Environmental Impact Assessment

660 MW Coal Fired Power Plant Construction Project

at Lakhra in

The Islamic Republic of Pakistan

Nippon Koei Co., Ltd
Mitsui Consultants Co., Ltd.
(Japan International Cooperation Agency Survey Team)

in association with
Hagler Bailly Pakistan (Pvt.) Ltd.

Main Report (Volume 1 of 2)

August 21, 2015

CONTENTS

Tables

Figures

CHAPTER 1. EXECUTIVE SUMMARY

The Government of Pakistan (GoP) is planning to set up a 660 MW ultra-supercritical coal fired power plant at Lakhra (the 'Project') to be financed by the Japan International Cooperation Agency (JICA) and other potential donors. The power plant will be setup adjacent to the existing Lakhra Fluidized Bed Combustion (FBC) Power Station (LFPS). The proposed Project will have a gross generation capacity of 660 megawatt (MW) and a net capacity of 600 MW. The plant will be owned and operated by the Lakhra Power Generation Company Limited (LPGCL), the implementing agency (IA) of the Project. GENCO Holding Company Limited (GHCL) will be the executing agency (EA). The proposed power plant will be designed to run on a blend of imported sub-bituminous coal and indigenous lignite from Thar.

This Environmental Impact Assessment (EIA) of the proposed Project is prepared to meet the regulatory requirements of Pakistan and Sindh province as well as the JICA Guidelines for Environmental and Social Considerations, April 2010 (JICA Guideline 2010). Since JICA Guidelines 2010 requires to confirm that projects do not deviate significantly from the World Bank's Safeguard Policy, appropriate references were made during the EIA study.

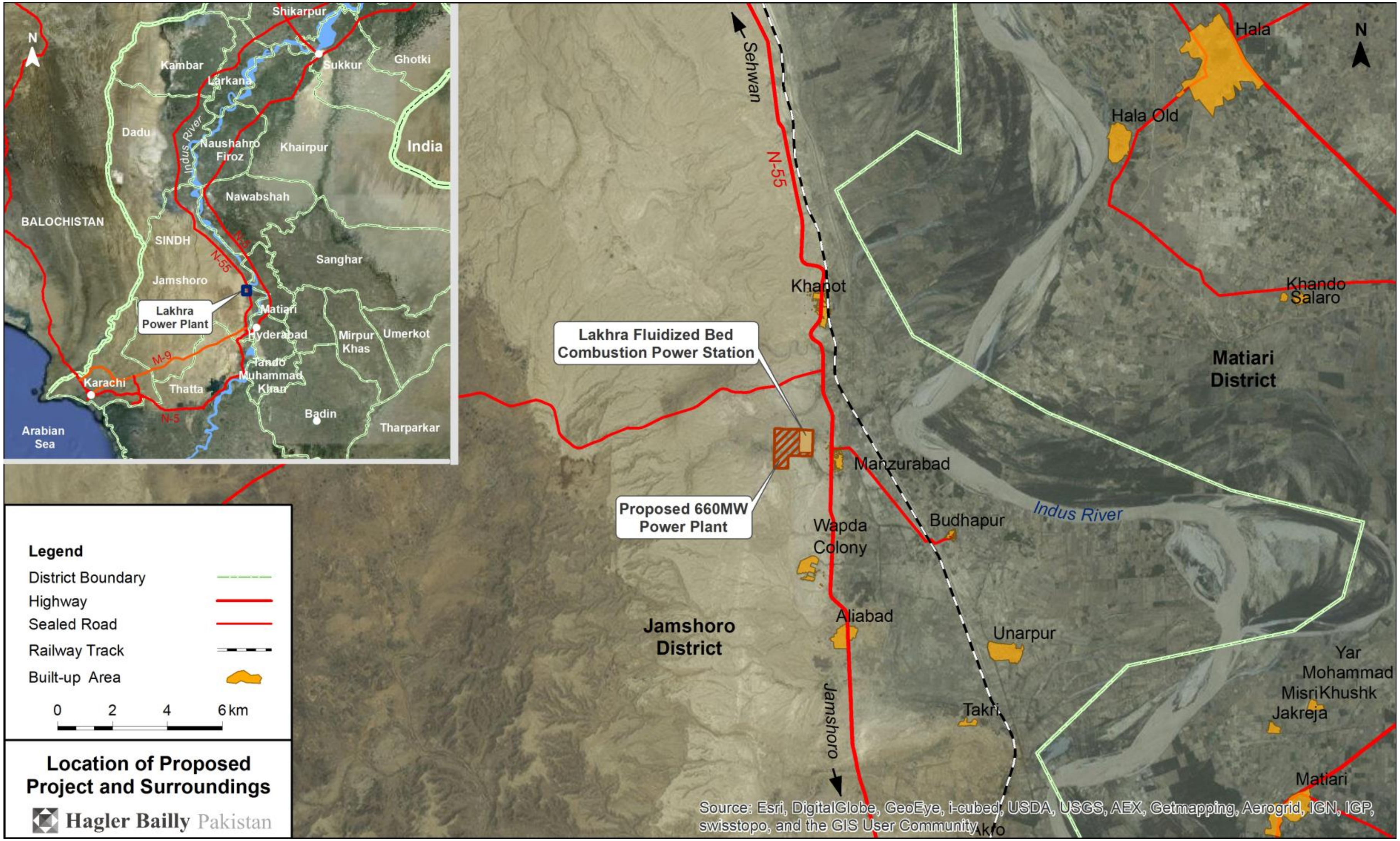
1.1 Project Setting

LFPS is located in Manjhand Taluka,[1] Jamshoro District, about 175 kilometers (km) northeast of Karachi and about 40 km northwest of Hyderabad. It is located on N-55 (Indus Highway) which is one of the main highways that connect Karachi with the rest of the country (**Figure 1-1**). The Indus River flows on the east of the plant at a distance of about 4 km. Water requirements of the LFPS are met through an inlet pipe connected to the Indus River. Barren plain of limestone is spread in the western side of LFPS. The plain has sparse vegetation and coal ash from the plant is disposed of here. The limestone is mined and used as a desulfurization material for the plant.

Lakhra area has a desert hot climate, characterized by a hot and dry summer and mild winter rainfall. The vegetation of this region is typical of arid regions, adapted to extreme seasonal temperatures and moisture fluctuation, and is thin and degraded. The population clusters in the surroundings of the LFPS can be broadly classified as rural and institutional housing colonies. The colony for the employees of LFPS locates about 3.5 km south of the power station having area of 46 ha (114 acres) in which 685 houses, mosque, hospital, primary school, club house, guest houses are accommodated. The area is fenced by rigid wall and secured by guard in 24 hours at the entrance gate. The buses for transporting the employees to the power stations are running in periodical time. The rural area population is found in small scattered villages. Agriculture is the main source of livelihood for the rural areas.

---

[1] A taluka is an administrative division and consists of an area of land with a city or town that serves as its headquarters, with possible additional towns, and usually a number of villages.



Source: Hagler Bailly Pakistan

Figure 1-1: Location of Proposed Project and Surroundings

1.2 Project Rationale

Pakistan is going through an acute power shortage. The gap supply-demand represents about one-third of the total demand in National Transmission and Despatch Company (NTDC) system. Chronic power shortages in Pakistan are the most serious constraints to the country's economic growth and job creation.

In addition to increasing the generation capacity, it is essential to lower the generation cost. One possible option is the hydropower. Hydropower despite being the ideal solution has long implementation period and is not attractive for addressing immediate issues. Other solutions are either too costly or have other technical or economic issues. In this background, coal offers a promising option in the medium as well as long-term to provide affordable power and diversify the energy mix. The GoP aims to increase the share of coal-based generation from nearly none now (0.07%) to about 39% in 5 years. This will be achieved through converting existing High Sulfur Fuel Oil (HSFO) generation units, replacing old inefficient units, and constructing new plants. Electricity generated from coal, with long-term fuel supply contracts, will also add stability to the power price.

1.3 The Proposed Project

The major systems of the proposed 660 MW plant include:

Unit capacity and load operation:

- Nominal capacity of 660 MW including auxiliary power consumption
- Net plant output of 600 MW

The plant is designed for base load operation.

Plant configuration:

- One ultra-supercritical system of a boiler, a turbine generator and auxiliaries
- Once-through boiler with pulverized coal (PC) firing
- Single reheat condensing, tandem-compound steam turbine
- Totally enclosed, three phase, 50Hz, synchronous generator
- Auxiliary plants; coal handling system, ash handling system, water treatment system

Fuel to be burned:

- Blended coal with 80% sub-bituminous coal and 20% Thar lignite
- 100% sub-bituminous coal when Thar lignite is not available
- Auxiliary light fuel oil to be used for startup and supporting firing at low plant load if necessary

Emission control:

- Particulate matter control: Electrostatic precipitator (ESP) with 99.7% efficiency
- Sulphur dioxide (SO2) control: Flue Gas Desulphurization (FGD) with 80% efficiency
- Nitrogen oxides (NOx): Low NOx firing technology in the boiler

Grid connection:

- Grid connection of 500 kV transmission lines

Water supply:

- Water-cooled condenser paired with a natural draft type cooling tower

The main fuel for the power plant will be imported sub-bituminous coal. Lignite in the ratio of 20% will be blended with the sub-bituminous coal. The design specifications of the fuel are:

Table 1-1: Fuel Specifications

Parameter	*Sub-bituminous (e.g., Imported Coal)*	*Lignite (e.g., Thar)*
	Selected Value	*Selected Value*
Proximate Analysis (Air-dried basis)		
Moisture (%ad)	14.3	47.6
Ash (%ad)	8.9	14.9
Volatile Matter (%ad)	39.5	47.9
Caloric Value		
High Heating Value (HHV) (kcal/kg)	5,000	3,146
Ultimate Analysis (Dry Ash Free basis*)		
Carbon (%daf)	76.6	74.0
Hydrogen (%daf)	5.52	6.1
Oxygen (%daf)	16.0	18.0
Sulfur (%daf)	0.7	2.5
Nitrogen (%daf)	1.15	1.0

*Excluded all moisture and ash

Note: Total values of ultimate analysis are not 100% due to numbers under decimal points.

For the purpose of design, blending percentage of lignite has been considered to be 20%.

