only use specified sanitary facilities provided by their employer and not in open areas;

- Restriction on burning solid waste;
- Restriction on dumping solid and liquid waste into nearby water bodies;
- Prohibition for cutting trees, and clearing vegetative areas for construction camps, and for cooking purpose as a source of fuel; and
- Prohibition on illegal hunting of local fauna.

The Code of Conduct should be written in local and simple language (Urdu and English) and signed by each site staff to specify that they have received a copy of the code; code explained and clarified to them; acknowledged adherence to this Code of Conduct as a condition of employment; and understood that violations of the Code can result in serious consequences. A copy of the code shall be displayed at strategic location of the site, and mainly in the contractor's site office.

d. Punjab Environmental Protection Agency (PEPA)

PEPA is the regulatory authority for issuance of NOC for the proposed Project. As part of its mandate, protection of environment is their responsibility. Therefore, the agency will undertake an audit (as and when required) of the activities of the Project (both phases i.e. Construction and Operation) with respect to the protocols as defined in EMP and in NOC. The specific responsibilities are as follows:

- Liaison with the Environmental Committee of PMA on the proposed Project to ensure compliance of measures as given in the EMP and in NOC issued by them for the construction activities of the proposed Project;
- Environmental Audit of the activities being undertaken by the Environmental Committee of PMA and all other relevant stakeholders as provided in the EMP and NOC through random site visits and meetings.

7.4.4 Institutional Arrangement for Implementation of EMP during O&M Phase

The proposed Project will be administrated by PMA during the O&M phase. PMA has established District Support & Monitoring Department to monitor the development works of every district and for technical support for District Government. Therefore; it is suggested that the Project Director of the proposed Project shall depute / hire Environment and Social Expert through District Support & Monitoring Department to monitor and implement EMP during operation phase.

The specific responsibilities of Environment and Social Expert are as follows:

- Coordinating with the operational staff working under the Regional General Manager and Project Director to monitor environmental compliance during operation phase;
- Advising on, and monitoring tree plantations along the road alignment as suggested in EMP;
- Reporting on the progress of environmental compliance to the Project Director and EPA-Punjab;
- Assess and propose mitigation measures for unforeseen long-term environmental and social impacts of operation; and

- Sustaining a working partnership among the PMA, EPA-Punjab, Agriculture, Irrigation, Forest and Wildlife departments of Lahore District to ensure compliance of EMP during operation phase.

7.5 ENVIRONMENTAL MITIGATION AND MANAGEMENT MATRIX

Environmental Mitigation and Management Matrix (EMMM) is considered as one of the main elements of EMP. The EMMM provides the framework for the implementation of the mitigating measures against each identified potential adverse impacts, and management and monitoring of the same during the design, construction and operation phases of the proposed Project. Table 7.1 shows impacts, mitigations and the responsible authority and organization for the implementation of the same during design, construction and operation phase.

The Contractor(s) will be responsible for the preparation of Site Specific EMP (SSEMP) on the same format of this EMMP along with the site-specific plans based on the guidelines provided in this Section.

Table 7.1: Environmental Mitigation and Management Plan during Design Phase

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
Preconstruction / Design Phase					
1.	**Topography** The construction and operation of the Murree train project are likely to induce substantial alterations to the natural topography of the region. Murree's terrain is characterized by steep slopes, rugged hills, and narrow valleys, making large-scale infrastructure development changes to the topography permanently.	• The project design would consider aesthetic concerns such as the tree plantation; • Use of tunnel-boring machines to minimize open cutting; • Construction of retaining walls and slope stabilization structures; • Landscape integration to preserve visual harmony with the environment; • Erosion control through proper drainage and sediment management systems; • Retaining structures such as gabions, cribs grids of wood or concrete beams filled with earth or rock), or other types of wooden barricades and grid works, usually battered back against the slope; • Best engineering design measures should be adopted keeping in view the aesthetics of the project area; and • Ground disturbances should be limited to only the areas necessary for project related construction activities.	• Audits and Checks	Design Consultant	Proponent
2.	**Route (Alignment) Optimization** Improper route selection of proposed glass train will lead to disturbance to ecological sensitive areas and social	• Most of the significant environmental, ecological and social impacts of the project have been addressed at the design phase. Environment team has closely worked with design team for the route optimization. In order to	• Confirmation of design incorporation. • Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	issues of resettlement and displacement of people.	minimize environmental, ecological and social issues at the design stage, various features have been considered. The train route alignment has been finalized by considering features (maximum avoidance to settlements, ecologically sensitive areas, mosques, Graveyards, major water resources, etc.) and efforts have been made to avoid or minimize impacts on ecological and social components of the environment.			
3.	**Environmentally Responsive Design Considerations** Designing of the project components without considering the prospective and futuristic needs can result in structures with low social acceptability and functionality. Improper designed infrastructure may lead to technical, environmental and financial problems. This includes railway track, station, tunnels, culverts, bridges, etc. If not properly planned and designed, it may lead to both social and environmental concerns. Moreover, utilization of the available spaces and designing the layout without considering the prospective and futuristic needs may result in design with low social	• Focus design work on minimizing use of natural resources, intrusion into natural waters, avoiding forests, scheduling of work to minimize wildlife interference, maintenance of surface runoff and planning location of work camps that minimizes short and long term negative effects. • All structural, layout and engineering designing should be in strict considerations with the applicable national and international by-laws and engineering parameters.	• Confirmation of design incorporation. • Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	acceptability and functionality.				
4.	**Infrastructure Design of Stations and Buildings** Inadequate provisions for water supply, sewerage, drainage and solid waste management at station and buildings may lead to health issues, odor and nuisance problem for public.	• All structural, layout and engineering designing should be in strict accordance with the applicable by-laws and engineering parameters; • Storm-water drainage system for the railway bridges should be carefully designed; and • Provision of culverts and plan for rehabilitation of the existing ones in the design at regular intervals to channel away the water from the elevated tracks to the lowest point.	• Confirmation of design incorporation. • Audits and Checks	Design Consultant	Proponent
5.	**Design of Level Crossings** Poorly designed level crossings can lead to serious injuries or accidents. Risks that arise at level crossings include user slips/trips/falls (including cyclists), trespass along the railway line itself, equipment damage due to vandalism, electric shock from overhead wires and vehicle collisions with barriers, pedestrians or other vehicles.	• Barriers or gates at public vehicular crossings to physically prevent vehicle or pedestrian users from crossing the railway. These may be operated: ○ Automatically upon detection of an approaching train, or ○ Manually by railway staff present at the crossing (or from an adjacent signal box) or via remote control from the signal box controlling the area • Colored lights which provide a visual indication to the user of whether, or not, it is safe to cross; this may also be combined with an audible alarm.	• Confirmation of design incorporation. • Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		• Telephones for the user to request permission from the signaller to cross. • Gates or stiles to highlight to the user where the boundary with the railway begins and ends. These can also prevent inadvertent trespass of children or animals onto the crossing or, in the case of locked gates, unauthorized use. • Signage to explain the safe method of using the crossing or to bring the user's attention to specific dangers. • Railway signs that signify trains to stop on the approach to crossings which are crossed over when identified as safe to cross by the train crew.			
6.	**Hydrology and Drainage pattern** The project can affect the natural surface and subsurface drainage pattern in the project area. The presence of excess water or moisture within the rail track will adversely affect the engineering properties of the materials used in its construction. Poor drainage can cause cut or fill failures, road surface erosion, and weakened subgrade followed by a mass failure. Improper drainage can modify surface	• Water must not be allowed to develop sufficient volume or velocity so as to cause excessive wear along ditches, below culverts, or along exposed running surfaces, cuts, or fills. • Natural drainage characteristics of a hill slope, as a rule, should not be changed. • Culverts should be placed at grade and in line with the centerline of the channel to avoid excessive erosion of soils above and below the culvert.	• Confirmation of design incorporation. • Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	water flow by concentrating flows at certain points and, in many cases, increasing the speed of flow.	• Culverts should be designed based on the flood history of the project area.			
7.	**Seismic Hazard** As per Building Code of Pakistan, Seismic Provisions, 2007, the project area is located in Seismic Zone 2B & 3 (moderate to high hazard), where peak horizontal ground acceleration from 0.16g to 0.32g. In this Zone, designing of various types of structures should be done on the basis of PGA. A high intensity earthquake impacting the project site can adversely impact the development.	• The proposed structures should be designed and constructed to withstand high intensity earthquakes. For seismic hazard analysis, updated structural, geotechnical and seismic studies should be conducted; and • To mitigate the seismic hazard, Seismic Building Code of Pakistan 2007 (SBC-07) should be adopted. This code specifies minimum requirements for seismic safety of buildings and has to be applied and used by engineers in conjunction with the necessary understanding of the concepts of structural, geotechnical and earthquake engineering.	• Confirmation of design incorporation. • Audits and Checks	Design Consultant	Proponent
8.	**Site Selection of Construction Camps** Improper site selection and location of construction camp(s) may lead to various social and environmental impacts which include loss of vegetation due to setting up construction camps, indiscriminate generation of solid waste, and discharge of sanitary effluent, water pollution and health & safety issues in the surrounding settlements.	• Construction camps should be designed to be self-contained to reduce demand on infrastructure and services of nearby communities and to minimize the removal of existing macro-plants; • There should be no resettlement issue for the location of the camps; • Camp site should be away from the residential areas and sensitive receptors; • Selection of sites for construction	• Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		camps shall be near the project area having proper access to the nearby main/link road; • The camps must be located in a place where the drainage from and through the camps will not threaten any domestic or public water supply; • Camp site must be adequate in size to prevent overcrowding of necessary structures; • The camp site should consider avoiding any damage of property, vegetation, irrigation, and drinking water supply systems; • The camp site must not be subject to periodic flooding; and • There should not be any ecological sensitive areas e.g. wildlife sanctuaries, game reserves, national parks, forest areas, etc. near to the construction camp site.			
9.	**Noise and vibration** Vibration as well as noise, is an environmental and human health concern; Both factors significantly impact comfort and quality of life. While vibrations from passing electric trains are generally too weak to damage buildings, they can still cause considerable annoyance and discomfort	• Some technical solutions consist of replacing the cast iron brake blocks with composite brake blocks or disc brakes, which reduce the pass-by noise level, as they do not increase the wheel roughness as much as the cast iron blocks. • Noise abatement measures such as fitting barriers along railway tracks, fitting noise dampeners and acoustic rail grinding should be carried out. • The composite brake blocks must be	• Confirmation of design incorporation. • Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	for people living near railway lines.	acoustically certified through the procedure set out in the TSI and meet well-defined limits.			
10.	**Public Utilities** Due to the proposed project, public utilities (electric poles, water pipes, power/ telephone lines, etc.) may be affected creating disruption of public services and inconvenience to the local residents.	• The provision in the design and budget for the relocation of the existing utility infrastructure wherever required and shall be finalized in consultation with the concerned department; and • All public utilities (e.g. electric lines, water pipes, power/ telephone lines, etc.) likely to be affected by the proposed project shall be relocated well ahead of time before the actual commencement of the construction work. •	• Audits and Checks	Design Consultant	Proponent
11.	**Emergency Management** Emergency management in case of natural and man-made disaster is a major concern. Increased incidents of disasters especially act of terror, fire, earthquakes etc. demand proper planning. An inefficient firefighting system and insufficient storage of fire water may pose a severe threat to human life and to the proposed Project.	• A separate building for fire brigade, emergency response equipment and staff may be considered in the design; • Emergency Response Plan is attached as Annex-III.	• Confirmation of design incorporation. • Audits and Checks	Design Consultant	Proponent
12.	**Flora**	• The camps, mobility of machinery and construction of temporary facilities	• Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	During the pre-construction phase, activities such as installation of construction camps, construction of temporary facilities & mobility of construction staff may damage the local vegetation/trees. As the heavy machinery and camps will be moved and installed, which require significant space due to which available vegetation is expected to be removed..	should be proper planned and well designed to avoid any loss to local green cover; • It is recommended to establish the construction camps where minimum or no vegetation exists; • Similarly, the alternate routes for roads and points for camps are recommended where no loss of vegetation is expected; and • The location of construction camp should be selected so, as to have limited environmental impact during construction phase and to reduce the cost and land requirement.			
13.	**Fauna** As movement and installations of machinery and vehicles will take place, so noise and habitat loss is expected. The routes of the available wildlife and other habitats may be affected due to camps set-up and machinery movements and installations. Temporary road may also affect the habitat of locally available fauna. This impact is site-specific, temporary, irreversible and low significant.	• Construction of proposed glass train in the Margalla Hill National Park, Murree-Kotli Sattian-Kahuta National Park and reserve forests and for removal of trees NOC from the concerned forest department will be required prior to the start of construction of the train route to make the work carried on through a proper channel. • It is suggested that the trees falling within the boundaries of the national park and reserve forest will be marked by the Forest Department before the start of the work. A joint visit by the employer, consultants and concerned forest department will be carried out. A document containing details of the	• Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		total trees to be felled having details of mitigation measures to be adopted during the construction phase of the project in the Reserve forests and details of the developments in the said forest will be provided to the concerned department for the issuance of NOC for the construction work to be carried out. • The camps, mobility of machinery and construction of temporary facilities should be proper planned and well designed to avoid any loss to local green cover; • It is recommended to establish the construction camps where minimum or no vegetation exists; • Similarly, the alternate routes for roads and points for camps are recommended where no loss of vegetation is expected; and • The location of construction camp should be selected so, as to have limited environmental impact during construction phase and to reduce the cost and land requirement.			
14.	**Fauna** As movement and installations of machinery and vehicles will take place, so noise and habitat loss is expected. The routes of the available wildlife and other habitats may be affected due to	• The standard measures must be adopted to minimize noise due to machinery movements and installations; • Wildlife movements and routes must be considered during activities and should be avoided to their maximum	• Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	camps set-up and machinery movements and installations.	level; • The alternate routes and points are recommended to avoid any damage to locally available fauna; • The camps shall be designed as properly fenced and gated to check the entry of animals in search of eatable goods; and • A waste management plan so that the wastes of the camps shall be properly disposed of to prevent it being eaten by animals, as it may be hazardous to them.			
15.	**Traffic Management** Fast-moving trains at rail-road crossings pose a significant safety hazard, with the potential to cause major accidents, severe injuries, and fatalities. This concern is particularly critical in areas like Murree, where road infrastructure is often constrained by hilly terrain, and visibility at crossings may be limited. At-grade rail-road crossings not only increase the risk of collisions but also contribute to severe traffic congestion, especially in peak tourist seasons. In such regions, the combination of high-speed rail traffic and inadequate crossing infrastructure underscores the	• Grade separations should be built at problematic crossings. • Vehicular traffic management systems at level crossings should also be upgraded. • Warning signs and gate lights need to be installed and warning bell should be operated by approaching train. Warning sign and disclaimers should be posted at all at-grade crossings. • Level crossings should be provided with round the clock manned/ automatic barriers to improve the safety at these locations. • Overhead pedestrian crossings should be provided where the alignment passes through major settlements. • Noise barriers in form of tree	• Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	urgent need for safety upgrades such as barriers, signals, overpasses, or underpasses to minimize risks to both motorists and pedestrians.	plantation should be planned at sensitive receptors. • Heavy fines strategy should be integrated in rail traffic safety regulations for violators. •			
16.	**Land Acquisition and Resettlement** Private land acquisition is involved in the construction of proposed project, which is multiple type of land. This impact will be permanent and major negative in nature. The land required for the construction of the proposed Murree Glass Train.	• Mitigation measures will involve careful site selection by the design team to minimize the impacts by avoiding the residences of affected families. • The Land Acquisition Act (LAA) of 1894 is the main law regulating land acquisition for public purpose. This impact can be mitigated by ensuring compliance of Land Acquisition Act, 1894, addressing community grievances on priority basis and timely compensation to affectees.	• Audits and Checks	Design Consultant	Proponent
17.	**Impact on Structures** In the RoW & CoI housing and commercial structures of different categories will be affected fully and partially due to project intervention. These structures exist in the ROW of the proposed road at different locations. In addition to these structures, hand pumps, boundary walls and other related structures are also under the	• The inventory and detailed measurement of structures and the number of Affected Household to be affected for clearing of RoW for the proposed Project and detailed measurement survey should be carried out for preparing the compensation. • Compensation of the structures should be evaluated and provided as per market rates; • Affected Persons should be compensated on full replacement cost	• Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	impact. These households are losing their residences permanent temporary and their relocation is involved.	of each category to construct a new structure of the same type; • Compensation of livelihood disturbance should be provided for the period of instruction of commercial activities; • Proper consultations and coordination's with APs during resettlement process. • Compensation for affected structures should be evaluated and provided as per market rates. • Affected Persons should be compensated on full replacement cost of each category to construct a new structure of the same type; and • Proper consultations and coordination's with PAPs during resettlement process.			
18.	**Impact on Community and Religious Structures** The community and religious structures are very sensitive to impact and need special care during execution of the project; because people think that these structures might not be rebuilt if once demolished. Mosque, Graveyard fall in the RoW of the proposed track. Shifting and demolishing of these structures may	• The effort will be made by making changes in design to avoid the sensitive and religious structures and to minimize the issues at possible extend. If needs demolishing, a mechanism will be developed for the restoration of these structures during the detailed design and during construction with the community consultation, and • Proper consultations and coordination's with the communities •	• Audits and Checks	Design Consultant	Proponent

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	cause serious social issues.				
Construction Phase					
19.	**Topography** Construction activities is expected to impact the topography of the area significantly except for those areas where physical activities including digging and excavation areas, storing or dumping sites for excessive material, storing areas and movement of heavy construction machinery will be carried out. The excavated material will be generated due to the construction of various infrastructure components of the project like Roads & Walkways and paved areas, stations, tunnels, drainage network, electrification system, and parking facilities. The area where excavated material is to be dumped will also be negatively impacted	The excavated material will require safe disposal by the Contractor. Most of the excavated material could be used in back filling process and concrete aggregate to be used in construction. A detailed development and operation plan for borrow areas must be prepared by the contractor at the pre-development phase (before the starts of extraction of material from each borrow area). Contractor should strictly follow the provisions of approved plan in order to minimize any adverse impact associated with the borrow areas. Likewise, excavated material should be dumped at suitable and approved disposal sites.	• Visual observation and photographic record • Site restoration and rehabilitation plan implementation	Construction Contractor	Proponent, SC
20.	**Soil Erosion and Contamination** Impact on topsoil and soil stability is mainly expected during the preparatory and construction works, which will be caused by the arrangement of the construction camp, construction site, replacement of the equipment,	• In order to prevent the damage and contamination of soil at the project site, surface layer of the soil should be removed and stored temporarily in pre-selected locations. The soil should be stockpiled separately. Stockpiles should be protected from wind and atmospheric precipitation and should be at least 50 meters away from	• Visual observation and photographic record • Site restoration and rehabilitation plan implementation	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	earthworks, arrangement of temporary and permanent infrastructures, etc. The soil would be exposed to erosion due to removal of vegetation, establishing construction camps / workshops and excavation etc. The most significant aspects in the construction phase of are excavation works and track works. These will expose soils in the affected project area leaving them vulnerable to erosion by surface run-off and wind. The overall threat could exist for the durations of construction works in the monsoon season. Besides, there is high possibility for soil pollution with substances due to leakages of fuels and oils from the heavy vehicles and machinery used for construction and due to applied chemicals during this phase.	surface water body; • Stored excavated material shall be covered and preferably reused, e.g. in construction of dykes etc.; • Sprinkling of water may help in reducing the erosion soil; • Use of heavy machinery should be restricted as far as possible to work sites only to avoid the destruction of soil structure; • Vehicles and equipment should be checked regularly. In case of damage and fuel / oil leakage, it should be repaired immediately. Damaged Vehicles should not be allowed on the construction sites; • In case of spillage of pollutants, spilled material should be localized and contaminated site should be immediately cleaned; Staff should be provided with appropriate means (adsorbents, shovels, etc.) and with personal protective equipment as well; • All spoils should be disposed of at site designated by LWMC and the site should be restored back to its original conditions; • Non-bituminous wastes from construction activities will be dumped in approved sites, in line with the guidelines for dump sites, and shall be covered; • Washing yards shall be paved to avoid seepage of runoff from the yard;			

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		• After completion of construction works, all kind of waste (including hazardous waste) will be collected and removed from the area. Hazardous waste should be removed for further management by the licensed contractor; and • Perennial grasses and shrubs trees should be planted to control the runoff on the site.			
21.	**Geo-Hazards** Construction of proposed project in mountainous region leads to wide spread environmental problems. It is clear that engineering works associated with the subgrades, bridges, and tunnels are the main factors influencing the degradation of the mountain environment. The critical areas are the geological hazards such as debris flows, landslides and slope instability. Newly built railways in the mountain areas are bound to lead to changes in the geomorphic features, destruction of vegetation and the arbitrary placing of immense quantities of spoils. These impacts will aggravate the degradation of the mountain environment if appropriate treatment measures are not	• Comprehensive investigations should be conducted for spatial distribution and current stage of development of landslides, debris flows, and other mass-wasting processes in the project area for assessing geohazards and safe infrastructure design; • Damage to the mountain environment shall be reduced as far as possible during the cutting & filling and other engineering works and control measures should be introduced to maintain the stability of unstable cutting slopes. Slope cutting at tunnel portals should be avoided as far as possible.	• Visual observation and photographic record • Site restoration and rehabilitation plan implementation	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	introduced.				
22.	**Water Quality** The potential sources of water pollution associated with the construction of proposed Project are runoff from the construction works area that may contain increased loads of sediments, suspended solids and other contaminants. Potential sources of pollution from the site include: • Runoff and erosion from exposed soil surfaces, earth work areas and stockpiles e.g. grouting and cement material with the rain; • Wash water from dust suppression sprays; • Fuel and lubricants from maintenance of construction vehicles and mechanical equipment; • Spillage of liquids stored on-site such as oil, diesel, and solvents etc. are likely to result in water pollution; and • Uncontrolled discharge of debris and rubbish such as packaging, construction material and refuse. The groundwater may get contaminated from the wastewater generation from the	• As a mandatory step, all the effluents will be disposed as per the requirements of PEQS. Moreover, to reduce the risk of surface and groundwater contamination, good management practices will be adopted to ensure that fuels, chemicals, raw sewage and wastewater effluent are disposed of in a controlled manner. These measures are described below: • Construction camp will be established in area with adequate natural drainage channels in order to facilitate the flow of the treated effluents after ensuring that PEQS are met; • The proponent will ensure that the construction work is confined within the project boundary and water bodies are prevented from pollution during construction; • The solid waste will be disposed of in designated landfill sites to sustain the water quality for domestic requirements; • Regular water quality monitoring according to determined sampling schedule; • Water required for construction shall be obtained in such a way that the water availability and supply to nearby	• Visual observation and photographic record • Regular environmental monitoring, sampling and testing reports	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	construction camps, leachate from improper dumping of solid waste. The impact is medium adverse in nature.	communities remain unaffected; • The contractor will ensure that construction debris do not find their way into the drainage which may get clogged; • To maintain the surface water flow/drainage, proper mitigation measures will be taken for the proposed project, like drainage structures; • Wastes will be collected, stored and taken to approve disposal site; • Wastewater effluent from the Contractors' workshops and equipment washing-yards will be passed through gravel/sand beds to remove oil/grease contaminants before discharging into the natural streams. According to the PEQS, the BOD concentration in sewage must be brought down to less or equal to 80 mg/l before being discharged into a natural stream having capacity to dilute the effluent. For wastewater apart from BOD, COD of 150 mg/l will also be checked; and • Similarly, if the sewage after treatment is to be discharged in to the land it will meet the requirements of the PEQS for disposal of wastewater.			
23.	**Deterioration of Ambient Air Quality** Air quality will be affected by fugitive	• All vehicles, machinery, equipment and generators used during construction activities should be kept in good working condition and be	• Visual observation • Regular environmental monitoring, sampling	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	dust emissions from construction machinery; dust from the unpaved surface and construction vehicles. Emissions may be carried over longer distances depending upon the wind speed, direction, temperature of surrounding air and atmospheric stability. Besides, multifarious construction activities and increased vehicular traffic (construction vehicles) would also contribute to the localized airborne dust. The Suspended Particulate Matter (SPM) tends to remain suspended in the environment for much longer and persistent time and is an environmental hazard. The objectionable impacts of settling of the suspended dust would be its dry deposition on vegetation, motor vehicles, structures, and other exposed surfaces. Exhausts from fossil fuel burning in the construction machinery will also deteriorate local air quality. Similarly, exhausts from generators can also have impacts on air quality in the vicinity. The deteriorated ambient air quality may cause health hazards to the residents of nearby localities.	properly tuned and maintained in order to minimize the exhaust emissions; • Open burning of solid waste from the Contractor's camps and at construction site should be strictly banned; • Preventive measures against dust should be adopted for on-site mixing and unloading operations; • Construction materials (sand, gravel, and rocks) and spoil materials will be transported through trucks covered with tarpaulins and all vehicles (e.g., trucks, equipment, and other vehicles that support construction works) will comply with the PEQS for carbon emissions and noise; • Regular water sprinkling of the site should be carried out to suppress excessive dust emission(s); • Emissions from power generators and construction machinery are important point sources at the construction sites. Proper maintenance and repair is needed to minimize the hazardous emissions; • Emissions from batching / asphalt plants can be controlled efficiently by the installation of cyclone / scrubbers. Diesel operated equipment should be equipped with well-maintained fuel filter and may be replaced timely (if required). In addition to that, regular	and testing reports • Vehicle maintenance records • Water sprinkling records.		

