Hagler Bailly Pakistan

DIGBY WELLS ENVIRONMENTAL

Appendix R: Soils & Sediments Assessment

Hagler Bailly Pakistan

Environmental and Social Impact Assessment of Reko Diq Mining Project

Soils and Sediments

Final Report

HBP Ref.: R4SL10RKG

October 1, 2024

Reko Diq Mining Company

Quetta

Acronyms

AAS	Atomic Absorption Spectroscopy
DWE	Digby Wells Environmental
ESIA	Environmental and Social Impact Assessment
HBP	Hagler Bailly Pakistan
ICP-OES	Inductively Coupled Plasma Optical Emission Spectroscopy
IFC	International Finance Corporation
m.a.m.s.l.	Meters Above Mean Sea Level
PIBT	Pakistan International Bulk Terminal Limited
PINSTECH	Pakistan Institute of Nuclear Science and Technology
PNAC	Pakistan National Accreditation Council
PS	Performance Standard
QC	Quality Control
RDMC	Reko Diq Mining Company
SSV	Soil Screening Values
SUPARCO	Space & Upper Atmospheric Research Commission
USEPA	United States Environmental Protection Agency

Contents

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Executive Summary

Barrick Gold Corporation (hereafter Barrick) through its subsidiary Reko Diq Mining Company (RDMC), in a Joint Venture partnership with the Government of Pakistan and the Government of Balochistan, is completing a feasibility study for the Reko Diq Mining Project (also referred to as the 'Project') in the western part of Balochistan Province of Pakistan. As part of the feasibility study, an Environmental and Social Impact Assessment (ESIA) has been conducted, including specialist studies. The ESIA will be part of the environmental permitting process and will provide a basis for the integration of environmental and social considerations into the Project design. RDMC appointed Digby Wells Environmental (hereafter Digby Wells) and Hagler Bailly Pakistan Pvt. Ltd (hereafter HBP) to carry out the proposed environmental and social studies and permitting process for the Project. This Specialist Report presents baseline soil and sediment quality where the Project facilities will be situated, potential Project related impacts on soil and sediments measures that will be implemented to mitigate the impacts and monitoring that will be carried out to assess the effectiveness of mitigation.

The Project is a Copper-Gold mining operation with an onsite processing plant to produce a high-quality copper-gold concentrate (the Concentrate) that will be exported for final processing into various products. The current Life-of-Mine (LoM) is 38 years in terms of defined resources (resources that have been identified already) with significant exploration upside.

The construction phase is anticipated to take approximately 40 months, including pre-stripping. The mine will be a truck-and-shovel open pit mining operation with processing facilities that include crushing, grinding, and flotation. The final Concentrate will be railed to Port Qasim for final export by ship.

The mine will be developed in two phases, Phase 1 is expected to have a capacity of 45 Mt per annum (Mtpa) and Phase 2 is expected to have a combined processing capacity of 90 Mtpa. Phase 1 operations are anticipated to commence towards the end of 2027 and Phase 2 operations in 2030.

Baseline Soil Quality

Soil samples were collected from 19 locations to assess the soil quality at various Project Components in Balochistan and Sindh provinces, along with sediment samples at 13 locations.

Soil samples collected at Reko Diq Mine Site and along the Road Transport Route were sent to PINSTECH, Islamabad for soil quality analysis and soil samples collected at Port Qasim in Sindh were tested at the Space & Upper Atmospheric Research Commission (SUPARCO) laboratory. **Section 4** provides the soil sampling methodology in further detail.

As a basis for interpreting the laboratory data, Soil Screening Values (SSV) and soil fertility guidelines were assessed. Where thresholds were not available, other sources were accessed to determine the chemical characteristics of the soils. The following

observations were made with respect to elevated soil parameters in samples collected at the following Project components:

- Mine Site: Chromium was detected above the Alberta Guidelines limit. Site investigations did not identify anthropogenic sources thus the Chromium is presumed to be geogenic and can naturally occur up to 100 mg/kg in certain soils[1]Additionally, Calcium, Potassium, Sodium, Chloride and Phosphorus were also detected above the Alberta Guideline limits but are geogenic in nature.
- Northern Groundwater System: Calcium, Potassium, Sodium, Chloride, Phosphorus and Boron were detected above the Alberta Guideline limits. The elevated mineral levels are geogenic and not associated with anthropogenic sources.
- Road Transport Route: Chromium was detected at all locations. The concentration of Chromium exceeded the Guideline limits but are geogenic in nature as no sources of Chromium were identified or observed along the Road Transport Route.
- Port Qasim:
  - Soil: The concentration of Calcium, Magnesium, Sodium, And Potassium exceeded the Alberta guidelines at several locations. The elevated mineral levels are geogenic and not associated with anthropogenic sources. Additionally, elevated concentrations of Cadmium are associated with contamination from the existing port facilities and port freight traffic were also detected.
  - Sediments: Boron was detected and exceeded the guideline values in all samples collected. The PIBT is a coal, clinker and cement terminal and boron naturally present in coal deposits can be released into the environment during coal handling, transportation, and combustion processes, leading to the deposition of boron-containing. Due to the presence of other nearby industries, the exact source of this Boron could not be determined.

Section 5 presents the baseline results in additional detail.

Impact Assessment

The following impacts were considered significant in accordance with the methodology for assessing the potential significance of impacts presented in **Section 4.4**:

- Impacts on soil quality due to Mine Site Construction
- Disturbance of Soil Due to Construction of Water Supply Pipeline
- Soil Contamination due to Improper Storage of Hazardous Materials or Management of Hazardous Waste

[1] Chrysochoou, M., Theologou, E., Bompoti, N., Dermatas, D., & Panagiotakis, I. (2016). Occurrence, Origin and Transformation Processes of Geogenic Chromium in Soils and Sediments. Current Pollution Reports, 2(4), 224-235. doi:10.1007/s40726-016-0044-2

- Disturbance of Soil Due to Pit Development.

All of the potential impacts will be "Minor" or below given the implementation of mitigation measures identified and presented in **Section 7**. **Section 8** provides a monitoring plan the Project will follow to ensure that all mitigation measures are in place and that all potential Project impacts can be proactively addressed and mitigated.

Recommendations

The Project's impacts on soil and sediments are not significant given that the mitigations identified are implemented and subsequent monitoring is carried out. The following is recommended:

- Storage, management and placement of stockpiles to ensure no runoff into water bodies occurs.
- Development of a **Hazardous Waste and Materials Management Plan** to prevent soil contamination
- Continued implementation of the **Ground Disturbance Control Plan** which will ensure that construction related disturbance of soils is kept to a minimum.
- Monitoring of stockpiles and hazardous material storage areas to ensure that soil related impacts do not occur.

1. Introduction

1.1 Background

Barrick Gold Corporation (hereafter Barrick) through its subsidiary Reko Diq Mining Company (RDMC), in a Joint Venture partnership with the Government of Pakistan and the Government of Balochistan, is completing a feasibility study for the Reko Diq Mining Project (also referred to as the 'Project') in the western part of Balochistan Province of Pakistan. As part of the feasibility study, an Environmental and Social Impact Assessment (ESIA) has been conducted, including specialist studies. The ESIA will be part of the environmental permitting process and will provide a basis for the integration of environmental and social considerations into the Project design. RDMC appointed Digby Wells Environmental (hereafter Digby Wells) and Hagler Bailly Pakistan Pvt. Ltd (hereafter HBP) to carry out the proposed environmental and social studies and permitting process for the Project.

This Specialist Report presents baseline soil and sediment quality where the Project facilities will be situated, potential Project related impacts on soil and sediments measures that will be implemented to mitigate the impacts and monitoring that will be carried out to assess the effectiveness of mitigation.

1.2 Objectives

The objectives of this study were to:

- Establish a pre-project baseline through data collection and review of secondary sources of information where appropriate.
- Determine the project's potential impacts based on an objective methodology.
- Identify the mitigations the project will implement to address its potential impacts.
- Establish a framework for monitoring to ensure that mitigation measures are effectively implemented and to proactively identify any adverse project impacts should they still occur.

2. Project Description

The Project is a Copper-Gold mining operation with an onsite processing plant to produce a high-quality copper-gold concentrate (the Concentrate) that will be exported for final processing into various products. The current Life-of-Mine (LoM) is 38 years in terms of defined resources (resources that have been identified already) with significant exploration upside.

The construction phase is anticipated to take approximately 40 months, including pre-stripping. The mine will be a truck-and-shovel open pit mining operation with processing facilities that include crushing, grinding, and flotation. The final Concentrate will be railed to Port Qasim for final export by ship.

The mine will be developed in two phases, Phase 1 is expected to have a capacity of 45 Mt per annum (Mtpa) and Phase 2 is expected to have a combined processing capacity of 90 Mtpa. Phase 1 operations are anticipated to commence in 2028 and Phase 2 operations in 2030.

2.1 Reko Diq Mine Site and Associated Facilities

Exhibit 2.1 provides an overview of the RDMS and the major proposed infrastructure.

The core infrastructure that will be established at the RDMS includes:

- Two main pits, Western Porphyry and Tanjeel (**Exhibit 2.1**). The mining method of these pits will be a 24-hour open-pit shovel and truck operation
- Two designated Waste Rock Dumps (WRD) for the waste rock from the Western Porphyries pit. The Tajeel Pit will have a separate WRD in its proximity
- Tailings storage facility (TSF)
- A processing plant.

2.1.1 Supporting Infrastructure

The proposed supporting infrastructure at the RDMS includes:

- Several sources for power supply will be utilised for the Project. The Project's estimated peak power requirements will be 183 megawatts (MW) in Phase 1 and 348 MW in Phase 2:
  - Diesel generators during the early works and construction phases until the establishment of the Heavy Fuel Oil (HFO) power station;
  - A Solar Photovoltaic (PV) system with an installed capacity of 183 MW in Phase 1 and 384 MW in Phase 2;
  - It is anticipated that the Project's energy requirements will be met through a grid connection from Year 15 (operational phase).
- Diesel, HFO and other sources of fuel will be railed to the site from Port Qasim and stored in bunded contained atmospheric tanks at the designated storage areas.

- Accommodation Facility to provide on-site accommodation for all employees and contractors;
- Security infrastructure;
- Waste management facilities:

2.1.2 Water Supply and Management

Water for the Construction Phase, Phase 1 and Phase 2 of the Project will be sourced from a sedimentary groundwater system located approximately 70 km to the northwest of the mining area referred to as the Northern Groundwater System (**Exhibit 2.1**). The system represents a small and isolated part of a much larger basin and there are no communities or community water sources located within the proposed borefield and its area of influence.

Water in the system is saline and challenging to access, and as such is not suitable for human consumption or most agricultural or industrial uses without significant treatment and abstraction infrastructure. There are currently no planned developments or users of the target groundwater system, and the scope of the Project would not preclude future use of the broader basin by others. Independent international best practice environmental and social impact assessment and hydrogeological studies, using physical surveying and remote sensing techniques, have demonstrated that there are no surface expressions of the groundwater system and no known dependent biodiversity.

This groundwater system is considered capable of enabling development and sustaining operation of the Project, which is expected to add significantly to the socio-economic advancement within the region and country through employment, infrastructure, and services.

2.2 Transport and Marine Port

The Project will use the existing road and rail networks to transport materials during construction and operational phases and utilise the air transportation option for personnel. The main Project transport routes (Road Transport Route and Rail Transport Route) are shown in **Exhibit 2.2**.

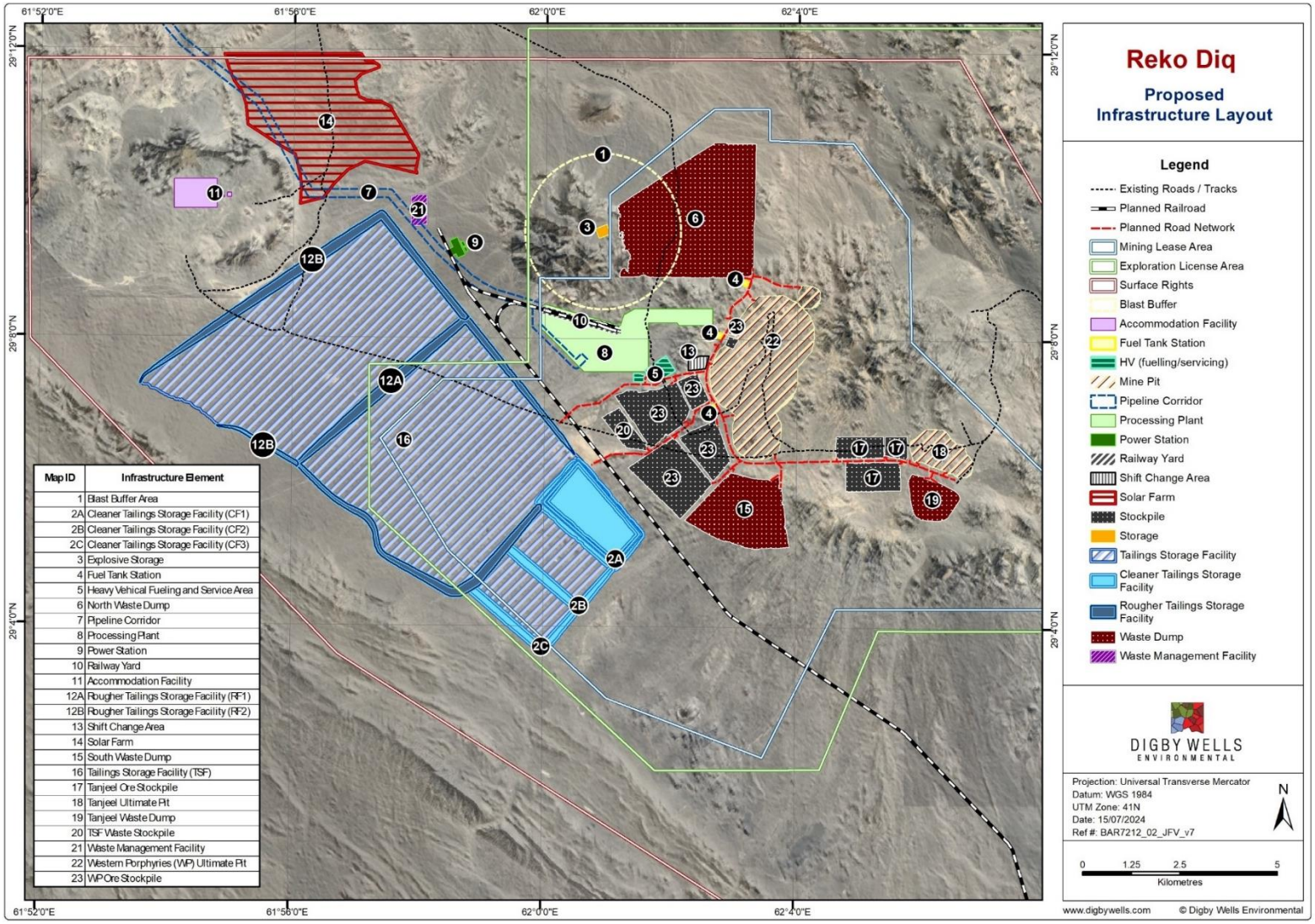
2.2.1 Transport of Concentrate to Port Qasim

The Concentrate will be transported from the RDMS processing plant to Port Qasim via an existing railway line, passing through the Balochistan and Sindh provinces. The existing rail route is approximately 1,350 km in length as outlined in **Exhibit 2.2**.

The Project will make use of the existing PIBT Terminal where all facilities are owned and operated by PIBT. An area will be leased to RDMC for the construction of a Concentrate storage shed.

An extract of the onshore and offshore layout is shown in **Exhibit 2.4**.

Exhibit 2.1: Proposed Reko Diq Mine Site Layout



Map ID	Infrastructure Element
1	Blast Buffer Area
2A	Cleaner Tailings Storage Facility (CF1)
2B	Cleaner Tailings Storage Facility (CF2)
2C	Cleaner Tailings Storage Facility (CF3)
3	Explosive Storage
4	Fuel Tank Station
5	Heavy Vehical Fueling and Service Area
6	North Waste Dump
7	Pipeline Corridor
8	Processing Plant
9	Power Station
10	Railway Yard
11	Accommodation Facility
12A	Rougher Tailings Storage Facility (RF1)
12B	Rougher Tailings Storage Facility (RF2)
13	Shift Change Area
14	Solar Farm
15	South Waste Dump
16	Tailings Storage Facility (TSF)
17	Tanjeel Ore Stockpile
18	Tanjeel Ultimate Pit
19	Tanjeel Waste Dump
20	TSF Waste Stockpile
21	Waste Management Facility
22	Western Porphyries (WP) Ultimate Pit
23	WP Ore Stockpile

Exhibit 2.2: Reko Diq Spatial Extent and Transport Routes (Rail Transport Route and Road Transport Route)

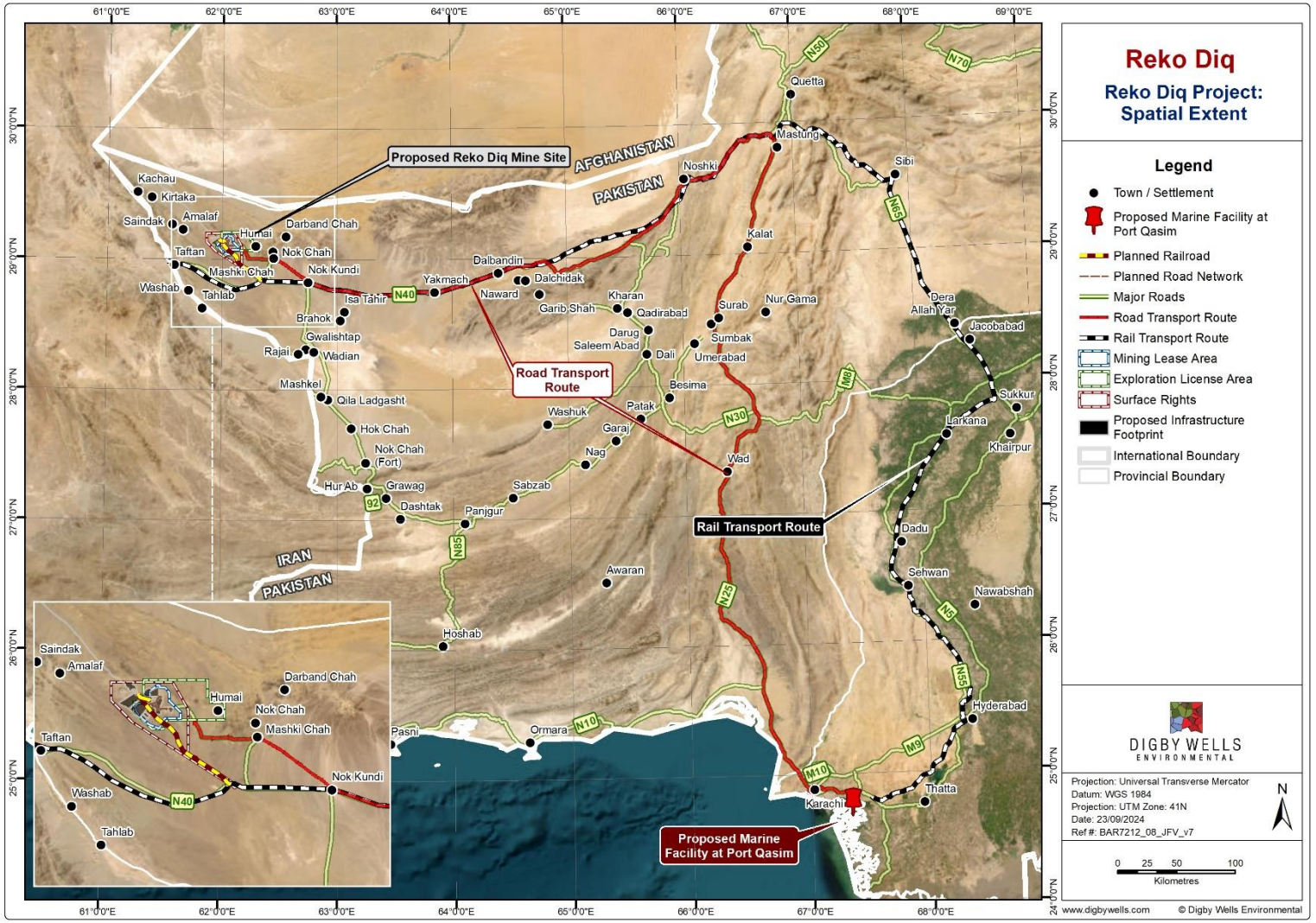


Exhibit 2.3: Proposed Rail Yard Layout at Port Qasim

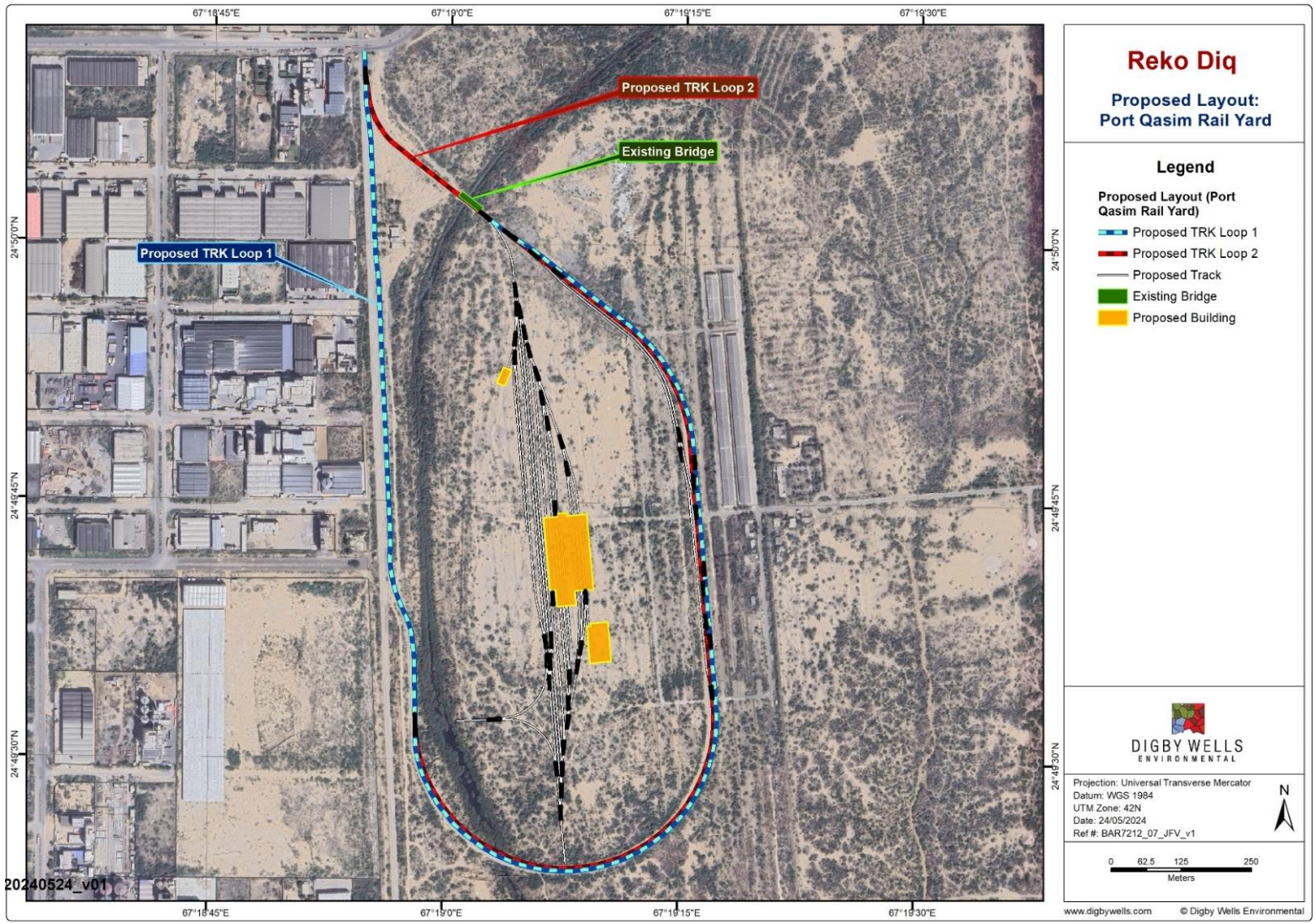
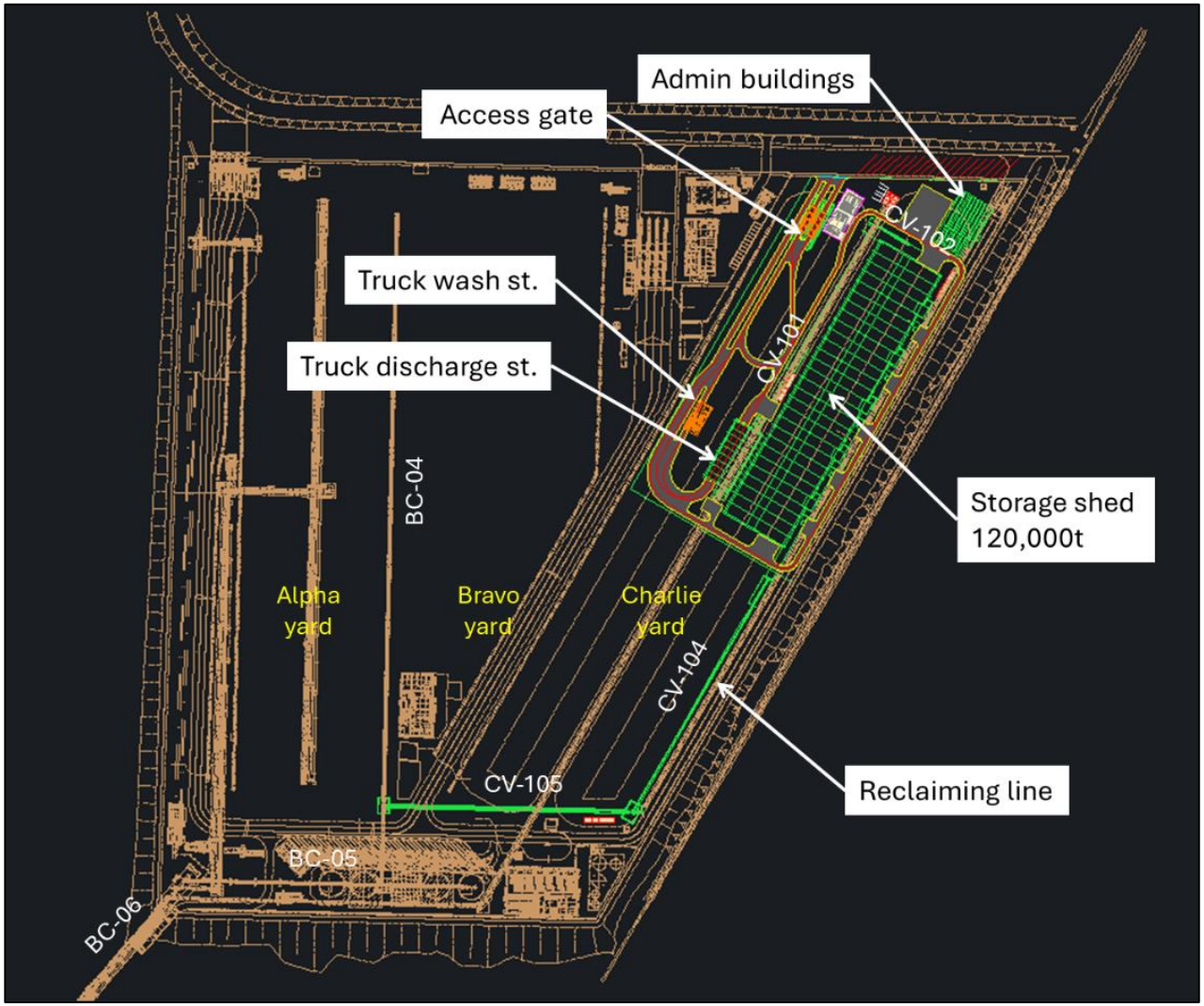


Exhibit 2.4: Layout of Concentrate Facilities at PIBT at Port Qasim



3. Legislative and Regulations Framework

This section is an overview of the applicable Pakistan legislation and international guidelines relevant to this Specialist Study. There are presently no Pakistan legislations that govern soil and sediment quality, thus international guidelines have been used for comparative purposes for information collected in the baseline.