Total coal consumption will depend on the ratio of blending of sub-bituminous and Thar coals. Coal consumption for the 660 MW plant for two possible scenarios is shown below:

Table 1-2: Coal Consumption for Two Fuel-Mix Scenarios

Coal	*Sub-bituminous*	*Lignite*	*Total*
Daily Consumption (tons)			
Scenario 1 (Coal "Singularity")	6,816	0	6,816
Scenario 2 (Coal "Blend")	6,053	1,513	7,567
Annual Consumption at 80% Plant Load Factor (million tons)			
Scenario 1 (Coal "Singularity")	2.00	0	2.00
Scenario 2 (Coal "Blend")	1.76	0.44	2.21

Imported coal for the Project will be transported by rail. Local lignite will be transported by road. Once Railway truck from Thar to Lakhra materialized, Government of Pakistan will start Thar lignite coal transportation by rail, after proper environmental & social procedures

Total ash production is estimated at 223,200 t/y with fly ash at 200,800 t/y and the rest being bottom ash. Production of FGD gypsum is estimated at 46,840 t/y. About 29.4 ha (72.77 acres) of land have been allocated as the ash disposal site with the capacity of about 5 years of ash and gypsum waste for the 660 MW project, assuming no utilization of ash for commercial purposes. Of the 29.4 ha land, about 11.4 ha (28.2 acres) need to be newly acquired whereas the remaining is owned by LPGCL.

1.4 Stakeholder Consultations

As a positive response from the stakeholders, the Project was valued in terms of its contribution for the electricity shortage in the country. The local communities hoped that duration of load shedding will be reduced. The women were generally content with the establishment of the power plant and were hopeful that the plant will bring economic and social development to their area. The local communities hoped that during the construction of new power plant, employment opportunities for locals will be created. They also hoped that before the construction of new power plant, the existing power plant will be rehabilitated.

The residents of Koreja settlement shown concern with coal fired power plant as they claim facing health problems due to the air emissions and ash from the existing power plant. Other concerns raised included excessive use of river water for the project, ecological impacts associated with land use, discharge of effluents from the proposed plant, and increase in traffic on N-55 due to the project. Most of the concerns raised were attributable to the existing power plant.

The concerns expressed by the stakeholders were examined and specific mitigation measures were incorporated in the Environmental Management Plan developed for the EIA to address the concerns. A grievance redress mechanism was proposed for the Project to meet the compliance requirements laid out under the relevant national legislation in accordance with the environmental and social safeguards laid out under JICA Guideline 2010 and World Bank Safeguard Policy.

1.5 Environmental Impact of New Plant

1.5.1 Air Quality Impacts

There are two modes of air pollution from the thermal power plant, point emissions from the stacks and fugitive emissions from the coal and ash handling and storage. Air pollutants from the stack are of primary concern and include respirable particulate matter (PM_{10} and $PM_{2.5}$)[1], oxides of nitrogen (NOx), and sulfur dioxide (SO_2). Significant health risks are associated with these emissions if the concentration of these pollutants in the ambient air exceeds the ambient air quality standards.

The emissions from the 660 MW plant were modeled with the following assumptions:

Scenario 1:

- 80 % Imported coal and 20 % Thar coal will be used
- Efficiency on HHV: 38.9 % (Imported 80 %. Thar 20 %)
- Environmental Controls: ESP (99.7%), FGD (80%), Low NO_x
- Plant load factor: 80%
- A stack height of 210 m is proposed for wider dispersion of gaseous pollutants and thereby dilution. A higher stack will also effectively disperse the thermal pollution from the stack.

Scenario 2:

- 100 % Imported coal will be used
- Efficiency on HHV: 39.7% (Imported 100%)
- Environmental Controls: ESP (99.7%), FGD (80%), Low NO_x
- Plant load factor: 80%
- A stack height of 210 m is proposed for wider dispersion of gaseous pollutants and thereby dilution. A higher stack will also effectively disperse the thermal pollution from the stack.

US Environmental Protection Agency (USEPA) regulatory model AERMOD (Air Dispersion Model) was used to simulate criteria pollutants from major sources in the project area and predict air quality for SO_2, NO_2 and PM_{10} and $PM_{2.5}$. A pre-processed hourly meteorological data for the study area for 2009, 2010, and 2011 were purchased and used in the model. Sensitive receptors such as schools and hospitals were incorporated in the model area to assess the impact of air quality on those areas.

The results show that the predicted increment caused by the proposed Project in Scenario 1 is very small in comparison to the background (without existing plant) and baseline (with

---

[1] Respirable particulate matter or PM_{10} are particulate matter (or dust) with particles less than 10 micrometer (a millionth of meter or micron) in diameter. Of particular concern is $PM_{2.5}$, that is, particulate matter with particles less than 2.5 micron in diameter.

existing plant operating at 30 MW) levels. However, the existing plant with inadequate is causing substantial amount of pollutants to the ambient air causing the pollutant concentration levels to exceed both the Sindh Environmental Quality Standards (SEQS) as well as the IFC guideline limits. If the existing plant is allowed to run in its present condition, the concentration SO_2, PM_{10} and $PM_{2.5}$ in the ambient air may continue exceeding the limits prescribed by SEQS as well as IFC guidelines. For the existing plant to comply with the SEQS, it will be necessary to rehabilitate the existing pollutant control systems. The predicted increment caused by the proposed Project running only on imported coal (Scenario 2) will be, in general, 5-10% smaller in comparison to the Scenario 1.

With rehabilitated control measures on the existing plant, the 660 MW plant meets all the limits prescribed by SEQS as well as IFC guidelines.

In general, IFC emission guidelines are different for degraded and non-degraded airsheds. The degraded airshed is defined by IFC as: *Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly*.[1]

As Pakistan has established national ambient air quality standards which, although not identical to those of the WHO, are comparable and even more stringent in certain cases, the decision of degraded or non-degraded airshed shall be based solely on the national criteria. For this purpose, a baseline monitoring undertaken is not considered sufficient to establish the year-round average concentration to categorize the airshed. However, based on the results of air quality modeling, it is argued that the airshed after rehabilitation of environmental control measures on the existing plant or its closure shall be considered as non-degraded as all ambient air quality standards (with the possible exception of $PM_{2.5}$) will be met.

IFC recommends that facilities in degraded airsheds should minimize incremental impacts by meeting IFC guidelines. Further, it suggest that "facilities or projects located within poor quality airsheds should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards"

The operation of existing plant after rehabilitation of pollution control system at its original design will result in reduction of concentration of SO_2 and $PM_{10.}$ Ambient air quality monitoring results (Table 5-15) indicates that SO_2 and NOx values are well within the Sindh Environmental Quality Standards (SEQS) limits. However PM_{10} and $PM_{2.5}$ are above the SEQS, the operation of existing plant after rehabilitation will improve the conditions to the extent to meet the ambient air quality standards with regard to PM_{10}, and that of $PM_{2.5}$ will be substantially reduced. This would result in re-classifying the airshed as non-degraded.

---

[1] This definition is provided in several places in the IFC's EHS Guidelines. For example, Tables 6(A), 6(B), 6(C) of the Thermal Power Plant Guidelines.

1.5.2 GHG Emissions

Emissions of CO_2 from burning of coal in the Project are estimated at 2.8 million t-CO_2/year. Fly ash can be used as a cement replacement and consultations with cement manufacturers located in the vicinity of the Project site indicate that the industry is keenly interested in pursuing this option. Recycling of fly ash results in reduction of GHG emissions associated with production of a corresponding quantity of cement. Potential for offset of GHG emissions assuming recycling of 75% of fly ash produced by the Project is estimated at 0.23 million tons of GHG annually.

1.5.3 Traffic Impact

Traffic impact on N-55 associated with transportation of local lignite/Thar coal will be minor as the blending quantity will be limited to 20% and the incremental traffic volume will be insignificant.

1.6 Environmental Management Plan

A comprehensive environmental management plan (EMP) has been developed. It includes the following:

- Environmental Mitigation Plan
- Environmental Monitoring Plan
- Institutional Framework for the EMP
- Institutional Strengthening of the Lakhra Power Generation Company Limited (LPGCL) and GENCO Holding Company Limited (GHCL)
- Reporting and Feedback Mechanism
- Performance Indicators
- Training Program
- Specific Management Plans (including Waste, Construction, Coal Dust, Ash, Spill, Fire Emergency and Transportation)
- Social Augmentation Program
- Ambient Air Quality Monitoring Program

The estimated budget for the environmental monitoring and management is US $866,000.

1.7 Conclusions

The proposed 660 MW power plant will be installed on the land adjacent to the existing LFPS. However, it will be an independent power plant, with its own management, fuel source, storage, utilities and operations.

The Project will fill critical gaps and provide significant support to the local economy as well as that of the country. The cost of a unit of electricity generated by using imported coal as fuel is less than 50% of that for fuel oil. In addition to reducing power outages which are affecting growth of the economy, the Project will also lower the average cost of power generation in the country by shifting the fuel mix in power generation from fuel oil to imported coal. A diversified fuel mix with a lower dependence on oil products for power generation will also improve the energy security of the country.

The results of air quality modeling show that the predicted increment in pollutant concentrations caused by the proposed Project is very small compared to the background levels. If the existing plant is allowed to run in its present condition, the concentration of SO_2, PM_{10} and $PM_{2.5}$ in the ambient air after commissioning of the proposed Plant may exceed the limits prescribed by SEQS as well as IFC Guidelines. For the proposed Plant to operate, it will therefore be necessary to rehabilitate the environmental controls on the existing plant. The 660 MW plant on its own meets all the air quality limits prescribed by SEQS as well as IFC guidelines. A detailed ambient air monitoring program including that of the $PM_{2.5}$ will be instituted.

Impacts on water quality, noise, and aquatic environment will be within acceptable limits. The proposed Project will bring improvement in ambient air quality as the rehabilitation of the emission controls on the existing plant would facilitate the realization of the new plant. The proposed Project will bring socioeconomic benefits to the community in the form of employment and business opportunities.

A comprehensive environmental management plan has been developed to ensure the implementation of the environmental and social mitigations measures committed in the EIA. It includes the monitoring plan, the required institutional set up for implementing the plan, reporting and feedback mechanism, performance indicators, training program, specific management plans for waste, construction activities, coal dust control, ash, spill control, fire control, and transportation. Grievance mechanism and social augmentation plan are also proposed.