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		maintenance activities comprising changing of lubricating oil, changing the air and fuel filter, cleaning the fuel system, draining the water separators and proper tuning may also help in reducing the emissions from diesel generators; • Construction equipment is generally left idling while the operators are on break or waiting for the completion of another task. Emissions from idling equipment tend to be high. Existing idling control technologies, which automatically shut the engine off after a preset time can reduce emissions, without intervention of the operators; • PEQS applicable to gaseous emissions generated by construction vehicles, equipment and machinery should be enforced during construction works; • Service roads (used for earthmoving equipment and general transport) should be regularly sprayed with water during dry weather; • All excavation work should be sprinkled with water; • Construction workers should be provided with masks for protection against the inhalation of dust; • Vehicles used for construction should be tuned properly and regularly to control emission of exhaust gases; • Ensure precautions to reduce the			

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		level of dust emissions from hot mix plants, crushers and batching plants should be taken up; e.g. providing them as applicable, with protection canvasses and dust extraction units. Mixing equipment should be well sealed and equipped as per existing standards; and • Regular monitoring of air quality in accordance with the formulated environmental monitoring plan (given in EMP).			
24.	**Noise and Vibration** The noise and vibration will be produced due to the operation of construction machinery equipment. Sources of noise and vibration during construction are heavy machinery such as bulldozers, excavators, stabilizers, concrete mixing plant, pneumatic drills, stone crushers, asphalt plants and other equipment. Noise and vibration are perceived as one of the most undesirable consequences of construction activity. The above machinery is expected to generate noise levels that would be severe in the Project Area. The noise and vibration may cause health hazards to the residents of nearby villages such as Nath Kalan, Their, etc.	• There are a variety of ways including Quieter Equipment; Modifying Existing Old Equipment; Barrier Protection; Work Activity Scheduling; Maintenance; Noise Perimeter Zones (NPZs) by which construction equipment and worksite noise can be controlled. • contractors should comply with submitted work schedule, keeping noisy operations away from sensitive points; implement regular maintenance and repairs and employ strict implementation of operation procedures; • Noise barriers in sensitive areas in the form of high boundary walls (concrete or wood), earth berms, etc. in front of schools, hospitals and mosques; • Within 200 m of the nearest habitation, construction work such as crushing, concrete mixing and	• Physical observation • Regular environmental monitoring, sampling and testing reports • Vehicle maintenance records	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		batching, mechanical compaction, etc., shall be stopped between 2200 and 0600 hours; • Inform people of the possible vibration before using Vibrating Rollers near settled areas. • Blasting shall be carried out according to relevant safety standards. Blasting schedules shall be publicly posted in areas where residences could be affected by the blasting noise; and • Public hearings to discuss appropriate solutions and materials to control noise (e.g. mud or brick walls, bushes, etc.)			
25.	**Borrow Areas/ Open Pits** Borrow / open pits and its excavation activities may result in land disputes, soil erosion, loss of potential cropland, loss of vegetation, landscape degradation, and damage to road embankments. Borrow/ open pits may also result in potential sources of mosquito breeding and may prove hazardous to human beings, livestock and wildlife. This will also degrade hygienic condition of the Project Area. This impact is permanent and high adverse in nature.	• Necessary permits will be obtained for any borrow pits from the competent authorities; • In borrow pits, the depth of the pit shall be restricted upto 5' and the sides of the excavation will have a slope not steeper than 1:4; • Soil erosion along the borrow pit shall be regularly checked to prevent/mitigate impacts on adjacent lands; and • In case borrow pits fill with water, measures have to be taken to prevent the creation of mosquito-breeding sites. • The Guideline Quarry Management Plan is attached as Annex-IV.	• Visual observation and photographic record • NOC record of permits • Check and audits	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
26.	**Operation of Construction Camps/Camp Sites** Mismanagement of construction camp activities can lead to various social and environmental impacts which include health and safety, traffic problems, soil degradation, loss of vegetation and assets on the selected land, solid waste and water pollution in the vicinity settlements. Furthermore, cultural differences, behavior of construction workers, potential disregard for local cultural norms can lead to increased tension between local communities and workers residing in the construction camps. This impact is temporary and moderate negative in nature.	• The project will seek to avoid sitting camps where their presence might contribute to any conflicts with locals; • Employment policies which aim to maximize job opportunities for local people will help to minimize tensions caused by different socio-cultural values; • Camps will be designed to be self-contained to reduce demand on infrastructure and services of nearby communities; • A comprehensive safety and security plan for the camp will be prepared which will comprise of a training manual, use of safety equipment and emergency preparedness; • Training will be provided to all staff on camp management rules and overall discipline and cultural awareness; • Waste Management Plan (refer Annex-V) will be implemented to ensure safe handling, storage, collection and disposal of construction wastes and the training of employees who handle waste; • Site for construction camp will be selected to minimize the removal of existing macro-plants at camp sites; • Photographical and botanical inventory of vegetation before clearing the site;	• Visual observation and photographic record. • Waste Management plan implementation	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		• Compensatory plantation to be done when construction work near ends; and • The contractor(s) shall ensure removal and rehabilitation of site upon completion.			
27.	**Wastewater Generation at Construction Camps** Wastewater will be generated at the construction camps by the workers. If the generated wastewater is not properly treated or disposed of, this may contaminate the surface water sources such as nullahs, drains, water channels etc. apart from soil contamination. The wastewater generation is estimated to be 6,600 liters/day[42] for 200 construction workers during construction phase of the proposed Project. This impact can be categorized as direct, moderate, site-specific, short term, temporary, high probability and reversible.	To dispose the liquid waste generated from the construction activities, the following steps will be taken by the Contractor: • Domestic and chemical effluents from the construction camp will be disposed by the development of on-site sanitation systems i.e. septic tanks (as shown in Figure 6.1); • Proper monitoring to check the compliance of PEQS will be carried out; • Sewage from construction camps will be disposed of after proper pre-treatment and processes such as soakage pit; and • The Contractor(s) will be responsible to submit details of site-specific wastewater management plan along with details of wastewater collection, transportation and its disposal.	• Visual observation and photographic record. • Waste Management plan implementation	Construction Contractor	Proponent, SC
28.	**Solid Waste Generation at Construction Camps**	• Solid Waste generated during construction and camp sites will be	• Visual observation and photographic	Construction Contractor	Proponent, SC

[42] Design Criteria of Public Health Engineering for Water Supply, Sewerage and Storm Water Drain (Domestic sewage generation = 80% of water consumed/day)

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	The solid waste generation is estimated to be 90 kg/day[43] for 200 construction workers during construction phase of the proposed Project. Different type of waste is likely to be generated during the construction phase of the proposed Project. The municipal waste will be in the form of food, cans, paper and wastewater from construction camps toilets and washing yards. Construction waste will include excavated soil, sand, gravel, rocks, asphalt, pieces of concrete, bricks, wood, metal pieces and electrical wires. Whereas, hazardous waste can be comprised of paints and construction chemicals. All these, if left unattended, can become a source of nuisance and environmental pollution in the Project Area. Insecure and unhygienic disposal of the solid wastes particularly garbage and trash may cause degradation of soil and land. Insecurely disposed off heaps of wastes containing kitchen garbage and food waste can serve as breeding	safely disposed in demarcated waste disposal sites and the contractor will provide a proper waste management plan; • Training of work force in the storage and handling of hazardous materials and chemicals Construction workers and supervisory staff should be encouraged and educated to practice waste minimization, reuse and recycling to reduce quantity of the waste; proper labeling of containers, including the identification and quantity of the contents, hazard contact information, etc; • Waste disposal plan must be reviewed during the entire construction phase in the light of changing weather conditions; • Emergency response plan shall be prepared to address the accidental spillage of fuels and hazardous goods; • Immediate collection of spilled oils/fuels/lubricants by collection of contaminated soils and skipping oils from surface water by applying appropriate technologies; • Reusing bitumen spillage; and disposing non-usable bitumen spills in a deep trench providing clay linings at	record. • Waste Management plan implementation		

[43] Source: The World Bank Report 2012 – What a Waste: A global review of solid waste management. Based on UNEP estimates for waste generation in the Asia Pacific. Average is 0.45 kg/capita/day.

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	grounds for the disease spreading vectors and rodents. Throwing away of solid wastes into water channels and the wastewater network can result into choking of the latter. These impacts are temporary and minor negative in nature.	bottom and filled with soil at the top (for at-least 0.5 m); • Used oil shall be collected in separate containers stored on impervious platform with restricted access and shall be sold to licensed contractor and the burning of waste oil shall be strictly restricted; • Segregating and stockpiling scarified/ milled bituminous material and reusing this material in sub grade/shoulders; • Construction waste such as waste wood can be recovered and recycled into wood for new building projects, and cement, bricks, and plaster can be crushed and reused in other construction and building projects; and • The contractor should ensure implementation of proposed Construction Waste Management Plan and it must be reviewed during the entire construction phase in the light of changing weather conditions.			
29.	**Traffic Management** Due to the proposed project construction activities and movement of heavy project vehicles for construction material supply, traffic problems may arise for the commuters and transporters travelling	To minimize traffic problems in the proposed Project Area, following measures will be considered: • Movement of vehicles carrying construction materials and equipment/machinery will be restricted during the daytime to	• Vehicle maintenance record • Training record • Implementation of TMP • Regular visual observations	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	especially through Ring Road and other Project Area access roads. The problems will include traffic jams and inconvenience to the public passing through the Project Area. It will also increase traffic load on the existing road network or access roads ultimately deteriorating the existing condition of the roads. The movement of vehicles along the haulage routes will cause soil erosion, debris flow, dust emissions, vibrational impacts, etc. Considering these consequences, this impact can be categorized as site-specific, medium negative, temporary and irreversible.	reduce traffic load and inconvenience to the local population; • Construction vehicles, machinery and equipment will be parked at designated areas (at construction camps site) to avoid un-necessary congestions along the major roads; • Damages of roads due to construction vehicles will be instantly repaired and/or compensated after the completion of work; • Proper sign boards will be provided for smooth flow of traffic; • Period of construction and area / location of construction site shall be informed to public in general and specifically to local residents; • Any closure of the roads (especially main roads) and deviations / diversions proposed should be informed to the riders through standard signs and displays; and • Traffic Management Plan (Annex-VI) will be prepared by the contractor and implemented to avoid traffic accidents, jams/public inconvenience.			
30.	**Green House Gas Abatement** The main sources of greenhouse gases (CO_2, CH_4, NO_x etc.) during the	• Regular motioning of the vehicles for engine efficiency; • All stakeholders (PMA, consultants, contractors, concessionaires) need to become aware that their actions at all	• Regular environmental monitoring, sampling and testing reports • Vehicle inspection	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	construction activities of the proposed Project will include both mobile and stationary sources. The mobile sources will be the construction and transportation vehicles while the stationary source will be the batching and asphalt plants. Emission of greenhouse gases cause global warming and other climatic changes on regional and global scale. The climate change due to global warming, may result in following impacts over a period of time: • Extended summer season; • Higher temperatures may result in more precipitation falling as rain rather than snow, hence earlier and greater runoffs, increased runoff may pose greater challenges for water management; • Increased natural hazards such as landslides and debris flows, extreme/unpredictable rainfall events, wind storms, droughts and wildfire: • Due to shift in temperatures and precipitation patterns runoff, stream/lake temperatures, suitable habitats may move upland, thereby declining in size, ecosystems become fragmented, number and composition of species will change with particular	stages of a project can contribute to reducing the CO_2 burden; • Elimination of unnecessary idling can save fuel, prolong engine life, and reduce emissions. It can also help reduce the noise levels associated with construction. Unnecessary idling occurs when trucks wait for extended periods of time to load or unload materials or supplies, or when equipment is left on when it is not being used. Constructions workers may take breaks and leave equipment running unnecessarily or may idle equipment because it is an ingrained habit; • Managing equipment operations and training workers to reduce unnecessary idling is a relatively easy way to lower operating costs and help reduce the environmental impact of construction; • A preventive maintenance program by the contractor seeks to maintain engines at their original level of performance and eliminate the high cost of catastrophic engine failure. Preventive maintenance is the systematic inspection, detection, and correction of potential construction equipment failures. It significantly reduces fuel consumption and emissions; and • Use of low sulfur and good quality	record • Plantation record		

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	threats to sensitive species; and • Increased damages to transportation infrastructure from extreme events, causing difficulties for access and emergency evacuation, and involves higher maintenance costs.	fuel in the construction vehicles or operating equipment that will reduce maintenance costs and harmful emissions. • Alternative energy resources shall be considered where possible; and • PEQS applicable to gaseous emissions generated by construction vehicles, equipment and machinery shall be enforced during construction works.			
31.	**Natural and Man-Made Disasters** Natural disasters (earthquakes) and accidents such as fire, falls, slips and trips may result in injuries, financial losses and may even lead to deaths. The workers shall be trained and facilitated to cope with such disasters.	• An Emergency Response Plan (ERP) for earthquakes and manmade disasters should be developed by contractor in coordination with Supervision Consultant and PMA and should be implemented in close consultation with the RESCUE Services and other concerned departments; • Training of the Contractor and PMA staff and employees regarding the emergency procedures and plans should be regularly conducted; • Emergency numbers should be clearly posted at active construction sites; and • Minor incidents and near misses should be reported by the contractor, and preventive measures should be formulated accordingly by the PMA management.	• Trainings, drills, record keeping • ERP implementation • Visual observation and photographic record.	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
32.	**Occupational Health and Safety** Occupational Health and Safety (OHS) related impacts will arise during construction phase activities including clearing of earth, levelling, compaction, carpeting, pavement finishing and testing & commissioning. Eye injury can be caused by stone or metal particles. Hazard of being hit by falling objects, major hand-arm and whole body vibration hazards, skin and respiratory tract irritation from exposure to cement dust, overexertion and awkward postures etc. will be another impact. Welding hazards include electric shock, fumes and gases, fire and explosions, falls from height, eye and head injuries etc.	• Providing basic medical training to specified work staff and basic medical service and supplies to workers; • Complying with the safety precautions for the construction workers as per International Labour Organization (ILO) Convention No. 62, as far as applicable to the Project Contract; • Training of workers in construction safety procedures, environmental awareness, equipping all construction workers with safety boots, helmets, gloves and protective masks, goggles, shields and monitoring their proper and sustained usage; • Contractor will ensure the provision of medicines, first aid kits, ambulance etc. at the camp site; • Work areas will be cordoned off where necessary; • Contractors will instruct their staff to use Personnel Protective Equipment (PPE) (e.g., wire containment, displaying warning signs along the work site, communicating advance warnings to mats) to enhance the safety; and • Safety lookouts will be built to prevent people and vehicles from passing at the time of hot or cold work; and	• Implementation of HSE Plan • Use of PPEs • Training Records • Work permits • Implementation of Emergency response plan and disaster management plan in case of natural disaster occurrence	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		• An emergency management plan must be devised by the contactor in close coordination with the provincial emergency services. • The Occupational Health and Safety Plan is attached as Annex-VII.			
33.	**Community Health and Safety** The construction activities and vehicular movement at construction sites may result in roadside accidents particularly inflicting local communities who are not familiar with presence of heavy equipment. Quality of groundwater and surface water resources available in the nearby local communities may be affected due to the construction activities, oil spillage and leakage, roadside accidents, etc. The labour works with different transmittable diseases may cause spread out of those diseases in the local residents. The construction areas located near the residential, settlements, may cause accident for the people moving near to those areas. Conflicts may arise between the local community and the construction workers, which may be	• Providing basic medical training to specified work staff and basic medical service and supplies to workers; • There will be proper control on construction activities and oil spillage leakage of vehicles; • The labourers with different transmittable diseases will be restricted within the construction site; • Ensure that the site is restricted for the entry of irrelevant people particularly children; • Efforts will be made to create awareness about road safety among the drivers operating construction vehicles; • Timely public notification on planned construction works; • Close consultation with local communities to identify optimal solutions for diversions to maintain community integrity and social links; • Provision of proper safety and diversion signage at sensitive/accident-prone spots;	• Implementation of HSE Plan • Use of PPEs • Community concerns record • Medical reports of worker	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	related to religious, cultural or ethnic differences, or based on competition for local resources. Tensions may also arise between different groups within the labor force, and pre-existing conflicts in the local community may be exacerbated.	• Setting up speed limits in close consultation with the local stakeholders; • The communicable disease of most concern during construction phase, like Sexually-Transmitted Disease (STDs) such as HIV/AIDS, will be prevented by successful initiative typically involving health awareness; education initiatives; training heath workers in disease treatment; immunization program and providing health service; • Reducing the impacts of vector borne diseases will be accomplished through implementation of diverse interventions aimed at eliminating the factors that lead to disease, which include prevention of larval and adult propagation of vectors through sanitary improvements and elimination of breeding habitat close to human settlements and by eliminating any unusable impounding of water; • The Contractor will prepare the construction camp management plan which, in addition to other components, will include the labor influx management plan. This will be reviewed and approved by PMA; and • Contractor will take due care of the local community and observe sanctity of local customs and traditions by his			

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		staff. Contractor will warn the staff strictly not to involve in any unethical activities and to obey the local norms and cultural restrictions.			
34.	**Communicable Diseases** The laborers in the Contractor Camp, truck drivers and like personnel who interact with each other have the potential for the spread of communicable diseases like COVID-19 and HIV/AIDS. Majority of the people living in the surrounding of the Project, and potential labor are not aware of the source, mode of communication or consequences of HIV/AIDS. Although their religious and cultural value system, to a large extent excludes the outbreak or rapid communication of COVID-19 and HIV/AIDS, yet its occurrence in such a situation cannot be precluded. It is necessary that awareness and preventive campaigns are run from time to time in the labor camps and the field offices of the Project to prevent the communicable diseases. There is a chance of spreading of an epidemic of Coronavirus disease (COVID-19) due to close interaction of	The Contractor shall: • Arrange to run an active campaign, in the labor camp, to make people aware of the cause, mode of transmission and consequences of HIV/AIDS; • SOPs related to the construction industry advised by National Action Plan for COVID-19 Pakistan to control spreading of COVID-19, shall be implemented by the contractor and should be strictly monitored. Guideline for COVID-19 are attached as Annex-VIII; • Strengthen the existing local health and medical services for the benefit of labor as well as the surrounding villages; • Ensure cleanliness and hygienic conditions at the labor camp by ensuring proper drainage and suitable disposal of solid waste. Inoculation against Cholera will be arranged at intervals recommended by the Health Department; • Locating a labor camp at least away from the villages (local settlement), and • Keep all the camps, offices, material	• Implementation of HSE Plan • Use of PPEs • Community concerns record • Medical reports of worker	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	the labor force during construction not only among the workers but also in the area	depots, machinery yards and work sites open for the inspection of health and safety measures and related documents.			
35.	**Resource Conservation** The materials used in construction of proposed project would include coarse aggregates (crush), fine aggregates (sand), steel, water, asphalt, reinforcement and cement. Almost all the materials to be used in the construction of proposed Project are non-renewable and therefore their sustainable use is necessary for the future use. Fuel will be used to operate construction machinery and asphalt and batching plants. Sustainable use of energy resources is very important not only to continue future use but also to help to reduce air emissions. For conservation of energy, efficiency of the engines and burning processes is very important also to help to reduce air emissions.	• Diesel and fuels with low sulphur content should be used to operate construction machinery and equipment's; • The efficient and well maintained equipment's and machinery should be used; • The equipment and machinery should be turned off when not in use; • Regular maintenance of machinery to avoid fuel leakages; • Reduction of wastage of water through training of workers involved in water use should be planned; • Plan for reuse of construction waste materials may be formulated; • A good camp design and an efficient worksite management plan should be prepared that may help the contractor to reduce the water demand, and wastewater and solid waste volumes to the lowest levels; and • Use of solar panels at camp sites to conserve energy. • The Resources Conservation Plan is attached as **Annex-IX**.	• Audits and Checks	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
36.	**Gender Based Violence (GBV)** In the society, female plays important role in managing household as well as in income earning activities, but they face various challenges to get access to educational institutions and employment opportunities due to cultural bindings, economic vulnerability and lack of facilities. Issues of gender violence may arise in the project area due to labour influx.	• Awareness should be created among the females at individual and community levels about the constructions sites; • During the timing of educational institutions workers should not be allowed to crowd in the surroundings; • Alternative routes for pedestrian should be provided to avoid mixing of women with workers; • Gender protection act should strictly be enforced during the construction activities in the Project Area, and monitor the implementation through field staff; • Raise awareness among the communities of the potential risks of GBV, and establish response services in the communities that can respond to instances of GBV (particularly those related to issues of labor influx); • The Contractor should make sure that no discrimination is made on the basis of gender while hiring of workers. Complete SOPs should be formed and implemented by the contactor regarding working women at site. Implementation on these SOPs should be monitored by the implementation Consultants. • Provisions of gender disaggregate bathing, changing, and sanitation facilities; and	• Audits and Checks	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		• Contractor should take proper measures to address and resolve issues relating to harassment, intimidation, and exploitation, especially in relation to women.			
37.	**Child Labor** There are two basic conventions on child labor adopted by the ILO, and one adopted by the United Nations. The ILO Minimum Age Convention, 1973 (No. 138) and its accompanying Recommendation (No. 146) set the goal of elimination of child labor, and the basic minimum age for employment or work (in developing countries at 14 years of age or the end of compulsory schooling, whichever is higher; and 15 or the end of compulsory schooling for developed countries). The Convention sets a minimum age of 2 years younger for "light work," i.e., 12 and 13 years, respectively; and a higher minimum age for dangerous or hazardous work (basically 18 years of age, but 16 in certain circumstances). The Convention also has various other flexibility clauses.	• Awareness should be created among the local communities about the adverse impacts of child labor. For the public awareness, meetings should be held in the Project Area, and announcements should be made using the available local platforms with the involvement of all sectors of the society; • Contractor through contractual agreement should be bound to follow the labor standards, rules and regulations during hiring the labor force and all activities should be monitored by the social and environmental staff of the implementing agency; • Client and Supervision consultant should ensure that contractor shall have its employment policy in accordance with relevant act and labor policies in Punjab and Pakistan; and • Contractor should ensure the presence of all persons at site are adults and have their proper identity cards with them. • Reduce or eliminate the worst forms	•		