Exhibit 3.1: Applicable Legislation and Guidelines

Name of Legislation, Policy, or Guideline	*Description and Relevance*
Alberta Tier 1 Soil and Groundwater Remediation Guidelines	In the absence of Pakistan legislation, International Guidelines were used to assess the baseline contamination in the soils and sediments. Two guidelines were used to obtain the full set of comparative values for various elements.
Dutch Soil Remediation Circular 2013 (Soil Protection Act of 1987)	

4. Methodology

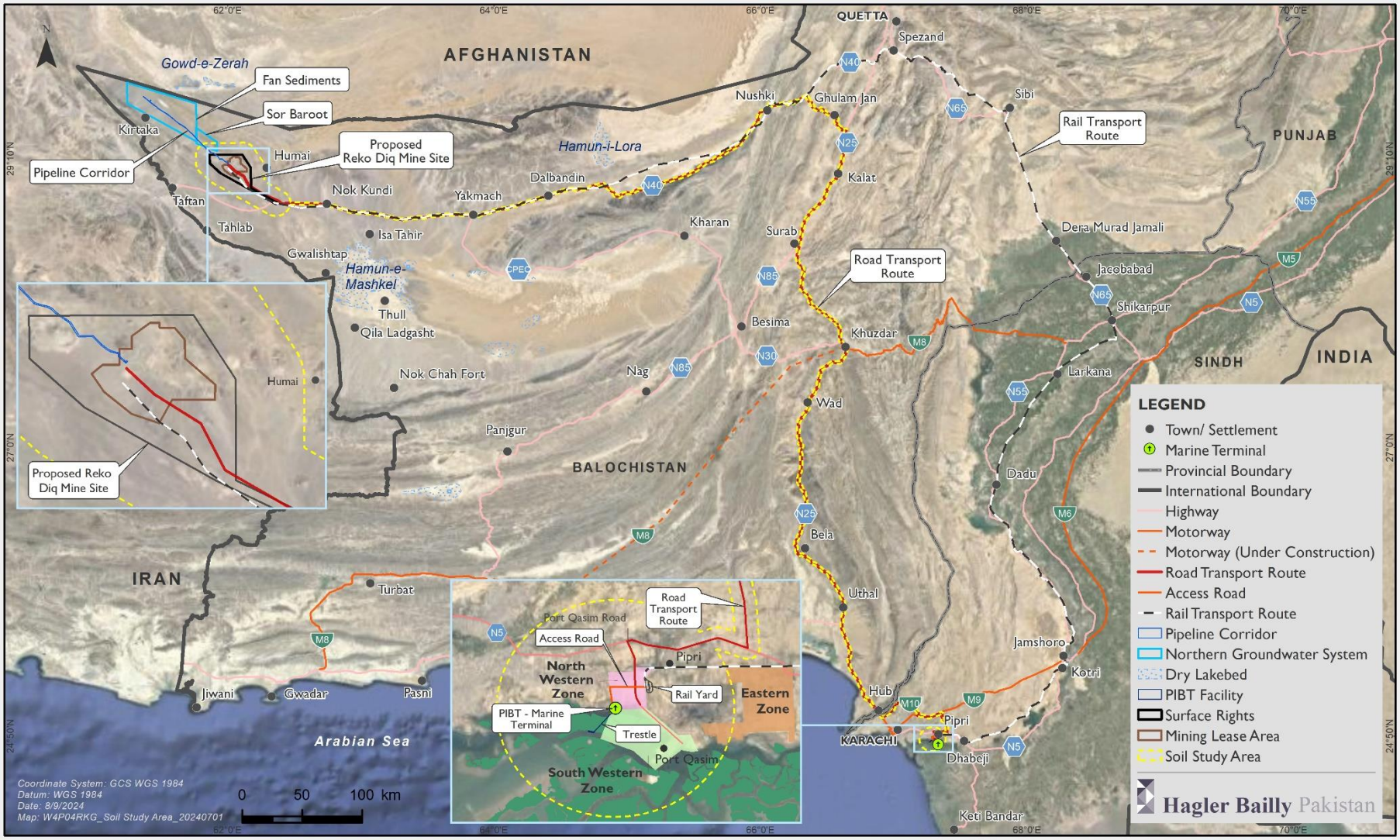
4.1 Overview of Study Area

The Study Area in which the Project's activities may impact the soils and sediments was delineated as follows:

- Reko Diq Mine Site: An area of 10 kilometres (km) around the proposed Reko Diq Mine Site area was selected to cover the Project footprint as this is considered to be the primary area of impact, plus surrounding areas to ensure a spatially representative sample area.
- Road Transport Route: The Road and Railway Transport Routes run parallel up until the settlement of Dalbandin. An area of 1 kilometre around the Road Transport Route was selected.
- Rail Transport Route: Expansion of the railway network will not be undertaken for the Project. As excavation and soil disturbance is limited along the Rail Transport Route, no soil samples were collected along this route.
- Port Qasim: An area of 10 kilometres were selected, at which contamination of soils can occur due to mishandling of copper concentrate. Sample collection for seabed sediments was undertaken within this area near creeks and other receptors of concern, whereas soil samples within this area were collected near the Rail Transport Route which connects to the terminal.

Exhibit 4.1 provides a map of the Study Area.

Exhibit 4.1: Study Area for Soils and Sediments



4.2 Scheduling of Surveys

The data on the quality of soils and sediments was collected through field surveys and sampling to establish the baseline conditions within the Study Area. The field surveys were carried out in both the Balochistan and Sindh provinces. The primary data was collected using pre-designed forms and sampling equipment. To ensure accuracy, quality control samples were also collected where appropriate. The field surveys were carried out in multiple rounds as follows:

- Round 1: The surveys completed under this round, referred to as '2020 Surveys', were carried out between August 24, 2020, and August 27, 2020. These samples were reported in a 2020 ESIA prepared for the Tanjeel Project. A total of six samples and one duplicate sample were collected.
- Round 2: The surveys completed under this round as part of the Reko Diq Mining Project ESIA, referred to as '2022 Surveys', were carried out between September 12, 2022, and October 14, 2022. A total of three samples were collected near the Road Transport Routes.
- Round 3: The surveys completed under this round as part of the Reko Diq Mining Project ESIA, referred to as '2023 Surveys', were carried out between October 09, 2023, and November 15, 2023. A total of ten soil samples were collected from Port Qasim along with one control sample from Keti Bandar. Additionally, thirteen sediment samples were also collected near Port Qasim along with one control sample from Keti Bandar.

4.3 Baseline Data Collection

This section details the rational for the selection of soil sampling locations and methods for the soil sample collection and subsequent analysis.

4.3.1 Soil Sampling Locations

Soil samples were collected from 19 locations to assess the soil quality at various Project Components in Balochistan and Sindh provinces, along with sediment samples at 13 locations. **Exhibit 4.2** presents a summary of soil sampling locations in the different rounds of surveys and **Exhibit 4.3** provides a summary of the sediment sampling, all conducted at Port Qasim. **Exhibit 4.6, Exhibit 4.8** and **Exhibit 4.9** provide photographs of the soil sampling activities.

Exhibit 4.2: Summary of Soil Sampling Locations for the Reko Diq Mining Project

Sample ID	*Location*	*Project Component*	*Sampling Round*	*Coordinates*	*Province*	*Rationale for Selection*
S1-20	Near abstraction point	Northern Groundwater System	Round 1	29°31'13.40" N 61°34'33.60" E	Balochistan	At the Northern Groundwater System to evaluate the soil quality at the water extraction point.
S2-20	At gypsum waste area of Tanjeel	Mine Site	Round 1	29° 06' 09.8" N 62° 05' 40.9" E	Balochistan	At gypsum waste area of Tanjeel to evaluate baseline soil quality prior to construction of the Project. This site serves as a reference point.
S3-20	At waste dump area of Tanjeel	Mine Site	Round 1	29° 05' 46.6" N 62° 06' 17.04" E	Balochistan	At waste dump area of Tanjeel to evaluate baseline soil quality prior to construction of the Project. This site serves as a reference point.
S4-20	At mining area of Tanjeel	Mine Site	Round 1	29° 06' 35.4" N 62° 06' 29.5" E	Balochistan	At mining area of Tanjeel to evaluate baseline soil quality prior to construction of the mine site. This site serves as a reference point.
S5-20	At heap leach pad area of Tanjeel	Mine Site	Round 1	29° 07' 15.9" N 62° 07' 13.8" E	Balochistan	At heap leach pad area of Tanjeel to evaluate baseline soil quality prior to construction of the mine site. This site serves as a reference point.
S6-20	Mine Area	Mine Site	Round 1	29°08'47.70" N 62°06'52.90" E	Balochistan	Within the Surface Rights Lease.
S7-20	Duplicate Sample	Mine Site	Round 1	29°08'47.70" N 62°06'52.90" E	Balochistan	Duplicate of S6, as a QC sample.
S1-22	Qadirabad	Road Transport Route	Round 2	28° 34' 04.45" N 65° 31' 20.72" E	Balochistan	An agricultural area which will be impacted on along the road route near Qadirabad to evaluate the soil quality and fertility before the Project. This site serves as a control location.
S2-22	Nok Kundi	Road Transport Route	Round 2	28° 46' 42.50" N 62° 40' 44.90" E	Balochistan	At a gravel plain near Nok Kundi to assess the soil quality before the construction of the Project.

Sample ID	*Location*	*Project Component*	*Sampling Round*	*Coordinates*	*Province*	*Rationale for Selection*
S3-22	Garib Shah	Road Transport Route	Round 2	28° 39' 52.43" N 64° 47' 11.19" E	Balochistan	At a mountain hill along the road route near Garib Shah to evaluate the soil quality before the Project. This site serves as a control location
SS1	At Korangi Fish Harbor	Port Qasim	Round 3	24°48'36.00" N 67°11'47.93" E	Sindh	At Korangi Fish Harbor to assess the soil quality at this location which will not be impacted by the Project. This site serves as a reference point.
SS2	At PIBT Coal Terminal Jetty	Port Qasim	Round 3	24°47'45.60" N 67°16'41.97" E	Sindh	At PIBT Coal Terminal Jetty to assess the soil quality before the Project. The Project will utilize the jetty if the PIBT site is selected for the marine facility.
SS3	At PIBT site north boundary	Port Qasim	Round 3	24°48'46.80" N 67°17'31.31" E	Sindh	At PIBT site north boundary to assess the pre-Project soil quality.
SS4	At Port Qasim Road	Port Qasim	Round 3	24°48'57.60" N 67°18'05.40" E	Sindh	At Port Qasim Road in the Northwestern Industrial Zone Port Qasim going towards PIBT.
SS5	At proposed rail route	Port Qasim	Round 3	24°48'46.80" N 67°17'57.77" E	Sindh	Port Qasim area.
SS6	At the existing rail route	Port Qasim	Round 3	24°50'06.61" N 67°18'57.60" E	Sindh	Along the existing Rail Transport Route below Pipri and adjacent to Northwestern Industrial Zone.
SS7	At the existing rail route	Port Qasim	Round 3	24°48'10.80" N 67°19'30.61" E	Sindh	Along the existing Rail Transport Route going towards Southwestern Industrial Zone.
SS8	At existing rail in the Southwestern Industrial Zone	Port Qasim	Round 3	24°47'37.21" N 67°20'09.60" E	Sindh	At existing rail in the Southwestern Industrial Zone to assess the pre-Project soil quality.
SS9	At Southwestern Industrial Zone	Port Qasim	Round 3	24°47'06.00" N 67°20'26.74" E	Sindh	At Southwestern Industrial Zone along the Port Qasim Road.
SS10	Keti Bandar	Port Qasim	Round 3	24°08'35.31" N 67°27'07.20" E	Sindh	At Keti Bandar which serves as a control location.
SS11	Duplicate Sample	Port Qasim	Round 3	Duplicate of SS4	Sindh	Duplicate sample

Exhibit 4.3: Summary of Sediment Sampling Locations

Sample ID	*Location*	*Project Component*	*Sampling Round*	*Coordinates*	*Province*	*Rationale for Selection*
SD1	Korangi Fish Harbor	Port Qastim	Round 3	24° 48' 10.39" N 67° 12' 20.94" E	Sindh	At Korangi Fish Harbor to assess the sedimentation contamination due to the discharge of effluents particularly from Korangi Industrial Area.
SD2	Jhari Creek	Port Qastim	Round 3	24° 46' 15.71" N 67° 13' 36.77" E	Sindh	Jhari Creek in the extended navigation channel near PIBT terminal
SD3	Kadiro Creek	Port Qastim	Round 3	24° 47' 05.63" N 67° 14' 57.44" E	Sindh	Kadiro Creek inside the channel near PIBT .
SD4	PIBT Terminal	Port Qastim	Round 3	24° 47' 24.79" N 67° 16' 30.78" E	Sindh	At PIBT site to see the pre-Project sediment contamination at PIBT Jetty if the Project selects this option for the marine facility.
SD5	PIBT site	Port Qastim	Round 3	24° 48' 15.02" N 67° 17' 10.08" E	Sindh	At PIBT terminal to see the pre-Project sediment contamination at PIBT Jetty.
SD6	Near FOTCO Oil Jetty	Port Qastim	Round 3	24° 46' 51.65" N 67° 17' 23.33" E	Sindh	Near FOTCO Oil Jetty.
SD7	Chara Creek in the extended channel	Port Qastim	Round 3	24° 45' 53.03" N 67° 16' 50.16" E	Sindh	Chara Creek in the extended channel.
SD8	West of previously considered marine terminal	Port Qastim	Round 3	24° 46' 25.99" N 67° 18' 27.97" E	Sindh	West of previously considered marine terminal location near Iron Ore and Coal Terminal Jetty.
SD9	Southwest of previously considered marine terminal	Port Qastim	Round 3	24° 45' 50.67" N 67° 19' 04.99" E	Sindh	Southwest of previously considered marine terminal location close to the Southwestern Industrial Zone of Port Qasim.
SD10	Previously considered marine terminal	Port Qastim	Round 3	24° 45' 56.99" N 67° 20' 16.94" E	Sindh	At previously considered marine terminal location to assess the pre-Project sediment quality.
SD11	Isaro Creek	Port Qastim	Round 3	24° 46' 06.42" N 67° 21' 36.83" E	Sindh	At Isaro Creek inside the channel east of previously considered marine terminal location.

Sample ID	*Location*	*Project Component*	*Sampling Round*	*Coordinates*	*Province*	*Rationale for Selection*
SD12	Gharo Creek in the extended navigation channel east of the previously considered marine terminal	Port Qastim	Round 3	24° 44' 52.23" N 67° 20' 42.16" E	Sindh	At Gharo Creek in the extended navigation channel east of the previously considered marine terminal location.
SD13	Keti Bandar	Port Qastim	Round 3	24° 07' 09.05" N 67° 27' 23.40" E	Sindh	At Keti Bandar which serves as a control location.
SD14	Duplicate Sample	Port Qastim	Round 3	Duplicate of SD4	Sindh	-

Exhibit 4.4: Soil Sampling Locations

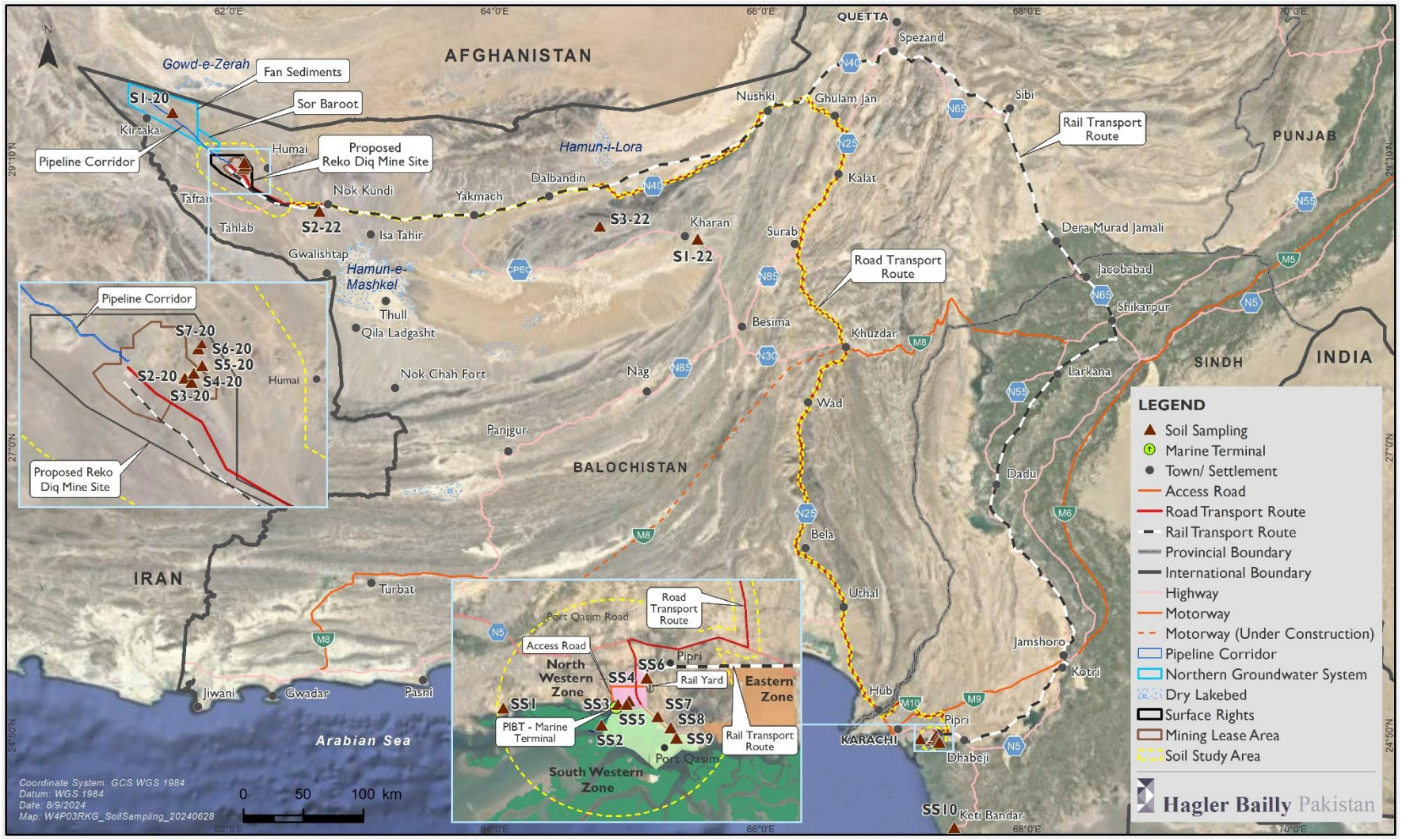


Exhibit 4.5: Sediment Sampling Locations

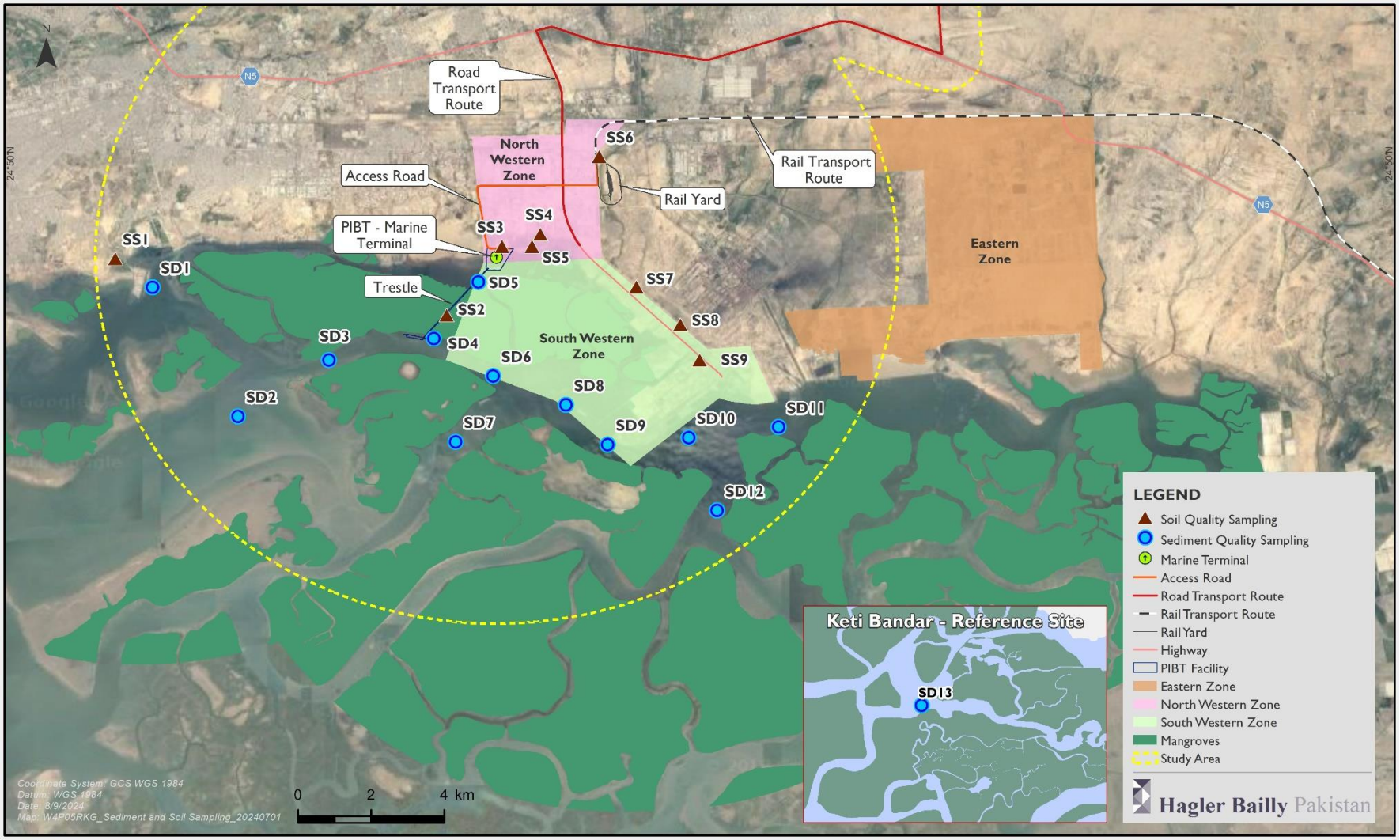


Exhibit 4.6: Soil Sampling Photographs – 2020 Surveys – Reko Diq Mine Site

Soil sampling Jar and Bag at S6-20

Soil sampling at S6-20

Soil sampling using SS Bailer at S1-20

Exhibit 4.7: Soil Sampling Photograph – Road Transport Route

Soil sampling using SS Bailer at S2-22

Exhibit 4.8: Soil Sampling Photographs at Port Qasim – 2023 Surveys

Soil sampling at SS2

Soil Sampling at SS3

Soil sampling Jar and Bag at SS6

Soil sampling Jar and Bag at SS8

Exhibit 4.9: Sediment Sampling Photographs

Sediment sampling at SD5

Sediment collection in Ziplock bags and bottles at SD1

Sediment sampling at SD4

Sample collection and preparation

Sediment sampling at SD7

4.3.2 Data Collection Methods and Analysis

Soil Sampling

Soil was collected using a Stainless Steel (SS) bailer. The top layer of approximately 0.025 m (6 inches) of soil was removed and then a topsoil sample of 1 to 1.5 kg was collected in zip-locked bags for soil fertility analysis. Another 250 g of sample was collected in glass jars for analysis of heavy metals. Field duplicates were collected as quality control samples to assess the precision of sampling and laboratory analysis that can affect the results and that consistent and unbiased procedures are used for analysis.