CHAPTER 2. INTRODUCTION

The Government of Pakistan (GoP) is planning to set up an ultra-supercritical coal fired thermal power plant at Lakhra to be financed by the Japan International Cooperation Agency (JICA) and possibly other financial institutions. The power plant will be setup within the premises of the existing Lakhra Fluidized Bed Combustion (LFBC) Power Station (LFPS), owned and operated by the Lakhra Power Generation Company Limited (LPGCL). The proposed power plant will have a net generation capacity of 600 megawatt (MW). The gross generation capacity of the Project will be 660 MW. The proposed power plant will be designed to run on a blend of imported sub-bituminous coal and indigenous lignite from Thar.

JICA Survey Team (JST) comprising Nippon Koei Co., Ltd. and Mitsui Consultants Co., Ltd. in association with Hagler Bailly Pakistan (Private) Ltd. has prepared an Environmental Impact Assessment (EIA) report (the 'Study') of the proposed power plant project as required under the Pakistan's national and provincial environmental laws, as well as the JICA Guideline 2010.[1]

2.1 Introduction to the EIA

2.1.1 Objectives

The following are objectives of the EIA Study based on the Pakistan's national and provincial environmental laws and the JICA Guideline 2010:

- Undertake consultation with the stakeholders to scope out the study and again to provide them with the feedback on the outcome of the study;
- Prepare a physical, ecological and social baseline of the area of influence (the 'Study Area') in order to evaluate the potential environmental impacts of the proposed activities, and serve as reference for future;
- Assess the potential environmental impact of the proposed activities and, where necessary, suggest mitigation measures to reduce any potential adverse impact to acceptable levels;
- Prepare an environmental management plan to ensure that the proposed mitigation measures and corrective action measures are implemented; and
- Prepare an EIA report complying with the legal requirements and the JICA Guideline 2010 for submission to the JICA and the Sindh Environmental Protection Agency (SEPA).

This report is prepared to meet the above objectives.

2.1.2 Scope of the EIA

The main components of the proposed project are shown in **Figure 2-1.** It includes the following:

---

[1] Guidelines for Environmental and Social Considerations, April 2010, Japan International Cooperation Agency http://www.jica.go.jp/english/our_work/social_environmental/guideline/pdf/guideline100326.pdf

1. The 660 MW coal fired power plant and associated facilities;
2. Water intake facility, intake pipeline and wastewater discharge pipelines;
3. Access roads; and
4. Transmission line to evacuate power generated at the proposed plant.

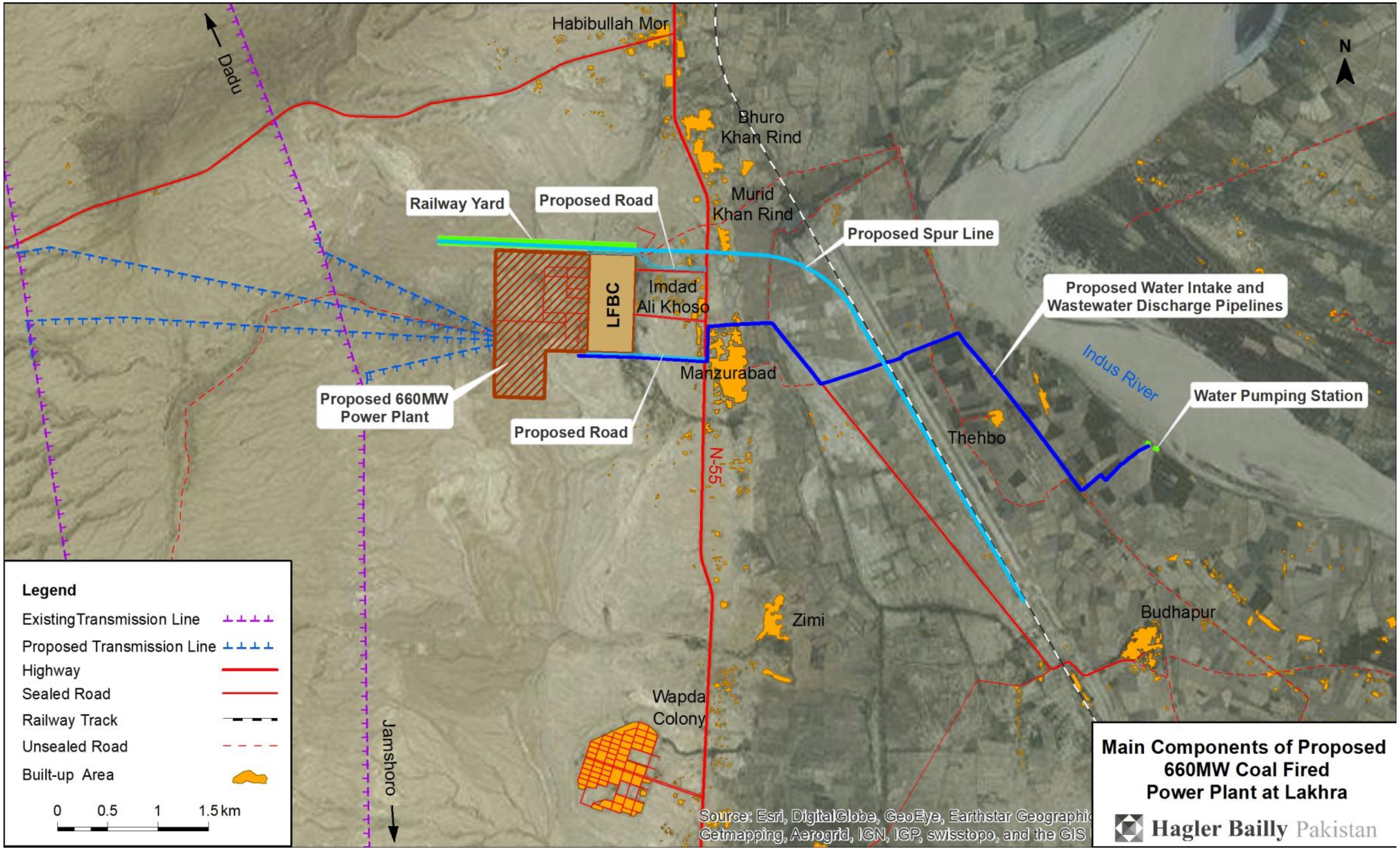
The scope of the EIA includes the following:

- Construction and operation of the 660 MW power plant;
- Transportation of equipment from ports of Karachi to the proposed project site;
- Transportation of coal from Thar to the proposed project site;
- Construction of water intake facility, intake pipeline and wastewater discharge pipelines; and
- Construction of access roads.

In this document, the term 'Project' has been used to cover the above components.

The scope of the study excludes:

- The operation of existing LFPS; any changes in its operation; designing and implementation of any corrective measures in the plant and partial or complete decommissioning of the plant, if planned. However, the impact of the LFPS on the existing environment is considered to the extent that it forms the baseline for the Project.
- The environmental impact of the construction and operation of the power transmission lines (T/Ls). The power from the proposed Project will be evacuated through 500 kilovolt (kV) T/Ls which will be constructed and connected to the existing Jamshoro and to Guddu T/L by National Transmission & Despatch Company (NTDC). The EIA required for the new T/Ls is being prepared separately by NTDC.
- The environmental impact of the construction and operation of railway components including extension of existing loop lines at four stations and construction of spur line from Budhapur railway station to the power plant site, which are required for transporting imported coal from Port Qasim to the site.



Note: ” Proposed Spur Line” is not included in the Project.

Source: Hagler Bailly Pakistan

Figure 2-1: Main Components of the Proposed 660 MW Coal Fired Power Plant at Lakhra

The role of different government agencies in the construction and operation of various components of the Project is shown in **Table 2-1**.

Table 2-1: Reports Prepared for Each Component

Component	*Regulatory Category*	*Report Prepared*	*Responsible Entity for EIA*	*Responsible Entity for Construction*	*Responsible Entity for Operation*
Power Plant and associated water supply facilities	EIA	EIA	GHCL	GHCL	GHCL
Railway Spur line and Loop lines	EIA	EIA	GHCL	PR	PR
Transmission line	EIA	EIA	NTDC	NTDC	NTDC

GHCL: GENCO Holding Company Limited

NTDC: National Transmission & Despatch Company Limited

PR: Pakistan Railways

2.2 Approval of the EIA and Other Permits

The preparation and approval of the EIA is a legal requirement (see **Chapter 3** for details). Approval of the EIA does not absolve the project proponent from requirements under other laws. Following are some of the related permits:

- **Environmental Impact Assessment** approval required from Sindh Environmental Protection Agency. The approval must be obtained prior to start of construction.
- **Land for Intake facility**. Approval required from Sindh Revenue Department. The approval must be obtained prior to occupying the site.
- **Water from Indus River**. Approval required from Irrigation Department to construct Intake Facility in Indus River. The Irrigation Department will also allocate water for the plant.

2.3 Land Acquisition

The total land required for the Project is 96.23 hectares (ha) of which 78.68 ha is state land, 0.18 ha is private land and 17.37 ha is un-surveyed land. The un-surveyed land is land for which the Revenue Department has no record of ownership. Such land is surveyed by the Revenue Department and unless some bonafide claim of ownership is presented, the land is registered in the name of state. The breakdown is as shown in **Table 2-2**.

Table 2-2: Land Requirement for the Project

	Total (ha)	*State Land (ha)*	*Un-surveyed Land (ha)*	*Private Land (ha)*
Pumping Station	0.04	0	0	0.04
Water Pipeline	1.17	0.83	0.20	0.14
Access Road	2.72	0	2.72	0
Power Plant	92.30	77.85*	14.45	0
Transmission line—No land to be acquired				
Total	**96.23**	**78.68**	**17.37**	**0.18**
		81.76%	**18.05%**	**0.19%**

*Note: This is the existing premises of LPGCL.

All land will be required following the Land Acquisition Act 1894 and in compliance with IFC Policy and JICA Guidelines. A separate Land Acquisition and Resettlement Action Plan (LARAP) is prepared for this purpose.