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		of child labor and rescue and rehabilitate the children in the worst forms of child labor. • Penalize contractors/employees using the worst forms of child labor and penalize adults who violate children's rights and who force children to enter child labor, especially in its worst forms. • Reduce the health hazards and dangers to young persons in the workplace. •			
38.	**Discovery of Heritage Sites/ Structures during Excavation** During excavation, there is a chance of finding artifacts. In case of finding any artifact, the contractor shall immediately report through Supervision Consultant to Directorate General (DG) of Archeology, Government of Punjab to take further suitable action to preserve those antiques or sensitive remains.	• Chance finds procedure (given in **Annex-X**) shall be adopted in case of any accidental discovery of cultural heritage.	• Implementation of chance find procedure	Construction Contractor	SC, Proponent
39.	**Flora** The project will involve destruction of vegetation cover on construction areas particularly along proposed project construction. It is initially examined that approximately 97 mature, sub-mature, of	• Cutting of trees and disturbance of trees shall be avoided as far as possible and select the alternate route for the proposed project as the impact on local ecosystem (especially trees) is expected as high. So, that negative effects on the process of natural regeneration of species are minimized	• Implementation of Tree Plantation Plan • Visual Observations	Construction Contractor in association with CDA or Forest Department	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	different tree/plants species may be disturbed (as per data from GIS) and physical verification by ground trothing. Moreover, exhaust of noxious gases from movement of heavy machinery and dust will pollute air which will adversely affect health and vigor of plants. During construction activities the Contractor's workers may damage the vegetation and trees (for use as fire-wood to fulfill the camps requirements). Overall, it can be stated that the large number of trees may be damaged in the proposed project activities.	and if possible an alternate area may be considered for proposed project, in which minimum ecological and environmental losses are expected; • Trees should be replanted or transplanted wherever possible, instead of cutting; • Tree plantation plan/ Afforestation Plan should be implemented preferably in the project area or nearby blank spaces within 500m radius possibly; • A tree plantation program shall be formulated with the recommendations and technical support of Forest Department; • NOC for tree cutting from the concerned authority is mandatory; • As a principal of 1:10, ten trees shall be planted in place of felling of one tree in consideration of mortality; • The proponent shall implement the program with the help of CDA and Forest Department and in consultation with concerned consultant ecologist; • Open fires should be banned in the area to avoid hazards of fire in the area; • Clearing of vegetation cannot be avoided at the areas specified for project structures, but damage to the natural vegetation may be minimized by establishing camp sites, workshops and batching plants on waste / barren			

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		land rather than on forested or green land; • However, if such type of land is not available, it shall be ensured that minimum clearing of the vegetation is carried out and minimum damage is caused to trees and undergrowth; • Construction vehicles, machinery and equipment will remain confined within their designated areas of movement; • The Contractor's staff and labor shall be strictly directed not to damage any vegetation such as trees or bushes; and • Contractor shall provide gas cylinders at the camps for cooking purposes and cutting of trees/bushes for fuel shall not be allowed.			
40.	**Fauna** During construction phase the existing population of birds, mammals and reptiles of the construction areas will be affected due to disturbance arising from construction activities involving excavation, movement of machinery and vehicular traffic, movement of labor, camping, etc. The existing fauna will leave the directly affected areas due to construction activities and human intervention. Some animals particularly	• Care shall be taken during construction activities for avoiding purposely or chance killing of animals; • If any wild species and habitat is found during construction, it must be dealt carefully and local wildlife department officials should be informed; • Hunting, poaching and harassing of animals shall be strictly prohibited, and Contractor shall be required to instruct and supervise its labor force accordingly and clear orders should be given in this regard; • The Contractor must be held	• Visual Observations	Construction Contractor	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	reptiles may get killed during the earthworks operations. Moreover, the movements of the mammals and reptiles will be restricted during the construction phase. Birds as well will tend to move away from the construction areas and find shelter and food elsewhere due to the activities mentioned above for fear of being hunted / trapped. Noise generated from machinery particularly during the night hours will even scare the wildlife residing in habitats located at some distance from the construction areas. Uncontrolled blasting may even disturb the fauna of the Project Area. Food and refuse at the Contractor's camps may attract animals that might in turn be hunted by the workers	responsible for instructing his work force accordingly and for enforcing this restriction. In addition, this shall have to be controlled by the Wildlife Department; • Special measures shall be adopted to minimize impacts on the wild birds, such as avoiding noise generating activities during the critical periods of breeding; • Noise generating activities shall not be carried out during the night by the work force; • Wastes of the camps shall be properly disposed of to prevent it being eaten by animals, as it may be hazardous to them; and • Noise produced due to construction activities may be kept to acceptable level.			
41.	**Loss of Habitat** Loss of wildlife and wildlife habitat is occurred both from direct and indirect activities associated with the proposed development. Alteration, fragmentation, or destruction of wildlife habitat can result in the direct loss or displacement	• It is highly recommended to avoid tree cutting in all the protected areas, Limit clearance of vegetation only to unavoidable areas. If it is unavoidable to cut trees in protected areas, then protected areas clearance procedure should be adopted. • Avoid blasting/construction activities during the breeding season of	• Implementation of Tree Plantation Plan • Visual Observations	Construction Contractor in association with CDA or Forest Department	Proponent, SC

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	of species and the ability of the ecosystem to support other biological resources such as the plant communities upon which the wildlife relied for survival. Mammals and birds seemed to avoid infrastructure in open areas over larger distances compared to forested areas. The construction work gives raise to landslides and other forms of erosion in steep forested landscapes. During the construction period, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the vicinity of project area. The operation of equipment will generate significant noise, especially during blasting which will have adverse impact on wildlife of the area. The noise may scare the fauna and force them to migrate to other areas.	resident birds from May to June after ensuring the presence of nests in the area. In the absence of nests (Ground or Tree nests) construction activities can be continued. • Afforestation plan must be implemented in true sense to restore the habitats of avifauna; • Carryout extensive reforestation and afforestation plan of the disturbed areas after construction activities; • Afforestation will be done in those areas in which there is low forest cover or in areas which have been clearly felled and leave barren. • Afforestation is highly important to maintain the biodiversity and ecological balances. • Avoidance of unnecessary revolving of engines and switch off equipment when not required. • Using enclosures for noisy equipment such as pumps or generators. • Minimizing the drop height of materials. • Special measures need to be adopted to minimize impacts on important resources, such as activities during critical periods of migration, breeding and feeding of birds and other wild animals. • Ecological expert from consultant should accompany with the contractor during construction phase in order to			

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		identify trees of high value regarding trees of large foliage which is suitable for wildlife and avifauna habitat. •			
42.	**Social/ Cultural Conflicts** During the construction phase of the project, conflicts may arise between labor force and Local communities that exists near the Project Area. Use of local resources (existing infrastructure and utilities) by the construction workers can generate stress on the local residents. Furthermore, difference in cultural values may also cause discomfort to local residents.	• Local labor should be preferably employed for the construction works; • Careful planning and training of work force to minimize disturbance to the local people; and • Public notification through print or electronic media during the entire construction phase to avoid any inconvenience in accessibility to the locals.	• Visual observations • Regular monitoring, audit and checks	Construction Contractor	Proponent, SC
		O&M Phase			
43.	**Surface Water** Surface water pollution during the operating period comes primarily from untreated sewage effluent discharged by passing train, which then washes into local surface waters.	• A spill contingency plan and good maintenance of track and rolling stock will help reduce the risk of accidental spills, and permit rapid action if an accident does occur. • All wastewater should be treated until it conforms to applicable discharge standards. Treatment may include septic tanks, oil separators, or connection to an existing municipal system.	• Regular monitoring, sampling and testing • Regular monitoring, audit and checks	Proponent	
44.	**Waste Generation**	• A comprehensive solid waste management system should be	• Implementation of WMP	Proponent	

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
	Solid wastes would generate from stations and maintenance facilities. The solid waste during operational phase will consist of food remains, plastics, metal and organic wastes littered by railway service users. Such wastes can cause blockage to drainage systems, chocking of water bodies and negative impacts on animal health. Some of these waste materials especially plastics/ polythene which are not biodegradable may cause long term injuries effects on the environment. Hazardous wastes could be generated during operation of the project due to accidental spillages impacting soil, groundwater, and adjacent water bodies	formulated for the operation phase; Waste storage containers with color coding should be placed at designated locations; • PMA should employee sanitary workers or hire contractor for waste collection and allocate budget for it; • Waste segregation should be done at source and requisite planning needs to be done to implement the segregation techniques through residents and commercial building users; • The biodegradable waste may be processed, treated and disposed of through composting as far as possible. The residual waste should be given to waste collectors or a certified third party contractor for final disposal at the designated landfill site; • Daily housekeeping of stations, roads and parks should be carried out to minimize the generation of waste. • Schedule inspection of the railway tracks to keep it clean and to identify any hazardous material.	• Regular monitoring, sampling and testing • Regular monitoring, audit and checks		
45.	**Emergency Preparedness and Response** During the operation phase, emergencies like fire and disasters such as earthquakes and flooding may occur.	• An Emergency Response Plans for storm flooding, earthquakes, and manmade disasters must be developed by the PMA, in close consultation with Fire Fighting Department (FFD), Rescue 1122	• Implementation of ERP • Plans for staff Training • Regular audit and checks	Proponent	

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		Services and Provincial Disaster Management Authority (PDMA); • Training of management staff and employees regarding the emergency procedures and plans should be regularly conducted; • Responsible person to implement the Emergency Response Plan should be clearly designated; • Emergency numbers should be clearly posted, so that a quick action is taken when an emergency arises; • Firefighting machinery and vehicles should be maintained regularly; and • Regular drills for fire emergencies should be carried out.			
46.	**Flora** During the operational phase of the proposed project, no significant impacts are envisaged or release of any significant pressure detrimental to flora. A reduced number of vehicles on the roads will lead to lower emissions of flue gases from both private and public transport passing through the project area, thereby contributing to improved air quality.	• The implementation of afforestation/plantation plan recommend in compensation for cutting of trees should start during operational stage, to ensure the ecological balance and to avoid any impact on local Environment; • Compensation to the forest department will be made according to the standard markets rate of standing volume for each tree. • The Forest and Wildlife Departments should implement afforestation and habitat enhancement programs in collaboration with local communities, developing nurseries, propagating plant stock, supervising planting	• Tree plantation plan • Visual observations • Audit and Checks	Proponent in association with PHA or Forest Department	

Sr. No.	Impacts	Mitigation Measure	Performance Monitoring Indicators	Responsibility	
				Implementation	Monitoring
		programs and undertaking aftercare/maintenance programs. • Hunting of wild animals and birds will be strictly prohibited; • It is highly recommended to avoid the reserve, protected forests, national park areas, critical sensitive habitats and the legally notified and ecologically important zones. • Proper check and balance of above mentioned activities is highly recommended. • Maintenance and security of the plantation should be done for at-least five years.			

KEY

DC	Design Consultant
CC	Construction Contractor
SC	Supervision Consultant
PMA	Punjab Mass Transit Authority

7.6 ENVIRONMENTAL MONITORING

Environmental Monitoring is undertaken during both the construction and operational phases, to ensure the effectiveness of the proposed mitigation measures against identified adverse environmental impacts in the EIA report.

The main objectives of the construction phase monitoring plan will be to:

- Monitor the actual impact of the works on the project site physical, biological and socio-economic receptors;
- Recommend mitigation measures for any unexpected impact or where the impact level exceeds the anticipated impact;
- Ensure compliance with legal obligations including safety on construction site; and
- Monitor the rehabilitation of borrow areas and the restoration of construction campsites as described in the EMMP; and
- Ensure the safe disposal of excess construction materials.

The main objectives of monitoring during the operational phase will be to:

- Appraise the adequacy of the EIA with respect to the Project's predicted long term impacts of operation on physical, biological and socio-economic environment;
- Evaluate the effectiveness of the mitigation measures proposed in the EMMP and recommend improvements, if and when necessary; and
- Compile periodic Environmental Monitoring reports on the basis of recommendations in EMMP.

7.6.1 Monitoring Strategy

Under the proposed monitoring strategy, it is recommended PMA should be responsible for all the monitoring activities. All the findings and results in the form of monitoring report will be finally shared with Punjab-EPA. The monitoring program has been designed carefully considering the identified impacts mentioned in Chapter-6. Table 7.2 provides environmental monitoring schedule for construction and operations stages of the proposed Project.

7.6.2 Budget Estimate for Environmental Monitoring and Compliance

Budget Estimate for Environmental Monitoring and Compliance during the Construction and Operation Phase has been summarized in Table 7.3.

Table 7.2: Environmental Monitoring Schedule

Sr. No.	Receptors	Monitoring Parameters / Performance Indicator	Location	Monitoring Mechanism	Monitoring and Reporting Frequency	Responsibility	Duration
1.	Water Resources/ Water Quality	Monitoring of Physical, Chemical and Biological parameters and its compliance with PEQS, 2016 for surface water and drinking water.	• Major receptors are Drains, distributaries and commercial / residential areas within the AOI of the proposed project. • Other proposed effluent discharge points are: ▪ Contractors camps; ▪ Concrete preparation plants; ▪ Fuel (Petrol. Oil and Grease) products storages; and ▪ Vehicle and machines repairing and servicing yards.	• Visual checks of laboratory activities; and • Discrete grab sampling and laboratory testing of water samples by EPA-Punjab Certified Laboratory for monitoring.	• Once before the start of construction activities; • On quarterly basis during the construction phase; • Bi-annually for at least one year during O&M phase; and • Visual inspection daily.	• PMA • Contractor • PMA	• As per PEQS, 2016.
2.	Soil Contamination	Soil contamination due to effluent / surface runoff and uncontrolled solid waste disposal activities at sites.	• Proposed Project Area; and • Other proposed sampling sites are: ▪ Construction camps; ▪ Equipment washing yards; ▪ Spillage points of fuel, chemicals and lubricants.	• Visual observations and checking of laboratory activities; • Sampling and laboratory testing for soil samples.	• Once before the start of construction activities; • On quarterly basis during the construction phase; • Bi-annually for at least one year during O&M phase; and • Visual inspection daily.	• PMA • Contractor • PMA	

Sr. No.	Receptors	Monitoring Parameters / Performance Indicator	Location	Monitoring Mechanism	Monitoring and Reporting Frequency	Responsibility	Duration
3.	Dust Emissions	Monitoring of PM_{10} and $PM_{2.5}$ and its compliance with PEQS, 2016 for Ambient Air.	Sensitive receptors (residential area, educational and health institutions, religious places and construction camps) within the AOI of the proposed project.	• Visual checks of laboratory activities; • Onsite Ambient Air Monitoring Equipment; and • Daily visual monitoring of dust emissions at construction route.	• Once before the start of construction activities; • On quarterly basis during the construction phase; and • Bi-annually for at least one year during O&M phase.	• PMA • Contractor • PMA	
4.	Noise Pollution	Monitoring of Noise Level and its compliance with PEQS 2016 for Noise.	Sensitive receptors (residential area, educational and health institutions, religious places and construction camps) within the AOI of the proposed project.	• Visual checks of laboratory activities; and • Onsite Noise Monitoring using Sound Meter.	• Once before the start of construction activities; • On quarterly basis during the construction phase; and • Bi-annually for at least one year during O&M phase.	• PMA • Contractor • PMA	
5.	Fumes and gases	Monitoring of CO, CO_2, SOx, NO_x, Lead and $PM_{2.5}$ PM_{10}, Vehicular emissions and its compliance with PEQS 2016.	Sensitive receptors (concrete plants, construction camps and vehicular emissions) within the AOI of the proposed project.	• Visual checks of laboratory activities; • Onsite Ambient Air Monitoring Equipment; and • Daily visual monitoring of dust emissions at construction route.	• Once before the start of construction activities; • On quarterly basis during the construction phase; and • Bi-annually for at least one year during O&M phase.	• PMA • Contractor • PMA	

Sr. No.	Receptors	Monitoring Parameters / Performance Indicator	Location	Monitoring Mechanism	Monitoring and Reporting Frequency	Responsibility	Duration
6.	Ecological Resources	Disturbance to natural habitat and uncontrolled floral cutting which can be avoidable.	Natural habitats within the AOI of the proposed project.	• Visual checks to ensure that only marked trees are cut within the Project corridor; and • Monitoring of Wildlife / birds hunting.	• Once before the start of construction activities; and • Visual inspection daily / weekly during construction and O&M phase.	• PMA • Contractor • PMA	
7.	Safety of workers	Medical record of workers	Construction site.	• Checking of accident/ near miss records. • Medical surveillance of Construction workers	• On quarterly basis during the construction phase.	• Contractor	
8.	Restoration of work sites	Site cleared and no solid and construction waste in the study area	Construction site and camp sites	• Visual inspection	• After completion of construction work	• Contractor	

7.6.3 Responsibilities for Environmental Testing and Reporting

The Construction Contractor (CC) will be responsible for environmental monitoring and reporting throughout the construction phase under the supervision of Environmental Engineer of Supervision Consultant (SC); in coordination with Project Director, PMA. During construction phase, environmental testing reports will be prepared on quarterly basis and one comprehensive report will be prepared at the end of the construction phase and will be submitted to each of the following authorities and institutions: (i) PMA and (ii) EPA- Punjab.

During the first year of the project operation, concessionaire will be responsible to conduct environmental testing and monitoring along with its cost through a third party contractor and EPA-Punjab certified lab. The reports will be prepared biannually and one comprehensive report will be prepared annually and submitted to the EPA-Punjab. Contents of the final report will include results of environmental monitoring in comparison to the standards for the various parameters, location and sampling time along with recommendations for the future environmental testing and monitoring.

7.6.4 Budget Estimate for Environmental Monitoring and Compliance

Budget Estimate for Environmental Monitoring and Compliance during the Construction and Operation Phase has been summarized in Table 7.3.