Soil samples collected at Reko Diq Mine Site and along the Road Transport Route were sent to PINSTECH, Islamabad for soil quality analysis which is a well-renowned and reputed laboratory in Pakistan. It is an ISO 9001:2015 certified laboratory registered with the Pakistan National Accreditation Council (PNAC). Soil samples collected at Port Qasim in Sindh were tested at the Space & Upper Atmospheric Research Commission (SUPARCO) laboratory, which is ISO certified and registered with Sindh-EPA, and i2 Analytical Lab, a UKAS accredited lab in Poland. For heavy metals analysis,[2] PINSTECH and i2 Analytical Lab both utilized the ICP-OES method for heavy metal analysis and for general parameter analysis[3], PINSTECH and SUPARCO have used the Atomic Absorption Spectroscopy (AAS) method. The results of analysis from both laboratories have comparable accuracy and detection limits and are thus presented collectively.

Samples were analysed for the following:

- General
  - pH
  - Conductivity
  - Calcium (Ca)
  - Magnesium (Mg)
  - Potassium (K)

[2] The SUPARCO lab was not contracted for this analysis.

[3] The i2 Analytical Lab was not contracted for this analysis.

- Sodium (Na)
- Carbonates
- Chloride (Cl–)
- Sulphate (SO4)
- Nitrate Nitrogen (NO^3–N)
- Ammonia (NH^3)
- Phosphorus (P)

- Metals
  - Aluminium (Al)
  - Antimony (Sb)
  - Arsenic (As)
  - Barium (Ba)
  - Boron (B)
  - Cadmium (Cd)
  - Chromium (Cr)
  - Copper (Cu)
  - Iron (Fe)
  - Lead (Pb)
  - Manganese (Mn)
  - Nickel (Ni)
  - Selenium (Se)
  - Strontium (Sr)
  - Zinc (Zn)
  - Mercury (Hg)

As a basis for interpreting the laboratory data, Soil Screening Values (SSV) and soil fertility guidelines were assessed. Where thresholds were not available, other sources were accessed to determine the chemical characteristics of the soils.

Due to non–availability of any local soil screening standards, Alberta Guidelines[4] and Dutch Standards[5] are used for comparison purposes. The results exceeding any of the standards are highlighted in the respective sections. Laboratory results for soil sampling and the quality control samples are provided in **Appendix A.**

[4] Alberta tier 1 soil and groundwater remediation guidelines: https://open.alberta.ca/publications/1926–6243

[5] Dutch Soil Remediation Circular 2013, version of 1 July 2013

Sediment Sampling

Sediment samples were collected from 13 locations between October 09, 2023, and November 15, 2023. Sediment samples were collected from a depth of 4-6 m below the water level with Van Veen sediment grab sampler, and then sediment was directly scooped into the sampling jars using the stainless-steel pan. Samples were sent to i2 Analytical Lab in UK for metals, hydrocarbons and monoaromatics analysis and to SUPARCO for particle size distribution analysis. Two jars were filled with sediment at each station (one for particle size analysis and one for chemical analysis).

Due to the non-availability of local standards for sediments, a comparison of the sampling results was made with the international guidelines including Alberta Guidelines[6] and Dutch Standards.[7] **Appendix A** includes the sediment data collected in 2023 Surveys.

4.4 Impact Assessment

The impact assessment methodology used for the Project involves two phases, namely impact identification and impact assessment. Impact identification was performed using an input-output model, whereby Project activities are superimposed onto the environmental and social baseline characteristics of the project area to generate assessment outputs in the form of instances of potential positive or negative biophysical and socio-economic changes in the environment.

A numerical assessment of the significance of potential Project-induced impacts was done as follows:

Significance = Consequence x Probability

Whereby

Consequence = Type of Impact x (Intensity + Spatial Scale + Duration)

And

Probability = Likelihood of an Impact Occurring

In addition, the formula for calculating consequence:

***Type of Impact** (Nature) = +**1** (Positive Impact) or -**1** (Negative Impact)*

The weight assigned to the various parameters for positive and negative impacts is provided for in the formula above and ratings presented in **Exhibit 4.10** with the

[6] Milligan, S., & Branch, L. P. (2022). Alberta Tier 2 soil and groundwater remediation guidelines.

[7] Dutch Guidelines. (2013). Soil and ground water criteria used in the Netherlands for contaminated land.

consequence matrix presented in **Exhibit 4.11**. The interpretation of the consequence ratings is presented in **Exhibit 4.12**.

4.5 Limitations and Assumptions

The following limitations and assumptions are inherent to this Report:

- There is presently no existing national legislation that governs soil disposal, management and reuse in Pakistan. Various Soil Screening Values (SSVs) have been derived from secondary literature and used as a basis for comparison.
- Sample collection during the initial round (2020 ESIA) was undertaken in accordance with local regulatory requirements and analysis was conducted in certified local laboratories accordingly. To accommodate Lender safeguards requirements, an international laboratory was engaged for analysis in later rounds, however, the results by both laboratories are comparable.
- Environmental aspects related to soil contamination resulting from improper management of hazardous waste and tailings disposal have been covered in separate Specialist Reports pertinent to hazardous waste, solid waste and tailings management.

Exhibit 4.10: Impact Assessment Parameter Ratings

Rating	*Intensity*		*Spatial scale*	*Duration (duration of an impact without mitigation)*	*Probability (over the life of the project)*
	Negative Impacts (Type of Impact = -1)	*Positive Impacts (Type of Impact = +1)*			
5	Significant impact on the environment. Irreparable and irreplaceable damage to highly valued species, habitat or ecosystem. Persistent severe damage. Irreparable and irreplaceable damage to highly valued items of great cultural significance or complete breakdown of social order.	Significant improvement to livelihoods and living standards of a large percentage of the population, as well as significant increase in the quality of the receiving environment.	Global Contribute to global impact	Inter -Generational >20 years	Certain / Definite There are sound evidence-based reasons to expect that the impact will definitely occur (90-100%)
4	Serious long term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of significance.	On-going and widespread positive benefits to local communities which improves livelihoods, as well as a positive improvement to the receiving environment. Average to intense social benefits to some people. Average to intense environmental enhancements.	Regional Will affect the entire province or region. A broad geographical area distinguished by similar features.	Long term 5-20 years	Likely The impact may occur (50-90%)
3	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of significance.	Average, on-going positive benefits, not widespread but felt by some.	Sub-regional Will affect the sub-regional / commune area e.g. district level/ areas within the region with similar features	Medium term 2 to 5 years	Probable Has occurred here or elsewhere and could therefore occur (20-50%)

Rating	*Intensity*		*Spatial scale*	*Duration (duration of an impact without mitigation)*	*Probability (over the life of the project)*
	Negative Impacts (Type of Impact = -1)	*Positive Impacts (Type of Impact = +1)*			
2	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of significance.	Average, on-going positive benefits, not widespread but felt by some.	Local Extending across the site and to nearby settlements. Sub-division of a district.	Short term Up to 2 years	Unlikely Has not happened yet but could happen once in the lifetime of the Project, therefore there is a possibility that the impact will occur (5-20%)
1	Minor effects on the biological or physical environment. Environmental damage can be rehabilitated internally with/ without the help of external consultants. Minor medium-term social impacts on the local population. Mostly repairable. Functions and processes not affected	Low positive impacts are experienced by very few of the population.	Site Specific Limited to the site and its immediate surroundings.	Immediate Hours to weeks but less than 1 month	Rare / improbable Conceivable, but only in extreme circumstances and / or has not happened during the lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures (1-5%).

Exhibit 4.11: Probability Consequence Matrix

Probability	Significance																									
5	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75
4	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60
3	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45
2	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30
1	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15
	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15
	Consequence																									

Exhibit 4.12: Significance Threshold Limits

Score	*Description*	*Rating*
57 to 75	A very beneficial impact which may be sufficient by itself to justify implementation of the Project. The impact may result in permanent positive change.	Major (positive)
39 to 56	A beneficial impact which may help to justify the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and/or social) environment.	Moderate (positive)
20 to 38	An important positive impact. The impact is insufficient by itself to justify the implementation of the Project. These impacts will usually result in positive medium to long-term effects on the social and/or natural environment.	Minor (positive)
3 to 19	A small positive impact. The impact will result in medium to short term effects on the social and/or natural environment.	Negligible (positive)
-3 to -19	An acceptable negative impact for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the social and/or natural environment. The impacts are reversible and will not result in the loss of irreplaceable aspects.	Negligible (negative)
-20 to -38	An important negative impact which requires mitigation. The impact is insufficient by itself to prevent the implementation of the Project but in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effects on the social and/or natural environment.	Minor (negative)
-39 to -56	A serious negative impact may prevent the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term change to the (natural and/or social) environment and result in severe effects. The impacts may result in irreversible damage to irreplaceable environmental or social aspects should mitigation measures not be implemented.	Moderate (negative)
-57 to -75	A very serious negative impact may be sufficient by itself to prevent the implementation of the Project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts will be irreplaceable and irreversible should adequate mitigation and management measures not be successfully implemented.	Major (negative)

5. Baseline Description

5.1 Topography

Exhibit 5.1 presents a map of the regional topography. The topographical environment at each Project Component is described in the subsections below.

5.1.1 Overview of Balochistan Province

The Balochistan plateau is in the southwestern part of Pakistan with altitudes ranging from 600 to 3,010 meters above mean sea level (m.a.m.s.l). Covering a vast expanse of 347,190 square kilometres (km^2), this region boasts diverse and distinct natural topographical characteristics. To the north, the Chagai Hills delineate an area characterized by a true desert, marked by inland drainage and *hamuns* (playas). The easternmost part comprises the Kirthar Range.[8]

Approximately 80 percent of the area of the Balochistan province is inter-mountainous. The remaining 20 percent consists of flood plains and coastal plains. Due to dominated mountainous terrain, only 15 percent of the landscape is available for human settlements, farms, and roads.[9]

The Reko Diq region stands as one of the several worn remnants of volcanic centres within the Chagai volcanic chain of mountains. This chain extends in an east-west direction across the Balochistan province, situated between Quetta to Taftan and the border with Afghanistan.[10]

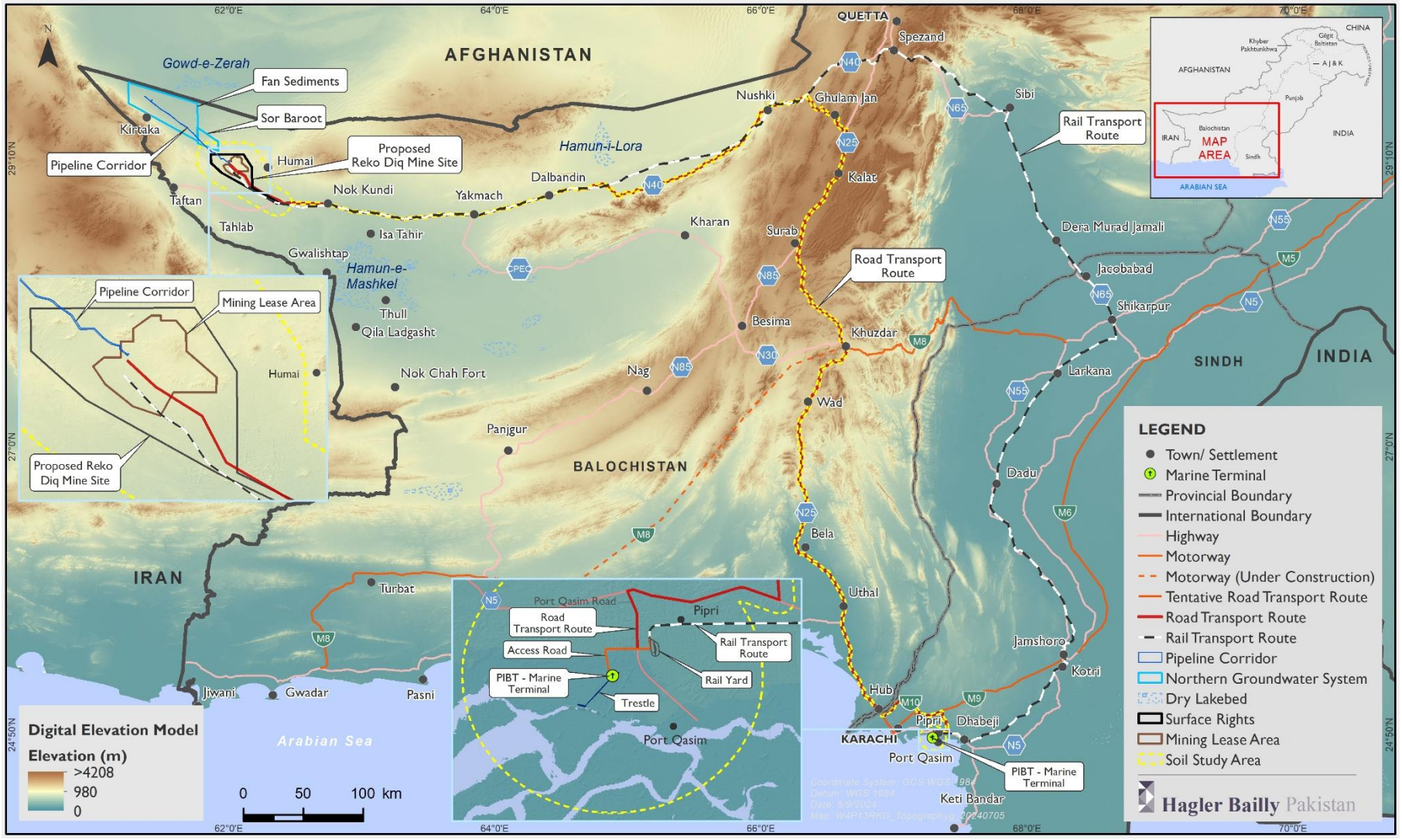
Gravel plains, sandy plains and shifting sand dunes are the dominant topographic features of the Reko Diq Mine Site area. The elevation gently descends while moving from the northwest (Pakistan-Iran border) to the southeast direction towards the Pakistan-Afghanistan border. The Fan Sediments along the Pakistan-Afghanistan border lie at an elevation ranging from ~450 to 1,000 m.a.m.s.l., lower than the communities in the Kach Mountains and Kirtaka Hills. The proposed Project will utilize water from the Fan Sediments area which is classified under the Northern Groundwater System in this Report.

[8] https://www.britannica.com/place/Pakistan/The-Balochistan-plateau accessed on December 12, 2023.

[9] https://www.adb.org/sites/default/files/linked-documents/48098-002-eiaab.pdf accessed on December 12, 2023.

[10] https://lifesmilestones.wixsite.com/benway/copy-of-home accessed on December 12, 2023.

Exhibit 5.1: Regional Topography



5.1.2 Overview of Sindh Province

Ridges, plains, and the coastal belt are the dominant topographic features of the Project Components located in Sindh Province. The following are the details of the main topographical features:

- Ridge and Runnel Upland in Sindh Kohistan: This is an area of rugged topography in the north. It is an offshoot of the Kirthar mountain range and forks away in a southwest direction from the main range at the mountain knot of Gorag at an altitude of 2,126 m.a.m.s.l., gradually decreasing in height as it approaches the Gadap plain.
- Plains and Plateau of Malir-Lyari Interfluous: The vast tract of land lying between the Malir and Lyari rivers forms the interfluous of the drainage systems of the two rivers. This area has very few natural drainage scars, which indicates the presence of a rocky base of alternating layers of consolidated sandstone, intervened by silt and clay beds.
- Plains and Hills of the Coastal Belt: The southern part of the Malir District follows the coastal strip of the Gharo and Korangi creeks, demarcating the northern boundary of the old Indus delta. The areas to the south of the east-west baseline of the triangular outline of the Karachi division subsided and were covered by the sea making a shallow basin. In the course of time, the deltaic deposits of the Indus River filled this shallow basin and the northern part of the basin, which coincided with a fault line making the coastal edge. The terrain rises gradually northward from the Arabian Sea, culminating in low, flat-topped, parallel hills. Sub-parallel ridges interrupted by wide intervening plains, categorized as marine denudation plains, sand dunes, and marine terraces, are prominent features of this area.

The land bordering the intertidal delta (i.e., mangroves and mudflats) within, and the east of the Study Area has an elevation less than 5 m.a.m.s.l.

5.1.3 Project Components in Reko Diq Mine Site

The topographical altitude within the Study Area for Reko Diq Mine Site ranges from 547 to 1,833 m.a.m.s.l. (**Exhibit 5.1**). The elevations north of the mine site are higher than in the south with elevation gradually rising at approximately 2 meters per kilometre from south to north within the Study Area.

5.1.4 Project Components in Northern Groundwater System

The topographical altitude within the Study Area for of the water supply investigation areas encompassing the Northern Groundwater System ranges from up to 560 m.a.m.s.l. (**Exhibit 5.1**).

5.1.5 Project Components in Road Transport Route

The topographical altitude within the Study Area along the Road Transport Route ranges up to 2,063 m.a.m.s.l., (**Exhibit** 5.1).

5.1.6 Project Components in Rail Transport Route

The topographical altitude within the Study Area along Rail Transport Route ranges up to 2,063 m.a.m.s.l., (**Exhibit 5.1**).

5.1.7 Project Components in Port Qasim

The topographical altitude within the Study Area at Port Qasim rises from sea level up to 106 m.a.m.s.l., (see **Exhibit 5.1**).

5.2 Geology

Exhibit 5.2 shows the regional geology across Balochistan and Sindh provinces as per the geological map of Pakistan.[11] The geological setting for each Project Component is described in the subsections below.

5.2.1 Overview of Balochistan Province

The Reko Diq porphyry complex is situated within the western Chagai magmatic belt in Pakistan. This magmatic belt extends over 400 km from east to west and 140 km from north to south along the border with Afghanistan and Iran. The development of the Chagai magmatic arc is attributed to the northward subduction of the Arabian oceanic plate beneath the southern edge of Eurasia.[12]

Geologically, the province is divided into four main geological regions. Central Mountains Range, Chagai Hills and Ras Koh Range, Makran Mountains Range and Chagai – Kharan Basin. The hills and mountain ranges consist predominantly of folded and faulted Mesozoic to middle Tertiary limestone. Mesozoic and Tertiary sedimentary rocks mostly consist of interbedded limestone, sandstone, shale, and marls which make up the bulk of the Central Mountains Range. Similar sedimentary rocks, in addition to the Cal alkaline and ultramafic intrusions, are found together with young quaternary volcanic rocks in the Ras Koh Range. This range is favourable for copper, iron, and sulphur deposits. The Makran Mountain Range includes central and coastal ranges and is mainly made up of a uniform sequence of tertiary and quaternary sedimentary rocks. The Chagai – Kharan Basin is mostly a desert basin partly filled with younger sedimentary rocks derived from surrounding mountain ranges.[13]

5.2.2 Overview of Sindh Province

The Study Area at Port Qasim covers four types of formations, including three coastal formations – these are, Coastal Sand Dune Deposits, Beach Sand Deposits, Mangrove Swamp Deposits, and Recent Alluvial Deposits, which consist of unconsolidated sand, silt, and gravel.

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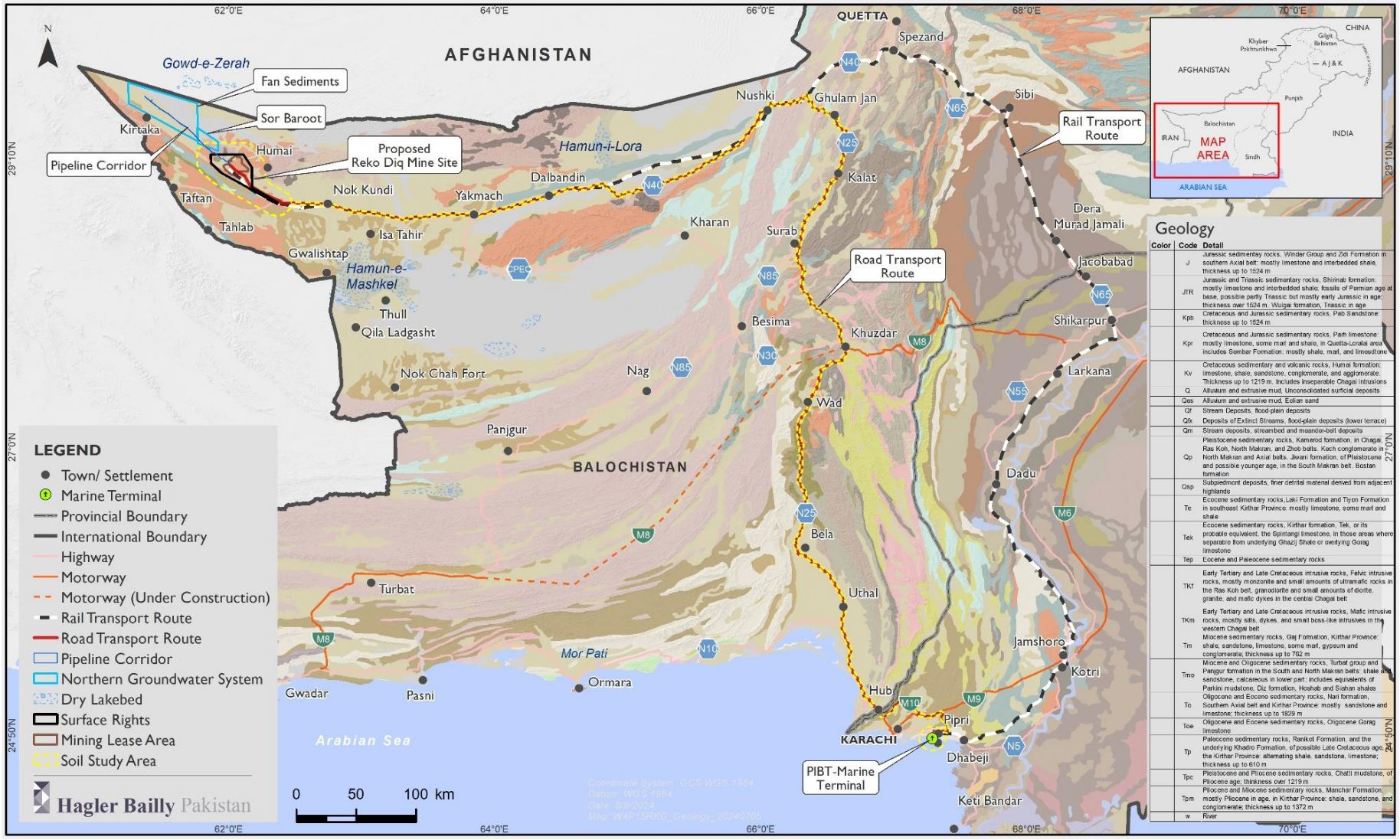
[11] Geological Survey of Pakistan (GSoP) and United States Geological Survey (USGS). “Geological Map of Pakistan [Scale: 1:2,000,000]” (1964)

[12] https://www.segweb.org/SEG/Events/Conference-Archive/2010/Conference-Proceedings/data/papers/posters/2337.pdf accessed on December 12, 2023

[13] ibid

Exhibit 5.2: Overview of Regional Geology



5.2.3 Project Components in Reko Diq Mine Site

The proposed Reko Diq Mine Site lies in the following lithological units (**Exhibit 5.2**):

- Quaternary:
  - Q (Alluvium and extrusive mud, unconsolidated surficial deposits).
  - Qes (Alluvium and extrusive mud, Eolian sand).
  - Qp (Pleistocene sedimentary rocks, Kamerod formation, in Chagai, Ras Koh, North Makran, and Zhob belts. Poorly consolidated shale, sandstone, and conglomerate; thickness up to 1,524 m).
  - Qv (Pleistocene volcanic rocks, Koh-i-Sultan Volcanic Group: green, red, and purple agglomerate, tuff, and andesitic lava; may be in part Recent in age; thickness up to 1,524 m).
- Tertiary
  - Te (Eocene sedimentary rocks, Washap formation, mostly limestone, and Robat limestone in western Chagai belt. Kullan formation, Erikalag limestone, and Kharan limestone in Ras Koh belt; thickness over ~305 m).
  - Tp (Paleocene sedimentary rocks, Juzzak formation in the western Chagai belt; thickness up to 2,438 m).
  - Toe (Oligocene and Eocene sedimentary rocks, Pishi group, in southwest Chagai belt, and Nauroz formation in eastern Ras Koh belt: mostly shale and sandstone; thickness up to 2,438 m).
- Cretaceous and Tertiary:
  - TKf (Early Tertiary and Late Cretaceous intrusive rocks, Felvic intrusive rocks, mostly monzonite and small amounts of ultramafic rocks in the Ras Koh belt, granodiorite and small amounts of diorite, granite, and mafic dykes in the central Chagai belt).
  - TKm (Early Tertiary and Late Cretaceous intrusive rocks, Mafic intrusive rocks, mostly sills, dykes, and small boss-like in the western Chagai belt). in the western Chagai belt).
- Cretaceous:
  - Kv (Cretaceous sedimentary and volcanic rocks, Humai formation: limestone shale, sandstone, conglomerate, and agglomerate. Thickness up to 1,219 m and includes inseparable Chagai intrusions).

5.2.4 Project Components in Northern Groundwater System

The water supply investigation areas lie in the following lithological units (**Exhibit 5.2**):

- Quaternary:
  - Q (Alluvium and extrusive mud, unconsolidated surficial deposits).
  - Qes (Alluvium and extrusive mud, Eolian sand).

- Qp (Pleistocene sedimentary rocks, Kamerod formation, in Chagai, Ras Koh, North Makran, and Zhob belts. Kech conglomerate in North Makran and Axial belts. Jiwani formation, of Pleistocene and possible younger age, in the South Makran belt. Bostan formation).