2.4 Institutional Arrangements

The key institutions involved in implementation of the proposed Project and their roles are the following:

- Economic Affairs Division, Government of Pakistan

  Borrower of finances

- GENCO Holding Company Limited (GHCL)

  Executing Agency (EA) of the Project (Supervise trainings, workshops and seminars for GHCL and personnel of the Project; monitor, coordinate and provide support to implementing agencies in construction work of the proposed Project; monitor implementation of the environmental management plan (EMP) and ensure that implementing agencies comply with all the legal requirements and the JICA Guideline 2010 requirements)

- Lakhra Power Generation Company Limited (LPGCL)

  Implementing Agency (IA) of the Project (Supervise construction of the Project; procurement of the contracts; supervise implementation of the EMP and the corrective action plan);

- Japan International Cooperation Agency (JICA)

  Main project financier

- Possible co-financiers

In addition to the above, additional institutional arrangements will be made for implementation of the project. These are described in **Chapter 9** of the EIA.

2.5 Project Setting

LFPS is located in Manjhand Taluka,[1] Jamshoro District, about 175 kilometers (km) northeast of Karachi and about 40 km northwest of Hyderabad. It is situated on N-55 (Indus Highway) which is one of the main highways that connect Karachi with the rest of the country (**Figure 2-2**).

The Indus River flows on the east of the Plant at a distance of about 4 km. Water requirements of the LFPS are met through an intake pipe connected to the Indus River.

Barren plain of limestone is spread in the western side of LFPS. The plain has sparse vegetation. The limestone is mined and used as a desulfurization material for the Plant.

Lakhra area has a desert hot climate, characterized by a hot and dry summer and mild winter rainfall. The vegetation of this region is typical of arid regions, adapted to extreme seasonal temperatures and moisture fluctuation, and is thin and degraded.

The population clusters in the surroundings of the LFPS can be broadly classified as rural and institutional housing colonies.

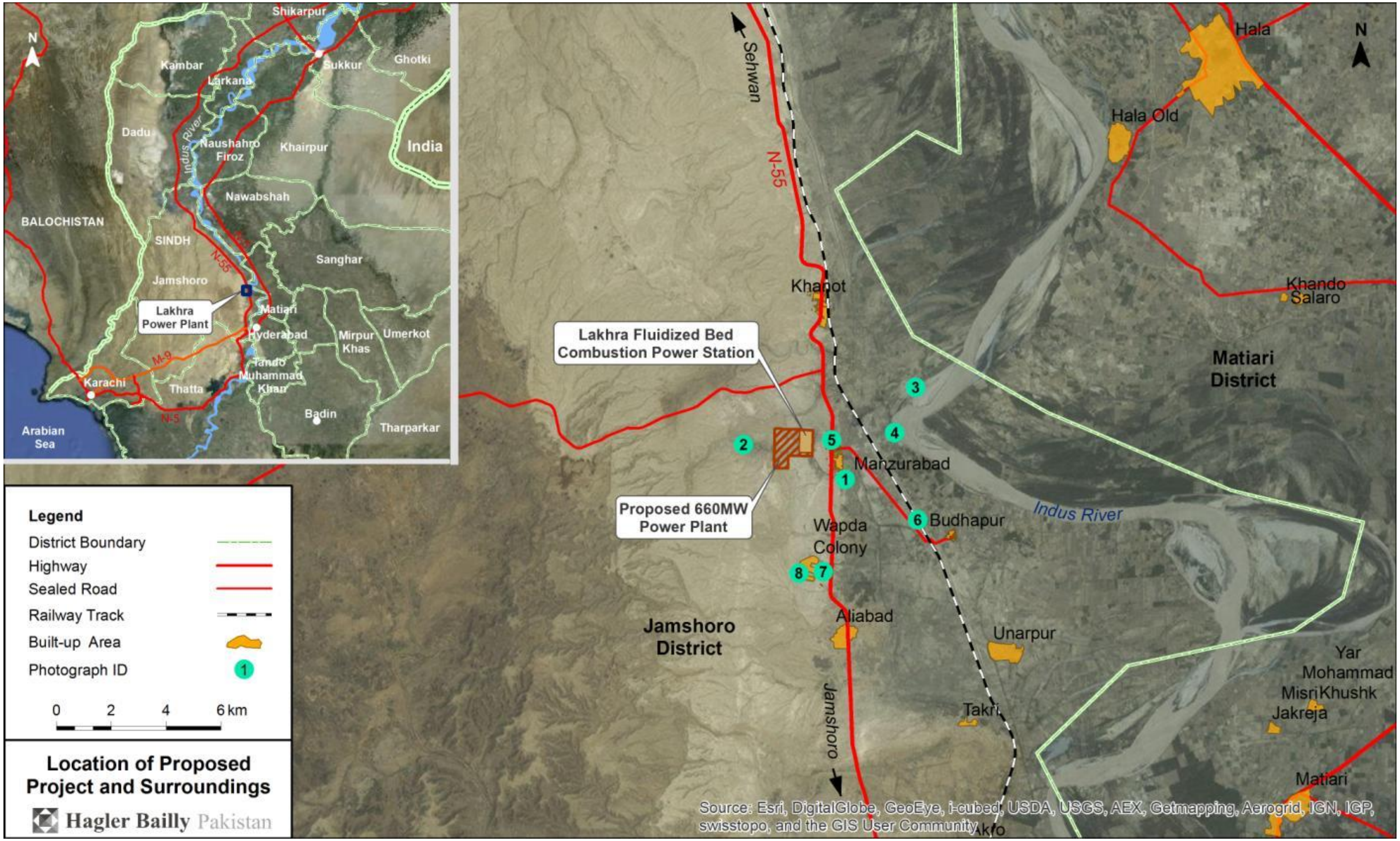
The colony for the employees of LFPS locates about 3.5 km south of the power station having area of 46 ha (114 acres) in which 685 houses, mosque, hospital, primary school, club house, guest houses are accommodated. The area is fenced by a boundary wall and secured by a security system. A bus system is provided by the LPGCL to transport employees between the power stations and the colony.

The rural area population is found in small scattered villages. Agriculture is the main source of livelihood for the rural areas.

Photographs of the project surrounding area are included in **Figure 2-3**.

---

[1] A taluka is an administrative division and consists of an area of land with a city or town that serves as its headquarters, with possible additional towns, and usually a number of villages.



Source: Hagler Bailly Pakistan

Figure 2-2: Location of Proposed Project and Surroundings

1 - Agricultural land

2 - Existing transmission line

3 - Indus River

4 - Existing intake facility

5 – Imdad Ali Khoso village

6 - Existing railway

7 - Wapda Colony

8 - Mosque in Wapda Colony

Source: JICA Survey Team

Figure 2-3: Photograph of LFPS Surrounding Area

2.6 Project Rationale

Pakistan is going through an acute power shortage. According to the National Electric Power Regulatory Authority (NEPRA)[1] there was a supply and demand gap of almost 6,000 MW in the country in 2012-13. The situation is shown in **Table 2-3**.

Table 2-3: Power Demand and Supply

Date	Generation Capacity (MW)	Demand During Peak Hours (MW)	Difference (MW)
June 30, 2012	12,320	18,940	-6,620
June 30, 2013	13,577	18,827	-5,250

Source: NEPRA State of the Industry Report 2013

The supply and demand gap represents about one-third of the total demand in NTDC system resulting in as much as 12 hours of load shedding in urban areas and at times more than 18 hours of load shedding in rural areas. The government is taking measures to fill the gap by increasing the generating capacity. However, it estimates that the gap will remain around 3,900 MW in 2017 despite the measures. Any slippage in the addition of new generation capacity or fuel availability will further widen the gap between supply and demand.

Chronic power shortages in Pakistan are the most serious constraint to the economic growth and job creation. The energy crisis continues to drag down the country’s economic performance and spark social instability. Increasing and unpredictable load shedding is estimated to constrain annual gross domestic product (GDP) growth by at least 2%. Hardest hit are the small- and medium-sized enterprises that employ the most number of people but cannot afford back-up electricity generators and fuel.

Table 2-4 shows the generation unit cost for each generation method in 2012. Average generation unit cost was Rs. 12/kWh in 2012. If the cost for transmission line extension corresponding to Rs. 2.7/kWh and losses due to fee collection and stolen power corresponding to Rs. 0.9/kWh are added to above generation unit cost, the generation unit cost at the demand point becomes Rs. 15.6/kWh. In 2012, average selling power unit price was Rs. 9.01/kWh and moreover in 2013 the average power price would be raised up by 30% in average. So Pakistan critically needs cheaper power generation systems.

Gas price for existing gas turbine power stations is cheaper than the other fuel due to local production. But most of the gas has been allotted to household and industrial use, and vehicles. As the demand for gas excesses the supply, there is chronic shortage of gas.

Large-sized hydro power needs about ten year and furthermore the power generation in dry season significantly drops. So hydropower cannot be stable power generation through the year.

[1] National Electric Power Regulatory Authority, State of the Industry Report 2013.

Table 2-4: Power Generation Cost of each Generation Method

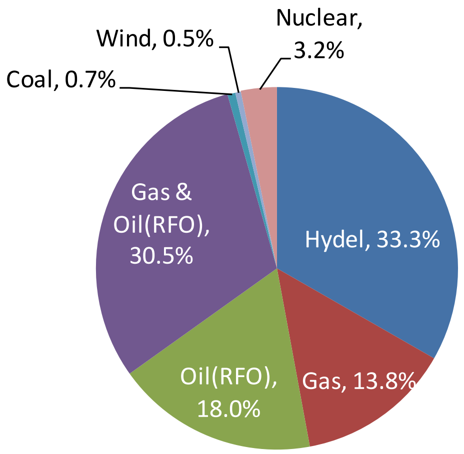
Generation Method	*Cost*	*Source*
Coal fired thermal Power Station (P/S) (with imported coals)	Rs. 7.6	Up-front tariff 600MW class
Coal fired thermal P/S (with Thar coal)	Originally more than Rs. 7.6 but less in a few years	The Thar Coal price is likely higher than the imported coal at the beginning the development of Thar Coal field. As the investment costs are collected and the amount of Thar coal production is increased, then the Thar Coal price is expected to be lower than the imported ones.
Gas turbine P/S (with domestic gas)	Rs. 7.9 - 8.3	NTDC Power System Statistics 2011 - 2012 Rs. 7.9 GTPS Kotri (2012) Rs. 8.3 GTPS Faisalabad (2011)
Gas turbine P/S (with imported gas)M	More than Rs. 10.0	Fuel cost will take Rs. 10/kWh with an estimation of gas price as 11 USD/MMBTU.
Residual Fuel Oil (RFO) thermal P/S	Rs. 17.0	National Power Policy 2013
Gas & RFO mixed thermal P/S	Rs. 12.0	National Power Policy 2013
Diesel (HSD) engine P/S	Rs. 23.0	National Power Policy 2013
Wind power	Rs. 15.5	Up-front tariff
Hydro power	Rs. 6.5	National Power System Expansion Plan 2011-2030 Main Report
(Reference) Photovoltaic power	Rs. 33.4	Government of Japan calculated in December 2011 (Japanese Yen 33.4).