Table 7.3: Budget Estimate for Environmental Monitoring and Compliance during the Construction and Operation Phase

Components	Parameters	Quantity (No. of samples x No. of Locations x Frequency)	Frequency	Responsibility	Duration	Cost (Rs.)
A) Construction Phase (24 Months)						
Ambient Air Quality	CO, NO_2, SO_2, Lead, SPM, $PM_{2.5}$ and PM_{10}	1x4x8= 32	Quarterly @ Rs. 30,000 per sample	CC and SC	24 hours	960,000/-
Noise Level	Day and night time levels on dB (A) Scale (min-max)	1x4x8= 32	Quarterly @ Rs. 2,000 per point	CC and SC	24 hours	64,000/-
Drinking Water Quality	**Physical Parameters:** Color, pH, Taste, Odour, Turbidity, Total Hardness as Calcium Carbonate and Total Dissolved Solids **Biological Parameters:** E. Coliform, Fecal Coliform and Total Coliform **Chemical Parameters:** Aluminum, Antimony, Arsenic, Barium, Cadmium, Chloride, Chromium, Copper, Cyanide, Fluoride, Lead, Manganese, Mercury, Nickel, Nitrate, Nitrite, Selenium, Residual Chlorine, Zinc and Phenolic Compounds	1x4x8= 32	Quarterly @ Rs. 20,000 per sample	CC and SC	-	640,000/-
Surface Water Quality	**Physical Parameters:** Temperature, pH, Color, Total Dissolved Solids, and Total	1x4x8= 32	Quarterly @ Rs. 20,000 per sample	CC and SC	-	640,000/-

Components	Parameters	Quantity (No. of samples x No. of Locations x Frequency)	Frequency	Responsibility	Duration	Cost (Rs.)
	Suspended Solids **Biological Parameters:** Biochemical Oxygen Demand, Chemical Oxygen Demand, and Fecal Coli **Chemical Parameters:** Grease and Oil, Lead, Phenolic compounds, Cyanide, Chloride, Fluoride, Anionic Detergents, Sulphate, Sulphide, Ammonia, Calcium, Cadmium, Chromium, Copper, Mercury, Selenium, Nickel, Silver, Zinc, Arsenic, Barium, Iron, Manganese, Boron and Total chloride					
					TOTAL (A) =	***2,304,000/-***
B) Operation Phase (12 Months)						
Ambient Air Quality	CO, NO_2, SO_2, Lead, SPM, $PM_{2.5}$ and PM_{10}	1x4x2 = 8	Biannually @ Rs. 30,000 per sample	PMA	24 hours	240,000/-
Noise Level	Day and night time levels on dB (A) Scale (min-max)	1x4x2 = 8	Biannually @ Rs. 2,000 per point	PMA	24 hours	16,000/-
Drinking Water Quality	**Physical Parameters:** Color, pH, Taste, Odour, Turbidity, Total Hardness as Calcium Carbonate and Total	1x4x2 = 8	Biannually @ Rs. 20,000 per point	PMA	-	160,000/-

Components	Parameters	Quantity (No. of samples x No. of Locations x Frequency)	Frequency	Responsibility	Duration	Cost (Rs.)
	Dissolved Solids **Biological Parameters:** E. Coliform, Fecal Coliform and Total Coliform **Chemical Parameters:** Aluminum, Antimony, Arsenic, Barium, Cadmium, Chloride, Chromium, Copper, Cyanide, Fluoride, Lead, Manganese, Mercury, Nickel, Nitrate, Nitrite, Selenium, Residual Chlorine, Zinc and Phenolic Compounds					
Surface Water Quality	**Physical Parameters:** Temperature, pH, Color, Total Dissolved Solids, and Total Suspended Solids **Biological Parameters:** Biochemical Oxygen Demand, Chemical Oxygen Demand, and Fecal Coli **Chemical Parameters:** Grease and Oil, Lead, Phenolic compounds, Cyanide, Chloride, Fluoride, Anionic Detergents, Sulphate, Sulphide, Ammonia, Calcium, Cadmium, Chromium, Copper, Mercury, Selenium,	1x4x2 = 8	Biannually @ Rs. 20,000 per point	PMA	-	160,000/-

Components	Parameters	Quantity (No. of samples x No. of Locations x Frequency)	Frequency	Responsibility	Duration	Cost (Rs.)
	Nickel, Silver, Zinc, Arsenic, Barium, Iron, Manganese, Boron and Total chloride					
					TOTAL (B) =	***576,000/-***
					GRAND TOTAL (A+B) =	***2,880,000/-***

KEY

CC Construction Contractor SC Supervision Consultant

PMA Punjab Mass Transit Authority

Notes:

- Provision must be given in annual budget of operation phase for environmental monitoring. For this, the cost of operation phase (i.e. Rs. 576,000/-) must be considered with an annual increment of 10%.
- All the environmental parameters will be analyzed as per Punjab Environmental Quality Standards (PEQS), 2016/NEQS 2010.

7.7 TREE PLANTATION

To minimize the negative impacts arising due to clearance of vegetation cover, Afforestation Plan/Plantation Plan shall be carried out by the Client in coordination with Forest Department/CDA, which has the requisite expertise and experience for such tasks. Detailed Tree Plantation Plan will be prepared after quantitative assessment of tree cutting involved for proposed project during design stage.

7.8 TRAINING AND CAPACITY BUILDING

An environmental and social training and technical assistance (TA) program is to be carried out before the implementation of the proposed project as it strengthens the institutional capacity required to manage the environmental and social issues. Contractor's environmental awareness and appropriate knowledge of environmental protection is critical to the successful implementation of the EMP because without appropriate environmental awareness, knowledge, and skills required for the implementation of the mitigation measures, it would be difficult for the Contractor(s) workforce to implement effective environmental protection measures.

pma will be responsible to engage TA consultant to conduct environmental and social training programs. The objective of the TA will be as follows:

- To help in establishment of appropriate systems;
- To train senior PMA staff, Contractor and Sub-Contractor workers and Supervision Consultant employees, responsible for managing environment and social tasks and planning during construction and post construction phase; and
- Training courses on specialized areas such as air, water and noise pollution monitoring.

Table 7.4 provides brief detail of the capacity building and training plan for the proposed project.

Table 7.4: Capacity Building Programs and Technical Assistance Services

Provided by	Contents	Trainees	Duration
TA Individuals, Consultants and Organizations specializing in Environmental Management and Monitoring	Short Seminars and Courses on: • Environmental laws and regulations; • Environmental Sustainability; and • Environmental Management and Monitoring Plan (EMMP)	Environmental staff of contractor and SC, PMA Staff and Contractor Workers	3 Days
TA Individuals, Consultants and Organizations specializing in Social Management and Monitoring, and Occupational Health and	Short Seminars and Courses on: • Occupational Health and Safety Plan (OHS); • Basic First Aid; • Occupational and Community Health and Safety Management;	Environmental staff of contractor and SC, PMA Staff and Contractor	3 Days

Provided by	Contents	Trainees	Duration
Safety	• Labour Camp Management; • Traffic Management; • COVID-19 Protection and Control; • Use and Importance of Personal Protective Equipment's (PPEs); and • Fire Safety and Emergency Response Measures.	Workers	
TA Individuals, Consultants and Organizations specializing in Environmental and Social Management and Monitoring	Short Seminars and Courses on: • Environmental Management Plan (EMP); • Environment Health and Safety Management; • Occupational Health and Safety; • Basic First Aid; • Waste Management; • Fire Safety and Emergency Response Measures; • Electrical Safety; and • Use and Importance of Personal Protective Equipment's (PPEs)	Operation and Maintenance Staff of PMA	3 Days

7.9 COMMUNICATION & DOCUMENTATION

Communication and documentation is an essential feature of EMP. The key features of such mechanism are:

7.9.1 Data Recording and Maintenance

All forms to be used for recording information during the environmental monitoring will follow a standard format which will correspond to the data base in to which all the gathered information will be placed. Check boxes will be used as much as possible to facilitate data entry. Tracking system will be developed for each form.

7.9.2 Database

The database may include the following information:

- Training programs;
- Staff deployment;
- Non-compliances;
- Corrective actions
- List of environmental data; and
- List of environmental data to be maintained:
  - Soil and land pollution;
  - Disposal of waste;
  - Water resources;

- Fuel oil and chemical spills;
- Vegetation record;
- Noise pollution;
- Air and dust pollution;
- Socio-economic data; and
- Ecological sensitivities.

7.9.3 Meetings and Reporting

Monthly meetings will be held at site during the construction phase. The purpose of these meetings will be to discuss the routine activities, non-compliances and their remedial measures. Various reports will also be produced at periodic time intervals, as provided in **Table 7.5** along with information regarding persons responsible for report preparation and review process. Additionally, minutes of meeting will also be submitted as part of routine environmental reports.

Table 7.5: Periodic Reporting Mechanism

Sr. No.	Report Category	Prepared by	Reviewed by
1	Monthly	Contractors' environmental staff	PMA / SC
2	Quarterly	Contractors' environmental staff	PMA / SC
3	Semi-Annual Environmental Monitoring Report (SAEMR)	Construction Supervision Consultant (CSC)	PMA / SC
4	Annual Report	Contractors' environmental staff	PMA / SC
5	Completion Report	Contractors' environmental staff	PMA / SC

7.9.4 Social Complaint Register

The Contractor will maintain a register of complaints record from local communities and measures taken to mitigate these concerns.

7.9.5 Photographic Records

Contractors will maintain photographic records during the implementation of the proposed Project. As a minimum, the photographic records will include the site photographs, all the roads, camp sites and monitoring activities, etc.

7.9.6 Non-Compliance of the EMP

The implementation of the proposed EMP involves inputs from various functionaries. The Contractor will be primarily responsible for ensuring implementation of the mitigation measures proposed in the EMP, which will be part of the contract documents. The provision of the environmental mitigation cost will be made in the total cost of Project, for which the Contractor will be paid on the basis of monthly compliance reports. However, if the Contractor fails to comply with the implementation of EMP and submission of the monthly

compliance reports, deductions will be made from the payments to the Contractor claimed under the heads of environmental components.

7.9.7 Review of Recorded Data

All the data and communication recorded and maintained by the Contractor will be periodically reviewed and checked by SC and PMA and necessary action will be recommended to Contractor to improve the recording and documentation.

7.10 MANAGEMENT PLANS

Various site-specific management plans will be prepared by Contractor as a part of EMP for the better management and implementation of EMP during all phases of the proposed Project. However, approval of these site-specific plans from PMA should be sought before start of construction activities. These site-specific plans are listed below but not limited to these:

- Tree Plantation / Reforestation Plan;
- Health, Safety and Environment (HSE) Management Plan;
- Emergency Preparedness and Response Plan;
- Site Restoration and Rehabilitation Plan;
- Waste Management Plan;
- Drinking Water Supply and Sanitation Plan
- Traffic Management Plan;
- Change Management Plan
- Quarry Management Plan; and
- Resource Conservation Plan.

7.11 PUBLIC DISCLOSURE

PMA will disclose this EIA to all the stakeholders prior to the start of the construction. This report will be made available to the stakeholders at places as designated by the PEPA. In addition, executive summary of the Report will be translated into Urdu language and made available to the affected communities and locals. The copies will also be kept at construction site for ease in accessibility of the locals. This will ensure the locals to be aware of the Project impacts, its mitigation, responsible staff and mode of implementation. In addition, the executive summary will also be published on PMA website.

7.12 EMP COST

The contractor will be responsible for implementation of mitigation measures and environmental Monitoring during construction phase, whereas PMA will be responsible for implementation of mitigation measures and environmental Monitoring during operation phase. For an effective implementation of environmental mitigation measures during construction and operational phase, it is very important to provide sufficient funds for the implementation of environmental and social mitigation measures, monitoring and training.

8 CONCLUSION AND RECOMMENDATIONS

8.1 GENERAL

The EIA report has been prepared in accordance with the requirements of the Pak-EPA Environmental Protection Act, 1997 and Punjab Environmental Protection Act, 2017 (Amended) and Review of IEE/EIA Regulations, 2022 and Pakistan EIA procedures.

8.2 CONCLUSION

Significant efforts were made to identify the main physical, ecological, social, cultural and environmental issues related to the construction and operation of the proposed Project. Various stakeholders including government departments and agencies were also contacted for obtaining salient information in this regard along with that from area residents.

During the pre-construction, construction and operational phases, following are the main issues and concerns:

- Removal of forest cover and clearance of vegetation;
- Disturbance to wildlife and wildlife habitat;
- Issues of geo-hazards and slope stability;
- Disturbance to the public movement and cultural norms during construction;
- Reduction in the daily routine activities of local residents during construction;
- Noise and air pollution due to the working of construction machinery during construction and traffic operation phases of the Project;
- Solid waste and wastewater generation during construction phase;
- Oil spillages from construction machinery, resulting in soil and groundwater contamination;
- Occupational and community health and safety issues; and
- Solid waste handling and disposal and waste water generation and treatment during operation phase.

Results of the EIA Study have shown that there are no critical environmental impacts associated with the proposed project. However, several concerns / impacts with regard to physical, ecological and social environment have been identified in report which needs to be mitigated by strict implementation of Environmental Management Plan. These impacts could also be reduced by proper and well planned meticulous design of the facility and by implementing an appropriate tree plantation plan. In fact, in times of diminishing economic and natural resources, using sustainable approaches in an urban infrastructure will help us to enhance quality of life and serve the needs of the present leaving provision for future generations to meet their needs.

8.3 RECOMMENDATIONS

An Environmental Monitoring/Management Plan (EMP) for both phases (construction and operation) has been developed as part of the report which provides a detailed mitigation matrix that covers impacts, mitigation measures, roles and responsibilities and timings to avoid, minimize or mitigate the adverse impacts of the proposed project.

Based on the field visit, environmental monitoring and analysis of primary and secondary data, following recommendations have been conferred so that the Proponent gets the necessary direction and clarity to ensure efficient environment friendly and compliant operation:

- The construction of the proposed Project should be done in accordance to Seismic Building Code of Pakistan, 2007;
- Proper location(s) for construction camps should be selected by contractor in close coordination with PMA that cause minimal/no damage to the prevailing environmental conditions of the project area;
- Formulation and implementation of a comprehensive safety and security plan by contractor before the start of the construction activities for the camps which should be comprised of a training manual, use of safety equipment, emergency preparedness and code of ethics;
- Wearing of Personal Protective Equipment (PPEs) such as helmet, masks, adequate footwear for bituminous pavement works, protective goggles and gloves should be made compulsory during construction activities and formulation and implementation of Health and Safety Plan (HSP) for construction workers;
- Preparation and implementation of Solid Waste Management Plan during construction stage by contractor in close coordination with concerned authorities for collection, reuse, recycling and disposal of waste;
- Employment opportunities should be provided to local people for skilled and unskilled works during construction stage;
- A provision of adequate budget in the overall cost of the Project for afforestation plan as per guidelines of the concerned departments;
- Soil contamination should be controlled by proper storage of chemicals;
- Surface runoff and wastewater generated during construction stage should be controlled and collected in septic tanks and soakage pits;
- Dust and fugitive emissions should be controlled by maintenance of equipment, fine tuning of the vehicles and regular sprinkling of water on soil;
- Noise and vibration should be controlled by equipment maintenance, by providing noise barrier and by scheduling the construction activities to avoid peak activity hours in the area;
- A comprehensive solid waste management plan to cater the waste during operation phase; and
- For effective implementation of suggested mitigation measures, the environmental mitigation and monitoring cost/EMP must be the part of the bidding document of the Contractor.



RECONNAISSANCE AND ROUTE SELECTION REPORT

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FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE

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1. Introduction and Background of Pakistan Railways Route: -

The Pakistan Railway Network forms the backbone of the country's intercity freight and passenger movement. Owned and operated by the Ministry of Railways, it serves as a strategic national asset, linking all four provinces and connecting major urban, industrial, and agricultural centers. The system is predominantly based on broad-gauge (1,676 mm) tracks and extends over approximately 7,800 kilometers, of which around 1,500 km is double-tracked. A very small portion of the railway was electrified in the 1960s–70s (e.g., Lahore–Khanewal), but that system is currently non-operational.

The network is organized around three primary arteries known as Main Lines. The most important among them is Main Line-1 (ML-1), which runs from Karachi to Peshawar via Hyderabad, Rohri, Multan, Lahore, and Rawalpindi. This corridor is the country's busiest and most commercially significant, supporting both heavy freight and long-distance passenger services. It is now being prioritized for full-scale modernization under the China–Pakistan Economic Corridor (CPEC), with plans to upgrade speed, safety, signaling systems, and track geometry to allow trains to run at speeds up to 160 km/h.

The Main Line-2 (ML-2) provides an alternate north–south route, starting from Kotri and passing through Dadu, Larkana, and Dera Ghazi Khan before reaching Attock in Punjab. It covers regions that are not served by ML-1 and offers redundancy for national connectivity. Similarly, Main Line-3 (ML-3) runs from Rohri to Chaman via Sibi and Quetta and is the only major rail corridor that penetrates Balochistan, a province that remains largely underserved. These corridors are essential not only for national cohesion but also for regional trade connectivity with Iran and Afghanistan.

Pakistan Railways has historically played a pivotal role in freight transport, especially for bulk commodities like oil, coal, fertilizers, and cement. However, over time, due to inadequate investments and competition from road transport, the rail freight market share has significantly declined. Today, freight accounts for only a small fraction of Pakistan

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Railway's revenue. Nevertheless, efforts are ongoing to revive freight services through private-public partnerships, dry port expansions, and more efficient terminal operations, especially in Lahore, Multan, and Karachi.

Passenger services continue to constitute the majority of railway operations. The network connects all major cities, and several express and intercity trains operate daily. Notable trains such as the Green Line Express (Karachi–Islamabad), Tezgam, and Khyber Mail offer long-distance services. Passenger trains are available in multiple classes: economy, air-conditioned, and business class. However, services are often criticized for being slow, unreliable, and poorly maintained, resulting in declining ridership over the years. This trend is being countered through digital ticketing systems, on-board improvements, and proposed high-speed corridors.

A crucial advantage of Pakistan's railway system is its potential for regional connectivity. Rail links to India via the Wagah–Attari (Samjhauta Express) and Khokhrapar–Munabao (Thar Express) existed until suspended in 2019 due to political tensions. The Quetta–Taftan route continues to link with Iran, forming part of the Economic Cooperation Organization (ECO) corridor that aims to enhance rail connectivity from Pakistan to Turkey and Central Asia. Proposed links to Afghanistan, especially via Chaman–Spin Boldak and Peshawar–Jalalabad, have strategic significance for trade and transit in the region.

The Government of Pakistan, under the Ministry of Railways, has outlined ambitious plans to revamp and modernize the network under its Vision 2025 and CPEC priorities. The flagship ML-1 Upgrade Project is valued at nearly $6.8 billion, aiming to improve safety, travel times, and operational efficiency. The project includes complete track rehabilitation, fencing, modern signaling, and upgraded stations. Once completed, ML-1 will form the spine of a modern, high-capacity north–south corridor for both freight and passenger movement.

Another strategic proposal is the Gwadar–Jacobabad rail link, part of the broader effort to connect the deep-sea port at Gwadar to the national rail network. This line would

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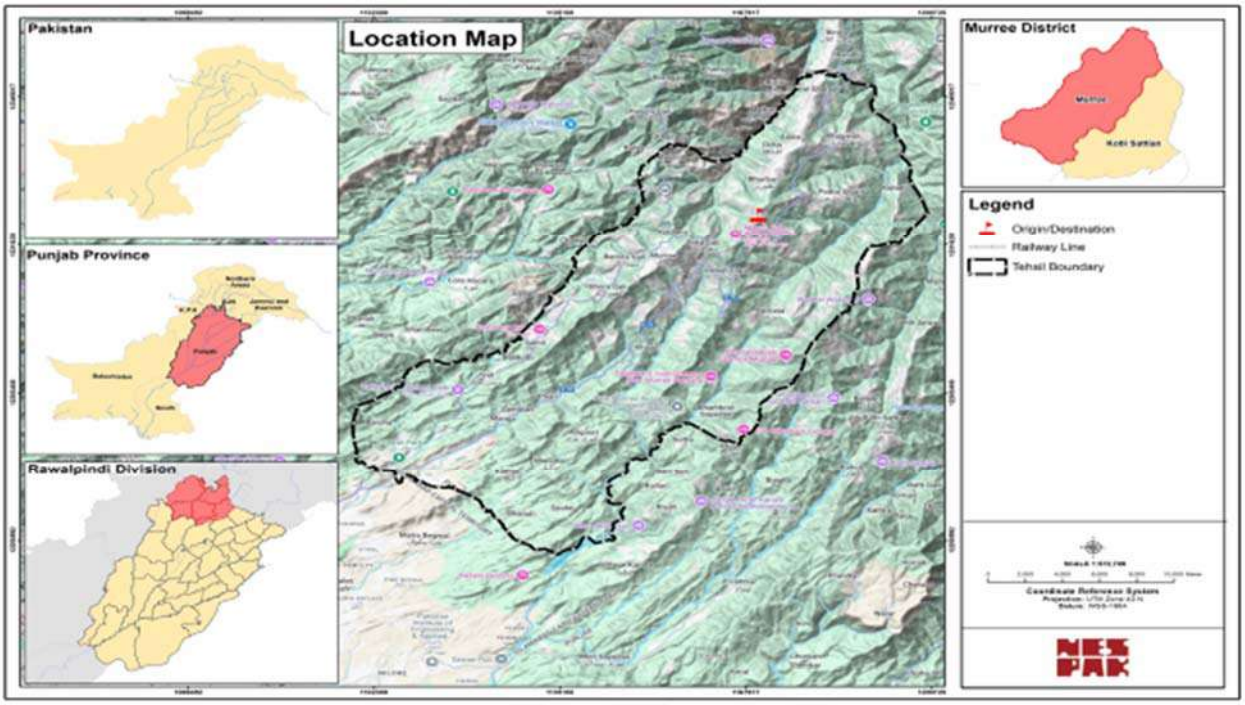
significantly improve port access for central Pakistan and reduce dependency on Karachi. It also enhances the long-term vision of connecting Gwadar to China's Xinjiang province via the Karakoram Highway, completing the land-based China–Pakistan trade corridor. However, these projects remain in early planning phases and require major financing and political coordination.

The current operational condition of Pakistan Railways is far from ideal. Much of the infrastructure, including bridges, signaling equipment, and rolling stock, is outdated or in need of urgent repair. Encroachments along right-of-way, theft, vandalism, and poor safety record have further reduced public confidence in the system. Revenue generation is weak, and the organization relies heavily on government subsidies to meet operational and pension costs. A lack of institutional reform and delays in project implementation remain major obstacles.

In conclusion, the Pakistan Railway Network remains a key component of national and regional mobility. With focused investments, modernization of infrastructure, and improved governance, the railway system can reclaim its role as a reliable and sustainable mode of transport. Projects under CPEC, especially ML-1 and the proposed Gwadar link, can transform Pakistan into a logistics hub linking South Asia, Central Asia, and the Middle East. However, the success of these initiatives depends on strategic planning, timely execution, and strong institutional reforms.

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Figure No. 1: Location Map of Murree



2. Existing Transportation Network and Route System: -

Rawalpindi is one of Pakistan's major metropolitan centers, serving as the twin city of the capital, Islamabad. The city is a hub of military, commercial, and administrative activity, and lies at the intersection of major national highways such as N-5 (GT Road) and N-75, as well as the Islamabad Expressway and Murree Road. It also has access to the M-1 and M-2 motorways, ensuring robust regional connectivity. The city is served by a dense local road network and is a terminus for multiple intercity and intra-city transport services.