5.2.5 Project Components in Road Transport Route

The Road Transport Route lies in the following lithological units (**Exhibit 5.2**):

- Quaternary:
  - Q (Alluvium and extrusive mud, unconsolidated surficial deposits).
  - Qes (Alluvium and extrusive mud, Eolian sand).
  - Qp (Pleistocene sedimentary rocks, Kamerod formation, in Chagai, Ras Koh, North Makran, and Zhob belts. Kech conglomerate in North Makran and Axial belts. Jiwani formation, of Pleistocene and possible younger age, in the South Makran belt. Bostan formation).
  - Qh (Alluvium and extrusive mud, silt, clay, and muddy sand underlying inland dry lakes (hamun) and commonly salt encrusted).
- Tertiary
  - QTp (Pleistocene and Pliocene sedimentary rocks, Ormara formation, sandy clay, sandstone, and conglomerate; of Late Pliocene and probable Pleistocene age; thickness up to 457 m).
  - Toe (Oligocene and Eocene sedimentary rocks, Pishi group, in southwest Chagai belt, and Nauroz formation in eastern Ras Koh belt: mostly shale and sandstone; thickness up to 2,438 m).
  - Te (Eocene sedimentary rocks, Washap formation, mostly limestone, and Robat limestone in western Chagai belt. Kullan formation, Erikalag limestone, and Kharan limestone in Ras Koh belt; thickness over 305 m).
  - Tp (Paleocene sedimentary rocks, Ranikot Formation, and the underlying Khadro Formation, of possible Late Cretaceous age, in the Kirthar Province: alternating shale, sandstone, limestone; thickness up to 610 m).
  - Tm (Miocene sedimentary rocks, Gaj Formation, Kirthar Province: shale, sandstone, limestone, some marl, gypsum and conglomerate; thickness about 762 m).
  - Tmo (Miocene and Oligocene sedimentary rocks, Turbat group and Panjgur formation in the South and North Makran belts: shale and sandstone, calcareous in lower part; includes equivalents of Parkini mudstone, Diz formation, Hoshab and Siahan shales).
- Cretaceous and Tertiary:
  - TKf (Early Tertiary and Late Cretaceous intrusive rocks, Felvic intrusive rocks, mostly monzonite and small amounts of ultramafic rocks in the Ras

Koh belt, granodiorite and small amounts of diorite, granite, and mafic dykes in the central Chagai belt).

- TKm (Early Tertiary and Late Cretaceous intrusive rocks, Mafic intrusive rocks, mostly sills, dykes, and small boss-like intrusive in the western Chagai belt).

- Cretaceous:
  - Kv (Cretaceous sedimentary and volcanic rocks, Humai formation: limestone shale, sandstone, conglomerate, and agglomerate. Thickness up to 1,219 m and includes inseparable Chagai intrusions).
- Triassic and Jurassic:
  - JTR (Jurassic and Triassic sedimentary rocks, Shirinab formation: mostly limestone and interbedded shale; fossils of Permian age at base, possible partly Triassic but mostly early Jurassic in age; thickness over 1,524 m).
- Jurassic and Cretaceous:
  - Kpr (Cretaceous and Jurassic sedimentary rocks, Parh limestone: mostly limestone, some marl and shale, in Quetta-Loralai area includes Sembar Formation: mostly shale, marl, and limestone).

5.2.6 Project Components in Rail Transport Route

The Rail Transport Route lies in the following lithological units (**Exhibit 5.2**):

- Quaternary:
  - Q (Alluvium and extrusive mud, unconsolidated surficial deposits)
  - Qbf (Piedmont, Sheetflood and flood-plain deposits of braided streams)
  - Qbr (Stream Deposits, Braided-stream deposits)
  - Qcm (Older terrace deposits, Chung formation, loess and flood-plain deposits of the middle terrace)
  - Qes (Alluvium and extrusive mud, Eolian sand)
  - Qf (Stream Deposits, flood-plain deposits).
  - Qfx (Deposits of Extinct Streams, flood-plain deposits (lower terrace))
  - Qh (Alluvium and extrusive mud, silt, clay, and muddy sand underlying inland dry lakes (hamun) and commonly salt encrusted)
  - Qm (Stream deposits, streambed, and meander-belt deposits)
  - Qmx (Deposits of Extinct Streams, streambed, and meander-belt deposits)
  - Qp (Pleistocene sedimentary rocks, Kamerod formation, in Chagai, Ras Koh, North Makran, and Zhob belts. Kech conglomerate in North Makran and Axial belts. Jiwani formation, of Pleistocene and possible younger age, in the South Makran belt. Bostan formation)

- Qpd (Piedmont and related deposits, Piedmont deposits, coarse detrital material derived from adjacent highlands)
- Qsp (Piedmont and related deposits, coarse detrital material derived from adjacent highlands)
- Qt (Deltaic and Tidal Deposits, tidal delta-marsh deposits)
- Qtx (Older Deltaic and Tidal deposits, tidal delta-marsh deposits)

- Tertiary
  - Te (Ecocene sedimentary rocks, Laki Formation and Tiyon Formation in southeast Kirthar Province: mostly limestone, some marl and shale)
  - Tek (Ecocene sedimentary rocks, Kirthar formation, Tek, or its probable equivalent, the Spintangi limestone, in those areas where separable from underlying Ghazij Shale or overlying Gorag limestone)
  - Tep (Eocene and Paleocene sedimentary rocks)
  - Tm (Miocene sedimentary rocks, Parkini mudstone, in the Southern Makran belt: mudstone with siltstone layers; thickness about 1,219 meters. Diz formation in the central North Makran belt: shale, sandstone, and thin sandy limestone beds; thickness about 2,438 m).
  - Tmo (Miocene and Oligocene sedimentary rocks, Turbat group and Panjgur formation in the South and North Makran belts: shale and sandstone, calcareous in lower part; includes equivalents of Parkini mudstone, Diz formation, Hoshab and Siahan shales)
  - To (Oligocene and Eocene sedimentary rocks, Nari formation, Southern Axial belt and Kirthar Province: mostly sandstone and limestone; thickness up to 1,829 meters)
  - Toe (Oligocene and Eocene sedimentary rocks, Pishi group, in southwest Chagai belt, and Nauroz formation in eastern Ras Koh belt: mostly shale and sandstone; thickness up to 2,438 m).
  - Tp (Paleocene sedimentary rocks, Ranikot Formation, and the underlying Khadro Formation, of possible Late Cretaceous age, in the Kirthar Province: alternating shale, sandstone, limestone; thickness up to 610 m).
  - Tpm (Pliocene and Miocene sedimentary rocks, Manchar Formation, mostly Pliocene in age, in Kirthar Province: shale, sandstone, and conglomerate; thickness up to 1,372 m).

- Cretaceous and Tertiary:
  - TKf (Early Tertiary and Late Cretaceous intrusive rocks, Felvic intrusive rocks, mostly monzonite and small amounts of ultramafic rocks in the Ras Koh belt, granodiorite and small amounts of diorite, granite, and mafic dykes in the central Chagai belt)

- TKm (Early Tertiary and Late Cretaceous intrusive rocks, Mafic intrusive rocks, mostly sills, dykes, and small boss-like intrusive in the western Chagai belt)

- Cretaceous:
  - Kv (Cretaceous sedimentary and volcanic rocks, Humai formation: limestone shale, sandstone, conglomerate, and agglomerate. Thickness up to 1,219 m and includes inseparable Chagai intrusions)
- Triassic and Jurassic:
  - JTR (Jurassic and Triassic sedimentary rocks, Shirinab formation: mostly limestone and interbedded shale; fossils of Permian age at base, possible partly Triassic but mostly early Jurassic in age; thickness over 1,524 m).
- Jurassic:
  - J (Jurassic sedimentary rocks, Windar Group and Zidi Formation in southern Axial belt: mostly limestone and interbedded shale, thickness up to 1,524 m).
- Jurassic and Cretaceous:
  - Kpr (Cretaceous and Jurassic sedimentary rocks, Parh limestone: mostly limestone, some marl and shale, in Quetta-Loralai area includes Sembar Formation: mostly shale, marl, and limestone).
  - Kpb (Cretaceous and Jurassic sedimentary rocks, Pab Sandstone: thickness up to 1,524 m).

5.2.7 Project Components in Port Qasim

Port Qasim has the following lithological units (**Exhibit 5.2**):

- Quaternary:
  - Q (Alluvium and extrusive mud, unconsolidated surficial deposits).
  - Qfx (Deposits of Extinct Streams, flood-plain deposits (lower terrace)).
  - Qt (Deltaic and Tidal Deposits, tidal delta-marsh deposits).
  - Qtx (Older Deltaic and Tidal deposits, tidal delta-marsh deposits).
- Tertiary
  - Tpm (Pliocene and Miocene sedimentary rocks, Manchar Formation, mostly Pliocene in age, in Kirthar Province: shale, sandstone, and conglomerate; thickness up to 1,372 m).
  - Tm (Tertiary: Miocene sedimentary rocks, Parkini mudstone, in the Southern Makran belt: mudstone with siltstone layers; thickness of about 1,219 meters. Diz formation in the central North Makran belt: shale, sandstone, and thin sandy limestone beds; thickness about 2,438 m).

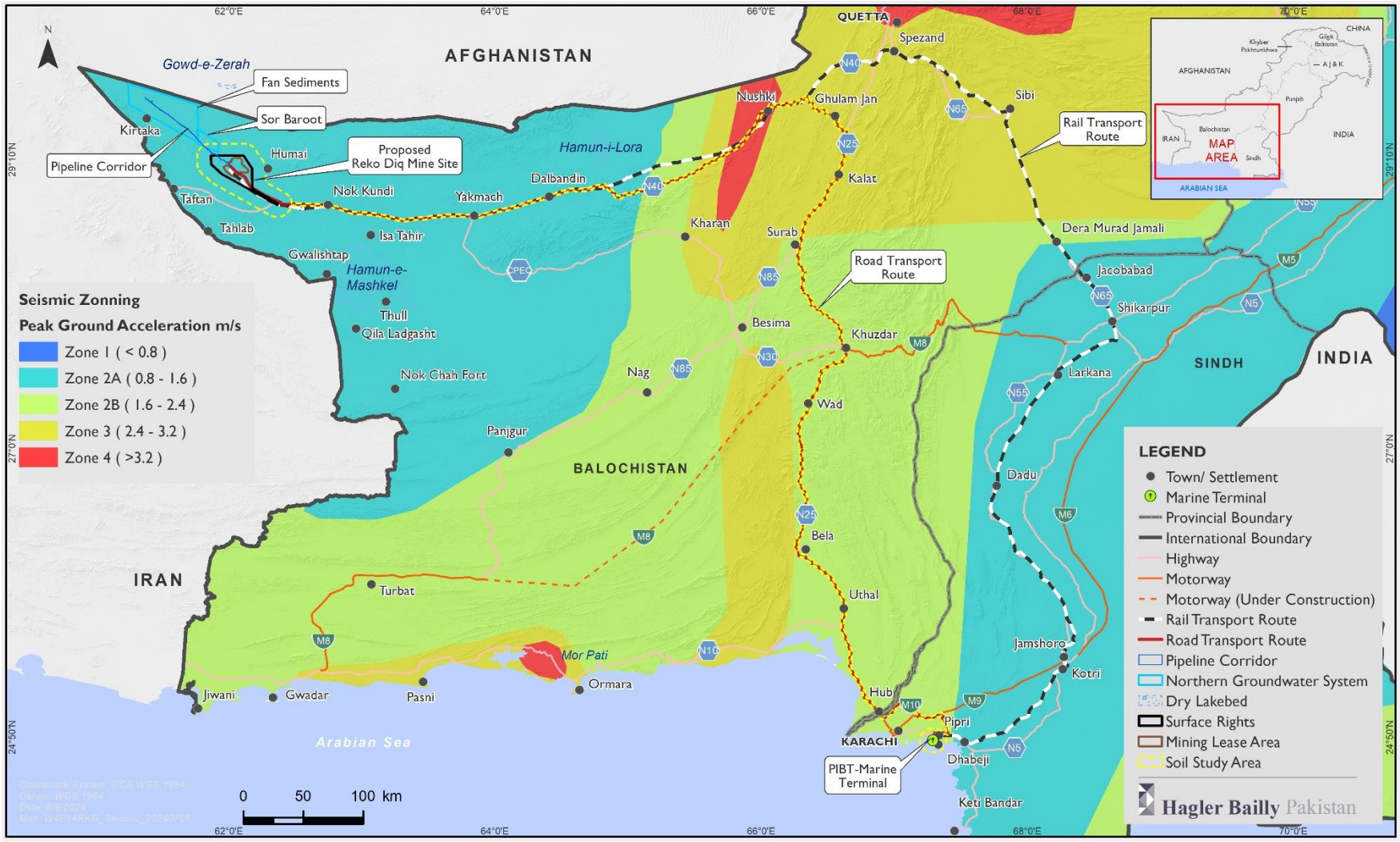
5.3 Seismicity

This section provides an overview of the seismicity of the region.

Exhibit 5.3 provides a map of the seismic zoning and **Exhibit 5.4** provides a map of the earthquake density of Pakistan. The seismicity layer of each Project Component is described in the subsections below.

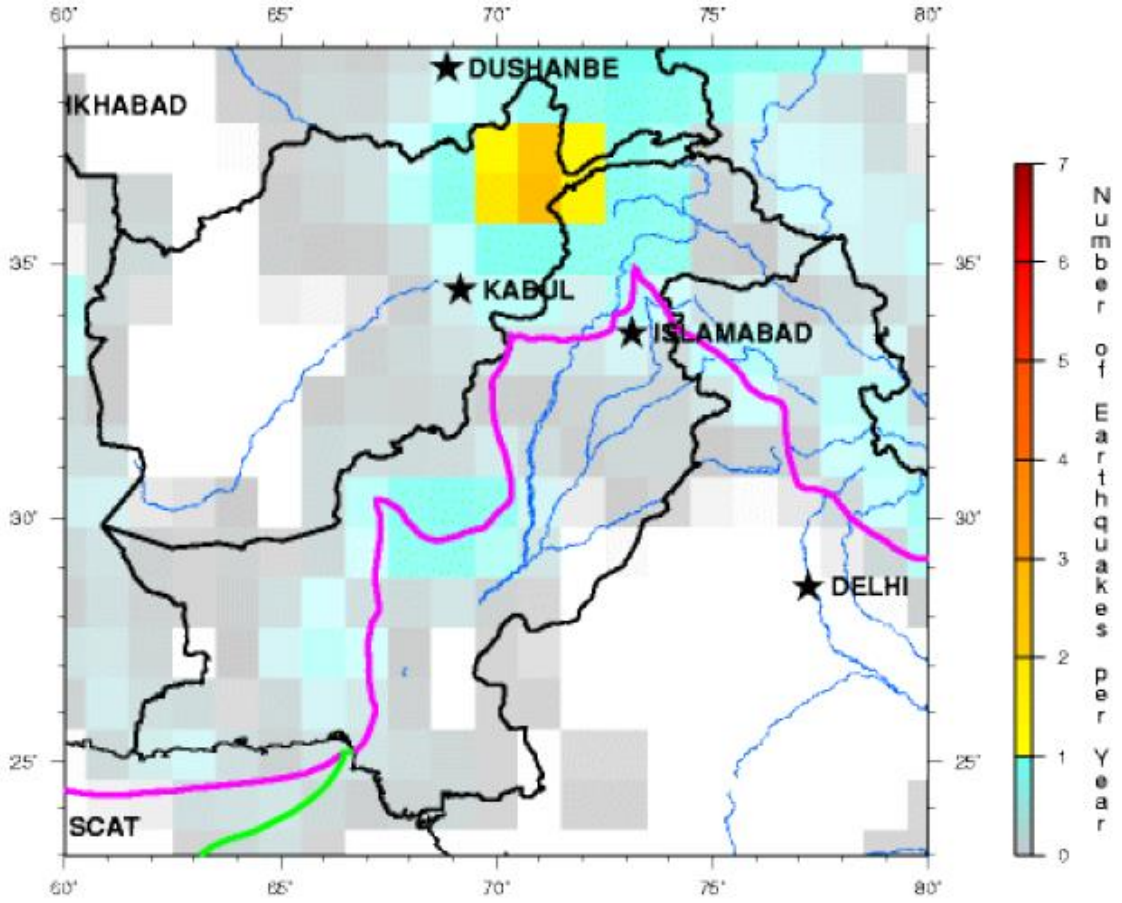
Different types of soils can amplify seismic waves, cause liquefaction, and influence soil-structure interaction during earthquakes. Local soil conditions affect ground motion, shaking intensity, and structural stability, making soil assessment crucial for earthquake-resistant design.

Exhibit 5.3: Seismic Zoning of Balochistan



Source: Government of Pakistan. 2007. *Building Code of Pakistan–Seismic Provisions Islamabad*: Ministry of Housing and Works.

Exhibit 5.4: Earthquake Density of Pakistan



Source: *"Earthquake Density of Pakistan"*, United States Geological Survey (USGS).

5.3.1 Overview of Balochistan Province

The entire province of Balochistan lies in a seismically active region. Over the past century, the surrounding region has witnessed 21 earthquakes of magnitude (M) 6 or higher.[14] Some events are as follows:

- An earthquake of M 5.9 occurred early morning on October 7, 2021, near Quetta, Balochistan, Pakistan. According to the National Seismic Monitoring Centre (NSMC), the earthquake was centred near the Harnai District (~100 km east of Quetta) and had a depth of ~14.97 km (9.3 miles). Such shallow earthquakes are felt more strongly than deeper ones. According to the Provincial Disaster Management Authority (PDMA) Balochistan, 20 people were killed, including eight children; and more than 300 were injured (42% children).[15]
- A M7.1 thrust earthquake with similar faulting characteristics to the October 2021 earthquake, occurred on February 27, 1997, ~40 km to the southeast of the

[14] https://earthquake.usgs.gov/earthquakes/eventpage/us6000fsg9/executive accessed on December 12, 2023.

[15] ibid.

October 2021 earthquake. This 1997 earthquake led to ~100 casualties and strong shaking in Quetta.

- An earthquake of M 8.6 on the Richter scale hit Balochistan on November 28, 1945, resulting in the loss of nearly 4,000 lives.[16]
- West of the Sulaiman Mountains, an M7.2 earthquake occurred on August 27, 1931, ~75 km to the southwest of the October 2021 earthquake.
- An M7.5 earthquake on May 30, 1935, located 205 km southwest of the October 2021 earthquake caused widespread destruction in Quetta and approximately 20,000 fatalities.[17]

The Building Code of Pakistan with Seismic Provisions – 2007[18] divides Pakistan into five seismic zones. These zones are divided based on the Peak Ground Acceleration (PGA) ranges and are presented in **Exhibit 5.5** and illustrated in **Exhibit 5.3**. According to these classifications, the Chagai District falls in Zone 2A with the PGA values from 0.08 to 0.16 g (where g is the acceleration due to gravity, which is equal to 9.80 meters per second square (m/s^2). **Exhibit 5.6** presents the seismic zoning of the Project Components in the Balochistan Province.

Exhibit 5.5: Seismic Zones and Peak Horizontal Ground Acceleration by Building Code of Pakistan – Seismic Provisions 2007

Seismic Zone	*Peak Horizontal Ground Acceleration*
1	0.05 to 0.08 g
2A	0.08 to 0.16 g
2B	0.16 to 0.24 g
3	0.24 to 0.32 g
4	> 0.32 g

Note: "g" is the acceleration due to gravity.

Exhibit 5.6: Seismic Zoning of the Districts in Balochistan Province in which Project Components are Located

District	*Project Component in District*	*Seismic Zoning – Peak Horizontal Ground Acceleration (m/s^2)*		
		Mostly lies in	*Some parts also lie in*	
Chagai	▶ Reko Diq Mine Site ▶ Water supply pipeline	Zone 2A (0.8 – 1.6)	Zone 2B (1.6 – 2.4)	

[16] https://www.adb.org/sites/default/files/linked-documents/48098-002-eiaab.pdf accessed on December 12, 2023.

[17] ibid.

[18] Government of Pakistan. 2007. *Building Code of Pakistan–Seismic Provisions Islamabad*: Ministry of Housing and Works.

District	*Project Component in District*	*Seismic Zoning – Peak Horizontal Ground Acceleration (m/s^2)*		
		Mostly lies in	*Some parts also lie in*	
	▶ Rail Transport Route between Reko Diq Mine site and Port Qasim			
Sibi	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 3 (2.4 – 3.2)		
Mustang	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 3 (2.4 – 3.2)		
Nasirabad	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2A (0.8 – 1.6)	Zone 2B (1.6 – 2.4)	
Nushki	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2B (1.6 – 2.4)	Zone 3 (2.4 – 3.2)	Zone 4 (>3.2)
Kachhi	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 3 (2.4 – 3.2)		
Quetta	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 3 (2.4 – 3.2)		

5.3.2 Overview of Sindh Province

Karachi is situated near the junction of three tectonic plates, Indo-Pakistan, Arabian and Eurasian Plates. The significant faults in the vicinity include the Rann of Kutch Fault in the east and the Pub-Null Fault in the west. The Rann of Kutch-Karachi fault, also known as Karachi-Jati-Allah Bund fault, passes close to the Eastern Industrial Zone of Port Qasim, where the Project will be constructed. According to one of the classifications, region of the Kirthar Ranges, 190 km east of the triple continental junction between the Arabian, Eurasian, and Indian plates. At this location, a moderate level of seismic activity exists, while large-magnitude earthquakes are rare.

Exhibit 5.7 presents the seismic zoning of the Project Components in the Sindh province. The Building Code of Pakistan places Karachi in Zone 2B corresponding approximately to Intensity VII of the Modified Mercalli Scale of 1931. The local effect of Scale VII earthquake is described as, ‘Everybody runs outdoors’. Damage is expected to be negligible in buildings of good design and construction, slight to moderate in ordinary structures, and considerable in poorly built or badly designed structures. The effect is felt in moving automobiles. The peak ground acceleration values in Zone 2 according to the Building Code of Pakistan range from 0.16 to 0.24 g.

The Study Area experiences an earthquake density of less than one per year (**Exhibit 5.4**). Earthquake epicentres, for magnitudes between M3.8 and 5.5, have been recorded along the Pab fault, Hab Fault, Ornach–Nal fault, and smaller micro faults east of Karachi and in the offshore areas southwest of Port Qasim.

Exhibit 5.7: Seismic Zoning of the Districts in Sindh Province in which Project Components are Located

District	*Project Component in District*	*Seismic Zoning – Peak Horizontal Ground Acceleration (m/s²)*
Karachi	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2B (1.6 – 2.4)
Jamshoro	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2A (0.8 – 1.6)
Larkana	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2A (0.8 – 1.6)
Jacobabad	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2A (0.8 – 1.6)
Thatta	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2A (0.8 – 1.6)
Dadu	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2A (0.8 – 1.6)
Shikarpur	Rail Transport Route between Reko Diq Mine Site and Port Qasim	Zone 2A (0.8 – 1.6)
Malir	Possible Berth Locations at Port Qasim	Zone 2A (0.8 – 1.6)

5.3.3 Project Components in Reko Diq Mine Site

The proposed Reko Diq Mine Site lies in Chagai District of Balochistan province. According to the provisions in Building Code of Pakistan 2007, the Chagai District falls in Zone 2A with the PGA values from 0.08 to 0.16 g (**Exhibit 5.3**).

5.3.4 Project Components in Northern Groundwater System

The area within the water supply investigation areas falls in Zone 2A with the PGA values from 0.08 to 0.16 g (**Exhibit 5.3**).

5.3.5 Project Components in Road Transport Route

The Road Transport Route encompassing the route from mine site to Port Qasim falls in four seismic zones; Zone 1 (<0.8g), Zone 2A (0.8g - 1.6g), Zone 2B (1.6g - 2.4g), and Zone 3 (2.4g - 3.2g) (**Exhibit 5.3**).

5.3.6 Project Components in Rail Transport Route

The Rail Transport Route starts from Chagai District in Balochistan Province and ends at Port Qasim in Malir District in Sindh Province. It passes through several districts and therefore, falls in four seismic zones; Zone 2A (0.8g - 1.6g), Zone 2B (1.6g - 2.4g), Zone 3 (2.4g - 3.2g), and Zone 4 (>3.2g) (**Exhibit 5.3)**. The section of Rail Transport Route in Chagai District in Balochistan and the section in Sindh from Jacobabad to Port Qasim fall in Zone 2A (0.8g - 1.6g). However, the section which passes by Mustang and Nushki districts of Balochistan fall in Zone 3 (2.4g - 3.2g), and Zone 4 (>3.2g), respectively. This is because of the Central Brāhui Range lies in these districts which is southern offshoot of the Himalayas, lying in the centre of the Balochistan plateau, Pakistan.

5.3.7 Project Components in Port Qasim

The concentrate storage and handling facility will be developed at Port Qasim which lies in Zone 2A (0.8g – 1.6g) (**Exhibit 5.3**).

5.4 Sampling Results and Discussions

A reconnaissance soil assessment within the proposed infrastructure areas (Study Area) was conducted together with a desktop assessment of the soils within the Area of Influence (AoI). The results of the field assessment are presented in the subsections below. The field survey involved verification of the preliminary desktop assessment. The soils associated with the Study Area were assessed and confirmed in-field where soil samples were collected for laboratory analysis.

Soil forms are conceptual generalisations based on specific soil properties. Each soil form consists of soil horizons, uniquely combined and integrated. The soils are classified according to the World reference base for soil resources as defined by the Food and Agricultural Organisation (FAO) of the United Nations, 2015 (FAO, 2014).

5.4.1 Soil Forms

The dominant soil in Balochistan has a homogenous porous structure invariably calcareous in nature. The lime content of the soil varies from five to 30 percent and is uniformly distributed in most soil textures, resulting in highly alkaline soils. Where having a high lime content (> 15 percent), the soil is hard when dry and friable which will prevent root penetration, decrease water infiltration and result in increased runoff. This can result in increased risk of flash floods during extreme weather events or heavy precipitation.

The organic matter content is generally low, in order of 0.3 to 0.5 percent. Most of the surface of mountains and hills slopes is bare rock without soil cover (about 70 percent). Small patches contain shallow, strongly calcareous, gravelly, and stony loams. The soil in the Piedmont plains is very deep, well drained, homogeneous, silty, and strongly calcareous with 18-20 percent lime content uniformly distributed.[19] The soil of the saline basin (playas) is characterized as strongly hygroscopic, gypsiferous and saline with local sodicity and pH value of 8.6 – 10.0.