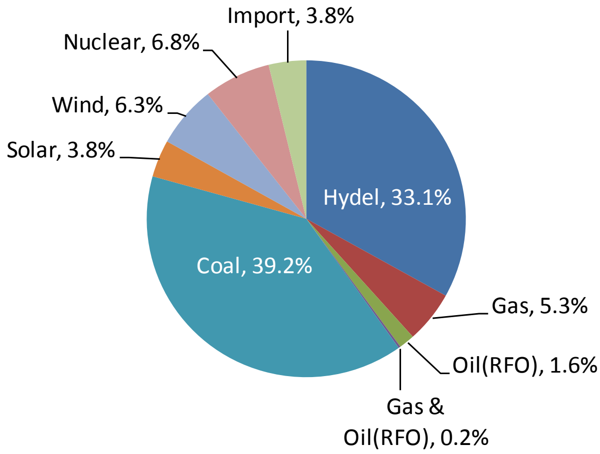
Source: JICA Survey Team

Therefore, the coal fired thermal power plant seems to be the most appropriate power generation system which solves the critical power shortage.

In addition to the economic impact, the shortage has environmental and social impacts as well. Other than complaints of general discomfort, students at schools have complained of effects of the load shedding on their studies. It has also resulted in deterioration of health care services. The environmental impact of the shortage has not been studied but potential impacts include increased use of firewood, kerosene, biomass, and firewood and their effects on deforestation and air quality. As there are no regulatory control over the emission from these small generators, widespread use of generators in the cities results in emissions of nitrogen oxides, particulate matter and sulfur dioxide (from diesel generators) from generator exhaust and hence contributing to the urban air pollution. These generators are also a major source of noise.

In this background, coal offers a promising option in the medium as well as long-term to provide affordable power and diversify the energy mix. The GoP (NTDC) aims to increase the share of coal-based generation from nearly none now (0.7%) to 39.2% in six years (**Figure 2-4**). This will require converting existing High Sulfur Fuel Oil (HSFO) generation units, replacing old inefficient units, and constructing new plants. Electricity generated from coal, with long-term fuel supply contracts, will also add stability to the power price.





Power Source Composition Status as of November 2013 (Total Installed Capacity: 20,829 MW)

Power Source Composition Plan (2013-14 to 2019-20) (Newly Installed Capacity: 26,296 MW)

Source: Annual Summary of Generation Addition (NTDC)

Figure 2-4: Power Source Composition Plan in Pakistan (NTDC)

2.7 Organization of the Report

The EIA contains 11 chapters as follows: After the **Executive Summary** (**Chapter 1**) and **Introduction** (this chapter), the **Legal and Institutional Framework** (**Chapter 3**) discusses the environmental laws of the country and the JICA Guideline 2010. A description of the existing LFPS and the proposed Lakhra Coal Fired Thermal Power Generation Project is provided in **The Proposed Project** (**Chapter 4**). The physical, ecological and socioeconomic baseline is presented in **Description of the Environment** (**Chapter 5**).

Following two chapters are **Information Disclosure, Consultation, and Participation** (**Chapter 6**) and **Analysis of Alternatives** (**Chapter 7**). These cover two key aspects of the EIA process.

The core of the EIA is the **Environmental Impacts and Mitigation Measures** (**Chapter 8**) which identifies the potential environmental and social impacts of the proposed Project, predicts their magnitude, evaluates the significance of impacts, and proposes mitigation measures, where required. This chapter is followed by the **Environmental Management Plan** (**Chapter 9**) which identifies various implementing mechanisms, institutional arrangements, monitoring mechanisms, and other plans to ensure effective implementation of the proposed mitigation measures. The **Grievance Redress Mechanism** (**Chapter 10**) proposes the mechanism to effectively address any grievances of the community and other stakeholders against the project.

Finally, **Conclusions** (**Chapter 11**) concludes the report. The background information and detailed data is provided in the appendices.

CHAPTER 3. Legal and Institutional Framework

In Pakistan, the history of legislation drafted specifically to protect the environment dates back to 1980s. This section provides a brief historical and constitutional context followed by a detailed discussion of relevant laws.

3.1 Historical and Constitutional Context

The development of statutory and other instruments for environmental management has steadily gained priority in Pakistan since the late 1970s. The Pakistan Environmental Protection Ordinance, 1983 was the first piece of legislation designed specifically for the protection of the environment. The promulgation of this ordinance was followed, in 1984, by the establishment of the Pakistan Environmental Protection Agency (Pak-EPA), the primary government institution at that time dealing with environmental issues. Significant work on developing environmental policy was carried out in the late 1980s, which culminated in the drafting of the Pakistan National Conservation Strategy. Provincial environmental protection agencies were also established at about the same time. The National Environmental Quality Standards (NEQS) were established in 1993. In 1997, the Pakistan Environmental Protection Act (PEPA) 1997 was enacted to replace the 1983 Ordinance. PEPA conferred broad-based enforcement powers to the environmental protection agencies. This was followed by the publication of the *Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations 2000* which provided the necessary details on the preparation, submission, and review of initial environmental examinations (IEE) and environmental impact assessments (EIA).

Prior to the 18th Amendment to the Constitution of Pakistan in 2010, the legislative powers were distributed between the federal and provincial governments through two 'lists' attached to the Constitution as Schedules. The Federal list covered the subjects over which the federal government had exclusive legislative power, while the 'Concurrent List' contained subjects regarding which both the federal and provincial governments could enact laws. The subject of 'environmental pollution and ecology' was included in the Concurrent List and hence allowed both the national and provincial governments to enact laws on the subject. However, as a result of the 18th Amendment this subject is now in the exclusive domain of the provincial government. The main consequences of this change were as follows:

- The Ministry of Environment at the federal level was abolished. Its functions related to the national environmental management were transferred to the provinces. To manage the international obligations in the context of environment, a new ministry—the Ministry of Climate Change—was created at the federal level.

- The PEPA 1997 was technically no longer applicable to the provinces. The provinces were required to enact their own legislation for environmental protection. However, to ensure legal continuity PEPA 1997 continued to be the legal instrument for environmental protection in the provinces till enactment of provincial law.

All provinces have now enacted their own environmental protection laws. These provincial laws are largely based on PEPA 1997 and, hence, provide the same level of environmental protection as the parent law. The provincial assembly of Sindh passed the Sindh Environmental Protection Act 2014 (the 'Sindh Act 2014') in March 2014.

Between 1993 and 2010, the Pak-EPA promulgated several rules, regulations, standards, and guidelines to implement the provisions of the PEPA 1997. It is understood that these instruments remain applicable in Sindh, unless they are superseded by a new instrument. In Sindh two such instruments have been promulgated, as will be discussed later in this chapter.

The discussion on regulatory requirements applicable to this project is, therefore, based on the Sindh law, the Sindh Environmental Protection Act 2014 and the rules, regulations, standards, and guidelines developed under the PEPA 1997 and the two instruments promulgated by the Government of Sindh.

3.2 Environmental Law

The Sindh Environmental Protection Act 2014 (Sindh Act 2014) is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The act is applicable to a broad range of issues and extends to air, water, industrial liquid effluent, marine, and noise pollution, as well as to the handling of hazardous wastes. The sections of Sindh Act 2014 that have a direct bearing on the proposed Project are listed below. The details are discussed in the following sections.

- Section 11 that deals with the Sindh Environmental Quality Standards (SEQS) and its application
- Section 13 that deals with hazardous substances
- Section 14 that prohibits various acts detrimental to the environment
- Section 15 that relates to vehicular pollution
- Section 17 that establishes the requirement for environmental impact assessment

Implementation of the provisions of the Sindh Act 2014 is made through several *rules* and *regulations*.[a] The relevant rules and regulations are

  - National Environmental Quality Standards (Self-Monitoring and Reporting by Industries) Rules, 2001
  - Environmental Samples Rules, 2001
  - The Pollution Charge for Industry (Calculation and Collection) Rules, 2001

[a] Rules and regulations are similar instruments but differ in their hierarchy. The power to make rules and regulations is given in the enabling law, PEPA 1997 and Sindh Act 2014 in this case. The rules are made by the government (federal or provincial, as the case may be) and require publication in the official gazette. Regulations are made by the government agency which is empowered by the law, environmental protection agencies in this case, and are not always published in the official gazette. Rules deal with relatively important matters such as delegation of powers and authorities, whereas regulations usually deal with procedural matters.

- Sindh Environmental Protection Agency (Review of Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2014 (IEE-EIA Regulations 2014)

Guidelines are issued by the Pak-EPA for preparation of environmental assessment. The relevant guidelines are discussed in Section 2.3.

3.3 Requirements for Environmental Impact Assessment

The articles of Sindh Act 2014 that have a direct bearing on the environmental assessment of the proposed Project are:

- Article 17(1): 'No proponent of a project shall commence construction or operation unless he has filed with the Agency[a] an initial environmental examination or an environmental impact assessment, and has obtained from the Agency approval in respect thereof.'

- Article 17(3): 'Every review of an environmental impact assessment shall be carried out with public participation…'

The IEE-EIA Regulations 2014 provides the necessary details on the preparation, submission, and review of the IEE and the EIA. Categorization of projects for IEE and EIA is one of the main components of the IEE-EIA Regulations 2014. Projects have been classified on the basis of expected degree of adverse environmental impact. Project types included in Schedule II of the regulations those that are likely to have potentially significant impact on the environment and thus an EIA is required for such projects, whereas those included in Schedule I as having potentially less adverse effects and therefore require an IEE. Coal fired power plants with capacity less than 50 MW is included in Schedule I (List of Projects requiring an IEE) whereas Coal power projects above 50 MW is included in Schedule II (List of Projects requiring an EIA). As the project involves development of a power plant of more than 50 MW, it falls within the category of Schedule II and an EIA has been prepared for it.