Murree, a hill station located at an altitude of approximately 2,300 meters above sea level, is a prime tourist destination in Pakistan. It falls under the jurisdiction of the Rawalpindi District and is accessible via Murree Expressway (E-75) and Old Murree Road from Islamabad and Rawalpindi. Its importance increases during the summer and winter months, attracting over a million visitors annually due to its cool climate and scenic

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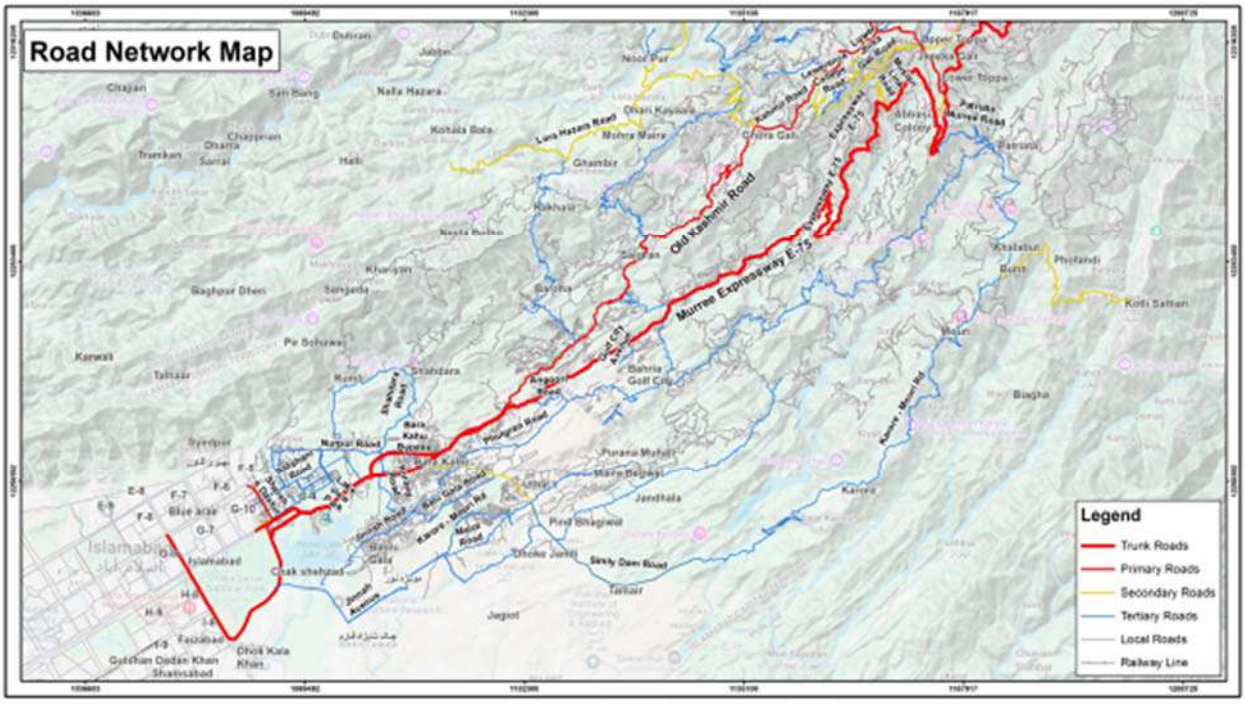
beauty. Despite its popularity, the access routes to Murree are limited and congested, particularly during peak tourist seasons.

Rawalpindi and Murree are primarily connected through two arterial routes: the Murree Expressway (E-75) and the Old Murree Road (N-75). Both roads traverse hilly terrain, with numerous hairpin turns and steep gradients. The Murree Expressway, developed as a modern dual carriageway, has improved travel conditions, but Old Murree Road remains in use due to its historical significance and closer access to central Murree. However, both roads converge in areas that frequently suffer from traffic jams, bottlenecks, and limited emergency response access.

Transport between Rawalpindi and Murree is primarily facilitated through private vehicles, vans, buses, and ride-hailing services. Public transport options are limited, with local buses and Hiace vans operating from major terminals in Rawalpindi such as Pirwadhai and Faizabad. The absence of a mass transit mode like rail limits capacity, increases vehicular load, and contributes to long travel times, pollution, and stress on the road infrastructure.

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Figure No. 2: - Existing Road Network Connecting two cities



The road between Rawalpindi and Murree is notoriously accident-prone, especially during winters when snowfall and fog reduce visibility. Over-speeding, brake failures, and driver fatigue on winding roads contribute to frequent accidents. The hilly terrain also makes road maintenance costly and vulnerable to landslides. While roads provide flexible access, their over-dependence leads to congestion, delayed emergency response, and higher environmental degradation. Thus, the current connectivity is neither safe nor sustainable for the level of demand.

Currently, there is no railway or air connectivity between Rawalpindi and Murree. Given Murree's geographical constraints and high elevation, air travel is unfeasible for regular public transport. This leaves rail as the only viable mass transit option that can sustainably move large numbers of tourists and local residents between the two cities. A rail corridor can absorb a significant portion of the seasonal traffic, reduce dependence on roads, and ensure safe, consistent, and climate-resilient mobility for future demands.

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The development of a dedicated tourist railway corridor between Rawalpindi and Murree is essential for long-term connectivity, tourism development, and environmental protection. The corridor would serve both economic and strategic objectives by providing year-round accessibility, enhancing regional integration, and promoting eco-tourism. Additionally, it would serve as a disaster-resilient route in case of road blockages due to landslides or snowstorms, thus maintaining uninterrupted access to this critical tourist region. A railway corridor from Rawalpindi to Murree offers several key advantages:

1. It has mass transit capability, allowing it to carry hundreds of passengers per train trip, making it ideal for handling large seasonal tourist volumes.
2. It is an environment-friendly mode of transport, producing significantly lower emissions per passenger compared to private vehicles or vans.
3. The railway can operate in all weather conditions, offering safer and more reliable travel even during snowfall, fog, or landslides that typically disrupt road traffic.
4. It provides a major boost to tourism, serving as an attractive and scenic travel option for both domestic and international visitors.
5. By offering a parallel mode of travel, the railway will help reduce road congestion on the Murree Expressway and Old Murree Road, especially during peak seasons.
6. The rail corridor enhances passenger safety, reducing the risks of road accidents that are common on steep and winding mountain roads.
7. It will creates economic opportunities by encouraging transit-oriented development and stimulating local economies through the creation of commercial zones near railway stations.

Route selection for the proposed rail corridor must consider topography, environmental sensitivity, urban sprawl, and access to existing transport hubs in Rawalpindi. Potential alignments should minimize deforestation and land acquisition impacts while ensuring maximum scenic and tourism value. The route must also integrate with Rawalpindi's urban terminals such as H-9 Railway Station or Faizabad and terminate at a location in Murree that can handle transit-oriented development and seasonal traffic surges without disrupting the town's core heritage areas.

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The growing demand, environmental cncerns, and safety issues necessitate a new, sustainable mode of transport. A dedicated tourist rail corridor addresses these challenges and aligns with national goals of climate resilience, regional development, and tourism enhancement. The next critical step is to evaluate and select the most feasible route, considering engineering, environmental, and socio-economic factors through satellite analysis, field reconnaissance, and stakeholder consultation.

3. Route Selection Criteria

The route selection criteria for the proposed Rawalpindi–Murree railway corridor is based on a combination of technical, environmental, and socio-economic factors. Key considerations include minimizing horizontal and vertical curvature to ensure operational safety and efficiency in the hilly terrain, avoiding geologically unstable zones prone to landslides, and selecting alignments with manageable gradients suitable for rail operations. Additionally, the route shall minimize forest disturbance, land acquisition, and resettlement impacts while ensuring proximity to population centers and tourist access points. Integration with existing transport hubs and future expansion are potential parameters. Following parameters were overviewed for the choosing the alignments

1. Route Alignment
2. Gradient and Curvature
3. Station Location
4. Passenger Experience
5. Environmental and Ecological Impact
6. Tunnel and Bridge Design
7. Safety and Security
8. Energy Efficiency and Sustainability
9. Financial and Operation Cost

1. Route Alignment

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The alignment shall be optimized to minimize construction in geologically unstable or environmentally sensitive areas, while also ensuring proximity to urban centers, resort zones, and access roads. Considering the mountainous terrain, the alignment must aim to reduce the need for excessive cut-and-fill operations while maintaining a smooth travel experience for passengers. The selection of the alignment will be based on a combination of satellite analysis, topographic surveys, and reconnaissance inputs.

2. Gradient and Curvature

Gradient and curvature play a critical role in the performance and safety of railway operations, especially in hilly regions. For the proposed corridor, it is essential to maintain gradients and adopt smooth horizontal curves with large radii to ensure efficient train movement. This may necessitate the use of tunnels or viaducts to overcome steep elevation changes while adhering to railway engineering standards. The design will consider appropriate transition curves and banking where required, particularly for sections involving sharp turns or slope transitions.

3. Station Location

Stations along the proposed corridor will be strategically located to serve major demand centers and tourist attractions. In Rawalpindi, integration with existing urban transport infrastructure such as the H-9 Railway Station or Faizabad Terminal will be prioritized. Along the corridor, potential stops may include intermediate resort areas or eco-tourism nodes. The final terminal station near Murree will be planned to offer ease of access without interfering with the congested town core, potentially incorporating park-and-ride facilities and last-mile shuttle connections to popular areas.

4. Passenger Experience

Enhancing passenger experience is key to attracting ridership, particularly in a corridor aimed at tourism. The railway system will be designed to offer a scenic and comfortable travel experience, featuring modern carriages with panoramic windows, climate-controlled interiors, and on-board facilities. Stations shall be equipped with user-friendly

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ticketing systems, waiting areas, and tourist information services. Timely operations, cleanliness, and accessibility features will contribute to making the corridor a reliable and appealing option for both tourists and local commuters.

5. Environmental and Ecological Impact

The corridor will be designed with a strong emphasis on minimizing ecological disruption. Intrusion into sensitive zones is unavoidable, mitigation strategies such as tunneling, noise barriers, and reforestation measures will be employed. The overall footprint of the railway is expected to be significantly lower than equivalent road infrastructure, aligning the project with broader environmental and climate resilience goals.

6. Tunnel and Bridge Design

For the mountainous terrain between Rawalpindi and Murree, the alignment will likely involve multiple tunnels and bridge structures. Tunnel design will incorporate modern safety provisions including ventilation, lighting, and emergency exits. Viaducts and bridges will be designed to span ravines, rivers, or unstable slopes while minimizing ground disturbance. Engineering design will adhere to seismic and geological safety standards, ensuring long-term structural reliability and minimal maintenance requirements.

7. Safety and Security

Safety is a fundamental requirement for the corridor's success. The railway will incorporate modern signaling systems, automatic train control, and secure fencing along the track to prevent unauthorized access. Stations and tunnels will include CCTV surveillance, fire alarms, and emergency communication systems. For passenger safety, platforms will feature barrier systems, tactile paving, and staff presence during operational hours. Special attention will be given to managing peak tourist crowds and seasonal influxes.

8. Energy Efficiency and Sustainability

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The corridor will be developed with energy efficiency as a core principle. Electrification or the use of hybrid propulsion systems will be explored to reduce dependence on fossil fuels. Infrastructure will include energy-efficient lighting, solar panels at stations, and regenerative braking systems in trains. Sustainable practices such as rainwater harvesting, green roofing, and eco-friendly construction materials will be incorporated where feasible. These features will lower long-term operating costs and support national climate goals.

9. Financial and Operational Cost

The financial viability of the corridor depends on a balanced analysis of capital investment and operational efficiency. While the upfront cost of constructing tunnels, bridges, and rail infrastructure is high, the long-term cost per passenger-kilometer is expected to be low, especially when compared to road-based transport. The project will explore public-private partnerships, tourism-based revenue generation, and non-fare income sources such as station-area commercial development. Efficient service scheduling and phased implementation may also help manage financial risk and improve return on investment.

4. Computer Aided Design

Layout design is done using state of the art highway design software AutoCAD Civil 3D, a modern computer aided design package. Railroad design is one of the most powerful capabilities of Civil 3D. It requires the use of several major Civil 3D features such as alignments, profiles, corridors and an understanding of how they fit together in a complete road-design model.

The software facilitates creation of a 3D representation of the ground surface through triangulation and subsequent contouring. It interactively superimposes finished surfaces, such as designed surfaces. All the inter-relationships between the surfaces, such as alignments, finished levels, slopes and earthwork quantities can be digitally computed with higher accuracy levels.

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The software also facilitates a designer to explore different vertical and horizontal alignments interactively, thus allowing them to optimize the design. Standard cross-sections representing homogenous sections for the project roads were developed and longitudinal profiles were designed accordingly. Finished grade profiles were created graphically using profile creation tools generated from a best fit analysis by keeping in view the local conditions of the ground surface. After finalizing the basic plan and profile of the roads, corridors were modelled that are the resulting dynamic 3D model representation built from the combination of horizontal, vertical and cross-sectional design elements.

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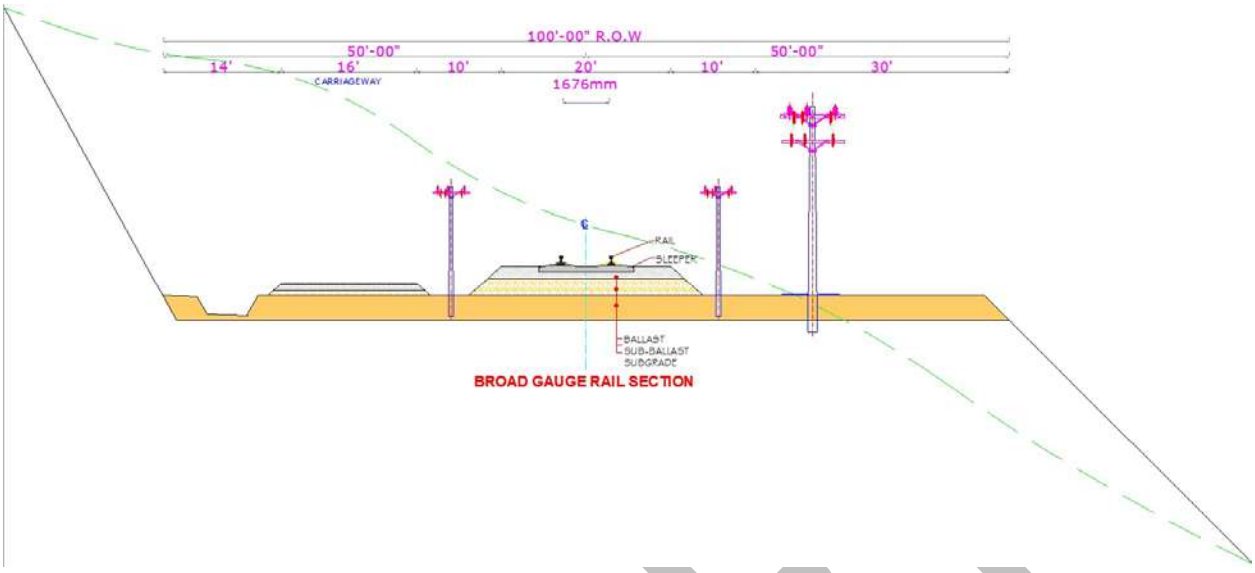
5. Proposed Cross Sections

A typical cross section of a railway track consists of several layers designed to support and guide the movement of trains. At the bottom is the formation or subgrade, which is the prepared natural ground, compacted to provide a stable foundation. Above this lies the ballast layer, made of crushed stone, which distributes loads, provides drainage, and keeps the track in place. On top of the ballast are sleepers (or ties)—usually made of concrete that maintain the correct gauge and hold the steel rails in position using fastening systems like clips and pads.

The rails themselves are laid in parallel and carry the actual load of the trains. They are shaped to guide the train wheels and are connected at joints or continuously welded. To ensure track stability and passenger comfort, shoulders of extra ballast are provided on both sides of the sleepers. The entire cross section is typically sloped to allow water drainage, and side drains are constructed outside the track formation. In electrified railways, overhead electrification poles and wiring are also included, supported by foundations placed beside the track.

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Figure No. 3: - Typical Railroad Cross Section



6. Optional Analysis for Proposed Routes:-

In pursuit of a sustainable and technically viable railway corridor between Rawalpindi/Islamabad and Murree, an optional analysis of potential alignments was conducted. This included a critical review of the previous alignment proposed in 2015 as well as three new route options developed through desk studies, satellite analysis, reconnaissance surveys, and stakeholder consultation. The primary focus during the alignment selection process was on minimizing gradients, avoiding major settlements, and ensuring feasibility for existing or reasonably adoptable rail technologies.

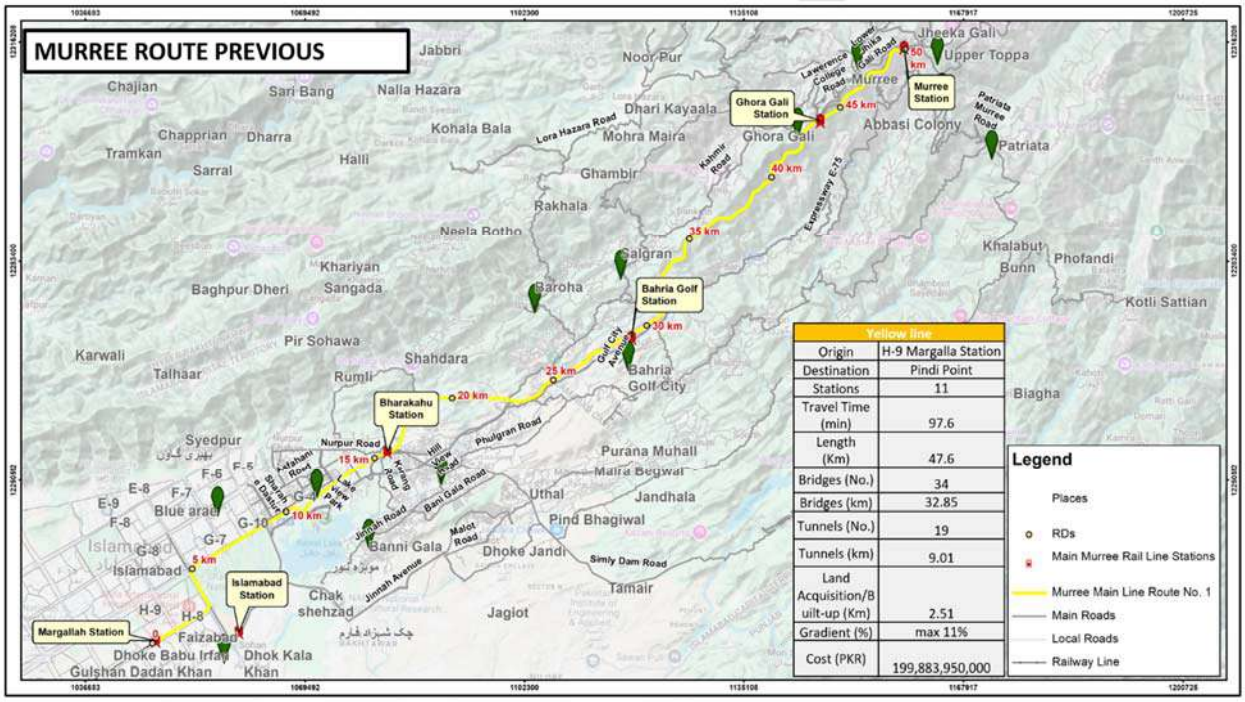
1. Review of the Previous Proposed Alignment (2015)

The initial alignment proposed by Pakistan Railways in 2015 as part of the Islamabad–Murree–Muzaffarabad Railway Feasibility Study was revisited at the onset of the desk study. While this alignment provided a general directional path, it was found to be technically unsuitable due to the excessively steep gradients, which exceeded the

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capabilities of conventional railway rolling stock operated by Pakistan Railways. The consultants at the time suggested using rack-and-pinion rail technology to overcome this, but the study on rack rail was never implemented. Furthermore, the alignment is now encroached by dense settlements, making it less viable for construction.

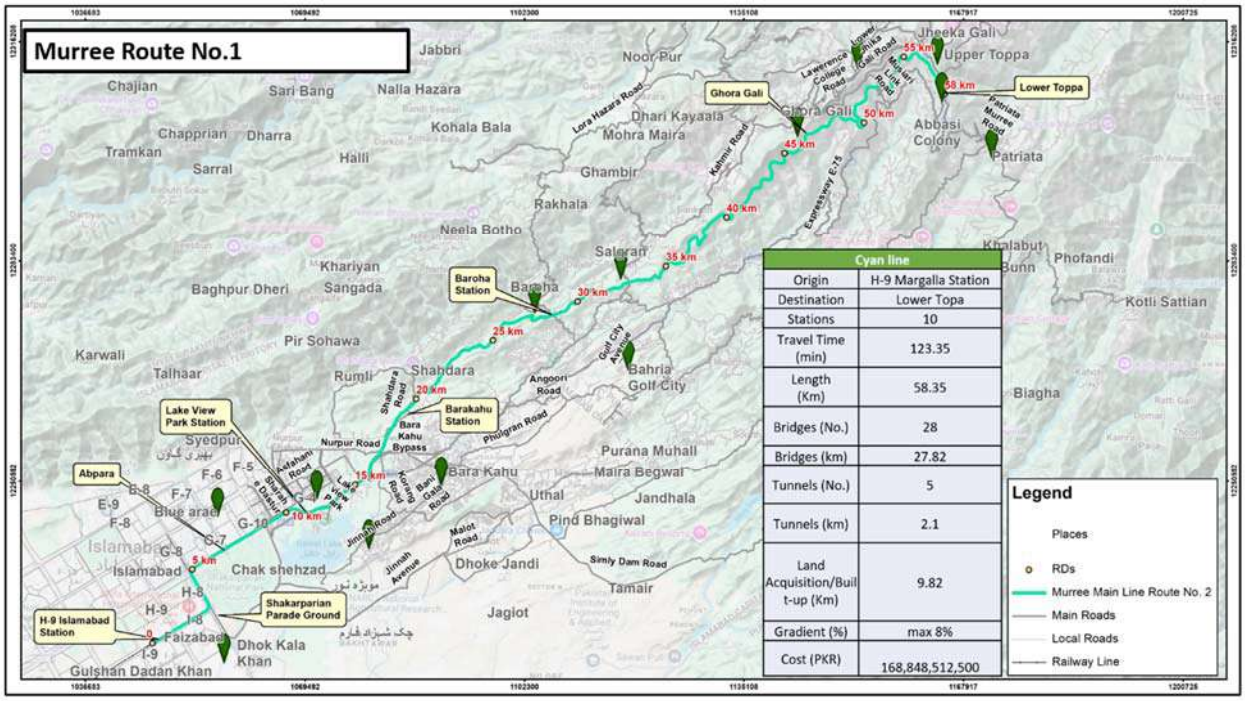
Figure No. 4: - Previous Alignment (2015)



2. Route No. 1 – H-9 to Lower Topa via Lake View Park and Baroha

Route No.1 initiates from the H-9 Islamabad Railway Station and proceeds through Shakarparian, Parade Ground, Aabpara, Lake View Park, Barakahu, Baroha, Ghora Gali, and terminates at Lower Topa. This route attempts to strike a balance between connectivity and topographic feasibility. It follows a relatively accessible corridor but encounters issues in gradient optimization near Ghora Gali. While parts of this corridor remain open for development, challenges persist due to terrain transition zones and limited ROW availability in steep or narrow sections. However, this alignment benefits from good tourism connectivity and intermodal linkage with Islamabad's existing transport system.