The loess plains have brown silt loams or very fine sandy loams and are strongly calcareous containing about 22 percent calcium carbonate. While sandy plains are extremely homogeneous. The lime content ranges between 5 and 10 percent.[20] The soils at the proposed mine site are shallow (less than 1 m deep in most places) and consist largely of sands and gravels with fines (silt and clay material) comprising an average of 10-30% of the total weight. A large proportion of the soil fraction has undergone aeolian (wind) transport and is still variably mobile depending on the soil fraction.

[19] Environmental Profile, Balochistan (LARUS-IT, Enschede: Netherland, 1992)

[20] Ibid

5.4.2 Soil Chemical and Physical Analysis

The results of the soil analysis for each Project Component are presented in the subsections below. There is presently no legislation in Pakistan that governs soil quality or mechanisms for storage, disposal and reuse. All soil sample results have been assessed against the Alberta Guidelines and Dutch Standards to determine any preexisting anthropogenic contamination of the soil in the Project baseline. The soil sample results have also been compared against thresholds provided in secondary information sources to determine their viability for reuse in site rehabilitation or for agriculture in **Section 6.2.1**.

Reko Diq Mine Site

Exhibit 4.4 shows the location of the Reko Diq Mine Site and the sampling carried out near this component.

Exhibit 5.8 provides the results of the soil sampling during the 2020 Surveys.

The following was derived from the laboratory analysis:

- The pH was within the limits prescribed in the Alberta Guidelines
- Carbonates were not detected except at location S4; however, no reference value is provided by the Standards. The carbonates are presumed to be geogenic in nature
- Antimony, Cadmium, Selenium, and Lead were below detection limits
- Arsenic, Copper, Barium, Nickel, Zinc and Mercury were detected but the concentration was below the limits prescribed in the Alberta Guidelines and Dutch Standards
- Chromium was detected above the Alberta Guidelines limit. Site investigations did not identify anthropogenic sources thus the Chromium is presumed to be geogenic and can naturally occur up to 100 mg/kg in certain soils[21]
- Calcium, Potassium, Sodium, Chloride and Phosphorus were detected above the Alberta Guideline limits. This suggests that the soil has excessive mineral content, limiting its viability for agricultural use or as topsoil for revegetation. The elevated mineral levels are geogenic and not associated with anthropogenic sources.

[21] Chrysochoou, M., Theologou, E., Bompoti, N., Dermatas, D., & Panagiotakis, I. (2016). Occurrence, Origin and Transformation Processes of Geogenic Chromium in Soils and Sediments. Current Pollution Reports, 2(4), 224-235. doi:10.1007/s40726-016-0044-2

Exhibit 5.8: Soil Sampling Results – 2020 Surveys – Reko Diq Mine Site

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*S2*	*S3*	*S4*	*S5*	*S6*
General									
pH	–	–	6–8.5	–	7.75	7.07	8.02	7.39	7.49
Conductivity	mS/cm	1.0	–	–	3.62	1.17	1.82	5.31	3.31
Calcium (Ca)	mg/kg	5.00	200	–	37,564	35,904	33,167	35,557	33,108
Magnesium (Mg)	mg/kg	0.15	–	–	17,054	10,279	9,950	13,162	14,359
Potassium (K)	mg/kg	32.00	17	–	3,864	1,358	1,251	2,567	2,139
Sodium (Na)	mg/kg	12.00	200	–	2,569	1,029	1,156	1,841	1,143
Carbonates	mg/kg	12	–	–	ND	ND	59.4	ND	ND
Chloride (Cl^-)	mg/kg	1.0	120	–	780	235	602	690	260
Sulphate (SO_4)	mg/kg	2.50	–	–	1,346	1,162	943	16,105	33,93
Nitrate Nitrogen (NO_3–N)	mg/kg	4.0	–	–	ND	2.84	4.12	11.5	5.64
Ammonia (NH_3)	mg/kg	0.02	–	–	1.22	0.1	2.4	0.2	0.25
Phosphorus (P)	mg/kg	2.50	50	–	231	253	214	212	252
Metals									
Aluminium (Al)	mg/kg	3.50	–	–	18,768	10,512	9,391	12,618	14,249
Antimony (Sb)	mg/kg	0.05	20	22	ND	ND	0.007	0.11	ND
Arsenic (As)	mg/kg	–	17	76	1.639	2.099	1.613	2.172	2.041
Barium (Ba)	mg/kg	0.50	750	–	86.49	75.4	57.2	51.91	45.08
Boron (B)	mg/kg	2.50	3.3	–	1.96	ND	ND	ND	ND
Cadmium (Cd)	mg/kg	0.50	3.8	13	ND	ND	ND	5.08	ND

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*S2*	*S3*	*S4*	*S5*	*S6*
Chromium (Cr)	mg/kg	1.00	64	180	79.7	83.38	76.83	65.35	47.1
Copper (Cu)	mg/kg	1.50	63	190	30.46	50.73	31.29	26.7	20.28
Iron (Fe)	mg/kg	1.00	–	–	25,250	22,441	22,142	21,731	21,272
Lead (Pb)	mg/kg	2.00	70	530	10.42	11.46	ND	21	ND
Manganese (Mn)	mg/kg	0.50	–	–	397	747	358	404	438
Nickel (Ni)	mg/kg	0.50	45	100	41.47	34.91	34.41	35.54	30.79
Selenium (Se)	mg/kg	0.05	1	100	ND	ND	ND	ND	ND
Strontium (Sr)	mg/kg	0.10	–	–	136	112	93	143	195
Zinc (Zn)	mg/kg	0.15	250	720	59.01	71.63	42.66	216.05	43.62
Mercury (Hg)	mg/kg	0.10	12	36	0.510	0.578	0.625	0.565	0.501

Note: LOD = limit of detection, ND = Not Detected or Below Detection Limit

Northern Groundwater System

Exhibit 4.4 shows the location of the Northern Groundwater System and the soil sampling carried out at this component.

Exhibit 4.4 shows the soil sampling locations and **Exhibit 5.9** provides results of the soil sampling at the Northern Groundwater System. From the measured values the following conclusions can be drawn:

The following can be derived from the data:

- The pH was within the limits prescribed in the Alberta Guidelines.
- Carbonates were not detected at this location.
- Antimony, Cadmium, and Lead were below detection limits.
- Boron was detected and exceeded the limits prescribed in the Alberta Guidelines.
- Chromium, Arsenic, Copper, Barium, Nickel, Selenium, Zinc and Mercury were detected but the concentration was below the limits prescribed in the Alberta Guidelines and Dutch Standards.
- Calcium, Potassium, Sodium, Chloride, Phosphorus and Boron were detected above the Alberta Guideline limits. The elevated mineral levels are geogenic and not associated with anthropogenic sources.

Exhibit 5.9: Soil Sampling Results – 2020 Surveys – Northern Groundwater System

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*S1-20 (Northern Groundwater System)*
General					
pH	–	–	6–8.5	–	7.46
Conductivity	mS/cm	1.0	–	–	3.71
Calcium (Ca)	mg/kg	5.00	200	–	46,649
Magnesium (Mg)	mg/kg	0.15	–	–	13,441
Potassium (K)	mg/kg	32.00	17	–	2,262
Sodium (Na)	mg/kg	12.00	200	–	2,081
Carbonates	mg/kg	12	–	–	ND
Chloride (Cl^-)	mg/kg	1.0	120	–	1,020
Sulphate (SO_4)	mg/kg	2.50	–	–	520
Nitrate Nitrogen (NO_3–N)	mg/kg	4.0	–	–	27
Ammonia (NH_3)	mg/kg	0.02	–	–	0.54
Phosphorus (P)	mg/kg	2.50	50	–	259
Metals					
Aluminium (Al)	mg/kg	3.50	–	–	16,193

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*S1-20 (Northern Groundwater System)*
Antimony (Sb)	mg/kg	0.05	20	22	ND
Arsenic (As)	mg/kg	–	17	76	1.321
Barium (Ba)	mg/kg	0.50	750	–	49.05
Boron (B)	mg/kg	2.50	3.3	–	5.78
Cadmium (Cd)	mg/kg	0.50	3.8	13	ND
Chromium (Cr)	mg/kg	1.00	64	180	50.5
Copper (Cu)	mg/kg	1.50	63	190	17.55
Iron (Fe)	mg/kg	1.00	–	–	28,604
Lead (Pb)	mg/kg	2.00	70	530	ND
Manganese (Mn)	mg/kg	0.50	–	–	451
Nickel (Ni)	mg/kg	0.50	45	100	28.49
Selenium (Se)	mg/kg	0.05	1	100	0.135
Strontium (Sr)	mg/kg	0.10	–	–	116
Zinc (Zn)	mg/kg	0.15	250	720	42.49
Mercury (Hg)	mg/kg	0.10	12	36	0.345

Road Transport Route

Exhibit 4.1 shows the Road Transport Route from Reko Diq Mine Site to Port Qasim.

Soil samples were collected from three locations along the Road Transport Route in the 2022 Surveys. **Exhibit 4.4** provides a map of the soil sampling locations and **Exhibit 5.10** provides the results.

- General Parameters:
  - The maximum pH was observed at S2-22 (Nok Kundi) and minimum at S3-22 (Road Route – Garib Shah). A maximum pH of 8.85 was observed, which can affect nutrient availability for agriculture. However, several crops can persist and grow at this pH as well.
  - The parameters calcium, sodium, potassium, and phosphorous exceed the Alberta Guidelines at all sampling locations. High sodium in the soil can cause soil structure deterioration and water infiltration problems. Similarly, high levels of calcium, magnesium and potassium can also cause imbalances and induce nutrient deficiencies. The elevated mineral levels are geogenic and not associated with anthropogenic sources.
  - The maximum total organic carbon was observed at S1-22 (Qadirabad) which was 2.25% of the total soil content, suggesting that this area would be suitable for agriculture, further evidenced as agriculture is readily carried out in this area. The presence of organic matter in soil should be more than 0.86 percent because to have a favourable effect upon physical properties of soils and

growth of vegetation. The total organ carbon values at other locations are close to this value, except for at S3-22 (Garib Shah) where it is significantly lower.

- The other parameters such as magnesium, carbonates, and ammonia were either not detected or detected in amounts that are below the limits prescribed in the Alberta Guidelines and Dutch Standards, or do not have applicable limits in the Alberta Guidelines or Dutch Standards.

- Metals:
  - The metals: Arsenic, Barium, Copper, Lead, Nickel, and Zinc were detected at all monitoring locations; however, the detected concentrations are within the limits in the Alberta Guidelines and Dutch Standards.
  - The maximum Aluminium concentration was observed at 43,683 mg/kg at S1-22 (Qadirabad) and a minimum 18,593 mg/kg at S3-22 (Garib Shah) and doesn't have limits prescribed in Alberta Guidelines and Dutch Standards
  - Boron was detected at all the locations and exceeded the limits prescribed in the Alberta Guidelines.
  - Chromium was detected at all locations. The concentration of Chromium exceeds the limits prescribed in the Alberta Guidelines at S1-22 (Qadirabad) and S2-22 (Nok Kundi) whereas, the concentration is below the limits prescribed in the Dutch Standards.

Exhibit 5.10: Soil Sampling Results – Road Transport Route

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*Road Transport Route*		
					S1 – Agricultural Area (Road Route - Qadirabad)	*S2 – Gravel Plain (Nok Kundi)*	*S3 – Mountain/ Hills (Road Route – Garib Shah)*
General Parameters							
pH	–	–	6–8.5	–	7.63	8.85	7.59
Total Organic Carbon (TOC)	%	–	–	–	2.25	0.78	0.54
Conductivity	mS/cm	1.0	–	–	0.53	3.24	0.11
Calcium (Ca)	mg/kg	5.00	200	–	44,861	21,680	29,229
Magnesium (Mg)	mg/kg	0.15	–	–	143,788	127,918	69,445
Potassium (K)	mg/kg	32.00	17	–	15,652	28,992	9,472
Sodium (Na)	mg/kg	12.00	200	–	4,800	55,463	3,552
Carbonates	mg/kg	12	–	–	ND	150	ND
Chloride (Cl^-)	mg/kg	1.0	120	–	189	2,575	12
Sulphate (SO_4)	mg/kg	2.50	–	–	563	2,846	152
Nitrate Nitrogen (NO_3–N)	mg/kg	4.0	–	–	12.5	29.0	ND
Ammonia (NH_3)	mg/kg	0.02	–	–	9	20	16
Phosphorus (P)	mg/kg	2.50	50	–	332	234	140
Metals							
Aluminium (Al)	mg/kg	3.50	–	–	43,683	38,052	18,593
Antimony (Sb)	mg/kg	0.05	20	22	ND	ND	ND
Arsenic (As)	mg/kg	–	17	76	7.93	7.40	5.45
Barium (Ba)	mg/kg	.50	750	–	97.09	79.78	93.62

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*Road Transport Route*		
					S1 – Agricultural Area (Road Route - Qadirabad)	*S2 – Gravel Plain (Nok Kundi)*	*S3 – Mountain/ Hills (Road Route – Garib Shah)*
Boron (B)	mg/kg	2.50	3.3	–	144	916	103
Cadmium (Cd)	mg/kg	0.50	3.8	13	ND	ND	ND
Chromium (Cr)	mg/kg	1.00	64	180	98.93	64.52	39.05
Copper (Cu)	mg/kg	1.50	63	190	35.24	37.43	11.68
Iron (Fe)	mg/kg	1.00	–	–	39,641	29,244	16,994
Lead (Pb)	mg/kg	2.00	70	530	15.51	8.97	7.29
Manganese (Mn)	mg/kg	0.50	–	–	618	409	254
Nickel (Ni)	mg/kg	0.50	45	100	112	46.76	34.24
Selenium (Se)	mg/kg	0.05	1	100	ND	ND	ND
Strontium (Sr)	mg/kg	0.10	–	–	346	187	183
Zinc (Zn)	mg/kg	0.15	250	720	77.18	53.50	28.30
Mercury (Hg)	mg/kg	0.10	12	36	ND	ND	ND

Note: LOD = limit of detection, ND = Not Detected or Below Detection Limit

Rail Transport Route

Exhibit 4.1 shows the Rail Transport Route from Reko Diq Mine Site to Port Qasim. No soil sampling was undertaken at this location as excavation of soils and their displacement will be minimal along this Route.

Port Qasim

Exhibit 4.4 and **Exhibit 4.5** shows the location of Port Qasim and the soil and sediment sampling carried out at this component respectively.

Soil

The soils of the Study Area at Port Qasim, Sindh are composed of brown loam and sand with gravel. The surface soil is dry and loose and subject to wind erosion and transportation. The general subsoil is described as a homogenous formation of dark grey very fine micaceous sand which exists below the seabed.

Ten soil samples were collected from Port Qasim, Sindh between October 09 and November 15, 2023. A sample from Keti Bandar was also collected as a control sample. General parameters were tested at SUPARCO, which is ISO certified and registered with SEPA and samples were also sent to i2 Analytical Lab, a UKAS accredited lab in Poland, for metals analysis.

Exhibit 4.4 shows soil sampling locations at Port Qasim, Sindh. The results are provided in **Exhibit 5.11** and **Exhibit 5.12**. The following can be derived from the data:

- Maximum moisture content of 33% was observed at SS2 (PIBT Jetty). This is due to the proximity of the sampling location to the sea.
- pH of all samples ranged from 7.7 to 8.2
- Maximum concentration of nutrients (calcium, magnesium, sodium, and potassium) was observed at SS9 (Port Qasim Road at Southwestern Zone towards the Government Terminal site) which exceeds the Alberta guidelines for calcium, sodium, and potassium. The elevated mineral levels are geogenic and not associated with anthropogenic sources.
- The other general parameters including chloride, sulphate, phosphorous, nitrate-nitrogen, and ammonia were detected at all locations. Chloride and phosphorous exceeded the Alberta guidelines at all locations, whereas no exceedances were observed for the other three elements. The elevated parameters have a naturally high geogenic abundance in these soils and are not associated with anthropogenic sources.
- Cadmium, Mercury, and Selenium were not detected at any of the sampling locations except at SS1 (Korangi Fish Harbour) where only Cadmium was detected, and the detected levels comply with Alberta Guidelines and Dutch Standards. The elevated levels of Cadmium are associated with contamination from the existing port facilities and port freight traffic.
- Antimony, Arsenic, Barium, Boron, Chromium, Copper, Lead, Nickel, and Zinc were detected at all locations, but the detected levels were within the Alberta Guidelines and Dutch Standards.

Exhibit 5.11: Soil Sampling Results – 2023 Surveys (SS1-SS5)

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SS1 (Korangi Fish Harbor)*	*SS2 (PIBT Coal Terminal Jetty)*	*SS3 (PIBT Site)*	*SS4 (Port Qasim Road in NW Zone)*	*SS5 (proposed Rail Route to PIBT Site)*
General									
Moisture Content	%	0.01	–	–	1.2	33	0.61	0.38	16
Total Organic Carbon (TOC)	%	0.1	–	–	1.3	1.3	0.1	< 0.1	< 0.1
pH	–	–	6–8.5	–	7.9	8.2	7.9	7.7	8.1
Conductivity	mS/cm	1.0	–	–	1.5	30.5	3.5	0.7	7.1
Calcium (Ca)	mg/kg	5.00	200	–	16,890.0	17,250.0	4,050.0	3,000.0	6,950.0
Magnesium (Mg)	mg/kg	0.15	–	–	749.0	2,110.0	1,850.0	1,050.0	1,300.0
Potassium (K)	mg/kg	32.00	17	–	1,970.0	1,350.0	846.0	810.0	913.0
Sodium (Na)	mg/kg	12.00	200	–	602.0	10,170.0	1,045.0	534.0	3,168.0
Carbonates	mg/kg	12	–	–	ND	100.0	ND	ND	210.0
Chloride (Cl^-)	mg/kg	1.0	120	–	870.0	14,270.0	1,780.0	756.0	4,650.0
Sulphate (SO_4)	mg/kg	2.50	–	–	1,250.0	2,760.0	1,052.0	840.0	1,580.0
Nitrate Nitrogen (NO_3–N)	mg/kg	4.0	–	–	2.4	4.8	3.7	3.4	4.7
Ammonia (NH_3)	mg/kg	0.02	–	–	110.0	350.0	550.0	300.0	420.0
Phosphorus (P)	mg/kg	2.50	50	–	1,200	890	130	290	490
Metals									
Aluminium (Al)	mg/kg	3.50	–	–	14,000	17,000	5,400	4,900	15,000
Antimony (Sb)	mg/kg	0.05	20	22	< 1.0	< 1.0	1.5	< 1.0	2.5

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SS1 (Korangi Fish Harbor)*	*SS2 (PIBT Coal Terminal Jetty)*	*SS3 (PIBT Site)*	*SS4 (Port Qasim Road in NW Zone)*	*SS5 (proposed Rail Route to PIBT Site)*
Arsenic (As)	mg/kg	–	17	76	9.6	8	11	12	11
Barium (Ba)	mg/kg	0.50	750	–	52	51	47	25	52
Boron (B)	mg/kg	2.50	3.3	–	28	14	5	3	21
Cadmium (Cd)	mg/kg	0.50	3.8	13	0.5	< 0.2	< 0.2	< 0.2	< 0.2
Chromium (Cr)	mg/kg	1.00	64	180	38	32	16	14	30
Copper (Cu)	mg/kg	1.50	63	190	33	18	6	6	15
Iron (Fe)	mg/kg	1.00	–	–	21,000	30,000	13,000	14,000	27,000
Lead (Pb)	mg/kg	2.00	70	530	12	17	4.9	5.3	11
Manganese (Mn)	mg/kg	0.50	–	–	370	310	380	260	490
Mercury (Hg)	mg/kg	0.10	12	36	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (Ni)	mg/kg	0.50	45	100	36	31	13	13	32
Selenium (Se)	mg/kg	0.05	1	100	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Strontium (Sr)	mg/kg	0.10	–	–	460	86	190	330	220
Zinc (Zn)	mg/kg	0.15	250	720	78	95	16	15	44

Note: LOD = limit of detection, ND = Not Detected or Below Detection Limit, NW = Northwestern

Exhibit 5.12: Soil Sampling Results – 2023 Surveys (SS6-SS10)

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SS6 (Existing rail route in NW Zone)*	*SS7 (Existing rail route towards SW Zone)*	*SS8 (Existing rail route at SW Zone)*	*SS9 (Port Qasim Road at SW Zone)*	*SS10 (Keti Bandar)*
General									
Moisture Content	%	0.01	–	–	0.73	2	0.17	2.2	19
Total Organic Carbon (TOC)	%	0.1	–	–	0.1	1	< 0.1	1.1	0.5
pH	–	–	6–8.5	–	7.9	8.1	8.2	7.9	8.0
Conductivity	mS/cm	1.0	–	–	0.8	1.0	0.7	14.2	10.1
Calcium (Ca)	mg/kg	5.00	200	–	5,420.0	5,500.0	3,300.0	18,200.0	9,850.0
Magnesium (Mg)	mg/kg	0.15	–	–	1,730.0	980.0	285.0	3,220.0	2,540.0
Potassium (K)	mg/kg	32.00	17	–	760.0	730.0	510.0	3,260.0	1,810.0
Sodium (Na)	mg/kg	12.00	200	–	385.0	590.0	385.0	6,815.0	4,107.0
Carbonates	mg/kg	12	–	–	ND	205.0	165.0	ND	ND
Chloride (Cl^-)	mg/kg	1.0	120	–	580.0	880.0	520.0	7,420.0	5,993.0
Sulphate (SO_4)	mg/kg	2.50	–	–	810.0	1,250.0	680.0	4,480.0	2,142.0
Nitrate Nitrogen (NO_3–N)	mg/kg	4.0	–	–	3.3	4.5	1.6	4.6	3.6
Ammonia (NH_3)	mg/kg	0.02	–	–	210.0	250.0	105.0	900.0	420.0
Phosphorus (P)	mg/kg	2.50	50	–	250	3,800	300	450	840
Metals									
Aluminium (Al)	mg/kg	3.50	–	–	53,00	53,000	3,600	5,600	23,000
Antimony (Sb)	mg/kg	0.05	20	22	3	< 1.0	< 1.0	2	2.5
Arsenic (As)	mg/kg	–	17	76	14	29	7.8	6.9	12
Barium (Ba)	mg/kg	0.50	750	–	27	200	16	58	83
Boron (B)	mg/kg	2.50	3.3	–	5	130	5	10	21

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SS6 (Existing rail route in NW Zone)*	*SS7 (Existing rail route towards SW Zone)*	*SS8 (Existing rail route at SW Zone)*	*SS9 (Port Qasim Road at SW Zone)*	*SS10 (Keti Bandar)*
Cadmium (Cd)	mg/kg	0.50	3.8	13	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Chromium (Cr)	mg/kg	1.00	64	180	17	49	12	18	40
Copper (Cu)	mg/kg	1.50	63	190	7	51	6	20	34
Iron (Fe)	mg/kg	1.00	–	–	14,000	32,000	9,200	15,000	3,8000
Lead (Pb)	mg/kg	2.00	70	530	20	17	4.9	14	14
Manganese (Mn)	mg/kg	0.50	–	–	300	490	230	320	620
Mercury (Hg)	mg/kg	0.10	12	36	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (Ni)	mg/kg	0.50	45	100	14	28	12	15	38
Selenium (Se)	mg/kg	0.05	1	100	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Strontium (Sr)	mg/kg	0.10	–	–	270	320	600	360	130
Zinc (Zn)	mg/kg	0.15	250	720	27	73	25	74	77

Note: LOD = limit of detection, ND = Not Detected or Below Detection Limit, NW = Northwestern, SW = Southwestern

Sediment

The substrate of the Study Area has very fine sediment i.e., mud and clay. The seabed is predominantly sand and silt while the sediment of the delta is fine grained. Detrital silicates and sulphides are the principal carriers of iron and other heavy metals and, therefore, make sediments a long-term contaminant sink.

Exhibit 4.5 shows the sampling locations**. Exhibit 5.13, Exhibit 5.14** and **Exhibit 5.15** provide the results of the sediment sampling.

Due to the non-availability of applicable local standards for sediments, a comparison of the sampling results was made with the international guidelines including Alberta Guidelines[22] and Dutch Standards.[23] **Appendix A** includes the sediment data collected in 2023 Surveys.

Soil water retention characteristics are strongly affected by soil texture. A higher clay content results in greater water retention. Similarly, the higher the sand fraction, the less water is retained by the soil (Gebregiorgis, 2003). Soil macropores allow a greater volume of water to drain more rapidly than would be expected from soil that is dominated by clay fractions.

- Particle Size Distribution
  - **Exhibit 5.13** presents the particle size distribution of 13 sediment samples. The sediment samples Exhibit a range of particle size distributions, with varying proportions of gravel, sand, silt, and clay. The dominant particle size fractions are sand and silt, with notable variability across samples. These findings align with the United States Department of Agriculture (USDA) standards for soil texture classification, where sediment samples can be classified based on their particle size distribution into categories such as sandy, silty, clayey, or loamy
  - Gravel (>2 mm): Samples SD2 and SD13 showed notable percentages of gravel, exceeding 20%. Gravel content is absent or negligible in the remaining samples
  - Sand (2.00 - 1.00 mm): Sand content varies across samples, with notable percentages observed in most samples. Samples SD3, SD5, SD6, SD9, and SD11 showed significant sand content ranging from approximately 12% to 22%
  - Sand (1.00 - 0.50 mm): Most samples Exhibit substantial sand content in this size range, with percentages ranging from approximately 7% to 19%. Samples SD1, SD7, SD8, and SD12 have notable sand content in this fraction
  - Sand (0.50 - 0.250 mm): Sand content remains prevalent in most samples, with varying percentages. Samples SD4, SD6, SD9, SD10, and SD11 have notable sand content in this size range

[22] Milligan, S., & Branch, L. P. (2022). Alberta Tier 2 soil and groundwater remediation guidelines.

[23] Dutch Guidelines. (2013). Soil and ground water criteria used in the Netherlands for contaminated land.