The word 'project' as defined in the Sindh Act 2014 includes new developments as well as modifications, expansions and rehabilitations of the existing projects. The proposed Project is considered a new development and not a modification to the existing Project because it will have its own separate staff, resources, financing, accounting, utilities, and administrative control. None of these items will be shared. Hence the existing project is not the subject of this EIA.

Regulation 9 of the IEE-EIA Regulations 2014 requires that '(1) Ten paper copies and two electronic copies of an IEE or EIA shall be filed with the Federal Agency; (2) Every IEE and EIA shall be accompanied by (a) an application, in the form set out in Schedule V; (b) copy of receipt showing payment of the review fee; (c) no objection certificates from the relevant departments in case of EIA shall be the part of reports; and (d) the environmental check list as per its guidelines.

[a] The term 'Agency' refers to the Sindh Environmental Protection Agency.

The prescribed procedure for review of EIA by the EPA is described in Regulations 10–17 and is depicted in **Figure 3-1**. The key features are:

- On acceptance of the EIA for review, EPA will place a public notice in national English and Urdu newspapers and in local language newspaper informing the public about the project and where it's EIA can be accessed. It will also set a date for public hearing which shall be at least 30 days after the publication of the notice.

- If it considers necessary, the EPA can form a Committee of Experts to assist the EPA in the review of the EIA. The EPA may also decide to inspect the project site.

- Article 17(4) of SEPA Act 2014 binds the SEPA to 'communicate its approval or otherwise … within a period of four months from the date the environmental impact assessment is filed complete in all respects in accordance with the regulations, failing which … the environmental impact assessment shall be deemed to have been approved, to the extent to which it does not contravene the provisions of this Act and the rules and regulations'.

Regulation 7 of the IEE-EIA Regulations 2014 pertains to the guidelines. It states that: '(1) The Agency may issue guidelines for preparation of an IEE or EIA or an environmental checklist, including guidelines of general applicability and sectoral guidelines indicating specific assessment requirements for planning, construction and operation of projects relating to a particular sector. (2) where guidelines have been issued under sub-regulation (1), an IEE or EIA shall be prepared, to the extent practicable, in accordance therewith and the proponent shall justify in the IEE or EIA or in environmental checklist any departure therefrom.' The relevant guidelines are the follows:

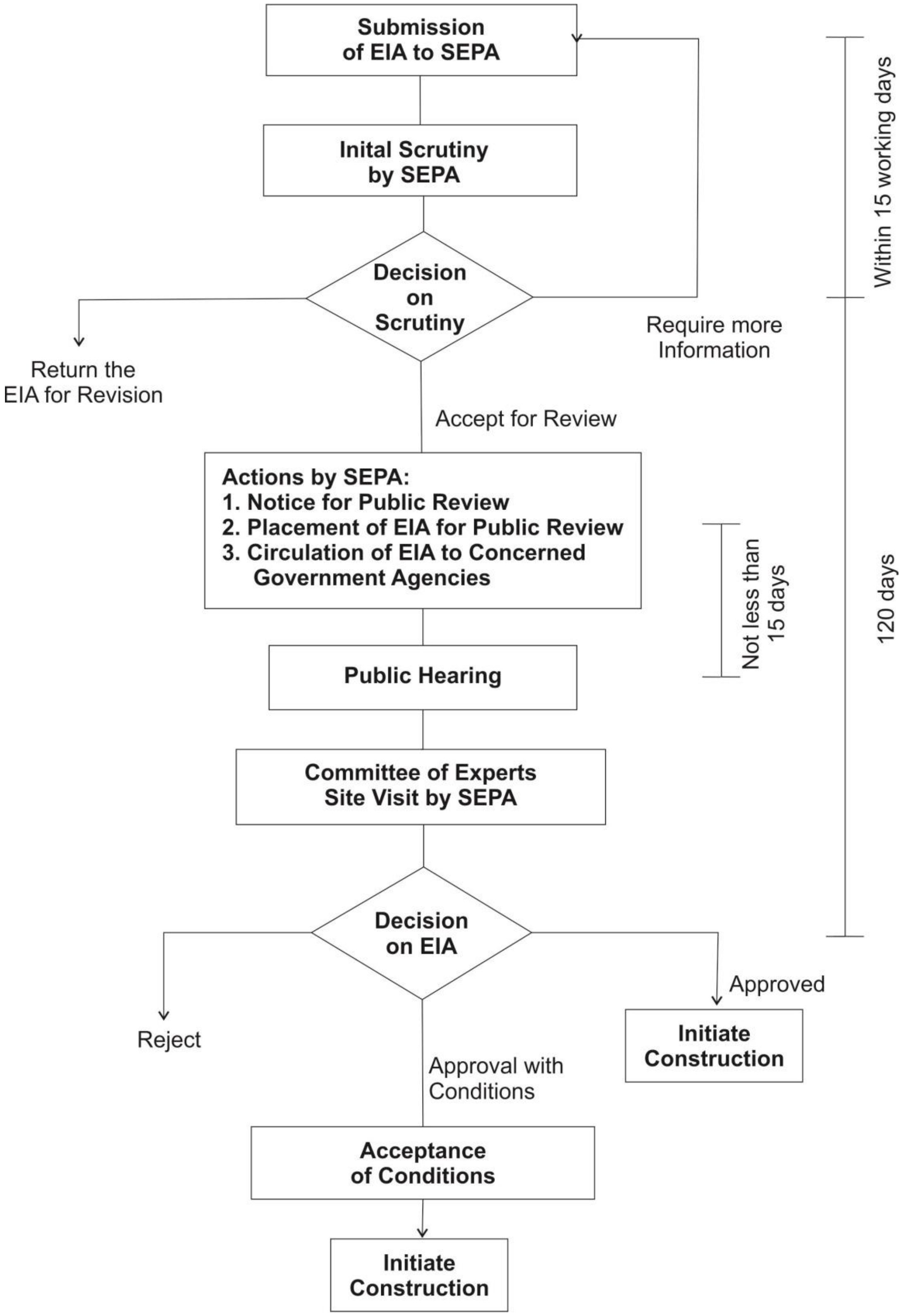
- Policy and Procedures for the filling, review, and approval of environmental assessments sets out the key policy and procedural requirement. It contains a brief policy statement on the purpose of environmental assessment and the goal of sustainable development and also states that environmental assessment be integrated with feasibility studies.

- Guidelines for the preparation and review of environmental reports which cover the following:

    - Scoping, alternatives, site selection, and format of environmental reports;

    - Identification, analysis and prediction, baseline data, and significance of impacts;

    - Mitigation and impact management and preparing an environmental management plan;



Source: JICA Survey Team

Figure 3-1: EIA Review and Approval Procedure

  - Reporting;
  - Review and decision making;
  - Monitoring and auditing;
  - Project management.
- Guidelines for Public Consultation which covers the following:
  - Consultation, involvement and participation;
  - Identifying stakeholders;
  - Techniques for public consultation (principles, levels of involvement, tools, building trust);
  - Effective public consultation (planning, stages of EIA where consultation is appropriate);
  - Consensus building and dispute resolution;
  - Facilitating involvement (including the poor, women, building community, and NGO capacity)
- *Guidelines for sensitive areas* which identifies the sensitive areas
- *Sectoral Guidelines for Environmental Reports-Thermal Power Stations* deal with major thermal power plants which will be defined as those producing electrical energy from fossil fuels (coal, gas, oil). The guideline is prepared to assist project proponents to identify the key environmental parameters those are required to be addressed to develop mitigation measures and alternatives that need to be considered in the actual EIA.

3.4 Hazardous Substances

Article 13 of the Sindh Act 2014 states that ‘Subject to the provisions of this Act, no person shall import, generate, collect, consign, transport, treat, dispose of, store, handle or otherwise use or deal with any hazardous substance except—(a) under a license issued by the Agency; or (b) in accordance with the provisions of any other law for the time being in force, or of any international treaty, convention, protocol, code, standard, agreement or other instrument to which Government is a party.’

Hazardous substance is defined in Article 2(xxv) of the Sindh Act 2014 as “(a) a substance or mixture of substances, other than a pesticide as defined in the Agricultural Pesticides Ordinance, 1971 (II of 1971), which, by reason of its chemical activity or toxic, explosive, flammable, corrosive, radioactive or other characteristics, causes, or is likely to cause, directly or in combination with other matters an adverse environmental effect; and (b) any substance which may be prescribed as a hazardous substance”

To date, SEPA has not prescribed any substance as hazardous nor has it defined the procedure for licensing. As and when, the procedure is defined and a license for any particular substance being used at the power plant is required, license will be obtained by the project Proponent. However, best industry practice and internationally acceptable guidelines for hazardous substances would be used for the proposed project.

3.5 Environmental Standards

Article 11(1) of the Sindh Act 2014 states that: ‘Subject to the provisions of this Act and the rules and regulations, no person shall discharge or emit or allow the discharge or emission of any effluent, waste, pollutant, noise or any other matter that may cause or likely to cause pollution or adverse environmental effects, as defined in Section 2 of this Act, in an amount, concentration or level which is in excess to that specified in Sindh Environmental Quality Standards…’

Between 1993 and 2010, the Pak-EPA promulgated several standards, the NEQS, which were applicable to the entire country. These include:

- Ambient air quality (9 parameters)
- Drinking water (32 parameters)
- Ambient noise
- Industrial effluents (32 parameters)
- Industrial gaseous emissions (18 parameters).

Following the promulgation of Sindh Act 2014, Sindh has notified its own ambient air quality standard. It is understood that the NEQS issued prior to Sindh Act 2014 remain in force in Sindh unless they are expressly amended, as is the case with the ambient air quality standards. As the Sindh Act 2014, does not have the provision for a national standard and PEPA 1997 is no longer applicable in Sindh, the term ‘Sindh Environmental Quality Standards’ is understood to include the NEQS (except ambient air quality standards) issued under PEPA 1997. However, the term NEQS is still used in this document where reference is made to older standards. The complete set of SEQS is included as **Appendix 1**.

All industrial standards (ambient air quality, gaseous emission, ambient noise, and industrial effluent) are applicable to the proposed Plant. These are further discussed in **Section 3.10**.