Figure No. 5: - Proposed Route No.1

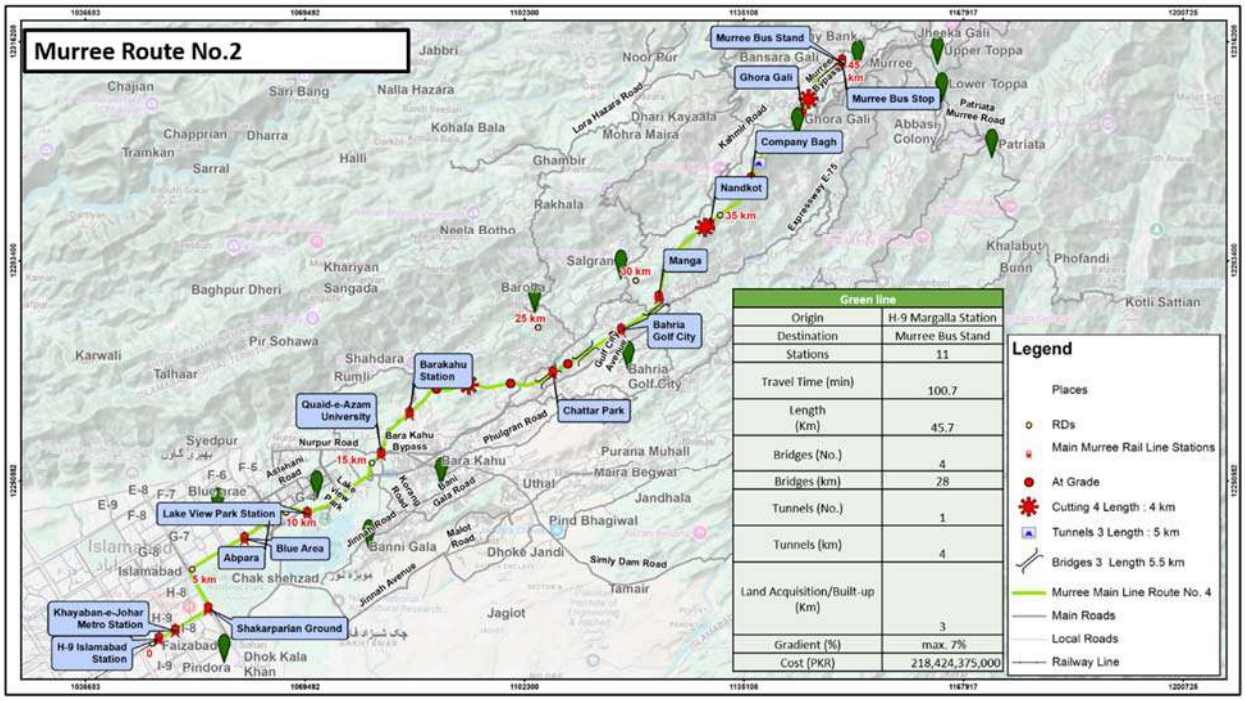


3. Route No. 2 – H-9 to Murree Bus Stand via Nandkot

Route No.2 also begins from H-9 Station and passes through Baroha, then turns northward through Nandkot, Ghora Gali, and terminates at Murree Bus Stand. This route was proposed after considering settlement-related obstructions in Lake View Park and Lower Topa. The alignment allows more direct access to Murree's central commercial area, thus enhancing the passenger experience. However, the corridor faces severe encroachment issues in both Lower Topa and Baroha, requiring significant relocation and land acquisition. The geometric profile of the route is also constrained by steeper gradients in the middle section.

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Figure No. 6: - Proposed Route No.2



4. Route No. 3 – Looping Alignment with Tunnels near Ghora Gali

Route No.3 was developed with the goal of managing the terrain-induced gradient challenge. It introduces two tunnel segments and loop geometry near Ghora Gali to lower the gradient to 4.8% (1:21)—an acceptable level for mountain railway operations. This alignment largely avoids dense settlements and geo-hazard red zones. While costlier due to tunneling, it offers significant technical advantages by ensuring smoother rail operations and reducing travel time interruptions. This option is the most geometrically optimized and technically sound, with better safety margins and potential for future scalability.

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Figure No. 7: - Proposed Route No.3

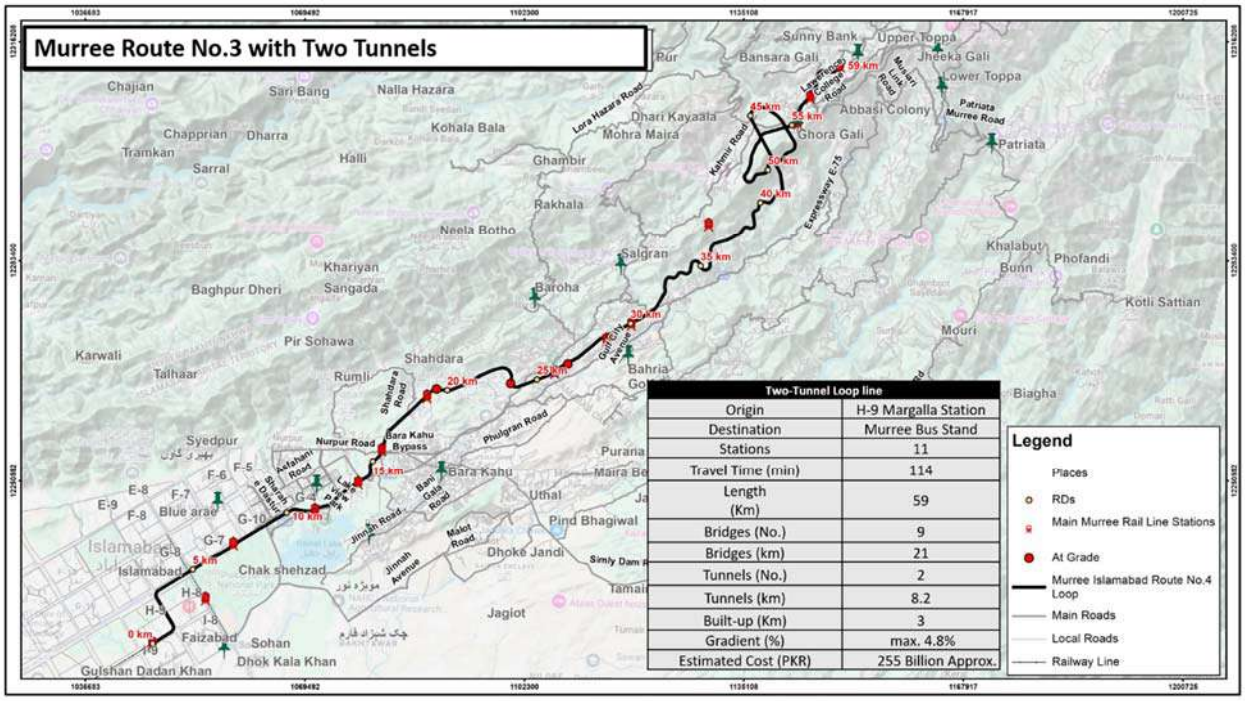


Table No. 1: - Summary of Routes

Alignment	Origin	Destination	Stations	Travel Time (min)	Length (Km)	Bridges (No.)	Bridges (km)	Tunnels (No.)	Tunnels (km)	Land Acquisition/Built-up (Km)	Gradient (%)	Estimated Cost (PKR) Billion
Route No.1 Cyan	H-9 Margalla Station	Lower Topa	10	123.35	58.35	28	27.82	5	2.1	9.82	max 8%	210.2
Route No.2 Blue	H-9 Margalla Station	Murree Bus Stand	10	94.6	44.6	6	32.5	3	5.5	1	max. 6%	240.3
Route No.3 Black	H-9 Margalla Station	Murree Bus Stand	11	114	62	9	21	2	8.2	-	4.8%	255

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Table No. 2: - Comparative Analysis

Criteria	Previous Alignment (2015)	Route No. 1	Route No. 2	Route No. 3
Gradient Feasibility	Steep (>6%) – not suitable for rail	Moderate to steep in some sections	Steep in mid-section	Optimized to 4.8% using tunnels & loops
Settlement Encroachment	High – alignment now in developed areas	Moderate – Barakahu & Baroha development	High – Baroha, Lower Topa settlements	Low – avoids dense development
Travel Time Efficiency	Low – longer and steeper	Moderate – acceptable route geometry	Moderate – more direct but constrained	High – efficient gradient with tunnels
Environmental Risk	High – cuts through sensitive forest areas	Medium – near urban-forest transition	Medium – passes near residential/forest mix	Low – mostly subgrade or tunnel sections
Constructability	Poor – major geometric and social barriers	Moderate – needs slope and soil stabilization	Low – complex terrain and dense zones	Good – engineered design with minimized cuts
Tourism & Connectivity	Limited – bypassed major scenic points	High – links tourism sites en route	High – connects to Murree Bus Stand	High – optimal balance of accessibility & view
Feasibility Verdict	Not Feasible	Technically Possible with Mitigations	Socially Challenging	Most Feasible Technically & Strategically

The previous alignment proposed in 2015 is no longer viable due to gradient limitations, operational incompatibility, and heavy encroachment. Among the new options, Route No. 3 emerges as the most technically and strategically feasible alignment, with an engineered approach to gradient management through tunneling and curvature control. While the initial construction cost is expected to be higher due to tunnel works, this route ensures smoother, safer, and more reliable railway operations. Routes No.1 and No.2, while partially feasible, face settlement-related challenges and suboptimal gradients.

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7. Geological Constraints and Fatal Flaw Analysis in Route Alignment Selection: -

Following the approval of the preliminary rail alignment and the selection of rolling stock (Diesel or Electric Multiple Units – DMU/EMU), a detailed reconnaissance survey was initiated. During this exercise, concerns were encountered at two critical locations within the approved corridor, necessitating minor realignments to bypass restricted areas. As the geological team conducted further assessments, it was reported that the last 5 kilometers of the alignment traversed through geologically unstable terrain where slope stability could not be guaranteed during construction or operation. Consequently, this segment was re-aligned to mitigate the risks associated with land sliding.

In addition, the originally proposed tunnel alignment (Route No.2) intended to manage gradient transitions, was found to be technically unfeasible, as the tunnel path paralleled the natural slope of the hill, making boring operations structurally unsafe. Alternative tunnel positions were explored in nearby zones, aiming to retain the required gradient, but none proved viable. Consultations with rolling stock manufacturers confirmed that the maximum allowable gradient for DMU/EMU operations is 5.0%. Based on this constraint and geological considerations, a new alignment was designed, spanning 62 kilometers, maintaining a 4.8% gradient, and incorporating two tunnels. This revised route was provisionally accepted by the competent authority.

However, during geotechnical investigations at the portal location of Tunnel No. 1, boreholes revealed crushed rock formations up to a depth of 11 meters, posing a significant hazard. The crushed rock not only threatens tunnel collapse during excavation but also endangers the structural stability of nearby settlements, including homes and commercial structures. These findings rendered the tunnel infeasible, and by extension, Route No. 3 was deemed non-viable.

These persistent geological barriers and the limitations of conventional rail systems, alternative rail technologies were reviewed. Among these, the straddle-type monorail

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system emerged as a technically viable option for the Islamabad–Murree corridor, due to its steeper gradient capability, lower footprint, and adaptability to difficult terrains.

8. Proposed Route No.4 (Straddle): -

In light of the fatal flaws identified during geological and geotechnical investigations along the previously considered alignments, particularly the challenges related to slope instability, crushed rock formations, and unsafe tunneling conditions, the final recommended alignment incorporates a Straddle Monorail System as a technically and economically feasible alternative to conventional railway. This decision follows extensive desktop studies, field reconnaissance, stakeholder consultations, and preliminary discussions with leading global rolling stock manufacturers.

The final alignment initiates from Lake View Park, diverging from the earlier proposal of starting at H-9 Railway Station. This change was necessitated by planning constraints within Islamabad, as advised by the local administration, who discouraged elevated structures within the urban limits due to ongoing and proposed urban development along Murree Road, Kashmir Chowk, and Shakarparian. While H-9 offered better regional integration within the broader railway network, Lake View Park provides an optimal origin point that balances technical feasibility, tourism access, and planning compatibility.

From Lake View Park, the monorail alignment follows similar corridors to earlier proposed routes, passing near Barakahu, Baroha, Ghora Gali, and curving toward Manga. At Manga, a northward diversion is introduced to avoid tunnel construction altogether, addressing the core geological limitations identified in previous alignment options. This revised route maintains gentle horizontal curves and manageable gradients, facilitated by the unique capabilities of the monorail system.

The Straddle Monorail was selected after evaluating a range of alternative rail systems, including rack rail, funicular railways, and cable cars. Based on international best

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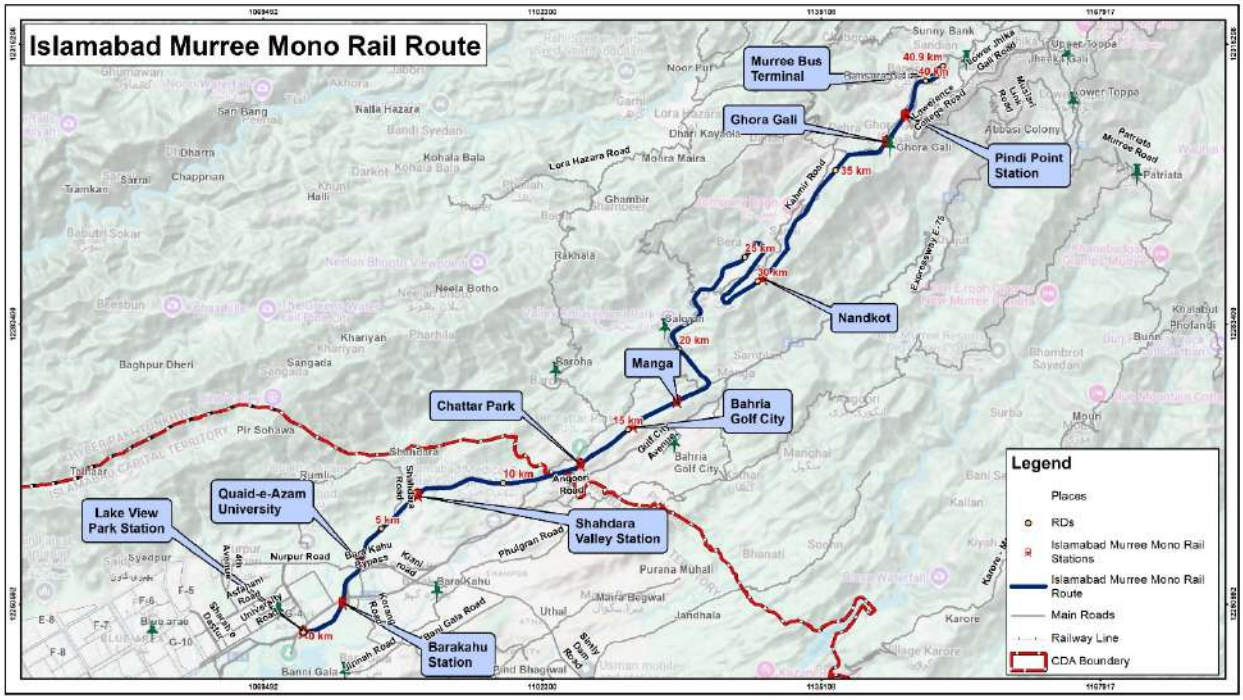
practices, the straddle monorail emerged as the most viable system due to the following key advantages:

1. The monorail can run on steep slopes of up to 6.0%.
2. It can turn easily with a small turning radius of 50 meters.
3. It costs less to build than regular rail systems.
4. It needs less space in height and width.
5. It requires less maintenance over time.
6. It runs on electricity taken directly from the track.
7. It is built above the ground, so it causes less disturbance to the land.
8. Passengers can enjoy wide scenic views during the ride.
9. It is used in developed countries like Japan, China, the USA, and Germany.
10. It is also used in countries like Malaysia, India, UAE, Thailand, and Brazil.
11. It can be built in a shorter time.
12. It is clean, quiet, and can carry many passengers

The adoption of the straddle monorail system not only overcomes the core technical and geological limitations of previous rail alignments but also aligns with modern urban mobility trends and sustainable transport practices.

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Figure No. 8: - Proposed Route No.4



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PUNJAB MASS TRANSIT AUTHORITY (PMA)

GOVERNMENT OF PUNJAB

FEASIBILITY STUDY FOR THE TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE



A Preliminary Approach on Construction Materials Availability

MAY, 2025

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A PRELIMINARY APPROACH ON CONSTRUCTION MATERIALS AVAILABILITY

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1. INTRODUCTION

1.1 GENERAL

The Tourist Glass Train Project, extending from Rawalpindi to Murree, represents a strategically significant infrastructure initiative designed to bolster regional tourism while delivering a unique and immersive travel experience through the picturesque and rugged terrains of northern Pakistan. This visionary project is aligned with national objectives to promote sustainable tourism and regional economic development. The proposed alignment traverses complex mountainous topography characterized by steep gradients, variable geological formations, and environmentally sensitive zones. Consequently, the successful execution of this project necessitates meticulous planning, robust engineering design, and the prudent selection and utilization of locally sourced construction materials.

Given the technical challenges inherent to railway construction in such a geomorphologically diverse setting including issues related to slope stability, subgrade integrity, and drainage management a comprehensive and site-specific assessment of available construction materials is a critical prerequisite. The availability, quality, and engineering suitability of soils, aggregates, and other construction materials directly influence not only the feasibility and cost-effectiveness of the project but also the safety, durability, and long-term performance of the railway infrastructure.

In recognition of the importance of material characterization and sourcing, the responsibility for conducting detailed construction material investigations was awarded to M/S F & M Pvt Ltd through a transparent and competitive procurement process, executed in accordance with the provisions of the Public Procurement Regulatory Authority (PPRA) rules and guidelines. The awarded scope of services encompasses comprehensive field investigations, in-situ sampling, visual classification, and laboratory testing of materials. It also includes a thorough evaluation of existing and potential local sources of fine and coarse aggregates, along with soil deposits, with the objective of formulating well-informed recommendations for their utilization in embankment fill, subgrade preparation, subbase layers, and concrete works.

This report presents the findings derived from extensive construction material investigations conducted along the proposed railway alignment. The methodology adopted for the study includes test pit excavations, visual soil and aggregate assessments, sample collection for laboratory testing, and site reconnaissance to identify viable natural material sources. For the initial 0+000 to 22+000 km stretch of the alignment, test pit excavations were successfully carried out at regular intervals to observe soil profiles, assess in-situ conditions,

and retrieve representative samples. The visual assessments focused on identifying soil classifications based on Unified Soil Classification System (USCS) criteria and evaluating general indicators of material competence for railway earthworks.

From chainage 22+000 to 60+000, however, the alignment enters a predominantly hilly and geologically exposed region, characterized by rugged topography, limited accessibility, and continuous outcropping of rock formations. Due to these constraints, excavation of conventional test pits was rendered infeasible. As an alternative, the investigation strategy for this segment was adapted to include the assessment of materials obtained from nearby natural drainage features, including perennial and seasonal streams. In particular, alluvial and fluvial deposits from the Dhund Haro River and other adjoining streambeds have been identified as potential sources of borrow materials. These materials will undergo further laboratory testing to evaluate their mechanical properties and determine their suitability for structural application in embankment, subgrade, and concrete layers.

It is pertinent to highlight that the present findings are largely based on visual inspections and field observations conducted during the initial phase of the investigation. While such assessments provide valuable preliminary insights into the general characteristics and anticipated engineering behavior of the encountered materials, they do not substitute for detailed laboratory analyses. The observed materials from the 0–22 km segment consist predominantly of sandy silts, gravels, and weathered rock fragments, which appear potentially suitable for use in fill and subgrade layers, subject to compliance with relevant gradation and compaction specifications.

In contrast, the segment from 22 km to 60 km features significant occurrences of shale and clay strata, both of which are generally unsuitable for embankment or subgrade use due to their low shear strength, high plasticity, and poor durability under cyclic moisture variation. These materials must be carefully avoided or stabilized through appropriate geotechnical treatments. The fluvial deposits from streambeds are expected to exhibit variable gradation and strength characteristics, necessitating rigorous testing before confirming their applicability.

1.2 EMBANKMENT, SUBGRADE, AND SUBBASE MATERIALS

Field investigations, including the excavation of fifteen test pits (TP-01 to TP-15), have been planned and excavated along the proposed alignment of the Tourist Glass Train Project. These investigations are intended to systematically characterize the in-situ geological and geotechnical conditions and to identify feasible local sources of construction materials suitable for use in embankments, subgrades, and subbase layers. Refer Figure 1 below for test pits plan.



Figure 1: Test Pit Plan (First 22 km)

The findings from the excavated test pits based primarily on visual and tactile observations at this stage are summarized below to provide a preliminary understanding of the encountered material types, their physical characteristics, and anticipated performance.

- **TP-01 to TP-08:**

  The materials encountered within the segment extending from TP-01 to TP-08 (excluding TP-07, which remains unexecuted due to green belt) predominantly consist of the following soil types:

  - **Silty clay / clayey silt**: These are fine-grained soils exhibiting low- to medium-range plasticity and present in a dry to slightly moist state at the time of excavation. The soils demonstrate cohesive behavior and exhibit sensitivity to moisture content fluctuations, which may lead to volumetric changes such as shrinkage and swelling. Such characteristics suggest moderate compressibility and a propensity for settlement under sustained loading conditions. The consistency and plasticity of these soils suggest limited strength without modification, necessitating detailed laboratory evaluation to confirm their mechanical performance parameters such as

shear strength, compressibility, and permeability. For further details of encountered material refer to Test Pit Logs appended as Appendix – A.

- **Silty clay with gravel and cobbles**: This category represents a heterogeneous soil matrix wherein fine cohesive materials are interspersed with randomly distributed coarse constituents, including gravel and cobble-sized particles. The mechanical behavior of such composite soils depends significantly on the gradation, packing density, and angularity of the coarser fraction. While the inclusion of gravel and cobbles can enhance shear resistance and load distribution, the variable distribution of these elements may lead to localized strength inconsistencies. As a result, uniform compaction, moisture control, and if required, mechanical or chemical stabilization (e.g., lime or cement treatment) are advised to enhance engineering performance and minimize deformation risks. For further details of encountered material refer to Test Pit Logs appended as Appendix – A.

These materials, in their natural state, may pose significant challenges in terms of settlement susceptibility, moisture-induced volume change, and reduced bearing capacity. Therefore, their appropriateness for embankment and structural fill applications must be confirmed through laboratory testing focused on Atterberg limits, Proctor compaction characteristics, California Bearing Ratio (CBR), and grain size distribution. Where properties are found deficient, engineered treatment strategies must be employed to meet the design specifications.