- Sand (0.25 - 0.125 mm): Sand content is prevalent across most samples, with varying percentages. Samples SD1, SD2, SD3, SD4, SD5, SD6, SD7, SD8, SD9, SD10, SD11, and SD12 have notable sand content in this fraction
- Sand (0.125 - 0.063 mm): Sand content remains significant across several samples, with percentages exceeding 15% in most cases. Samples SD1, SD3, SD4, SD5, SD6, SD7, SD8, SD9, SD10, SD11, and SD12 Exhibit notable sand content in this fraction
- Silt (0.063 - 0.0312 mm): Silt content varies across samples, with notable percentages observed in several samples. Samples SD1, SD3, SD4, SD5, SD6, SD7, SD8, SD9, SD10, SD11, and SD12 Exhibit notable silt content, exceeding 15% in some cases
- Silt (0.0312 - 0.004 mm): Silt content remains prevalent in most samples, with percentages ranging from approximately 6% to 33%. Samples SD4, SD5, SD6, SD7, SD8, SD9, SD10, SD11, and SD12 Exhibit notable silt content in this fraction
- Clay (<0.004 mm): Clay content varies across samples, with notable percentages observed in several samples. Samples SD1, SD3, SD4, SD5, SD6, SD7, SD8, SD9, SD10, SD11, and SD12 Exhibit notable clay content, with percentages ranging from approximately 3% to 11%

A summary is as follows:

- Samples SD2, SD10, SD11, and SD12 Exhibit a mix of sand, silt, and clay, indicating a loamy soil texture
- Samples SD3, SD4, and SD6 Exhibit higher proportions of sand and silt, indicating a sandy loam or loamy sand texture
- Sample SD5 showed high sand content across all fractions, indicating a sandy texture
- Sample SD13 exhibits a balanced mix of sand, silt, and clay, indicating a loam texture

- Chemical Analysis:
  - **Exhibit 5.14** and **Exhibit 5.15** presents the chemical analysis of the 13 sediment samples and a comparison with Alberta Guidelines and Dutch Standards
  - SD13 (Keti Bandar), the reference location, generally shows lower levels of contaminants compared to other samples, indicating relatively cleaner sediment conditions
  - SD1 (Korangi Fish Harbor) exhibits significantly higher moisture content (64.0%) and total organic carbon content (5.8%) compared to other samples. SD1 (Korangi Fish Harbor) stands out with significantly higher moisture content and petroleum and metal contamination compared to other samples, indicating potential differences in sediment properties or environmental conditions at this location

- Antimony, bismuth, mercury, silver, selenium, and thallium were below detection limits at all locations. The rest of the metals except Boron are below the limits prescribed in the Alberta Guidelines and Dutch Standards
- Boron was detected and exceeded at all locations. The maximum concentration of 36 mg/kg was observed at SD5 (PIBT Jetty). PIBT is a coal, clinker and cement terminal and boron naturally present in coal deposits can be released into the environment during coal handling, transportation, and combustion processes, leading to the deposition of boron-containing dust. Improper storage and handling practices, as well as coal washing processes, may further contribute to boron contamination. However, due to the presence of other nearby industries, the exact source of this boron cannot be determined at this stage. The elevated boron levels suggest that use of the soil from these locations for backfilling may result in health concerns
- Benzene, toluene, ethylbenzene, and xylene levels were below detection limits at all sampling locations
- TPH levels were below detection limits at all sampling locations except at SD1 (Korangi Fish Harbor), SD4 (PIBT Marine Terminal), and SD5 (PIBT Jetty) indicating petroleum hydrocarbon contamination at these locations. Of these three locations, the maximum TPH levels of 230 mg/kg were observed at SD1. This is possibly because the location receives the industrial discharges from Korangi Industrial Zone. Moreover, the activities at harbour including fuelling of boats and ships for fishing and the possible spills during fuel transfer operations may contribute to these levels at this location.

Exhibit 5.13: Sediment Sampling Results for Particle Size Distribution

PSD	*Gravel*	*Sand*					*Silt*		*Clay*
(%)	*(>2 mm)*	*(2.00 - 1.00 mm)*	*(1.00 - 0.50 mm)*	*(0.50 - 0.25 mm)*	*(0.25 - 0.125 mm)*	*(0.125 - 0.063 mm)*	*(0.063 - 0.0312 mm)*	*(0.0312 - 0.004 mm)*	*(<0.004 mm)*
SD1	–	–	3.0	5.0	18.0	31.0	36.0	7.0	–
SD2	22.5	22.2	17.9	17.6	14.9	5.0	–	–	–
SD3	–	9.3	13.1	17.7	18.3	18.9	16.3	6.4	–
SD4	–	–	2.0	6.0	15.0	29.0	40.0	8.0	–
SD5	–	3	12.0	30.0	39.0	12.0	4.0	–	–
SD6	–	4.8	8.2	14.0	16.9	19.0	20.0	13.2	3.8
SD7	–	–	–	3.6	8.9	22.3	28.4	30.8	6.1
SD8	–	–	–	2.7	5.6	18.7	27.9	37.9	7.2
SD9	–	–	–	2.8	7.2	22.0	28.4	33.3	6.3
SD10	–	–	3.5	7.8	19.4	23.3	28.0	12.7	5.2
SD11	–	3.4	6.8	11.9	18.3	20.3	22.4	13.6	3.3
SD12	–	3.3	6.5	9.7	16.5	22.4	25.0	13.6	3.0
SD13	–	–	1.0	2.0	9.0	15.0	32.0	30.0	11.0

Exhibit 5.14: Sediment Sampling Results – 2023 Surveys (SD1-SD6)

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SD1 (Korangi Fish Harbor)*	*SD2 (Jhari Creek)*	*SD3 (Kadiro Creek)*	*SD4 (PIBT Marine Terminal)*	*SD5 (PIBT Jetty)*	*SD6 (FOTCO Oil Jetty)*
General										
pH	–	–	–	–	8.2	8.0	7.9	8.2	8.4	8.0
Moisture Content	%	0.01	–	–	64.0	19.0	53.0	56.0	65.0	41.0
Total Sulphur - sulphur elemental	%	0.005	500	–	1.3	770.0	7,300.0	0.8	1.9	4,000.0
Total Organic Carbon (TOC)	%	0.1	–	–	5.8	0.2	2.8	5.1	10.0	1.3
Total Nitrogen (Kjeldahl)	mg/kg	5	–	–	5,200.0	370.0	1,200.0	3,400.0	10,000.0	2,500.0
Heavy Metals / Metalloids										
Aluminium (aqua regia extractable)	mg/kg	30	–	–	22,000.0	5,500.0	17,000.0	21,000.0	17,000.0	16,000.0
Antimony (aqua regia extractable)	mg/kg	1	20	22	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	3.1
Arsenic (aqua regia extractable)	mg/kg	1	17	76	10	9.6	11.0	10	7.2	9.5
Barium (aqua regia extractable)	mg/kg	1	750	–	44	36	69.0	53	43	70.0
Beryllium (aqua regia extractable)	mg/kg	0.06	–	–	0.74	0	0.8	0.73	0.62	0.7
Bismuth (aqua regia extractable)	mg/kg	5	–	–	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Boron (total)	mg/kg	1	3.3	–	24	8.8	17.0	28	36	14.0
Cadmium (aqua regia extractable)	mg/kg	0.2	3.8	13	1	< 0.2	0.6	1	<0.2	0.5
Chromium (aqua regia extractable)	mg/kg	1	64	180	60	20	46.0	39	35	39.0
Cobalt (aqua regia extractable)	mg/kg	0.15	20	–	11	7	13.0	12	8.6	13.0
Copper (aqua regia extractable)	mg/kg	1	63	190	44	7	42.0	32	36	33.0
Iron (aqua regia extractable)	mg/kg	40	–	–	36,000	15000	29,000.0	35,000	28,000	27,000.0
Lead (aqua regia extractable)	mg/kg	1	70	530	16	7	18.0	12	23	16.0
Lithium (aqua regia extractable)	mg/kg	0.1	–	–	35	< 0.1	38.0	35	25	38.0
Manganese (aqua regia extractable)	mg/kg	1	–	–	380	380	430.0	390	270	470.0
Mercury (aqua regia extractable)	mg/kg	0.3	12	36	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SD1 (Korangi Fish Harbor)*	*SD2 (Jhari Creek)*	*SD3 (Kadiro Creek)*	*SD4 (PIBT Marine Terminal)*	*SD5 (PIBT Jetty)*	*SD6 (FOTCO Oil Jetty)*
Molybdenum (aqua regia extractable)	mg/kg	0.25	4		2.8	< 0.25	1.6	1.4	15	0.7
Nickel (aqua regia extractable)	mg/kg	1	45	100	38	19	40	37	35	36
Phosphorus (aqua regia extractable)	mg/kg	20	–	–	1,000	390	790.0	820	930	680.0
Silver (aqua regia extractable)	mg/kg	1	20	–	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Selenium (aqua regia extractable)	mg/kg	1	1	100	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Strontium (aqua regia extractable)	mg/kg	10	–	–	87.0	9,200.0	1,700.0	95.0	93.0	2,300.0
Thallium (aqua regia extractable)	mg/kg	5	–	–	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Tin (aqua regia extractable)	mg/kg	1	5	–	2.7	< 1.0	2.6	2.8	1.9	2.2
Titanium (aqua regia extractable)	mg/kg	15	–	–	430.0	380.0	600.0	650.0	260.0	690.0
Vanadium (aqua regia extractable)	mg/kg	1	130	–	42.0	23.0	43.0	41.0	37.0	41.0
Zinc (aqua regia extractable)	mg/kg	1	250	720	150.0	29.0	120.0	85.0	180.0	84.0
Calcium (aqua regia extractable)	mg/kg	20	200	–	36,000.0	93,000.0	31,000.0	37,000.0	43,000.0	34,000.0
Magnesium (aqua regia extractable)	mg/kg	20	–	–	19,000.0	5,900.0	9,300.0	18,000.0	10,000.0	8,900.0
Potassium (aqua regia extractable)	mg/kg	20	17	–	5,300.0	1,700.0	4,600.0	5,000.0	4,700.0	4,300.0
Sodium (aqua regia extractable)	mg/kg	20	200	–	22,000.0	3,600.0	12,000.0	18,000.0	32,000.0	8,400.0
Monoaromatics										
Benzene	mg/kg	0.005	0.046	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Toluene	mg/kg	0.005	0.52	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ethylbenzene	mg/kg	0.005	0.073	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
p & m-xylene	mg/kg	0.005	0.99	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
o-xylene	mg/kg	0.005	0.99	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Petroleum Hydrocarbons										
TPH1 (C10 - C40)	mg/kg	10	–	–	230.0	< 10	< 10	85.0	39.0	< 10

Values exceeding Alberta or Dutch standards are shaded.

Exhibit 5.15: Sediment Sampling Results – 2023 Surveys (SD7-SD13)

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SD7 (Chara Creek)*	*SD8 (Iron Ore and Coal Terminal Jetty)*	*SD9 (Southwest of Marine previously considered marine terminal)*	*SD10 (Gov Site - previously considered marine terminal)*	*SD11 (Isaro Creek)*	*SD12 (Gharo Creek)*	*SD13 (Keti Bandar)*
General											
pH	–	–	–	–	8.4	9.1	7.8	8.2	8.2	8.6	8.1
Moisture Content	%	0.01	–	–	35.0	26.0	29.0	37.0	23.0	30.0	29.0
Total Sulphur - sulphur elemental	%	0.005	500	–	1,800.0	1,500.0	1,700.0	2,300.0	1,500.0	1,700.0	0.0
Total Organic Carbon (TOC)	%	0.1	–	–	1.1	0.6	0.7	0.9	0.4	0.6	0.2
Total Nitrogen (Kjeldahl)	mg/kg	5	–	–	870.0	720.0	730.0	1,000.0	620.0	770.0	570.0
Heavy Metals/Metalloids											
Aluminium (aqua regia extractable)	mg/kg	30	–	–	20,000.0	21,000.0	16,000.0	16,000.0	10,000.0	15,000.0	30,000.0
Antimony (aqua regia extractable)	mg/kg	1	20	22	< 1.0	< 1.0	2.3	2.4	< 1.0	2.7	< 1.0
Arsenic (aqua regia extractable)	mg/kg	1	17	76	13.0	14.0	11	9.4	6.5	7.5	17
Barium (aqua regia extractable)	mg/kg	1	750	–	97.0	91.0	82	60	48	57	110
Beryllium (aqua regia extractable)	mg/kg	0.06	–	–	0.9	1.0	0.67	0.68	1	1	1
Bismuth (aqua regia extractable)	mg/kg	5	–	–	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Boron (total)	mg/kg	1	3.3	–	14.0	14.0	9.9	14	8.7	11	14
Cadmium (aqua regia extractable)	mg/kg	0.2	3.8	13	< 0.2	< 0.2	< 0.2	<0.2	< 0.2	< 0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	64	180	46.0	47.0	37	40	29	34	49
Cobalt (aqua regia extractable)	mg/kg	0.15	20	–	15.0	15.0	13	14	11	12	16
Copper (aqua regia extractable)	mg/kg	1	63	190	34.0	36.0	25	25	16	21	38

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SD7 (Chara Creek)*	*SD8 (Iron Ore and Coal Terminal Jetty)*	*SD9 (Southwest of Marine previously considered marine terminal)*	*SD10 (Gov Site - previously considered marine terminal)*	*SD11 (Isaro Creek)*	*SD12 (Gharo Creek)*	*SD13 (Keti Bandar)*
Iron (aqua regia extractable)	mg/kg	40	–	–	33,000	35,000	28000	28000	22000	27000	47,000
Lead (aqua regia extractable)	mg/kg	1	70	530	16.0	15.0	11	11	7.4	9.7	16
Lithium (aqua regia extractable)	mg/kg	0.1	–	–	39.0	45.0	35	33	30	35	44
Manganese (aqua regia extractable)	mg/kg	1	–	–	810.0	760.0	480	650	400	440	880
Mercury (aqua regia extractable)	mg/kg	0.3	12	36	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Molybdenum (aqua regia extractable)	mg/kg	0.25	4		0.6	0.7	0	1	0	0	0.6
Nickel (aqua regia extractable)	mg/kg	1	45	100	44.0	46.0	36	38	29	34	49
Phosphorus (aqua regia extractable)	mg/kg	20	–	–	660.0	430.0	670	750	490	480	450
Silver (aqua regia extractable)	mg/kg	1	20	–	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Selenium (aqua regia extractable)	mg/kg	1	1	100	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Strontium (aqua regia extractable)	mg/kg	10	–	–	2,000.0	2,300.0	1,800.0	2,400.0	1,800.0	2,000.0	82.0
Thallium (aqua regia extractable)	mg/kg	5	–	–	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Tin (aqua regia extractable)	mg/kg	1	5	–	2.4	1.8	1.8	1.9	1.7	1.9	2.0
Titanium (aqua regia extractable)	mg/kg	15	–	–	740.0	760.0	850.0	670.0	770.0	790.0	620.0
Vanadium (aqua regia extractable)	mg/kg	1	130	–	51.0	51.0	42.0	41.0	35.0	39.0	56.0
Zinc (aqua regia extractable)	mg/kg	1	250	720	79.0	77.0	61.0	66.0	51.0	61.0	79.0
Calcium (aqua regia extractable)	mg/kg	20	200	–	37,000	37,000	36,000	40,000	35,000	38,000	41,000
Magnesium (aqua regia extractable)	mg/kg	20	–	–	9,900	10,000	8,800	9,000	7,600	8,400	21,000

Parameter	*Unit*	*LOD*	*Alberta Guidelines*	*Dutch Standards*	*SD7 (Chara Creek)*	*SD8 (Iron Ore and Coal Terminal Jetty)*	*SD9 (Southwest of Marine previously considered marine terminal)*	*SD10 (Gov Site - previously considered marine terminal)*	*SD11 (Isaro Creek)*	*SD12 (Gharo Creek)*	*SD13 (Keti Bandar)*
Potassium (aqua regia extractable)	mg/kg	20	17	–	5,100	5,200	4,200	4,300	3,300	3,900	5,600
Sodium (aqua regia extractable)	mg/kg	20	200	–	7,400	5,100	4,700	7,800	3,700	4,900	5,400
Monoaromatics											
Benzene	mg/kg	0.005	0.046	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Toluene	mg/kg	0.005	0.52	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ethylbenzene	mg/kg	0.005	0.073	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
p & m-xylene	mg/kg	0.005	0.99	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
o-xylene	mg/kg	0.005	0.99	–	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Petroleum Hydrocarbons											
TPH1 (C10 - C40)	mg/kg	10	–	–	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Values exceeding Alberta or Dutch standards are shaded.

6. Impact Assessment

This section discusses the potential impacts that may result from the Project, along with associated mitigation measures. The assessment has been undertaken in accordance with the methodology provided in **Section 4.4**.

A phased approach was undertaken for four phases of the Project's lifecycle. The following impacts were considered significant and have been detailed below:

- Impact SS01: Impacts on soil quality due to Mine Site Construction
- Impact SS02: Disturbance of Soil Due to Construction of Water Supply Pipeline
- Impact SS03: Soil Contamination due to Improper Storage of Hazardous Materials or Management of Hazardous Waste
- Impact SS04: Disturbance of Soil Due to Pit Development.

All impacts related to Port Qasim were screened out as no construction or dredging will take place at the existing PIBT terminal, which will be used for storage and shipment of the concentrate. Impacts relating to the construction and laying of the water supply pipeline from the Northern Groundwater System have been discussed in the Early Works ESIA which was submitted to the Balochistan Environmental Protection Agency (BEPA) in 2024. Furthermore, no soil related impacts in relation to Port Qasim are expected as an existing terminal will be used for the storage of the product.

6.1 Design Phase Impacts

No impacts on soil during the design phase of the Project are expected in consideration of the Project's siting, proximity to receptors and scope of excavation activities.

6.2 Construction Phase Impacts

The construction phase of the Project will be when most of the soil related impacts of the Project are expected to occur as most of the excavation is expected to occur during this time.

6.2.1 Disturbance of Soil Due to Mine Site Construction

Excavation activities can significantly impact soils by causing erosion, compaction, and loss of structure, which reduce soil fertility and water infiltration. The removal of topsoil can deplete nutrients essential for plant growth. Additionally, construction activities can alter natural drainage patterns, leading to flooding or waterlogging, and disturb habitats, harming local flora and fauna.

There is presently minimal vegetation, and the land is not of economic value for the local communities, of which the nearest is situated approximately 15 km from the mine site. The soil's mineral content at the mine site as detailed in **Section 5.4** exceeds guidelines limits for mineral content which limits its viability for use in agriculture**. Exhibit 6.1** provides a comparison of the baseline soil quality against recommended mineral content

ranges for the growth of wheat and date palms.[24] [25] It can be observed that exceedances occur for all recommended values, limiting the suitability of these soils for use in agriculture.

Exhibit 6.1: Suitability of Soil for Agriculture in Comparison to Soil Samples

Parameter	*Wheat*	*Dates*	*S2-20*	*S3-20*	*S4-20*	*S5-20*	*S6-20*
Calcium	600 –1000	400 – 600	37,564	35,904	33,167	35,557	33,108
Potassium	150 – 250	150 – 250	3,864	1,358	1,251	2,567	2,139
Sodium	< 50	< 200	2,569	1,029	1,156	1,841	1,143

Erosion related risks because of modification of the site topography are also minimal as topsoil coverage is minimal, and the soil is generally unsuitable for agriculture. Thus, any erosion related modifications will have no impacts beyond some loss of visual amenity . Additionally, the Project will manage storm water flows to ensure that no long-term waterlogging occurs at the mine site due to modification of the topography.

The Project will implement several mitigation measures, including planning its construction activities to minimise disturbance to the soil and natural topography. Additionally, the Project will develop a **Land Disturbance Control Plan**. The Plan will at minimum include adequate provisions for:

- Excavation areas
- Management of backfill
- Measures for rehabilitation of the landscape

Impact SS01			
Phase: Construction			
Impact Description: Degradation of soil due to construction and excavation of the mine site.			
Prior to Mitigation/Management			
Dimension	**Rating**	**Interpretation of Rating**	**Significance**
Duration	5	Inter-Generational - >20 years	Moderate (negative) -40
Extent	1	Site Specific Limited to the site and its immediate surroundings.	
Intensity	2	Moderate effects on receptors. *Soil erosion and improper management of stockpiles and result in siltation and blocking of stormwater channels, in addition to being a visual nuisance and source of dust.*	
Probability	5	Certain / Definite There are sound evidence-based reasons to	

[24] Havlin, J. L., Beaton, J. D., Tisdale, S. L., & Nelson, W. L. (2013). Soil Fertility and Fertilizers: An Introduction to Nutrient Management. Pearson.

[25] Zaid, A., & Arias, E. J. (2002). Date Palm Cultivation. FAO Plant Production and Protection Paper 156.

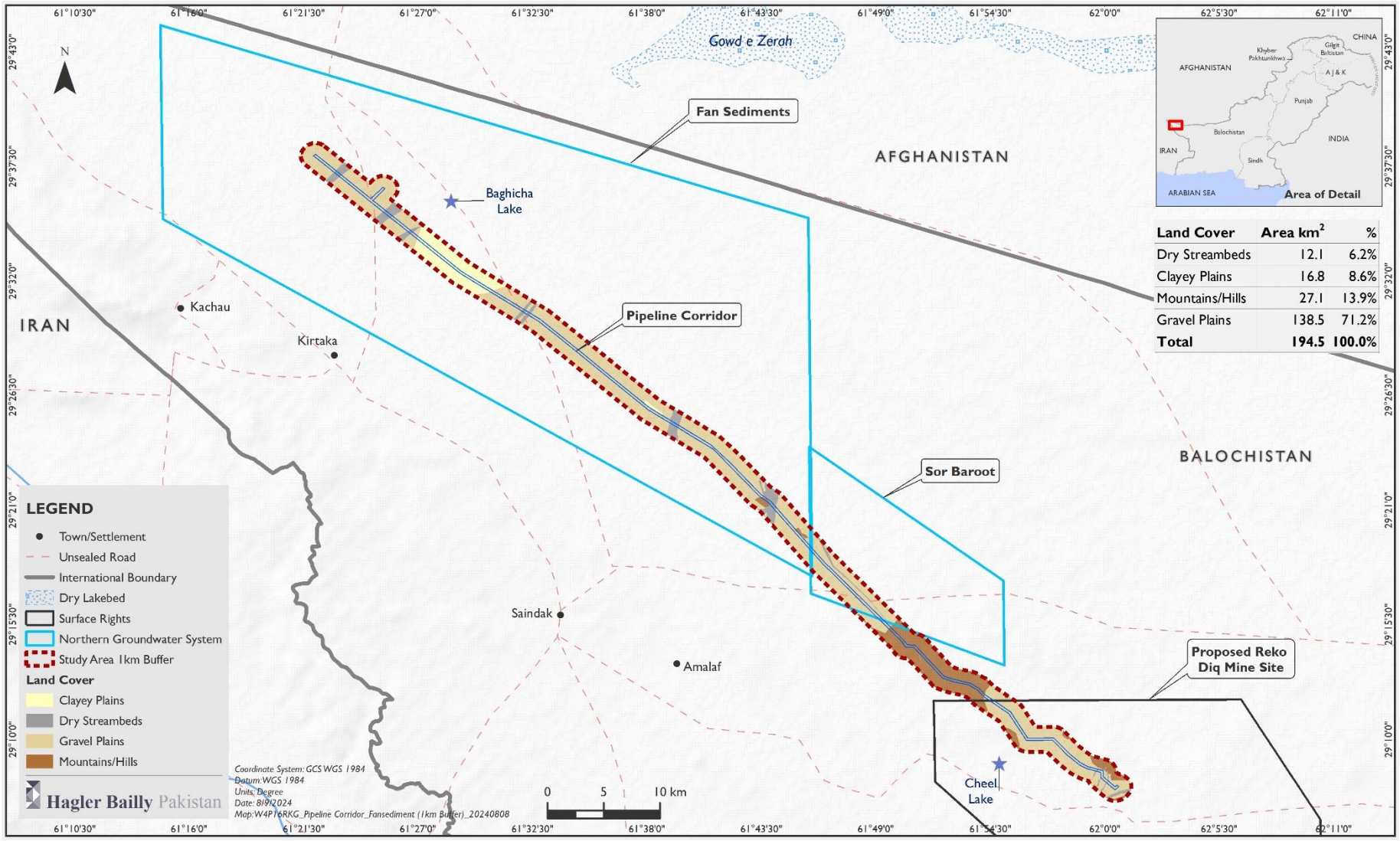
		expect that the impact will definitely occur (90-100%)	
Nature	Negative		
Mitigation/Management Actions			
▶ .Limit the movement of heavy machinery to designated pathways to prevent widespread soil compaction. ▶ Use diversion channels or berms to redirect clean water away from disturbed soils and reduce erosion risk. ▶ Plan construction activities to minimise the area of soil disturbance and avoid sensitive areas. ▶ The Project will develop a **Ground Disturbance Control Plan**. The Plan will at minimum include adequate provisions for: ▷ Excavation areas ▷ Management of backfill ▷ Measures for rehabilitation of the landscape			
Post-Mitigation			
Dimension	**Rating**	**Interpretation of Rating**	**Significance**
Duration	5	Inter-Generational - >20 years	Minor (negative) -35
Extent	1	Site Specific Limited to the site and its immediate surroundings.	
Intensity	1	Minor effects on biological or physical environment. *The mitigation measures will minimize erosion related impacts.*	
Probability	5	Certain / Definite There are sound evidence-based reasons to expect that the impact will definitely occur (90-100%)	
Nature	Negative		

6.2.2 Disturbance of Soil Due to Construction of Water Supply Pipeline

The pipeline construction can impact soils by causing erosion, compaction, and loss of structure, which reduces soil fertility and water infiltration. The removal of topsoil can deplete nutrients essential for plant growth. Additionally, construction activities can alter natural drainage patterns, leading to flooding or waterlogging, and disturb habitats, harming local flora and fauna.

According to the land-use map provided in **Exhibit 6.2** where excavation activities are expected to occur, there is minimal vegetation, and the land is not of economic value to the local communities. The pipeline will not cross or disturb any water courses, springs, or surface water bodies. Only scattered vegetation of minimal ecological diversity exists along the planned water pipeline.