Under the National Environmental Quality Standards, Self-Monitoring and Reporting (SMART) by Industry Rules 2001, industrial units are responsible for monitoring their gaseous and liquid discharges and reporting them to the relevant environmental protection agency. As fuel and coal fired thermal power plant falls under the Schedule II Category (Category A) of industrial categorization and reporting procedure for SMART, environmental monitoring reports required to be submitted in monthly basis to the relevant authorities. The project proponents will report their emission and effluent to the SEPA in accordance with the rules.

3.6 Other Relevant Laws

3.6.1 The Forest Act 1927

The Act empowers the provincial forest departments to declare any forest area reserved or protected. The act also empowers the provincial forest departments to prohibit the clearing of forests for cultivation, grazing, hunting, removing forest produce, quarrying, felling, and lopping. Vegetation clearing will be required in the site preparation for the power plant but since the area is not declared as a reserve forest this law will have no implication on the project.

3.6.2 Factories Act 1934

Particular sections of the act applicable to this project are:

- Section 13(1): Every factory shall be kept clean and free from effluvia arising from any drain, privy or other nuisance.
- Section 14(1): Effective arrangements shall be made in every factory for the disposal of wastes and effluents due to the manufacturing process carried on therein.
- Section 16(1): In every factory in which, by reason of the manufacturing process carried on, there is given off any dust or fume or other impurity of such a nature and to such an extent as is likely to be injurious or offensive to the workers employed therein, effective measures shall be taken to prevent its accumulation in any work-room and its inhalation by workers and if any exhaust appliance is necessary for this purpose, it shall be applied as near as possible to the point of origin of the dust, fume or other impurity, and such point shall be enclosed so far as possible.
- Section 16(2): In any factory no stationary internal combustion engine shall be operated unless the exhaust is conducted into open air and exhaust pipes are insulated to prevent scalding and radiation heat, and no internal combustion engine shall be operated in any room unless effective measures have been taken to prevent such accumulation of fumes therefrom as are likely to be injurious to the workers employed in the work-room.
- Section 20(1): In every factory effective arrangements shall be made to provide and maintain at suitable points conveniently situated for all workers employed therein a sufficient supply of whole-some drinking water.
- Section 26(1) d(i): In every factory the following shall be securely fenced by the safeguards of substantial construction which shall be kept in position while the parts of machinery required to be fenced are in motion or in use, namely – (a) every part of an electric generator, a motor or rotary convertor.

3.6.3 The Sindh Irrigation Act 1879

This Act empowers the GoS to use the natural sources of water such as lakes, rivers, and streams, for supply of water for irrigation and other purposes. It allows the government to develop the required infrastructure, for example, canals, channels, pipelines, for the supply of water. It also allows the government to charge fee for the supply of water and regulate the water supply. The Irrigation Department of the Government of Sindh is the concerned department to which the project proponents have to apply to seek permit to obtain water from Indus River. The irrigation department will also charge fee as per the prevalent rates.

3.7 Environmental Guidelines

3.7.1 JICA Guidelines for Environmental and Social Considerations (April 2010)

(1) Categorization

As per JICA Guideline 2010, the project is classified into four categories according to the extent of environmental and social impacts, taking into account an outline of project, scale, site condition, etc. Projects are assigned to one of the four categories shown in **Table 3-1**.

The Project is categorized as Category A under JICA Guidelines (2010) as the Project falls into thermal power sector.

Table 3-1: JICA Project Categories

Category	*Project Description and Requirements*
Category A	Proposed projects are classified as Category A if they are likely to have significant adverse impacts on the environment and society. Projects with complicated or unprecedented impacts that are difficult to assess, or projects with a wide range of impacts or irreversible impacts, are also classified as Category A. These impacts may affect an area broader than the sites or facilities subject to physical construction. Category A, in principle, includes projects in sensitive sectors, projects that have characteristics that are liable to cause adverse environmental impacts, and projects located in or near sensitive areas.
Category B	Proposed projects are classified as Category B if their potential adverse impacts on the environment and society are less adverse than those of Category A projects. Generally, they are site-specific; few if any are irreversible; and in most cases, normal mitigation measures can be designed more readily.
Category C	Proposed projects are classified as Category C if they are likely to have minimal or little adverse impact on the environment and society.
Category FI	Proposed projects are classified as Category FI if they satisfy all of the following requirements: JICA's funding of projects is provided to a financial intermediary or executing agency; the selection and appraisal of the sub-projects is substantially undertaken by such an institution only after JICA's approval of the funding, so that the sub-projects cannot be specified prior to JICA's approval of funding (or project appraisal); and those sub-projects are expected to have a potential impact on the environment.

Source: JICA Guideline 2010

(2) Impacts to be Assessed

The impacts to be assessed with regard to environmental and social considerations include impacts on human health and safety, as well as on the natural environment, that are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety. Items to be addressed in the specific project are narrowed down to the needed ones through the scoping process.

In addition to the direct and immediate impacts of projects, the derivative, secondary, and cumulative impacts as well as impacts associated with indivisible projects will also be assessed with regard to environmental and social considerations, so far as it is rational. The life cycle impact of a project period is also considered.

Various kinds of relevant information are needed in order to assess impacts on the environment and local communities. There are, however, uncertainties in predicting such impacts caused by the incomplete understanding of impact mechanisms and the limited information available. Therefore, if the scale of uncertainty is considered to be large, project proponents etc. provide environmental and social considerations that include preventive measures as much as possible.

(3) Laws, Regulations and Standards of Reference

In principle, JICA confirms that projects meet the requirements for environmental and social considerations stated in the Guidelines in the following ways.

JICA confirms that projects comply with the laws or standards related to the environment and local communities in the central and local governments of host countries; it also confirms that projects conform to those governments' policies and plans on the environment and local communities.

JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies, and refers as a benchmark to the standards of international financial organizations; to internationally recognized standards, or international standards, treaties, and declarations, etc.; and to the good practices etc. of developed nations including Japan, when appropriate. When JICA recognizes that laws and regulations related to the environmental and social considerations of the project are significantly inferior to the aforementioned standards and good practices, JICA encourages project proponents etc., including local governments, to take more appropriate steps through a series of dialogues, in which JICA clarifies the background of and reasons for the inferior regulations and takes measures to mitigate the adverse impacts when necessary.

JICA takes note of the importance of good governance surrounding projects in order that measures for appropriate environmental and social considerations are implemented.

JICA discloses information with reference to the relevant laws of project proponents etc. and of the government of Japan.

(4) Consultation with Local Stakeholders

In principle, project proponents etc. consult with local stakeholders through means that induce broad public participation to a reasonable extent, in order to take into consideration the environmental and social factors in a way that is most suitable to local situations, and in order to reach an appropriate consensus. JICA assists project proponents etc. by implementing cooperation projects as needed.

In an early stage of cooperation projects, JICA holds discussions with project proponents etc. and the two parties reach a consensus on frameworks for consultation with local stakeholders.

In order to have meaningful meetings, JICA encourages project proponents etc. to publicize in advance that they plan to consult with local stakeholders, with particular attention to directly affected people.

In the case of Category A projects, JICA encourages project proponents etc. to consult with local stakeholders about their understanding of development needs, the likely adverse impacts on the environment and society, and the analysis of alternatives at an early stage of the project, and assists project proponents as needed.

In the case of Category B projects, JICA encourages project proponents etc. to consult with local stakeholders when necessary.

JICA encourages project proponents etc. to prepare minutes of their meetings after such consultations occur.

(5) Loan Aid Cooperation Projects for Category A projects

Project proponents etc. must submit EIA reports for Category A projects. For projects that will result in large-scale involuntary resettlement, a Resettlement Action Plan (RAP) also must be submitted. For projects that will require the measures for indigenous people, an Indigenous People Plan (IPP) must be submitted as well.

JICA publishes the status of host countries' submission of major documents on environmental and social considerations on its website. Prior to its environmental review, JICA also discloses the following: (1) EIA reports and environmental permit certifications, (2) RAPs for projects that will result in large-scale involuntary resettlement, and (3) IPPs for projects that address issues of indigenous people. Specifically, JICA discloses EIA reports 120 days prior to concluding agreement documents. In addition, JICA discloses a translated version of these major documents, subject to approval by project proponents etc.

JICA undertakes its environmental reviews based on the EIA and other documents submitted by project proponents etc. Environmental reviews for Category A projects examine the potential positive and negative environmental impacts of projects. JICA examines necessary measures to avoid, minimize, mitigate, or compensate for potential negative impacts, as well as measures to promote positive impacts, if any such measures are available. JICA also examines the results of information disclosure and local stakeholder consultation.

JICA discloses the results of environmental reviews on its website after agreement documents are concluded.

3.7.2 World Bank/IFC Environmental, Health and Safety Guidelines for Thermal Power Plants, 2008

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, based on environmental assessments and/or environmental audits as appropriate, with an appropriate timetable for achieving them.

This document includes information relevant to combustion processes fueled by gaseous, liquid, and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these. The emission guidelines for boilers are included in **Appendix 2**.

3.8 Institutional Framework

3.8.1 Sindh Government Institutions

Under the Sindh Act 2014, SEPA is an autonomous agency. For administrative purposes, it is part of the Forest, Environment and Wildlife Department of the Government of Sindh. SEPA is a regulatory agency with the following main functions:

- Enforcement of Sindh Act 2014
- Prepare environmental policies for approval of the GoS
- Implement environmental policies
- Publish annual state of the environment report for Sindh
- Prepare or revise SEQS
- Ensure implementation of SEQS
- Establish systems and procedures for environmental management
- Promote research and studies on environmental issues
- Issue license for handling of hazardous substance
- Certify environmental laboratories
- Initiate legislation for environmental protection
- Provide assistance to government agencies in case of environmental accidents
- Providing advice to the government on issues related to environment
- Assist governments agencies in implementation of waste management schemes
- Provide guidance to public on environmental matters

- Assist education institutions in prescribing environmental curricula
- Undertake measures to enhance awareness on environment among general public
- Disseminate knowledge on environment
- Specify safeguards for the prevention of accidents which may cause pollution
- Review and approve mitigation plans and give guidance for clean-up operations
- Encourage the formation and working of nongovernmental organizations, community organizations and village organizations for environmental protection
- Carry out any other task related to environment assigned by the government.