➢ **TP-09 to TP-13:**

The materials encountered in the region spanning TP-09 through TP-13 (excluding TP-10 and TP-11) primarily consist of:

- **Sandy gravel with cobbles and boulders**: These are dominantly granular deposits characterized by high permeability, minimal plasticity, and superior load-bearing capacity. The materials are indicative of alluvial or colluvial origin and are composed of a well-graded mixture of sand, gravel, and coarse fractions, including cobbles and occasional boulders. These physical attributes render the material highly suitable for subgrade and subbase applications, particularly where high drainage capacity and internal friction are critical for structural performance. For further details of encountered material refer to Test Pit Logs appended as Appendix – A.

Given the variable particle size distribution and the presence of oversized particles, these materials will require mechanical processing such as screening and sieving to ensure conformity with gradation requirements specified for subbase and subgrade layers. Quality verification through standard geotechnical testing (e.g., grain size

analysis, specific gravity, sand equivalent for subbase, and compaction testing) will be essential to establish their suitability. Subject to favorable test results, this material represents a cost-efficient and locally accessible source for engineered fill applications, offering both technical and logistical benefits.

This segment's natural gravels, if confirmed through quality testing, offer a cost-effective and locally available solution for structural fill and subbase applications. Material available in this segment requires screening / processing to extract oversize material and to adjust gradation as required.

- **TP-10, TP-11, TP-14 and TP-15:**

The materials encountered in the TP-10, TP-11, TP-14 and TP-15 primarily consist of:

- **Silty Clay / Clayey Silt:** These fine-grained soils are characterized by low to moderate plasticity and were encountered in slightly moist to moist condition during excavation activities. They exhibit cohesive behavior and are notably responsive to changes in moisture content, often undergoing volumetric transformations such as swelling when wet and shrinkage upon drying. These moisture-sensitive properties imply a moderate degree of compressibility and a tendency to settle under prolonged loading. Given their plastic consistency and limited inherent strength, these soils are unlikely to perform adequately without treatment or stabilization. As such, comprehensive laboratory testing is essential to accurately determine their geotechnical properties, including shear strength, consolidation potential, and hydraulic conductivity. For further details of encountered material refer to Test Pit Logs appended as Appendix – A.

Within the alignment segment extending from chainage 22+000 to 60+000, the execution of conventional test pit excavations was rendered impracticable due to the presence of extensively exposed rock formations. Consequently, alternative methods of material investigation are recommended, particularly focusing on the assessment of alluvial deposits from nearby streambeds. In this regard, naturally occurring streambed materials from the Dhund Haro River and its tributaries should be systematically evaluated. The streambed alluvium, consisting mainly of gravels and sands transported through hydrodynamic processes, offers a potential source of embankment, subgrade and subbase fill. However, these materials are often characterized by variable gradation, particle shape, and potential contamination with silts or organic matter. It is therefore imperative to subject representative samples to comprehensive laboratory testing to determine parameters such as particle size

distribution, angularity, compaction behavior, and bearing capacity. Only those materials that demonstrate compliance with project specifications should be approved for use.

It is pertinent to mention that much of this alignment section is underlain by weak lithologies such as shale and expansive clay, which are highly problematic from a geotechnical standpoint. These materials generally exhibit poor load-bearing capacity, high plasticity indices, and a propensity for volumetric instability when subjected to moisture fluctuations. Their structural inadequacy renders them unsuitable for use in critical applications such as embankment cores or subgrade layers. Accordingly, such materials must be identified in the field and excluded from reuse in construction.

Furthermore, during the active construction phase, it is essential to implement a systematic real-time material evaluation protocol. This includes visual inspection, field classification, and selective laboratory testing of excavated materials to verify their compliance with the design specifications for embankment, subgrade and subbase construction. Such proactive quality control measures will facilitate the optimal reuse of suitable in-situ materials, minimize the importation of borrow material, and ultimately contribute to the long-term durability and stability of the railway infrastructure. This practice not only enhances technical efficiency but also supports cost control and environmental sustainability within the project corridor.

1.3 BORROW AREAS

Three potential borrow areas, designated as BA-1, BA-2, and BA-3, have been identified for sourcing fill material for subbase and subgrade construction. Representative soil samples have been collected from each of these locations to evaluate the material's engineering suitability in accordance with relevant geotechnical standards.

The first borrow area, BA-1, is situated in close proximity to Test Pit TP-13, offering logistical advantages due to its nearness to the project alignment. One sample has been obtained from this site for laboratory evaluation. The second borrow area, BA-2, is located in the Shahdara Valley near Quaid-e-Azam University. A single sample has also been collected from this location, which is known for its natural deposits suitable for construction applications. The third source, BA-3, is Korang River in upstream of Chhatar Park. A sample has similarly been retrieved from this site for testing purposes.

Preliminary visual classification of the samples indicates that all three borrow sources predominantly contain sandy gravel with minor amounts of clay. This gradation is generally favorable for subbase and subgrade layers; however, laboratory testing including grain size analysis, Atterberg limits, compaction characteristics and other necessary tests is required to confirm their compliance with project specifications.

It is important to note that all identified borrow materials contain oversize particles that must be removed prior to use. Screening operations will be necessary at each borrow site to eliminate these oversized fractions and ensure the processed material meets the gradation requirements for engineered fill.

1.4 TESTING REQUIREMENTS

All materials collected from executed test pits and borrow areas must be subjected to a comprehensive suite of standard laboratory tests to evaluate and confirm their engineering suitability for use in various structural layers of the project, such as embankments, subgrades, and subbases. These tests are essential for determining the physical and mechanical characteristics of the soils, which directly influence their performance under load and environmental conditions. The testing program shall include, but not be limited to, the following:

- Grain Size Distribution (ASTM D6913)

  This test determines the particle size distribution of soil samples, which is critical for classifying soils and understanding their drainage characteristics, compaction behavior, and suitability for various engineering applications.

- Atterberg Limits (ASTM D4318)

  These limits (Liquid Limit, Plastic Limit, and Plasticity Index) provide insight into the plasticity characteristics of fine-grained soils, helping to assess their workability, expansiveness, and potential for volumetric changes under varying moisture conditions.

- Standard/Modified Proctor Compaction (ASTM D698 / D1557)

  These compaction tests establish the optimal moisture content and maximum dry density of soils, ensuring proper compaction during field placement for achieving desired strength and stability.

- California Bearing Ratio – CBR (ASTM D1883)

  The CBR test evaluates the strength of embankment, subgrade and base course materials by measuring their resistance to penetration, providing a key design parameter for pavement and embankment structures.

- Specific Gravity (ASTM D854)

Determining the specific gravity of soil solids helps in identifying soil type and is also essential in various calculations such as void ratio, porosity, and unit weight.

- Chemical Analysis (as required)

  Chemical testing may be conducted to detect the presence of potentially harmful substances such as sulfates, chlorides, or organic matter, which could adversely affect the performance and durability of soils.

- Los Angeles Abrasion Test (as required) ASTM C131/C131M or ASTM C535

  This test assesses the hardness and abrasion resistance of aggregate materials, especially for coarse-grained soils or crushed rock intended for subbase or base course layers.

- Sand Equivalent (as required) ASTM D2419

  This test is used to measure the relative proportion of fine dust or clay-like particles in granular soils, which can impact the drainage and compaction properties of the material.

Based on the results obtained from the above tests, soils meeting the required specifications and performance criteria will be selected and approved for use in the construction of embankments, subgrades, and subbase layers. Any soils found to be non-conforming or unsuitable may be subjected to improvement techniques such as stabilization with lime, cement, or other additives or, if necessary, replaced entirely with more appropriate borrow material that meets the project's engineering requirements.

2. AGGREGATE SOURCES

2.1 GEOLOGICAL VUNERABILTY AND SIGNIFICANCE OF CONSTRUCTION MATERIAL STUDIES

The Murree Glass Train Project represents a strategically significant and technically sophisticated mass transit development initiative, conceptualized to establish a direct and efficient transportation link between the densely populated urban centers and the elevated, tourism-centric region of Murree. Encompassing an alignment of approximately 60 kilometers, the proposed railway corridor ascends to altitudes exceeding 2,000 meters above sea level, navigating through a complex topographical and geological setting that forms part of the outer Himalayan foothills. This mountainous terrain, although scenically remarkable, presents a series of formidable engineering and environmental challenges due to its steep gradients, structurally fragile lithology, and persistent tectonic activity.

Of paramount concern is the proximity of the proposed alignment to the Main Boundary Thrust (MBT). A major active tectonic boundary that demarcates the collision zone between the Indian and Eurasian tectonic plates. The MBT is a well-documented seismogenic structure known to generate frequent low-to-moderate magnitude earthquakes, and it has historically been associated with several high-magnitude seismic events in northern Pakistan. Consequently, any infrastructure development within this geodynamic context necessitates a rigorous and multidimensional assessment of geotechnical risks, particularly those associated with ground shaking, liquefaction potential, slope instability, and the differential behavior of foundation soils. In such a high-risk seismic environment, the structural resilience and long-term serviceability of rail infrastructure are intrinsically dependent on the engineering quality, geochemical compatibility, and mechanical behavior of the construction materials utilized throughout the project.

The regional geological regime is typified by a predominance of alternating sedimentary strata, comprising interbedded shales and sandstones. These lithological units are often found in a highly weathered state, exhibiting extensive jointing, planar discontinuities, and variable degrees of mechanical degradation. Shales, in particular, pose a serious engineering challenge; they are susceptible to swelling, slaking, and rapid disintegration upon exposure to moisture. Their low shear strength and poor durability under cyclic loading conditions make them unsuitable as natural subgrade or structural fill without appropriate stabilization measures. Moreover, their tendency to undergo volumetric changes when wet can lead to differential settlement and embankment distress, particularly under repeated dynamic loads transmitted by rail traffic. The mechanical anisotropy and rapid weathering of

these materials necessitate careful screening, classification, and treatment during the design and construction phases.

In addition to these geological impediments, the project area is characterized by a high-energy hydrological environment. The region experiences intense seasonal precipitation, particularly during the monsoon period, which results in accelerated surface runoff, soil saturation, and erosion. Numerous ephemeral and perennial watercourses traverse the alignment corridor, and groundwater frequently seeps from fractured bedrock zones, especially at slope toes and cut faces. These hydrological conditions increase the risk of slope instability phenomena, including shallow translational slides, deep-seated rotational failures, and surface erosion on embankments. If not properly addressed through material selection and drainage design, these processes can lead to progressive degradation or sudden failure of critical infrastructure elements such as embankments, cuttings, retaining structures, and foundations.

In this context, drainage-sensitive and hydrologically compatible construction materials must be prioritized. Materials used in embankment construction, subgrade preparation, concrete production, and structural backfills must exhibit high resistance to water-induced softening, erosion, and leaching, as well as demonstrate compatibility with the seismic and hydrogeological dynamics of the region. Selection criteria should therefore include properties such as gradation stability, cohesion, permeability, resilience under repeated wet-dry cycles, and resistance to chemical weathering and sulfate attack. The long-term durability of materials under combined hydraulic and seismic loading conditions is essential to ensuring the functional integrity and safety of the railway corridor.

Given the scale, complexity, and environmental sensitivity of the Murree Glass Train Project, the preliminary assessment of construction material availability and engineering suitability emerges as a fundamental task during the early phases of planning and design. This preliminary study serves as the cornerstone for making informed decisions regarding material sourcing, geotechnical compatibility, cost optimization, and environmental management. A systematic investigation and cataloging of local material sources—including quarries, borrow areas, and potential stabilization agents—will enable a balanced approach that meets both technical specifications and sustainability goals. By identifying sources that meet the required engineering standards, the project can minimize material transportation distances, thereby reducing carbon footprint and construction costs, while also ensuring logistical feasibility in a remote and topographically challenging area.

Furthermore, such early-stage material assessments provide critical data to support the detailed geotechnical investigations required for the final design phase. Understanding the

variability, quality, and performance characteristics of locally available materials enables the development of site-specific engineering solutions tailored to the complex geological and environmental setting of the region. For instance, the identification of locally available stabilizers (e.g., lime, cement, fly ash) could support soil improvement strategies for weak subgrades, while durable aggregates from nearby hard rock quarries could be prioritized for concrete and base layers to reduce long-term maintenance.

Accordingly, NESPAK strongly recommends that a comprehensive program of geotechnical and construction material investigations be undertaken in accordance with relevant national standards (such as ASTM, AASHTO, and BS) and international best practices. These investigations should encompass laboratory testing, in-situ field assessments, durability evaluations, and source approval protocols to ensure the engineering compatibility and sustainability of selected materials.

To specifically meet the projected demand for coarse and fine aggregates in concrete and structural works, a detailed reconnaissance and evaluation of all potentially accessible construction aggregate sources is of paramount importance. This includes the systematic identification, geological characterization, and quality assessment of rock quarries capable of producing aggregates with the required mechanical strength, abrasion resistance, and durability. The fine aggregates, particularly sands to be used in concrete production, must also be evaluated for gradation, cleanliness, deleterious content, and mineralogical composition to ensure compliance with applicable design standards. Strategic sourcing from reliable, high-quality aggregate deposits will play a crucial role in achieving the performance, cost-efficiency, and longevity objectives of this flagship infrastructure project.

2.2 COARSE AGGREGATES

The proposed alignment of the Murree Glass Train project is strategically located in proximity to several well-documented and geologically favorable sources of coarse aggregates, a factor that is expected to significantly facilitate construction logistics, quality assurance, and cost-efficiency. Among these sources, the Margalla and Khanpur quarries stand out as the most prominent and extensively utilized aggregate supply sites in the region. These quarries are not only operationally mature but are also recognized at the national level for their ability to consistently deliver high-performance crushed limestone aggregates suitable for a wide spectrum of heavy civil engineering applications.

The Margalla quarry, located near Taxila in the Islamabad Capital Territory, and the Khanpur quarry, situated adjacent to Khanpur Dam in Haripur District, are both developed on extensive limestone formations belonging primarily to the Jurassic and Eocene age sedimentary sequences. These lithologies are characterized by dense, compact, and

homogenous limestone, which yields aggregates with superior physical and mechanical properties. The aggregates derived from these sources routinely exhibit high compressive strength, low Los Angeles abrasion values (indicating excellent resistance to mechanical wear), minimal water absorption (typically below 2%), and favorable particle shape characteristics conducive to proper interlocking and compaction. Their gradation profiles can be engineered to meet specific project requirements, whether for subbase and base course layers or concrete production, and their performance history in high-load transport infrastructure including highways, bridges, and airport pavements attests to their reliability and structural integrity.

In compliance with ASTM, AASHTO, and National Highway Authority specifications, the materials from Margalla and Khanpur quarries have consistently met or exceeded the acceptance criteria for use in concrete and pavement layers. Parameters such as Aggregate Crushing Value (ACV), Flakiness and Elongation Index, Soundness (ASTM C88), and Alkali-Silica Reactivity (ASTM C1260/C1293) are within acceptable thresholds, ensuring both short-term mechanical performance and long-term durability. For the Murree Glass Train project, which involves the construction of bridges, culverts, station platforms, retaining walls, and elevated track sections, the dependable quality of aggregates from these quarries renders them the preferred choice for all structural and load-bearing concrete applications.

In addition to these well-established sources, preliminary geological reconnaissance has identified a potential supplementary coarse aggregate resource located in the **Ghora Gali** region, which lies closer to the project alignment. This prospective source comprises naturally occurring limestone outcrops, though their engineering suitability remains unverified. Because this site has not yet been developed for commercial quarrying or subjected to formal approval by regulatory authorities, a comprehensive and methodical testing program is required to evaluate the quality and reliability of the material before any utilization in construction activities.

The evaluation process for **Ghora Gali** limestone source must include a full suite of standardized laboratory tests to assess the physical, mechanical, and chemical properties of the aggregate. These should include:

- Aggregate Crushing Value (ACV) to assess resistance to fragmentation under applied loads;
- Los Angeles Abrasion Test (ASTM C131/C535) to determine resistance to wear and mechanical degradation;
- Soundness Test (ASTM C88) using sodium or magnesium sulfate solutions to evaluate resistance to weathering under wet-dry cycles;

- Flakiness and Elongation Indices to ensure optimal particle shape and packing;
- Specific Gravity and Water Absorption (ASTM C127) for understanding density-related characteristics;
- Alkali-Aggregate Reactivity (AAR) testing (ASTM C1260 / C1293) to identify any potential expansive reactions between aggregate minerals and cement alkalis;
- Petrographic Analysis (ASTM C295) to classify mineral composition, texture, and deleterious constituents such as chert, mica, or soft inclusions.

If the results of these assessments confirm that the **Ghora Gali** limestone meets the specified performance and durability criteria, the site could be considered a viable alternative or supplementary source, offering substantial logistical and economic advantages. Its relative proximity to the construction corridor would reduce transportation costs, lower carbon emissions, and potentially improve the construction schedule by ensuring timely and localized supply of coarse aggregates.

For use in concrete, coarse aggregates must satisfy a stringent set of performance-based criteria. They must exhibit consistent nominal sizes as defined in the structural design, a well-graded particle size distribution conducive to dense packing and reduced voids, and minimal presence of deleterious substances such as clay lumps, organic matter, or friable particles. Moreover, aggregates must demonstrate low water absorption (<1%), high resistance to mechanical degradation, and chemical stability under the conditions prevailing in the concrete matrix, including alkalinity, moisture fluctuation, and potential exposure to aggressive environmental agents.

The parent rock from which the aggregate is derived must possess high uniaxial compressive strength, low porosity, and stable mineralogy to minimize the risk of alkali-silica or alkali-carbonate reactions, which can severely compromise concrete integrity over time. Crushed limestone sourced from the Margalla and Khanpur quarries inherently meets these requirements and has a long-standing record of performance in high-strength concrete used for critical infrastructure components. These include bridge decks, viaduct piers, retaining wall footings, and platform slabs, where long-term durability, dimensional stability, and resistance to environmental loading are non-negotiable design imperatives.

It is critical to underscore that, regardless of source, all coarse aggregates intended for use in any aspect of railway infrastructure construction must be subjected to a full program of laboratory-based qualitative and quantitative analyses prior to their inclusion in concrete mix designs or structural fill applications. Routine quality control protocols must also be implemented at source and on-site to ensure that aggregate properties remain within

specified tolerance limits throughout the duration of the project. Batch-to-batch variability must be monitored to mitigate risks related to inconsistent strength, workability, or long-term durability of concrete and granular materials.

In conclusion, the availability of established, high-quality aggregate sources near the alignment particularly from Margalla and Khanpur combined with the promising potential of local sources such as Ghora Gali, provides the project with a strong foundation for meeting material supply demands. However, the reliance on rigorous material testing, certification, and quality assurance processes remains imperative to achieving the engineering performance and safety benchmarks that this high-profile and geologically sensitive railway project demands.

2.3 FINE AGGREGATE

Fine aggregates represent a vital component in the composition of concrete, mortar, and other construction materials, contributing significantly to the structural performance, workability, finishability, and durability of the final product. For the Murree Glass Train project given its elevated alignment, challenging terrain, and structural complexity the selection and quality assurance of fine aggregate sources are of paramount importance. Fortunately, the regional geology and alluvial geomorphology provide access to two well-known and historically reliable sources of natural sand: **Lawrencepur and Qibla Bandi.** Both sources are situated within economically viable transport distances from the project corridor and have been routinely employed in a variety of civil infrastructure works, including highways, dams, buildings, and bridges, across Punjab and northern Pakistan.

The Lawrencepur sand deposit, located near Attock along the banks of the Indus River, is particularly esteemed for it's uniformly graded and naturally washed silica-rich sands. This material is characterized by well-rounded to sub-rounded grain morphology, a product of prolonged fluvial transport and natural abrasion processes. The rounded grain structure is especially advantageous in concrete production as it improves the flowability and workability of fresh concrete mixes, reduces internal friction, and facilitates efficient compaction, which is particularly beneficial in heavily reinforced or congested formworks. Additionally, the uniform texture and cleanliness of Lawrencepur sand result in a lower water and cement demand, contributing to more economical and performance-efficient concrete mixtures. These qualities make Lawrencepur sand an ideal choice for high-performance structural concrete, including slabs, beams, bridge decks, and precast elements.

Qibla Bandi sand, sourced from the Haro River basin in the Hazara region, also offers promising characteristics for use in concrete and mortar applications. While slightly coarser

in texture compared to Lawrencepur sand, Qibla Bandi sand possesses favorable gradation properties and exhibits low levels of deleterious materials such as mica, organic matter, and silt. The sand has seen widespread usage in public sector projects and has demonstrated reliable performance in terms of compressive strength gain, durability, and surface finish in cast-in-place and precast concrete. Given its regional accessibility and competitive cost, it can serve as either a primary or supplementary source of fine aggregate for the Murree Glass Train project, particularly in general-purpose concrete and masonry work.

From an engineering standpoint, the suitability of fine aggregates for use in concrete is governed by a comprehensive set of technical specifications and laboratory performance indicators, which must be verified for every source prior to approval and use. These include:

- Sieve analysis (ASTM C136 / AASHTO T27) to determine particle size distribution and ensure conformity with prescribed gradation envelopes for structural concrete;
- Fineness Modulus (FM) calculation to assess the coarseness or fineness of the sand, ideally ranging between 2.3 and 3.1 for concrete applications;
- Silt, clay, and dust content tests (ASTM C117 / BS 882) to verify cleanliness and mitigate potential reduction in bond strength and increased water demand;
- Organic impurity tests (ASTM C40) to detect humic acids or other contaminants that may interfere with cement hydration or cause delayed setting;
- Specific gravity and water absorption (ASTM C128) to estimate density and moisture characteristics that influence batching and mix water calculations;
- Sand Equivalent Test (ASTM D2419) to evaluate relative cleanliness and clay content through sedimentation analysis;
- Chemical testing (as required) to detect soluble sulfates, chlorides, or other compounds that could lead to steel reinforcement corrosion or alkali-silica reactions.

It is essential to emphasize that even for well-established sources like Lawrencepur and Qibla Bandi, routine material testing and validation remain non-negotiable. Sand quality can be affected by various dynamic factors such as upstream erosion, seasonal flooding, anthropogenic disturbances, and shifts in dredging or excavation zones. These variations can result in fluctuations in gradation, organic content, or contamination levels, all of which have a direct impact on the performance and durability of concrete structures. Therefore, the project specifications must mandate a robust quality control protocol, including periodic sampling, laboratory testing, and source re-verification at defined intervals during the construction lifecycle.

Moreover, storage and handling of fine aggregates at the construction site must follow best practices to prevent segregation, contamination, or moisture intrusion. Stockpiles should be constructed on impermeable surfaces, protected from surface runoff and windblown debris, and should allow for proper drainage to avoid saturation. Saturated surface dry (SSD) conditions should be ensured before batching to maintain consistency in water-cement ratio and avoid deviations in mix design performance.