Exhibit 6.2: Land Use 1 km around the Planned Water Supply Pipeline



The soil that will be disturbed due to the pipeline construction is of minimal agricultural value. There is no existing agriculture in or near the soil that will be disturbed by the pipeline, and the soil's mineral content near the pipeline as detailed in **Section 5** exceeds guidelines limits for mineral content which limits its viability for use in agriculture**.** **Exhibit 6.3** provides a comparison of the baseline soil quality against recommended mineral content ranges for the growth of wheat and date palms across various literature sources.[26] [27] [28] It can be observed that exceedances occur for all recommended values, limiting the suitability of these soils for use in agriculture.

Exhibit 6.3: Suitability of Soil for Agriculture

Parameter	*Wheat*	*Dates*	*Baseline (S1-20)*
Calcium	600 –1000	400 – 600	33,108
Potassium	150 – 250	150 – 250	2,139
Sodium	< 50	< 200	1,143

Erosion related risks because of modification of topography are minimal as excavation is minimal with backfill to occur immediately following installation of the pipeline. The topography may result in the runoff of excavated material into the Bagicha Lake, situated 1 km from the construction area. The Project will ensure that material is not stockpiled near this location and is transported or reused for backfill.

The Project will develop a **Ground Disturbance Control Plan**. The Plan will at minimum include adequate provisions for:

- Excavation areas
- Management of backfill
- Measures for rehabilitation of the landscape

Impact SS02			
Phase: Construction			
Impact Description: Degradation of soil due to construction and excavation of the water supply pipeline.			
Prior to Mitigation/Management			
Dimension	**Rating**	**Interpretation of Rating**	**Significance**
Duration	3	Medium term 2 to 5 years	Negligible (negative) -15

[26] Beaton, J. D., Tisdale, S. L., & Nelson, W. L. (2005). Soil fertility and fertilizers: an introduction to nutrient management.

[27] Brady, N. C., & Weil, R. R. (1996). The nature and properties of soils

[28] Zaid, A., & Arias-Jimenez, E. (2002). Date palm cultivation FAO plant and protection paper.

Extent	1	Site Specific Limited to the site and its immediate surroundings.	
Intensity	1	Minor effects on biological or physical environment.	
Probability	3	Probable Has occurred here or elsewhere and could therefore occur (20-50%).	
Nature	Negative		
Mitigation/Management Actions			
▶ Strip and stockpile topsoil separately from subsoil, and ensure it is reused to the extent possible to preserve its fertility. ▶ Plan construction activities to minimise the area of soil disturbance and avoid sensitive areas. ▶ The Project will develop a **Ground Disturbance Control Plan**. The Plan will at minimum include adequate provisions for: ▷ Excavation areas ▷ Management of backfill ▷ Measures for rehabilitation of the landscape			
Post-Mitigation			
Dimension	**Rating**	**Interpretation of Rating**	**Significance**
Duration	3	Medium term 2 to 5 years	Negligible (negative) -5
Extent	1	Site Specific Limited to the site and its immediate surroundings.	
Intensity	1	Minor effects on biological or physical environment.	
Probability	1	Rare / improbable Conceivable, but only in extreme circumstances and / or has not happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materializing is very low as a result of design, historic experience or implementation of adequate mitigation measures (1-5%).	
Nature	Negative		

6.3 Operations Phase Impacts

No excavation activities will occur during the operations phase besides pit development at the Mine Site. The potential impacts are described below.

6.3.1 Disturbance of Soil Due to Pit Development

The pit development will result in the generation of large quantities of waste ore as well as soil. Additionally, the pit development can alter natural drainage patterns, leading to flooding or waterlogging, and disturb habitats, harming local flora and fauna.

The Project will implement several mitigation measures, including planning its excavation activities to minimise disturbance to the soil. Additionally, the Project will develop a **Ground Disturbance Control Plan**. The Plan will at minimum include adequate provisions for:

- Excavation areas
- Management of backfill
- Measures for rehabilitation of the landscape

<table>
<tr><td colspan="4">Impact SS03</td></tr>
<tr><td colspan="4">Phase: Operations</td></tr>
<tr><td colspan="4">Impact Description: Disturbance of Soil Due to Pit Development.</td></tr>
<tr><td colspan="4">Prior to Mitigation/Management</td></tr>
<tr><td>Dimension</td><td>Rating</td><td>Interpretation of Rating</td><td>Significance</td></tr>
<tr><td>Duration</td><td>5</td><td>Inter-Generational - >20 years</td><td rowspan="5">Moderate (negative) -40</td></tr>
<tr><td>Extent</td><td>1</td><td>Site Specific
Limited to the site and its immediate surroundings.</td></tr>
<tr><td>Intensity</td><td>2</td><td>Moderate effects on receptors.
Soil erosion and improper management of stockpiles and result in siltation and blocking of stormwater channels, in addition to being a visual nuisance and source of dust.</td></tr>
<tr><td>Probability</td><td>5</td><td>Certain / Definite
There are sound evidence-based reasons to expect that the impact will definitely occur (90-100%)</td></tr>
<tr><td>Nature</td><td>Negative</td><td></td></tr>
<tr><td colspan="4">Mitigation/Management Actions</td></tr>
<tr><td colspan="4">▶ Limit the movement of heavy machinery to designated pathways to prevent widespread soil compaction.
▶ Use diversion channels or berms to redirect clean water away from disturbed soils and reduce erosion risk.
▶ Plan construction activities to minimise the area of soil disturbance and avoid sensitive areas.
▶ The Project will develop a Ground Disturbance Control Plan. The Plan will at minimum include adequate provisions for:
▷ Excavation areas
▷ Management of backfill
▷ Measures for rehabilitation of the landscape</td></tr>
<tr><td colspan="4">Post-Mitigation</td></tr>
<tr><td>Dimension</td><td>Rating</td><td>Interpretation of Rating</td><td>Significance</td></tr>
<tr><td>Duration</td><td>5</td><td>Inter-Generational - >20 years</td><td rowspan="2">Minor (negative) -35</td></tr>
<tr><td>Extent</td><td>1</td><td>Site Specific
Limited to the site and its immediate surroundings.</td></tr>
</table>

Intensity	2	Minor effects on biological or physical environment. *The mitigation measures will minimize erosion related impacts.*	
Probability	5	Certain / Definite There are sound evidence-based reasons to expect that the impact will definitely occur (90-100%)	
Nature	Negative		

6.3.2 Soil Contamination due to Improper Storage of Hazardous Materials or Management of Hazardous Waste

The Project's operation activities will require the storage of hazardous materials and generate hazardous waste in the form of used containers for solvents, lubricants, cleaning materials as well as electronic waste. The hazardous materials, if stored improperly or improper disposal of hazardous waste can result in contamination of the soil and groundwater.

The Project shall develop a **Hazardous Waste and Materials Management Plan** which will at minimum include the following:

- Identification of waste streams and quantities.
- Mechanisms for disposal of hazardous waste, including a list of licensed hazardous waste contractors.
- Mechanisms for safe storage of hazardous materials such as secondary storage and sheltered disposal areas.
- Monitoring requirements and implementing worker training.

Impact 08			
Phase: Operations			
Impact Description: Improper management of solid and hazardous waste			
Prior to Mitigation/Management			
Dimension	**Rating**	**Interpretation of Rating**	**Significance**
Duration	5	Inter-Generational - >20 years	Minor (negative) -33
Extent	4	Regional Will affect the entire province or region. A broad geographical area distinguished by similar features.	
Intensity	2	Moderate, short-term effects but not affecting ecosystem function.	
Probability	3	Probable Has occurred here or elsewhere and could therefore occur (20-50%)	
Nature	Negative		

Mitigation/Management Actions			
▶ The Project shall implement a Hazardous Waste and Materials Management Plan.			
Post-Mitigation			
Dimension	**Rating**	**Interpretation of Rating**	**Significance**
Duration	5	Inter-Generational - >20 years	Negligible (negative) -11
Extent	4	Regional Will affect the entire province or region. A broad geographical area distinguished by similar features.	
Intensity	2	Moderate, short-term effects but not affecting ecosystem function.	
Probability	1	Rare / improbable Conceivable, but only in extreme circumstances.	
Nature	Negative		

6.4 Decommissioning Phase Impacts

The decommissioning activities will involve site rehabilitation to the extent possible. As no excavation will occur, the disturbance and displacement of existing soils will be minimal.

6.5 Impacts on Soils and Sediments due to Climate Change

Change in climatic conditions, particularly an increase in the annual precipitation and the increase in the number of flood events can exacerbate impacts on soil by increasing erosion of soils and resulting in morphological changes to the topography.

The climate change assessment of the Reko Diq Mine Site (BAR7212 – Climate Change Specialist Assessment of Reko Diq Gap Analysis and Scope of Work for Environmental Studies) estimates a ~27% increase in annual precipitation and a 155% increase in 50-year flood hazard intensity.

The increase in the annual precipitation and flood hazard intensity will exacerbate runoff and erosion related impacts if they are not managed properly. The **Ground Disturbance Control Plan** will adopt a precautionary approach and will investigate the Project's excavation and adjoining areas and on the basis of topography, will determine whether erosion related risks will emerge in the future.

This assessment does not account for changes in wind speeds, although the contribution of wind speed relative to erosion from precipitation will likely be minor. The Ground Disturbance Plan will emphasis stockpile management to ensure that wind related dispersion of dust around the site is minimized.

7. Environmental/Social Management Plan

The Environmental Management Plan for managing all soil-related impacts is presented below.

Exhibit 7.1: Environmental Management Plan — Soils

Impacts	*Activity*	*Mitigation Measures*	*Recommended Action Plans*	*Time period for implementation*
Construction Phase				
Disturbance of soil due to Mine Site Construction	Excavation and disposal of soil	▶ Limit the movement of heavy machinery to designated pathways to prevent widespread soil compaction. ▶ Use diversion channels or berms to redirect clean water away from disturbed soils and reduce erosion risk. ▶ Plan construction activities to minimise the area of soil disturbance and avoid sensitive areas.	Ground Disturbance Control Plan	Continually, during construction
Degradation of soil due to construction and excavation of the water supply pipeline.	Excavation and disposal of soil	▶ Strip and stockpile topsoil separately from subsoil, and ensure it is reused to the extent possible to preserve its fertility. ▶ Plan construction activities to minimise the area of soil disturbance.	Ground Disturbance Control Plan	Continually, during construction
Operations Phase				
Disturbance of soil due to Mine Pit Development	Excavation and disposal of soil	▶ Limit the movement of heavy machinery to designated pathways to prevent widespread soil compaction. ▶ Use diversion channels or berms to redirect clean water away from disturbed soils and reduce erosion risk.	Ground Disturbance Control Plan	Continually, during operations

Impacts	*Activity*	*Mitigation Measures*	*Recommended Action Plans*	*Time period for implementation*
		▶ Plan construction activities to minimise the area of soil disturbance.		
Soil Contamination due to Improper Storage of Hazardous Materials or Management of Hazardous Waste	Hazardous materials storage and disposal	The Plan shall include: ▶ Identification of waste streams and quantities. ▶ Mechanisms for disposal of hazardous waste, including a list of licensed hazardous waste contractors. ▶ Mechanisms for safe storage of hazardous materials such as secondary storage and sheltered disposal areas. ▶ Monitoring requirements and implementing worker training.	Hazardous Waste and Materials Management Plan	Continually, during operations

8. Monitoring Plan

Aspects that will be monitored regarding soils are presented below.

Exhibit 8.1: Environmental Monitoring Plan — Soil

Aspect	*Type of Monitoring*	*Monitoring Frequency*
Construction Phase		
Soil Erosion	Visual inspections for signs of erosion or wind deposition, especially in significant rainfall seasons.	Twice every year (fixed time of the year)
Operations Phase		
Soil Erosion	Visual inspections for signs of erosion or wind deposition, especially in significant rainfall seasons.	Quarterly and after large storm events
Rehabilitation	Visual inspections to ensure that site restoration is carried out as per the requirements of designated rehabilitation plans.	Quarterly and after storm events
Decommissioning Phase		
Soil Erosion	Visual inspections for signs of erosion or wind deposition, especially in significant rainfall seasons.	Quarterly and after large storm events
Rehabilitation	Visual inspections to ensure that site restoration is carried out as per the requirements of designated rehabilitation plans.	Annually (fixed time of the year)

9. Conclusions and Recommendations

9.1 Specialist Impact Statement

The Project's impacts on soil and sediments are not significant given that the mitigations identified are implemented and subsequent monitoring is carried out. Climate change predictions have been considered when assessing the Project's impacts and determining the mitigation measures.

9.2 Key Findings and Recommendations

The key findings and recommendations of this Study are summarized below:

- No community receptors were identified near the excavation areas.
- The baseline data collected concluded that agricultural significance of the soils is minimal, and that no prior contamination was detected. The soil analysis revealed high concentrations of metals and some minerals within the soil which exceed the Soil Screening Values (SSVs) which are geogenic in nature as the soils in the region are highly metalliferous.
- Storage, management and placement of stockpiles to ensure no runoff into water bodies occurs will significantly mitigate any potential impacts on the soil integrity and quality.

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Appendix A: Soil Quality Data

See the following pages.

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ISO 9001:2015 CERTIFIED

Directorate of Systems & Services

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11 September, 2020

ANALYSIS REPORT

Customer Contact: Hagler Bailly Pakistan (Pvt.) Ltd.
Block 1, Commercial Area,
Street 21, F8/2, Islamabad

Customer Reference: F0019LAB
Sample ID: Groundwater, Soil
Submitted By: Dr. Sheherzad Akhtar

CAFD No: 5680
Date Registered: 31-08-2020

Report No: CAFD-5680-2020 4454
No. of Samples: 15
Technique: HGAAS

Concentration (ng/mL or ppb)

Element	E06252	E06253	E06254	E06255	E06256	E06257	E06258	E06259	LOD
Hg	ND	ND	ND	ND	ND	ND	ND	ND	0.67
As	251.0	5.03	6.86	11.35	11.25	ND	ND	ND	0.69
Sb	87.0	56.0	38.0	53.0	50.0	67.0	43.0	49.0	0.72
Se	ND	6.91	8.42	ND	ND	ND	ND	ND	0.68

Concentration (ng/g or ppb)

Element	E06260	E06261	E06262	E06263	E06264	E06265	E06266	LOD
Hg	345.0	510.0	578.0	625.0	565.0	501.0	381.0	28.67
As	1321.0	1639.0	2099.0	1613.0	2172.0	2041.0	1891.0	29.60
Sb	ND	ND	ND	72.0	110.0	ND	ND	30.89
Se	135.0	ND	ND	ND	ND	ND	ND	33.47

RSD ≤ 5.0% ND = Not detected LOD = Limit of determination

Note:
1. These samples were collected by yourself (or your agent) and analyzed as received at this division.
2. This report is not valid for judicial use.
3. The analyzed samples may be collected back within one month of the issuance of this report, if required.

(Analyst) 11/09/2020
Tanveer Ahmad

Lab Incharge 11/09/2020

Group Head 2020.09.11

Head CAFD 11/09/2020

Central Analytical Facility Division

ISO 9001:2015 certified

Directorate of Systems & Services

Pakistan Institute of Nuclear Science & Technology, Post Office Nilore, Islamabad, Pakistan

Tel.: (051)9248772, Fax: (51)9248808, Email: cafdoffice@yahoo.com

September 11, 2020

ANALYSIS REPORT

Customer Contact: Hagler Bailly Pakistan

Customer Reference: F0020LAB
Sample ID: Soil sample
Submitted By: Dr.Sherherzad Akhter

CAFD No: 5680
Date Registered: 31-08-2020
Report No: CAFD-5680-2020/4452
No. of Samples: 07
Technique used: HPLC & Instrumental method

Sr #	Sample ID	pH	Conductivity (mS/cm)	Chloride (mg/L)	Nitrate Nitrogen (mg/L)	Ammonia (mg/L)
1.	E06260	7.46	3.71	1020	27.0	0.54
2.	E06261	7.75	3.62	780	ND	1.22
3.	E06262	7.07	1.17	235	2.84	0.10
4.	E06263	8.02	1.82	602	4.12	2.4
5.	E06264	7.39	5.31	690	11.5	0.20
6.	E06265	7.49	3.31	260	5.64	0.25
7.	E06266	7.53	3.26	310	6.54	0.65
8.	LOD	-	0.001	2.0	4.0	0.02

ND= Not Detected LOD= Limit of Detection

Note:
1. These samples were collected by yourself (or your agent) and analyzed as received at this division.
2. This report is not valid for judicial use.
3. The analyzed samples may be collected back within one months of the issuance of this report, if required.

Analyst
(Irum Noureen) 11/09/2020

Lab Incharge

Group Head 2020.09.11

Head CAFD 11/09/2020

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September 15, 2020

ANALYSIS REPORT

Customer Contact: Hagler Bailly Pakistan, F-8/2, Islamabad.
Customer Reference: F0019LAB
Sample Type: Soil Samples
Submitted By: Dr. Sheherzad Akhtar

CAFD No: 5680
Date Registered: 31-08-2020
Report No: CAFD-5680-2020/4451
No. of Samples: 15
Technique: ICP-OES

Concentration (µg/g)

Sr. No.	Elements	S# 1 E06260	S# 3 E06261	S# 4 E06262	S# 5 E 06263	S# 6 E06264	S# 7 E 06265	S# 10 E06266
1	Al	16193	18768	10512	9391	12618	14249	15368
2	B	5.78	1.96	ND	ND	ND	ND	ND
3	Ba	49.05	86.49	75.40	57.20	51.91	45.08	39.89
4	Ca	46649	37564	35904	33167	35557	33108	31171
5	Cd	ND	ND	ND	ND	5.08	ND	ND
6	Cr	50.50	79.70	83.38	76.83	65.35	47.10	41.16
7	Cu	17.55	30.46	50.73	31.29	26.70	20.28	25.42
8	Fe	28604	25250	22441	22142	21731	21272	22532
9	K	2262	3864	1358	1251	2567	2193	2239
10	Mg	13441	17054	10279	9950	13162	14359	15549
11	Mn	451	397	747	358	404	438	450
12	Na	2081	2569	1029	1156	1841	1143	1318
13	Ni	28.49	41.47	34.91	34.41	35.54	30.79	28.46
14	P	259	231	253	214	212	252	267
15	Pb	ND	10.42	11.46	ND	21.00	ND	ND
16	SO_4	520	1346	1162	943	16105	3393	2870
17	Sr	116	136	112	93	143	195	210
18	Zn	42.49	59.01	71.63	42.66	216.05	43.62	47.30

RSD ≤ 2.0 % ND = Not detected

Note:
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- This report is not valid for judicial use
- The analyzed samples may be collected back within one month of the issuance of this report, if required.

Analyst
(Ahmad Naveed Sajid)

Lab Incharge 15/09/2020

Group Head

Head CAFD 15/09/2020

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Tel.: (051)9248772, Fax: (51)9248808, Email: cafdoffice@yahoo.com

September 15, 2020

ANALYSIS REPORT

Customer Contact: Hagler Bailly Pakistan Block1 Commercial Area Street 21, F8/2 Islamabad
Customer Reference: Nil
Sample ID: Water/Soil Sample
Submitted By: Dr. Sheherazad Akhtar

CAFD No: 5680
Date Registered: 31-08-2020
Report No: CAFD-5680-2020 4453
No. of Samples: 15
Technique: Titration

Concentration (mg/L)

Parameter	E06252	E06253	E06254	E06255	E06256	E06257	E06258	E06259	LOD
Alkalinity	44	68	60.8	218	220	ND	ND	ND	5

Parameter	E06260	E06261	E06262	E06263	E06264	E06265	E06266	LOD
Carbonate	ND	ND	ND	59.4	ND	ND	ND	5

LOD = Limit of determination ND = Not Detected

Note:
1. The samples were collected by yourself (or your agent) and analyzed as received at this division.
2. This report is not valid for judicial use.
3. The analyzed samples may be collected back within one month of the issuance of this report, if required.

15-09-2020
(Analyst)
Adil Jamil

Lab Incharge
Group Head
2020.09.15

Head CAFD
15/09/2020

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October 25, 2022

ANALYSIS REPORT

Customer Contact: Hagler Bailly Pakistan, F8/2, Islamabad
Customer Reference: F20016LA03
Sample Type: Soil samples
Submitted By: Dr. Sheherzad Akhtar

CAFD No: 6394
Date Registered: 17-10-2022
Report No: CAFD-6394-2022/ 565
No. of Samples: 06
Technique: ICP-OES

Concentration (µg/g)

Sr. #	Elements	S# 1	S# 2	S# 3	S# 4	S# 5	S# 6
1	Al	43683	38052	18593	28130	35279	28246
2	As	7.93	7.40	5.45	5.59	7.00	6.91
3	B	144	916	103	175	637	185
4	Ba	97.09	79.78	93.62	54.21	70.66	29.79
5	Ca	44861	21680	29229	65096	30029	62241
6	Cd	ND	ND	ND	ND	8.56	ND
7	Cr	98.93	64.52	39.05	60.68	63.55	61.05
8	Cu	35.24	37.43	11.68	13.99	20.68	14.85
9	Fe	39641	29244	16994	23676	22228	25088
10	Hg	ND	ND	ND	ND	ND	ND
11	K	15652	28992	9472	13813	21995	13419
12	Mg	143788	127918	69445	89815	137657	92624
13	Mn	618	409	254	445	296	464
14	Na	4800	55463	3552	4854	526669	5152
15	Ni	112	46.76	34.24	65.62	51.64	69.74
16	P	332	234	140	524	182	541
17	Pb	15.51	8.97	7.29	14.01	9.28	15.19
18	SO_4	563	2846	152	54769	46385	33095
19	Sb	ND	ND	ND	ND	8.56	ND
20	Se	ND	ND	ND	ND	8.56	ND
21	Sr	346	187	183	1415	645	572
22	Zn	77.18	53.50	28.30	49.78	45.11	43.96

RSD ≤ 2.0 % ND = Not detected

Note
- These samples were collected by yourself (or your agent) and analyzed as received at this division.
- This report is not valid for judicial use.
- The analyzed samples may be collected back within one month of the issuance of this report, if required.

25.10.22
Analyst
(Ahmad Naveed Sajid)

25/10/2022
Lab Incharge
Group Head

Head CAFD
2022.10.27

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October 24, 2022

ANALYSIS REPORT

Customer Contact: Hagler Bailly, Pakistan
CAFD No: 6394
Date Registered: 17-10-2022
Customer Reference: F20016LAB
Report No: CAFD-6394-2022/ 5866
Sample ID: Soil Sample
No. of Samples: 06
Submitted By: Dr. Sheherzad Akhtar
Technique used: Instrumental Methods

Sr No.	Sample ID	pH	Conductivity (mS/cm)	Ammonia (mg/Kg)	Nitrate-N (mg/Kg)	Chloride (mg/Kg)
1	S-1	7.63	0.53	9.0	12.5	189.0
2	S-2	8.85	3.24	20.0	29.0	2575
3	S-3	7.59	0.11	16.0	ND	12.0
4	S-4	7.12	2.56	95.0	12	143
5	S-5	7.68	46.9	50.0	123	97194
6	S-6	7.38	2.56	40.0	ND	126
LOD		-	1.0	0.02	4.0	1.0

LOD = Limit of Detection ND = Not Detected

Note:
1. These samples were collected by yourself (or your agent) and analyzed as received at this division.
2. This report is not valid for judicial use.
3. The analyzed samples may be collected back within one month of the issuance of this report, if required.

Analyst
(Irum Noureen) 24/10/2022

Lab Incharge 24/10/22

Group Head 24.10.22

Head CAFD 2022.10.27

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October 24, 2022

ANALYSIS REPORT

Customer Contact Hagler Bailly, Pakistan

Customer Reference: F20016LAB
Sample ID: Soil Samples
Submitted By: Dr. Sheherzad Akhtar

CAFD No: 6394
Date Registered: 17-10-2022
Report No: CAFD-6394-2022/867
No. of Samples: 06
Technique used: CHNS/O Analyzer

Concentration (%)

S.No	Sample ID	Total Organic Carbon (TOC)
1	S1	2.25
2	S2	0.78
3	S3	0.54
4	S4	1.88
5	S5	0.79
6	S6	3.62

RSD ≤ 2

Note:
1. These samples were collected by yourself (or your agent) and analyzed as received at this division.
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24/10/2022
Analyst
(Sidra Nadeem)

24/10/22
Lab Incharge
Group Head

Head, CAFD
2022.10.24

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October 20, 2022

ANALYSIS REPORT

Customer Contact Hagler Bailly Pakistan Block1 Commercial Area, Street 21, F8/2, Islamabad

Customer Reference: NIL

Sample ID: Water Sample

Submitted By: Dr. Sheherzad Akhtar

CAFD No: 6394

Date Registered: 17-10-2022

Report No: CAFD-6394-2022/ 5608

No. of Samples: 06

Technique used: Titration

Concentration (µg/g)

Parameter	S-1	S-2	S-3	S-4	S-5	S-6	LOD
Carbonate	ND	150	ND	ND	ND	ND	12

ND = Not detected LOD = Limit of Determination

Note:

1. **These samples were collected by yourself (or your agent) and analyzed as received at this division.**
2. This report is not valid for judicial use.
3. The analyzed samples may be collected back within one months of the issuance of this report, if required.