In the context of the Murree Glass Train project, which involves construction across highly variable climatic and geological zones, the importance of consistently high-quality fine aggregates cannot be overstated. The use of substandard or improperly tested sand can lead to reduced concrete strength, poor surface finish, excessive shrinkage, and long-term durability issues, particularly in elements exposed to freeze-thaw cycles, water ingress, or de-icing chemicals. Given the project's exposure to high rainfall, potential frost action, and elevated seismic risks, only fine aggregates that meet all technical and environmental performance criteria should be incorporated into any structural or non-structural concrete elements.

In summary, the availability of reliable and high-quality fine aggregate sources at Lawrencepur and Qibla Bandi offers a strong foundation for meeting the sand requirements of the Murree Glass Train project. However, this advantage must be supported by a rigorous program of quality verification, performance testing, and supply chain oversight to ensure that only compliant materials are introduced into the concrete production process. Such due diligence is indispensable for achieving the long-term safety, serviceability, and sustainability objectives of this complex and high-altitude transit infrastructure initiative.

3. MANUFACTURED MATERIALS

In addition to the awarded scope pertaining to natural construction material investigations, NESPAK proactively undertook a supplementary assessment concerning the availability of manufactured construction materials in the vicinity of the project alignment. This extended evaluation was incorporated into the study to provide a more comprehensive understanding of material sourcing options, with particular focus on the accessibility of cement, steel reinforcement, and admixtures from nearby industrial and commercial suppliers. The inclusion of this assessment aims to facilitate efficient procurement planning, cost optimization, and streamlined logistics during the construction phase of the Murree Glass Train Project.

3.1 CEMENT

Cement, being a fundamental component in all structural and pavement-related works, must be readily available in consistent quality and quantity throughout the duration of the Murree Glass Train Project. To ensure uninterrupted construction activities and adherence to quality benchmarks, a consistent and timely supply of cement is essential. Fortunately, the project's location offers convenient access to several major cement manufacturing plants within a practical transportation range, all of which are capable of fulfilling large-scale construction demands in accordance with relevant ASTM and PS (Pakistan Standards) specifications.

Several established cement plants are situated within a 150 to 200 km radius of the project alignment. These include facilities operated by Maple Leaf Cement, Bestway Cement, D.G. Khan Cement, and Fauji Cement, among others. These manufacturers are recognized for their high-quality production of Ordinary Portland Cement (OPC) and Sulphate-Resisting Cement (SRC), which are commonly used in infrastructure works including bridges, culverts, retaining walls, station structures, and pavement layers. Most plants have integrated quality control laboratories, automated production lines, and efficient dispatch systems, ensuring that the cement supplied meets the physical and chemical requirements stipulated for heavy civil engineering applications.

The proximity of these production units to the project corridor offers logistical advantages in terms of reduced transportation time and cost, while also providing flexibility in terms of procurement options—ranging from bulk supply to site-specific storage arrangements. These cement manufacturers have an established presence in public sector infrastructure development and are capable of meeting project-specific delivery schedules, even under high demand conditions. Routine quality certifications, consistent supply volumes, and ease of access make these regional cement plants a reliable source for meeting the full spectrum

of cement-related requirements throughout the construction phase of the Murree Glass Train Project.

3.2 STEEL

Steel reinforcement is a fundamental construction material required for the development of structural components such as bridges, station buildings, retaining walls, culverts, and foundation systems along the Murree Glass Train alignment. Ensuring consistent availability of high-strength and specification-compliant steel is essential for maintaining construction timelines and meeting structural safety standards. Fortunately, the project corridor lies in close proximity to several reputable steel manufacturers and rolling mills situated in and around Islamabad, Rawalpindi, Taxila, and Hattar areas known for their industrial production capacity and well-established distribution networks.

Notably, Fazal Steel (FSL) and Ittehad Steel, both located in Islamabad's industrial area, are among the region's most reliable sources of high-grade deformed steel bars and billets. These manufacturers produce reinforcement steel conforming to ASTM A615 Grade 60 and PS:1879 standards, with in-house quality control laboratories ensuring batch consistency and compliance with engineering specifications. Similarly, Nomee Steel, situated in Hattar Industrial Estate, is a major supplier of high-strength rebars and structural steel, servicing a wide range of infrastructure projects across northern Pakistan. Its geographic proximity to the project site offers logistical advantages in terms of cost efficiency and delivery lead times.

In addition to these larger producers, Pak Steel and Capital Steel, located in Islamabad and near Tarnol respectively, serve as reliable regional suppliers of re-rolled and hot-rolled reinforcement bars. These facilities cater to both medium- and large-scale civil works and maintain flexible production capacities to meet varying demand volumes. With this cluster of steel manufacturing units located within a 50–70 km radius of the project alignment, the Murree Glass Train Project benefits from a robust and diversified steel supply network. This ensures not only ready availability of materials but also reduces the risks associated with transportation delays and supply chain disruptions. Routine procurement from these nearby sources also facilitates ongoing quality verification and adherence to construction schedules.

3.3 ADMIXTURES

The availability of concrete admixtures in the vicinity of the Rawalpindi to Murree Glass Train Project is well-supported by the presence of leading construction chemical suppliers and distributors operating within the Rawalpindi–Islamabad metropolitan region. Several well-established companies such as Sika Pakistan, BASF Master Builders, Mapei, CHRYSO, Grace Construction Products and others maintain regional offices or distribution centers in

Islamabad, ensuring reliable and timely access to a comprehensive range of concrete admixtures. These include high-range water reducers (superplasticizers), set retarders, accelerators, air-entraining agents, shrinkage-reducing compounds, and waterproofing admixtures all critical for improving concrete performance in high-altitude, variable-climate environments such as Murree.

The proximity of these suppliers enables quick logistical turnaround and technical support, which is especially valuable during the execution of structural concrete works in challenging terrain. Additionally, several local distributors and construction chemical dealers maintain inventories of imported and locally manufactured admixtures that comply with international standards such as ASTM C494 and EN 934. Technical representatives from these companies often provide on-site support for dosage optimization and performance evaluation, ensuring that the concrete mixes meet project-specific strength, durability, and workability requirements under the region's temperature and humidity conditions. This localized supply infrastructure enhances both material quality assurance and construction efficiency for the Project.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

a) The Murree Glass Train alignment traverses a geologically complex and seismically active region, including proximity to the Main Boundary Thrust (MBT), requiring careful geotechnical and material consideration.

b) The presence of weak sedimentary rocks such as shales and sandstones, combined with steep slopes and high elevation changes, poses significant challenges for embankment stability and foundation design.

c) Active hydrology, high rainfall intensity, and frequent landslides exacerbate the risks associated with slope failure, erosion, and subgrade degradation.

d) Locally available construction materials must be evaluated for mechanical strength, durability under wet conditions, and long-term stability in a dynamic environment.

e) Preliminary data indicates the urgent need for detailed investigations to validate material suitability and ensure structural safety and project longevity.

f) Construction material investigations along the Tourist Glass Train alignment revealed a diverse range of geological conditions, with materials varying significantly in composition and quality across the test pit locations.

g) From TP-01 to TP-08 (excluding TP-07), the subsurface material predominantly consists of silty clay, clayey silt, and silty clay with gravel and cobbles, indicating cohesive soil conditions with moderate to good engineering properties.

h) From TP-09 to TP-13, (excluding TP-10 and TP-11) the soils transition into sandy gravel with cobbles and boulders, exhibiting superior drainage, compaction, and load-bearing characteristics conditionally suitable for structural layers.

i) In TP-10, TP-11, TP-14 and TP-15 subsurface material consist of silty clay / clayey silt.

j) Based on previous performance record reliable coarse aggregate sources are available at Margalla and Khanpur quarries, which are known for producing high-quality crushed limestone meeting the standards for concrete and structural fills.

k) A potential coarse aggregate source exists at Ghora Gali, though it requires extensive testing and formal approval prior to use.

l) Fine aggregate suitable for concrete can be sourced from the established deposits at Lawrencepur and Qibla Bandi, both known for their cleanliness and favorable gradation characteristics.

m) All sources of material whether soil, coarse aggregate, or fine aggregate must be subjected to full laboratory testing prior to approval and use.

n) High-quality manufactured construction materials, including cement, steel, and chemical admixtures, are readily available in close proximity to the project site. These materials can be sourced and transported to the site in a cost-effective and logistically efficient manner, ensuring continuity and quality in construction operations.

4.2 RECOMMENDATIONS

A. General

- The Murree Glass Train alignment traverses a geologically complex and seismically active region, including proximity to the Main Boundary Thrust (MBT), requiring careful geotechnical and material consideration.
- The presence of weak sedimentary rocks such as shales and sandstones, combined with steep slopes and high elevation changes, poses significant challenges for embankment stability and foundation design.
- Active hydrology, high rainfall intensity, and frequent landslides exacerbate the risks associated with slope failure, erosion, and subgrade degradation.
- Locally available construction materials must be evaluated for mechanical strength, durability under wet conditions, and long-term stability in a dynamic environment.
- Preliminary data indicates the urgent need for detailed investigations to validate material suitability and ensure structural safety and project longevity.

B. Embankment Works

- Use cohesive soils from TP-01 to TP-08, TP-10, TP-11, TP-14 and TP-15 only after confirming suitability through qualitative analysis.
- In areas where high plasticity or low strength is identified, apply soil improvement techniques such as lime or cement stabilization or remove and replace the soils with superior materials.
- Ensure embankment fill is placed in controlled layers and compacted to the specified degree to achieve desired density and stability.
- Avoid the use of materials with excessive organic content or high moisture variation without proper treatment.

C. Subgrade Works

- Employ granular soils from TP-09 to TP-13 (excluding TP-10 and TP-11) for subgrade construction due to their favorable strength and permeability characteristics.
- Process and grade the material to eliminate oversized particles and ensure consistent compaction behavior.
- Conduct CBR testing to confirm that the material meets the minimum strength requirements for subgrade applications.
- Avoid placing subgrade over cohesive materials without proper treatment or replacement if the underlying soils exhibit shrink-swell potential or inadequate bearing capacity.
- Use of any material as subgrade is subjected to successful qualification of specified quality criteria.

D. Subbase Works

- Utilize sandy gravel from TP-09 to TP-13 (excluding TP-10 and TP-11) for subbase construction, subject to screening and gradation control to meet subbase specifications.
- Perform Los Angeles Abrasion, gradation analysis, and soundness testing to verify durability and performance under cyclic loading.
- Material must be tested for specified parameters prior to use.
- Where natural material is insufficient or non-compliant, supplement subbase requirements using crushed aggregates from established quarry sources.
- Maintain strict quality control during placement to ensure uniformity and strength development across the entire alignment.

E. Concrete Works

- Source coarse aggregates primarily from Margalla and Khanpur quarries, ensuring compliance with ASTM C33 and other National and International standards for size, gradation, strength, chemical and mineralogical composition and durability.
- Consider Ghora Gali limestone as an option only after it passes all required physical and chemical tests, including petrographic analysis, abrasion resistance, and alkali-silica reactivity.

- Use fine aggregates from Lawrencepur and Qibla Bandi, ensuring each batch is tested for fineness modulus, silt content, organic impurities, and absorption capacity.
- Conduct continuous monitoring and testing of aggregates during the construction phase to ensure consistent concrete mix quality and structural integrity.
- Qualitative analysis as specified in International standard and project specification is mandatory prior to use any aggregate.

F. Manufactured Materials

- Steel can be sourced from Fazal Steel (FSL) and Ittehad Steel, Nomee Steel, Pak Steel, Capital Steel or any other source confirming the quality parameters specified by the latest editions of applicable international standards and project's specification.
- Cement can be procured and transported from Maple Leaf Cement, Bestway Cement, D.G. Khan Cement, Fauji Cement or any other cement factory in near vicinity of the project site. Cement must be tested to confirm the compliance with the latest editions of applicable international standards prior to use.
- Concrete admixtures may be procured and transported to the site by Sika Pakistan, BASF Master Builders, Mapei, CHRYSO, Grace Construction Products and any other supplier and distributor in near vicinity of the project area. The admixture must be compliant to the latest editions of applicable international standards and must be capable of excellent performance in variable climate. Admixture must be compatible to the type of cement used.

5. DISCLAIMER

This report has been prepared by National Engineering Services Pakistan Pvt. Ltd. (NESPAK) for **"**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE". The material contained in this report reflects engineering characteristics of soils / rocks and recommendations on the basis of visual field conditions at the time of preparation of this report. This report is based on visual observations during ongoing construction material studies and some changes may be observed after lab testing of collected samples.

This document and the information are solely for the use of the authorized recipient. Any use, which a third party makes of this report or any reliance on or decisions to be made based on it, are the responsibility of such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions.

During construction, the construction activity may alter the conditions from those prevailing at the time, this report was written or may reveal somewhat different conditions at places. This may require performance of additional investigations during the construction stage so as to adjust the design to safeguard against the revealed conditions. NESPAK does not accept any responsibility for change in conditions and design recommendations provided in this report due to above circumstances.

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-01
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-318495m	N-3726182m		**Date**	30-05-2025 To 30-05-2025
GWT(m)	Nil				

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Grass Cover, roots, plantation **From 0.10m to 1.00m:** Brown silty clay / clayey silt, low to medium plastic, moist	Bulk sample TP-01-CS-1 (0.10m to 1.00m)	1.781 Gms/c.c @ 0.65m					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-02
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-320062m	N-3724968m		**Date**	30-05-2025 To 30-05-2025
GWT(m)	Nil				

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Grass Cover, **From 0.10m to 1.00m:** Greyish Brown silty clay /clayey silt with gravel, low plastic, moist	Bulk sample TP-02-CS-1 (0.10m to 1.00m)	1.769 Gms/c.c @ 1.00m					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-03
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-321292m		N-3725798m	**Date**	01-06-2025 To 01-06-2025
GWT(m)	Nil				

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.50m:** Grass Cover, Polythene bags and waste material **From 0.50m to 1.00m:** Light Brown silty clay /clayey silt, low to medium plastic, dry	**Bulk sample TP-03-CS-1 (0.50m to 1.00m)**	1.714 Gms/c.c @ 0.60m					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-04
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-322751m		N-3726639m	**Date**	29-05-2025 To 29-05-2025

GWT(m): Nil

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Grass Cover, **From 0.10m to 1.00m:** Brown Silty clay / Clayey silt with gravel, low to medium plastic, moist	Bulk sample TP-04-CS-1 (0.10m to 1.00m)	1.735 Gms/c.c @ 0.30m					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-05
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-323632m	N-3728144m		**Date**	29-05-2025 To 29-05-2025
GWT(m)	Nil				

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Top layer covered with grass, trees and bushes **From 0.10m to 1.00m:** Light brown silty clay / clayey silt with trace gravel, low to medium plastic, dry	Bulk sample TP-05-CS-1 (0.10m to 1.00m)	1.751 Gms/c.c @ 0.30m					
1.20 – 3.00				Bottom of testpit							

Appendix - A (Test Pit Logs)

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-06
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-324615m		N-3728932m	**Date**	29-05-2025 To 29-05-2025

GWT(m): Nil

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.05m:** Grass Cover, **From 0.10m to 1.00m:** Brown silty clay with 20-25% gravel and 15-20% cobbels. Low to medium plastic, dry.	Bulk sample TP-06-CS-1 (0.10m to 1.00m)	1.849 Gms/c.c @ 0.15m					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-08
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-324967m	N-3731980m		**Date**	29-05-2025 To 29-05-2025
GWT(m)	Nil				

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.40m:** Grass Cover, dense forest, roots, **From 0.10m to 1.00m:** Light Brown silty clay / clayey silt, medium plastic, moist	Bulk sample TP-08-CS-1 (0.40m to 1.00m)	1.744 Gms/c.c @ 0.30m					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-09
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-326247m	N-3732502m		**Date**	29-05-2025 To 29-05-2025
GWT(m)	Nil				

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Grass Cover, light brown clay mixed with gravel, **From 0.10m to 1.00m:** Sandy gravel with 20-25% cobbles and minor brown silty clay, dry	Bulk sample TP-09-CS-1 (0.10m to 1.00m)	1.876 Gms/c.c @ 0.60m					
1.20				Bottom of testpit							
1.30 – 3.00											

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-10
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-327311m	N-3732900m		**Date**	29-05-2025 To 29-05-2025

GWT(m): Nil

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Grass Cover, **From 0.10m to 1.00m:** Light Brown silty clay / clayey silt, low to medium plastic, dry	Bulk sample TP-10-CS-1 (0.10m to 1.00m)	FDT could not be conducted due to interruption by Lake View park management					
1.20				Bottom of testpit							
1.30 – 3.00											

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-11
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-328012m	N-3733119m		**Date**	02-06-2025 To 02-06-2025
GWT(m)	Nil				

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Grass Cover, **From 0.10m to 1.00m:** Light Brown clayey silt, low plastic, moist	Bulk sample TP-11-CS-1 (0.10m to 1.00m)	1.800 Gms/c.c @ 0.75m					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-12
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-328781m		N-3733911m	**Date**	27-05-2025 To 27-05-2025

GWT(m): Nil

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Top Layer covered with grass, trees, bushes and shrubs in the area. **From 0.10m to 1.00m:** Brownish grey sandy gravel with 15-20% cobbels, 5-10% boulders and minor clay.	Bulk sample TP-12-CS-1 (0.10m to 1.00m)	FDT could not be conducted due to presence of cobbels and boulders					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-13
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-328960m	N-3734771m		**Date**	01-06-2025 To 01-06-2025
GWT(m)	Nil				

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0.00m to 1.00m:** Sandy gravel with cobbels and boulders, mixed with brown clay	Bulk sample TP-13-CS-1 (0.00m to 1.00m)	FDT could not be conducted due to Cobbels and boulders					
1.20				Bottom of testpit							
1.30 – 3.00											

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-14
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-329617m		N-3735845m	**Date**	02-06-2025 To 02-06-2025

GWT(m): Nil

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Grass Cover, **From 0.10m to 1.00m:** Brown silty clay / clayey silt, low to medium plastic, dry	Bulk sample TP-14-CS-1 (0.10m to 1.00m)	1.799 Gms/c.c @ 0.70m					
1.20 – 3.00				Bottom of testpit							

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-15
Sheet 1 OF 1

TESTPIT LOG

Job No.	4806	**Project**	**FEASIBILITY STUDY FOR TOURIST GLASS TRAIN FROM RAWALPINDI TO MURREE**	**Location**	Along the Alignment
GE (m)	-	**Client**	Punjab Mass Transit Authority	**Contractor**	M/s F & M Pvt Ltd.
Coordinates	E-330956m		N-3737345m	**Date**	31-05-2025 To 31-05-2025

GWT(m): Nil

Depth in meter	Elevation in meter	Legend	Unified Classification Symbol	DESCRIPTION OF MATERIAL	Sample Type/No.	Field Density Test: Wet Density g/cm³	Field Density Test: Moisture Content %	Lab Density Test: Max. Dry Density g/cm³	Lab Density Test: Optimum M.C %	Compaction %	Remarks
0.10 – 1.00				**From 0 to 0.10m:** Grass Cover, **From 0.10m to 1.00m:** Brown silty clay / clayey silt, low to medium plastic, moist	Bulk sample TP-15-CS-1 (0.10m to 1.00m)	1.810 Gms/c.c @ 0.85m					
1.20 – 3.00				Bottom of testpit							



PLATE 1: Depth verification of TP – 12

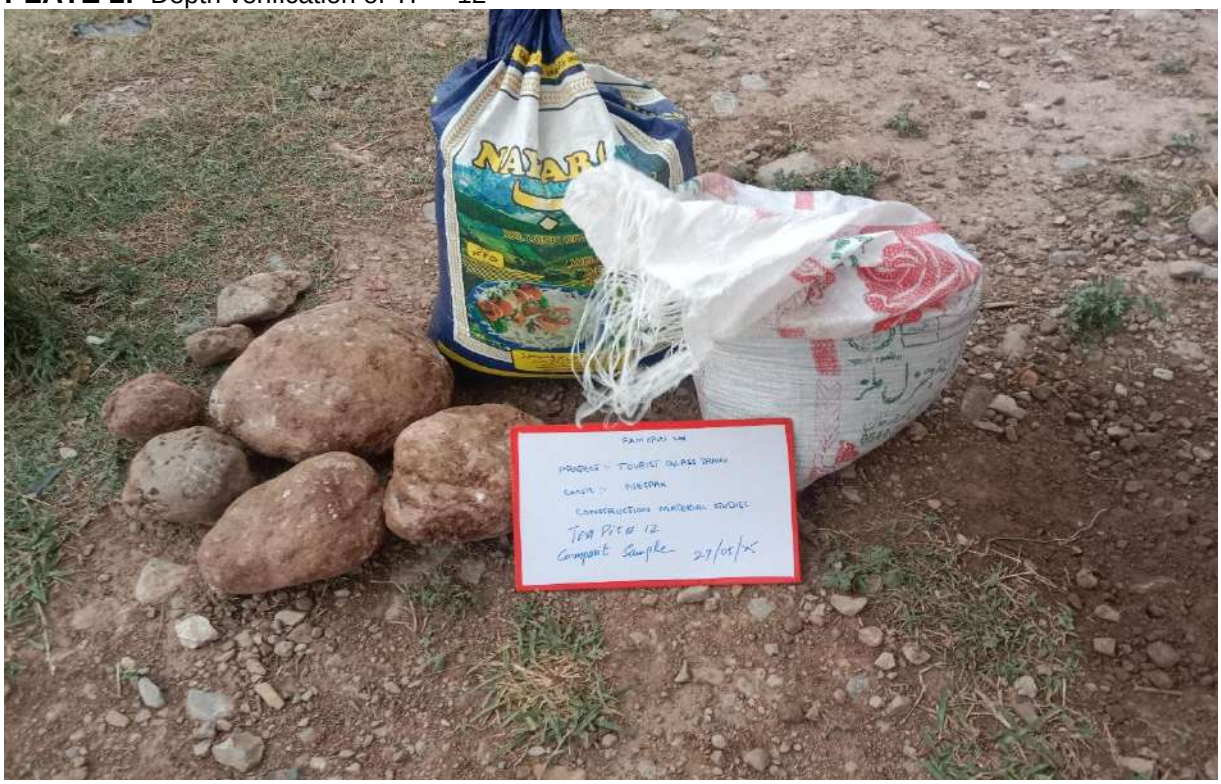


PLATE 2: Composit sample collected from TP – 12



PLATE 3: Collection of composit sample from TP – 05



PLATE 4: Depth verification of TP – 06



LATE 5: Depth verification of TP – 09



PLATE 6: Excavation of TP – 04 is in progress



PLATE 7: Collection of composite sample from Borrow Area BA – 1



PLATE 8: Composit Samples collected from Test Pits and Borrow Area