Analyst
Adil Jamil

Lab Incharge
Group Head

Head, CAFD

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October 09, 2023

ANALYSIS REPORT

Customer Contact: Hagler Bailly Pakistan, F8/2, Islamabad.
Customer Reference: F30018LAB
Sample Type: Soil samples
Submitted By: Dr. Sheherzad Akhtar

CAFD No: 6971
Date Registered: 02-10-2023
Report No: CAFD-6971-2023/ 6474
No. of Samples: 03
Technique: ICP-OES

Concentration (µg/g)

Sr. #	Elements	S7	S8	S9
1	Al	40313	41365	34388
2	As	7.90	15.24	7.79
3	B	ND	37.87	11.08
4	Ba	89.07	170.19	81.71
5	Ca	32314	76008	60534
6	Cd	ND	ND	ND
7	Cr	114.26	86.30	66.03
8	Cu	33.38	31.44	18.50
9	Fe	32400	34040	26026
10	Hg	ND	ND	ND
11	K	12815	18618	22287
12	Li	18.40	26.37	21.34
13	Mg	145487	126511	104792
14	Na	9740	77013	28109
15	Ni	101	82.92	59.06
16	P	298	181	526
17	Pb	11.48	15.92	13.11
18	SO_4	4228	27929	43517
19	Sb	ND	ND	ND
20	Se	ND	ND	ND
21	Sr	260	409	698
22	Zn	55.79	57.15	48.84

RSD ≤ 2.0 % ND = Not detected

Note:
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09.10.23
Analyst
(Ahmad Naveed Sajid)

09/10/2023
Lab Incharge
Group Head

Head CAFD
2023.10.26

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October 17, 2023

ANALYSIS REPORT

Customer Contact:	Hagler Bailly, Pakistan	**CAFD No:**	6971
		Date Registered:	02-10-2023
Customer Reference:	F30018LAB	**Report No:**	CAFD-6971-2023/6475
Sample ID:	Soil Sample	**No. of Samples:**	03
Submitted By:	Dr. Sheherzad Akhtar	**Technique used:**	Instrumental methods

Sr No.	Sample ID	Sample # 7	Sample # 8	Sample # 9	LOD
1	pH	7.35	7.38	7.25	
2	Conductivity (µS/cm)	231	3500	2240	0.1
3	Chloride (mg/Kg)	83	6300	3250	0.5
4	Ammonia (mg/Kg)	4	11	15	0.02
5	Nitrate-Nirogen (mg/Kg N)	09	81	33	0.4

LOD = Limit of Detection

Note:
1. These samples were collected by yourself (or your agent) and analyzed as received at this division.
2. This report is not valid for judicial use.
3. The analyzed samples may be collected back within one month of the issuance of this report, if required.

Analyst
(Irum Noureen) 17/10/23

Lab Incharge 17/10/23

Group Head 17/10/23

Head CAFD 2023.10.26

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October 20, 2023

ANALYSIS REPORT

Customer Contact	Hagler Bailly Pakistan Block #1 Commercial Area Street 21 F8/2 Islamabad.	**CAFD No:**	6971
		Date Registered:	02-10-2023
Customer Reference:	F30018LAB	**Report No:**	CAFD-6971-2023/6476
Sample ID:	Soil Sample	**No. of Samples:**	03
Submitted By:	Dr. Sheherzad Akhtar	**Technique used:**	Titration

Parameter	S-7	S-8	S-9	LOD
Carbonate (mg/kg)	ND	ND	ND	12mg/kg

ND = Not detected LOD = Limit of Determination

Note:

1. These samples were collected by yourself (or your agent) and analyzed as received at this division.
2. This report is not valid for judicial use.
3. The analyzed samples may be collected back within one months of the issuance of this report, if required.

Adil Jamil 20/10/23

Analyst
Adil Jamil

Lab Incharge Humaira 20/10/23

Group Head 20/10/23

Head, CAFD 2023.10.26

Central Analytical Facility Division

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October 26, 2023

ANALYSIS REPORT

Customer Contact	Hagler Bailly Pakistan Block #1 Commercial Area Street 21 F8/2 Islamabad.	**CAFD No:**	6971
		Date Registered:	02-10-2023
Customer Reference:	F30018LAB	**Report No:**	CAFD-6971-2023/6477
Sample ID:	Soil Sample	**No. of Samples:**	03
Submitted By:	Dr. Sheherzad Akhtar	**Technique used:**	Classical method

Concentration (%)

Samples	TOC
S-7	0.24
S-8	0.19
S-8	0.18

Note:
1. These samples were collected by yourself (or your agent) and analyzed as received at this division.
2. This report is not valid for judicial use.
3. The analyzed samples may be collected back within one months of the issuance of this report, if required.

26/10/2023

Analyst
Muhammad Danish

Lab Incharge 26/10/2023

Group Head 26/10/2023

Head, CAFD 2023.10.26

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R-051(A) Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-1)** Grab/Composite: Grab

Date of Sample Collection: 21-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S . No	Parameters	Unit	Results	Method
1	pH	-	7.89	pH Meter
2	Total Organic Carbon (TOC)	%	1.62	Loss on Ignition
3	Conductivity	mS	1.45	Multiparameter
4	Calcium (Ca)	mg/Kg	16890	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	749	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	1970	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	602	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	ND	Titration
9	Chloride	mg/Kg	870	HACH 8021
10	Sulphate (SO_4)	mg/Kg	1250	HACH 8051
11	Nitrate Nitrogen ($NO_3 - N$)	mg/Kg	2.4	HACH 8171
12	Ammonia (NH_3)	mg/Kg	110	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	1.6	HACH 8190

*SEQS: Sindh Environmental Quality Standard

1. Sample analyzed by: _____

   Reviewed by: _____

2. Signature of In-charge of environmental laboratory/ DH (EM&M): _____
   Name: _____
   Designation: _____

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

SEPA Certified Lab (EPA/LAB Certificate 06/2009)
EMS (ISO 14001 2015), Certified Lab [illegible]
OHSMS (ISO 45001 2018), Certified Lab [illegible]

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R-051(B)   Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-2)**   Grab/Composite: Grab

Date of Sample Collection: 19-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S . No	Parameters	Unit	Results	Method
1	pH	-	8.15	pH Meter
2	Total Organic Carbon (TOC)	%	2.50	Loss on Ignition
3	Conductivity	mS	30.5	Multiparameter
4	Calcium (Ca)	mg/Kg	17250	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	2110	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	1350	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	10170	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	100	Titration
9	Chloride	mg/Kg	14270	HACH 8021
10	Sulphate (SO_4)	mg/Kg	2760	HACH 8051
11	Nitrate Nitrogen ($NO_3 - N$)	mg/Kg	4.8	HACH 8171
12	Ammonia (NH_3)	mg/Kg	350	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	3.6	HACH 8190

***SEQS**: Sindh Environmental Quality Standard

1. Sample analyzed by: ____________

   Reviewed by: ____________

2. Signature of In-charge of environmental laboratory/ DH (EM&M): ____________
   Name: ____________
   Designation: ____________

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R- 051(e) Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-3)** Grab/Composite: Grab

Date of Sample Collection: 19-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S . No	Parameters	Unit	Results	Method
1	pH	-	7.89	pH Meter
2	Total Organic Carbon (TOC)	%	0.61	Loss on Ignition
3	Conductivity	mS	3.48	Multiparameter
4	Calcium (Ca)	mg/Kg	4050	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	1850	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	846	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	1045	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	ND	Titration
9	Chloride	mg/Kg	1780	HACH 8021
10	Sulphate (SO_4)	mg/Kg	1052	HACH 8051
11	Nitrate Nitrogen (NO_3 – N)	mg/Kg	3.7	HACH 8171
12	Ammonia (NH_3)	mg/Kg	550	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	3.95	HACH 8190

*SEQS: Sindh Environmental Quality Standard

1. Sample analyzed by: _____

   Reviewed by: _____

2. Signature of In-charge of environmental laboratory/ DH (EM&M): _____
   Name: _____
   Designation: _____

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R- 057(D) Date: 11-12-2023

Name of Industry / Client M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-4)** Grab/Composite: Grab

Date of Sample Collection: 22-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S. No	Parameters	Unit	Results	Method
1	pH	-	7.74	pH Meter
2	Total Organic Carbon (TOC)	%	0.42	Loss on Ignition
3	Conductivity	mS	0.70	Multiparameter
4	Calcium (Ca)	mg/Kg	3000	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	1050	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	810	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	534	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	ND	Titration
9	Chloride	mg/Kg	756	HACH 8021
10	Sulphate (SO_4)	mg/Kg	840	HACH 8051
11	Nitrate Nitrogen (NO_3-N)	mg/Kg	3.4	HACH 8171
12	Ammonia (NH_3)	mg/Kg	300	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	1.85	HACH 8190

*SEQS: Sindh Environmental Quality Standard

1. Sample analyzed by: ______

Reviewed by: ______

2. Signature of In-charge of environmental laboratory/ DH (EM&M): ______
Name: ______
Designation: ______

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R- 051(E) Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-5)** Grab/Composite: Grab

Date of Sample Collection: 22-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S . No	Parameters	Unit	Results	Method
1	pH	-	8.05	pH Meter
2	Total Organic Carbon (TOC)	%	1.03	Loss on Ignition
3	Conductivity	mS	7.1	Multiparameter
4	Calcium (Ca)	mg/Kg	6950	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	1300	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	913	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	3168	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	210	Titration
9	Chloride	mg/Kg	4650	HACH 8021
10	Sulphate (SO_4)	mg/Kg	1580	HACH 8051
11	Nitrate Nitrogen (NO_3 – N)	mg/Kg	4.7	HACH 8171
12	Ammonia (NH_3)	mg/Kg	420	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	4.36	HACH 8190

*SEQS: Sindh Environmental Quality Standard

1. Sample analyzed by: _____

   Reviewed by: _____

2. Signature of In-charge of environmental laboratory/ DH (EM&M): _____
   Name: _____
   Designation: _____

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

SEPA Certified Lab (EPA/LAB Certificate 06/2003)
EMS (ISO 14001:2015), Certified Lab (PcSP R-15107-EM)
OHSMS (ISO 45001:2018), Certified Lab (PcSP O-07112-OH)

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R-051(F) Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-6)** Grab/Composite: Grab

Date of Sample Collection: 22-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S. No	Parameters	Unit	Results	Method
1	pH	-	7.85	pH Meter
2	Total Organic Carbon (TOC)	%	0.55	Loss on Ignition
3	Conductivity	mS	0.77	Multiparameter
4	Calcium (Ca)	mg/Kg	5420	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	1730	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	760	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	385	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	ND	Titration
9	Chloride	mg/Kg	580	HACH 8021
10	Sulphate (SO_4)	mg/Kg	810	HACH 8051
11	Nitrate Nitrogen ($NO_3 - N$)	mg/Kg	3.3	HACH 8171
12	Ammonia (NH_3)	mg/Kg	210	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	1.75	HACH 8190

*SEQS: Sindh Environmental Quality Standard

1. Sample analyzed by: _____

   Reviewed by: _____

2. Signature of In-charge of environmental laboratory/ DH (EM&M): _____
   Name: _____
   Designation: _____

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R- 051(G) Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-7)** Grab/Composite: Grab

Date of Sample Collection: 22-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S. No	Parameters	Unit	Results	Method
1	pH	-	8.10	pH Meter
2	Total Organic Carbon (TOC)	%	2.75	Loss on Ignition
3	Conductivity	mS	1.02	Multiparameter
4	Calcium (Ca)	mg/Kg	5500	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	980	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	730	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	590	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	205	Titration
9	Chloride	mg/Kg	880	HACH 8021
10	Sulphate (SO_4)	mg/Kg	1250	HACH 8051
11	Nitrate Nitrogen (NO_3 – N)	mg/Kg	4.6	HACH 8171
12	Ammonia (NH_3)	mg/Kg	250	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	3.95	HACH 8190

*SEQS: Sindh Environmental Quality Standard

1. Sample analyzed by: _____

   Reviewed by: _____

2. Signature of In-charge of environmental laboratory/ DH (EM&M): _____
   Name: _____
   Designation: _____

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R-051(H) Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2 Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-8)** Grab/Composite: Grab

Date of Sample Collection: 22-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S . No	Parameters	Unit	Results	Method
1	pH	-	8.24	pH Meter
2	Total Organic Carbon (TOC)	%	0.33	Loss on Ignition
3	Conductivity (1:1)	mS	0.71	Multiparameter
4	Calcium (Ca)	mg/Kg	3300	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	285	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	510	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	385	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	165	Titration
9	Chloride	mg/Kg	520	HACH 8021
10	Sulphate (SO_4)	mg/Kg	680	HACH 8051
11	Nitrate Nitrogen ($NO_3 - N$)	mg/Kg	1.6	HACH 8171
12	Ammonia (NH_3)	mg/Kg	105	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	1.85	HACH 8190

*SEQS: Sindh Environmental Quality Standard

1. Sample analyzed by: ______________________

   Reviewed by: ______________________

2. Signature of In-charge of environmental laboratory/ DH (EM&M): ______________________

   Name: ______________________

   Designation: ______________________

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R- 051(I) Date: 11-12-2023

Name of Industry / Client M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-9)** Grab/Composite: Grab

Date of Sample Collection: 22-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S . No	Parameters	Unit	Results	Method
1	pH	-	7.91	pH Meter
2	Total Organic Carbon (TOC)	%	1.75	Loss on Ignition
3	Conductivity	mS	14.2	Multiparameter
4	Calcium (Ca)	mg/Kg	18200	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	3220	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	3260	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	6815	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	ND	Titration
9	Chloride	mg/Kg	7420	HACH 8021
10	Sulphate (SO_4)	mg/Kg	4480	HACH 8051
11	Nitrate Nitrogen (NO_3 – N)	mg/Kg	4.6	HACH 8171
12	Ammonia (NH_3)	mg/Kg	900	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	9.3	HACH 8190

***SEQS**: Sindh Environmental Quality Standard

1. Sample analyzed by: _____

   Reviewed by: _____

2. Signature of In-charge of environmental laboratory/ DH (EM&M): _____
   Name: _____
   Designation: _____

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R- 051(J) Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-10)** Grab/Composite: Grab

Date of Sample Collection: 20-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S . No	Parameters	Unit	Results	Method
1	pH	-	7.96	pH Meter
2	Total Organic Carbon (TOC)	%	1.67	Loss on Ignition
3	Conductivity	mS	10.1	Multiparameter
4	Calcium (Ca)	mg/Kg	9850	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	2540	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	1810	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	4107	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	ND	Titration
9	Chloride	mg/Kg	5993	HACH 8021
10	Sulphate (SO_4)	mg/Kg	2142	HACH 8051
11	Nitrate Nitrogen ($NO_3 - N$)	mg/Kg	3.6	HACH 8171
12	Ammonia (NH_3)	mg/Kg	420	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	6.5	HACH 8190

*SEQS: Sindh Environmental Quality Standard

1. Sample analyzed by: _____

   Reviewed by: _____

2. Signature of In-charge of environmental laboratory/ DH (EM&M): _____
   Name: _____
   Designation: _____

PAKISTAN SPACE & UPPER ATMOSPHERE RESEARCH COMMISSION

SUPARCO

(SUPARCO ENVIRONMENTAL LABORATORY)

SEL / ESMS / SOP / WM / ANX-E/ 01

LABORATORY ANALYSIS REPORT

Report reference No: 10405-ES/R- 051(K) Date: 11-12-2023

Name of Industry / Client: M/s Hagler Bailly Pakistan.

Address: Block-1 Commercial Area, Street 21, F8/2
Islamabad, Pakistan

Phone: +92 51 2857200-7

Nature of sample/ID: **Soil Sample (SS-11)** Grab/Composite: Grab

Date of Sample Collection: 22-10-2023

Date of sample received: 23-10-2023

Sample collected/sent by: Client

Date of completion of analysis: 20-11-2023

S. No	Parameters	Unit	Results	Method
1	pH	-	7.96	pH Meter
2	Total Organic Carbon (TOC)	%	0.37	Loss on Ignition
3	Conductivity	mS	0.83	Multiparameter
4	Calcium (Ca)	mg/Kg	3000	Atomic Absorption Spectrometer
5	Magnesium (Mg)	mg/Kg	830	Atomic Absorption Spectrometer
6	Potassium (K)	mg/Kg	610	Atomic Absorption Spectrometer
7	Sodium (Na)	mg/Kg	486	Atomic Absorption Spectrometer
8	Carbonates	mg/Kg	ND	Titration
9	Chloride	mg/Kg	720	HACH 8021
10	Sulphate (SO_4)	mg/Kg	348	HACH 8051
11	Nitrate Nitrogen (NO_3 – N)	mg/Kg	1.3	HACH 8171
12	Ammonia (NH_3)	mg/Kg	180	HACH 8038/ USEPA 350.3
13	Phosphorus (P)	mg/Kg	2.23	HACH 8190

***SEQS**: Sindh Environmental Quality Standard

1. Sample analyzed by: _____

   Reviewed by: _____

2. Signature of In-charge of environmental laboratory/ DH (EM&M): _____
   Name: _____
   Designation: _____

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NR BDO: 000039239

t: 004832 3426011
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e: contact@i2analytical.com

Analytical Report Number : 23-65673

Project / Site name:	RKG	**Samples received on:**	31/10/2023
Your job number:		**Sample instructed on/ Analysis started on:**	31/10/2023
Your order number:	4758V3	**Analysis completed by:**	07/11/2023
Report Issue Number:	1	**Report issued on:**	08.11.2023
Samples Analysed:	11 soil samples		

i2 Analytical Limited Sp. z o.o.
Oddział w Polsce
ul. Pionierów 39
41-711 Ruda Śląska
NIP: 2050000782

Dominika Liana
Młodszy Specjalista
Działu Analiz Raportów

Signed:

Dominika Liana
Reporting Specialist
For & on behalf of i2 Analytical Ltd.

Other office located at: 7 Woodshots Meadow Croxley Green Business Park Watford Herts WD18 8YS UK

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils - 4 weeks from reporting
leachates - 2 weeks from reporting
waters - 2 weeks from reporting
asbestos - 6 months from reporting

Sampling and delivery by client.

Excel copies of reports are only valid when accompanied by this PDF certificate.

Analytical Report Number: 23-65673
Project / Site name: RKG
Your Order No: 4758V3

Lab Sample Number				2862348	2862349	2862350	2862351
Sample Reference				SS1	SS2	SS3	SS4
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied
Date Sampled				21/10/2023	19/10/2023	19/10/2023	22/10/2023
Time Taken				1520	1615	1740	1125
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**				
Moisture Content	%	0.01	NONE	1.2	33	0.61	0.38
General Inorganics							
Total Organic Carbon (TOC)	%	0.1	ISO 17025	1.3	1.3	0.1	< 0.1
Heavy Metals / Metalloids							
Aluminium (aqua regia extractable)	mg/kg	30	ISO 17025	14000	17000	5400	4900
Antimony (aqua regia extractable)	mg/kg	1	ISO 17025	< 1.0	< 1.0	1.5	< 1.0
Arsenic (aqua regia extractable)	mg/kg	1	ISO 17025	9.6	8	11	12
Barium (aqua regia extractable)	mg/kg	1	ISO 17025	52	51	47	25
Boron (total)	mg/kg	1	ISO 17025	28	14	5.1	3.2
Cadmium (aqua regia extractable)	mg/kg	0.2	ISO 17025	0.5	< 0.2	< 0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	ISO 17025	38	32	16	14
Copper (aqua regia extractable)	mg/kg	1	ISO 17025	33	18	5.5	5.7
Iron (aqua regia extractable)	mg/kg	40	ISO 17025	21000	30000	13000	14000
Lead (aqua regia extractable)	mg/kg	1	ISO 17025	12	17	4.9	5.3
Manganese (aqua regia extractable)	mg/kg	1	ISO 17025	370	310	380	260
Mercury (aqua regia extractable)	mg/kg	0.3	ISO 17025	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	ISO 17025	36	31	13	13
Phosphorus (aqua regia extractable)	mg/kg	20	ISO 17025	1200	890	130	290
Selenium (aqua regia extractable)	mg/kg	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0
Strontium (aqua regia extractable)	mg/kg	10	NONE	460	86	190	330
Zinc (aqua regia extractable)	mg/kg	1	ISO 17025	78	95	16	15
Calcium (aqua regia extractable)	mg/kg	20	ISO 17025	110000	43000	200000	290000
Magnesium (aqua regia extractable)	mg/kg	20	ISO 17025	6700	9500	3700	4900
Potassium (aqua regia extractable)	mg/kg	20	ISO 17025	4000	4000	1300	1100
Sodium (aqua regia extractable)	mg/kg	20	ISO 17025	3600	8800	1300	720

U/S = Unsuitable Sample I/S = Insufficient Sample

Analytical Report Number: 23-65673
Project / Site name: RKG
Your Order No: 4758V3

Lab Sample Number				2862352	2862353	2862354	2862355
Sample Reference				SS5	SS6	SS7	SS8
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied
Date Sampled				22/10/2023	22/10/2023	22/10/2023	22/10/2023
Time Taken				1145	1205	1230	1245
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**				
Moisture Content	%	0.01	NONE	16	0.73	2	0.17
General Inorganics							
Total Organic Carbon (TOC)	%	0.1	ISO 17025	< 0.1	0.1	1	< 0.1
Heavy Metals / Metalloids							
Aluminium (aqua regia extractable)	mg/kg	30	ISO 17025	15000	5300	53000	3600
Antimony (aqua regia extractable)	mg/kg	1	ISO 17025	2.5	2.7	< 1.0	< 1.0
Arsenic (aqua regia extractable)	mg/kg	1	ISO 17025	11	14	29	7.8
Barium (aqua regia extractable)	mg/kg	1	ISO 17025	52	27	200	16
Boron (total)	mg/kg	1	ISO 17025	21	4.5	130	4.9
Cadmium (aqua regia extractable)	mg/kg	0.2	ISO 17025	< 0.2	< 0.2	< 0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	ISO 17025	30	17	49	12
Copper (aqua regia extractable)	mg/kg	1	ISO 17025	15	7	51	5.7
Iron (aqua regia extractable)	mg/kg	40	ISO 17025	27000	14000	32000	9200
Lead (aqua regia extractable)	mg/kg	1	ISO 17025	11	20	17	4.9
Manganese (aqua regia extractable)	mg/kg	1	ISO 17025	490	300	490	230
Mercury (aqua regia extractable)	mg/kg	0.3	ISO 17025	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	ISO 17025	32	14	28	12
Phosphorus (aqua regia extractable)	mg/kg	20	ISO 17025	490	250	3800	300
Selenium (aqua regia extractable)	mg/kg	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0
Strontium (aqua regia extractable)	mg/kg	10	NONE	220	270	320	600
Zinc (aqua regia extractable)	mg/kg	1	ISO 17025	44	27	73	25
Calcium (aqua regia extractable)	mg/kg	20	ISO 17025	83000	260000	89000	160000
Magnesium (aqua regia extractable)	mg/kg	20	ISO 17025	9500	3900	8200	5200
Potassium (aqua regia extractable)	mg/kg	20	ISO 17025	2900	1200	2500	740
Sodium (aqua regia extractable)	mg/kg	20	ISO 17025	7100	550	870	660

U/S = Unsuitable Sample I/S = Insufficient Sample

Analytical Report Number: 23-65673
Project / Site name: RKG
Your Order No: 4758V3

Lab Sample Number				2862356	2862357	2862358
Sample Reference				SS9	SS10	SS11
Sample Number				None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied
Date Sampled				22/10/2023	20/10/2023	22/10/2023
Time Taken				1345	1610	1330
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**			
Moisture Content	%	0.01	NONE	2.2	19	0.52
General Inorganics						
Total Organic Carbon (TOC)	%	0.1	ISO 17025	1.1	0.5	< 0.1
Heavy Metals / Metalloids						
Aluminium (aqua regia extractable)	mg/kg	30	ISO 17025	5600	23000	3700
Antimony (aqua regia extractable)	mg/kg	1	ISO 17025	1.8	2.5	< 1.0
Arsenic (aqua regia extractable)	mg/kg	1	ISO 17025	6.9	12	14
Barium (aqua regia extractable)	mg/kg	1	ISO 17025	58	83	20
Boron (total)	mg/kg	1	ISO 17025	10	21	3.1
Cadmium (aqua regia extractable)	mg/kg	0.2	ISO 17025	< 0.2	< 0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	ISO 17025	18	40	14
Copper (aqua regia extractable)	mg/kg	1	ISO 17025	20	34	5.6
Iron (aqua regia extractable)	mg/kg	40	ISO 17025	15000	38000	10000
Lead (aqua regia extractable)	mg/kg	1	ISO 17025	14	14	4.7
Manganese (aqua regia extractable)	mg/kg	1	ISO 17025	320	620	250
Mercury (aqua regia extractable)	mg/kg	0.3	ISO 17025	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	ISO 17025	15	38	13
Phosphorus (aqua regia extractable)	mg/kg	20	ISO 17025	450	840	170
Selenium (aqua regia extractable)	mg/kg	1	ISO 17025	< 1.0	< 1.0	< 1.0
Strontium (aqua regia extractable)	mg/kg	10	NONE	360	130	330
Zinc (aqua regia extractable)	mg/kg	1	ISO 17025	74	77	15
Calcium (aqua regia extractable)	mg/kg	20	ISO 17025	120000	55000	290000
Magnesium (aqua regia extractable)	mg/kg	20	ISO 17025	5500	21000	3500
Potassium (aqua regia extractable)	mg/kg	20	ISO 17025	1700	4900	920
Sodium (aqua regia extractable)	mg/kg	20	ISO 17025	9200	8300	360

U/S = Unsuitable Sample I/S = Insufficient Sample

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* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
2862348	SS1	None Supplied	None Supplied	Brown sand with gravel.
2862349	SS2	None Supplied	None Supplied	Brown clay with vegetation.
2862350	SS3	None Supplied	None Supplied	Brown sand with gravel.
2862351	SS4	None Supplied	None Supplied	Brown sand with gravel.
2862352	SS5	None Supplied	None Supplied	Brown clay.
2862353	SS6	None Supplied	None Supplied	Brown sand with gravel.
2862354	SS7	None Supplied	None Supplied	Brown sand with gravel.
2862355	SS8	None Supplied	None Supplied	Brown sand.
2862356	SS9	None Supplied	None Supplied	Brown sand with gravel.
2862357	SS10	None Supplied	None Supplied	Brown clay.
2862358	SS11	None Supplied	None Supplied	Brown sand with gravel.

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Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L038-PL	D	ISO 17025
Moisture Content	Moisture content, determined gravimetrically. (30 oC)	In house method.	L019-UK/PL	W	NONE
Total organic carbon (Automated) in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	In house method.	L009-PL	D	ISO 17025

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.