SEPA will be responsible for the review and approval of the EIA of the proposed Project.

3.8.2 International and National NGOs

International environmental and conservation organizations, such as the International Union for Conservation of Nature (IUCN) and the World Wide Fund for Nature (WWF), have been active in Pakistan for some time. Both these organizations have worked closely with the government and have played an advisory role with regard to the formulation of environmental and conservation policies. Since the Rio Summit, a number of national environmental NGOs have also been formed, and have been engaged in advocacy and, in some cases, research. The most prominent national environmental NGOs, such as the Sustainable Development Policy Institute (SDPI) are members of the Pakistan National Committee of the IUCN.

Environmental NGOs have been particularly active in advocacy, promoting sustainable development approaches. Much of the government's environmental and conservation policy has been formulated in consultation with leading NGOs, who have also been involved in drafting new legislation on conservation.

3.9 International Treaties

Important international environmental treaties that have been signed by Pakistan and may have relevance to the Project are listed in **Table 3-2**. They concern: climate change and depletion of the ozone layer; biological diversity and trade in wild flora and fauna; desertification; waste and pollution; and cultural heritage.

Table 3-2: International Environmental Treaties Endorsed by Pakistan

Topic	*Convention*	*Date of Treaty*	*Entry into force in Pakistan*
Climate change and the ozone layer	United Nations Framework Convention on Climate Change - the primary objective is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.	1992	1994
	Kyoto Protocol to the United Nations Framework Convention on Climate Change - enabled by the above Convention on Climate Change. It has more powerful	1997	2005

Topic	*Convention*	*Date of Treaty*	*Entry into force in Pakistan*
	and legally binding measures. It sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas emissions.		
	Vienna Convention for the Protection of the Ozone Layer - acts as a framework for the international efforts to protect the ozone layer with a primary objective to protect human health and the environment against adverse effects resulting from human activities that modify or are likely to modify the ozone layer.	1985	1993
	The Montreal Protocol on Substances that Deplete Ozone Layer and associated amendments - enabled by the Vienna Convention, it is designed to protect the ozone layer by phasing out the production and consumption of a number of substances believed to be responsible for ozone depletion.	1987	1993
Waste and pollution	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal - regulates the transboundary movement of hazardous waste and other waste with a stated purpose to protect human health and the environment against the adverse effects from generation and management of hazardous waste and other waste. The Convention provides for three sets of measures with binding obligations. These are: Strict control of transboundary movement of hazardous waste; Environmentally sound management of hazardous waste; and Enforcement and implementation of the provisions of the convention at international and national levels.	1989	1994
	International Convention on Oil Pollution Preparedness, Response and Co-operation	1990	1995
	Stockholm Convention on Persistent Organic Pollutants –seeks to protect human health and the environment from Persistent Organic Pollutants, which are chemicals that remain intact in the environment for long periods, become widely distributed geographically and accumulate in the fatty tissue of humans and wildlife.	2001	2008
Desertification	International Convention to Combat Desertification – with an objective to combat desertification and mitigate the effects of drought. It is supported by international cooperation and partnership arrangements, with the aim of achieving sustainable use of land and water resources and sustainable development in affected areas.	1994	1997
Biodiversity and the protection of plants and animals	Convention on Biological Diversity – covering ecosystems, species, and genetic resources and also the field of biotechnology. The objectives are: conserve of biological diversity; sustainable use of its components; and fair and equitable sharing of benefits arising from	1992	1994

Topic	*Convention*	*Date of Treaty*	*Entry into force in Pakistan*
	genetic resources.		
	Cartagena Protocol on Biosafety to the Convention on Biological Diversity - addresses potential risks posed by living modified organisms resulting from modern biotechnology.	2000	2009
	Bonn Convention on the Conservation of Migratory Species of Wild Animals - aims to conserve terrestrial, marine and avian migratory species throughout their range. It is concerned with the conservation of wildlife and habitats on a global scale.	1979	1987
	Memorandum of Understanding concerning Conservation Measures for the Siberian Crane - parties undertake to provide strict protection to Siberian Cranes, and identify and conserve wetland habitats essential for their survival.	1998	1999
	Convention on International Trade in Endangered Species of Wild Fauna and Flora - to ensure that international trade in specimens of wild animals and plants does not threaten their survival.	1973	1976
	International Plant Protection Convention (1997 Revised Text) - to prevent the international spread of pests and plant diseases. It requires maintenance of lists of plant pests, tracking of pest outbreaks, and coordination of technical assistance between member nations.	1951/52	1954
	Agreement for the Establishment of the Near East Plant Protection Organization - to establish the Near East Plant Protection Organization (NEPPO), which promotes international co-operation with a view to implementing International Plant Protection Convention.	1993	2009
	Plant Protection Agreement for the Asia and Pacific Region and amendments – establishes the Asia and Pacific Plant Protection Commission to review and promote the region's progress in the implementation of the Agreement. Trade in plants and plant products are regulated by certification, prohibition, inspection, disinfection, quarantine, destruction, etc., as necessary.	1955 (amended 1967)	1958 (amended 1969)
	Convention on Wetlands of International Importance especially as Waterfowl Habitat and associated protocols and amendments - to promote conservation and sustainable use of wetlands. The Ramsar List of Wetlands of International Importance now includes almost 1,800 sites (known as Ramsar Sites). There are currently 19 Ramsar sites in Pakistan.	1971 (amended 1987)	1976 (amended 1994)
Cultural heritage	Convention concerning the Protection of the World Cultural and Natural Heritage - requires parties to adapt a general policy on the protection of the natural and	1972	1976

Topic	*Convention*	*Date of Treaty*	*Entry into force in Pakistan*
	cultural heritage, to set up services for such protection, to develop scientific and technical studies, to take appropriate legal, technical, scientific and administrative measures and to foster training and education for such protection.		

3.10 Environmental Standards and Guidelines Applicable to the Projects

The proposed project is legally required to comply with the SEQS for gaseous emission, and liquid effluent, and SEQS for ambient air quality. In addition, JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies, International Finance Corporation (IFC) Guidelines, and refers as a benchmark to the standards of international financial organizations; to internationally recognized standards, or international standards, treaties, and declarations, etc.; and to the good practices etc. of developed nations including Japan, when appropriate.

The environmental standards applicable in Sindh are NEQS as developed by Pakistan Environmental Protection Agency prior to 18th Amendment. The only exception is the ambient air quality standards which Sindh Environmental Protection Agency has notified separately. In **Table 3-3** and **Table 3-4**, comparisons of SEQS and IFC Guidelines for key parameters of emission and ambient air quality are provided for reference. The details are placed in **Appendix 1** and **Appendix 2**. **Table 3-5** provides a comparison of SEQS and IFC Guideline limits for effluents. **Table 3-6** provide a comparison of SEQS and IFC Guideline limits for noise.

Table 3-3: Comparison of SEQS and IFC Guideline Limits for Emission of Key Pollutants from Coal Fired Power Plant

Parameter	*Source of Emission*	*National Standards*	*IFC Guidelines*
SEQS for Industrial Gaseous Emissions[a]			
Particulate matter	Boilers and furnaces: coal-fired	500 mg/Nm³	For NDA: 50 mg/Nm³ For DA: 30 mg/Nm³
Carbon monoxide	Any	800 mg/Nm³	-
Nitrogen Oxides	Coal-fired	1,200 mg/Nm³	For NDA: 510 mg/Nm³ For DA: 200 mg/Nm³
SEQS for Sulfur Dioxide and Nitrogen Oxides[b]			
Sulfur Dioxide	Power plant operating on oil and coal	100 - 500 Tons per day	For NDA: 200-850 mg/Nm³ For DA: 200 mg/Nm³
Nitrogen Oxides	Power plant operating on oil and coal	For lignite fossil coal: 260 ng/J of heat input	For NDA: 510 mg/Nm³ For DA: 200 mg/Nm³

Notes:

For additional parameters and explanation, see complete SEQS in **Appendix 1** and IFC Guidelines in **Appendix 2**.

A "-" in the fourth column indicates that IFC has not provided any guidelines for the parameter

NDA = Non-degraded airshed; DA = Degraded airshed

In respect of emissions of sulfur dioxide and nitrogen oxides, the power plants operating on oil and coal as fuel shall comply with the standards stated in SEQS for sulfur dioxide and nitrogen dioxides in addition to SEQS for industrial gaseous emissions.

[a] SEQS for Industrial Gaseous Emissions is originally NEQS which was issued in [PART II] THE GAZETTE OF PAKISTAN, EXTRA, OCT, 19, 1995.

[b] SEQS for Sulfur Dioxide and Nitrogen Oxides is originally NEQS which was amended version of "SEQS for Industrial Gaseous Emissions".

Table 3-4: Comparison of SEQS and IFC Guideline Limits for Ambient Air Quality

Pollutants	*Time-weighted Average*	*Sindh Standards ($\mu g/m^3$)*	*IFC Guidelines ($\mu g/m^3$)*
Sulfur Dioxide (SO_2)	Annual Average	80	–
	24 hours	120	125
Oxide of Nitrogen as (NO)	Annual Average	40	–
	24 hours	40	–
Oxide of Nitrogen as (NO_2)	Annual Average	40	40
	24 hours	80	–
Ozone (O_3)	1 hour	130	–
Suspended Particulate Matter (SPM)	Annual Average	360	–
	24 hours	500	–
Respirable particulate Matter. PM_{10}	Annual Average	120	70
	24 hours	150	150
Respirable Particulate Matter. $PM_{2.5}$	24 hours	75	75
	Annual Average	40	35
Lead (Pb)	Annual Average	1	–
	24 hours	1.5	–
Carbon Monoxide (CO)	8 hours	5,000	–
	1 hour	10,000	–

Notes:

1. For additional parameters and explanation, see complete SEQS in **Appendix 1** and IFC Guidelines in **Appendix 2**.
2. A "–" in the fourth column indicates that IFC has not provided any guidelines for the parameter or they are to be established by the environmental assessment

Table 3-5: Comparison of SEQS and IFC Guideline Limits for Effluents (mg/l, unless otherwise defined)

Parameter	*SEQS (Into Inland Waters)*	*IFC Guidelines*
Temperature increase	=<3°C	–
pH value	6 to 9	6 to 9
Five-day bio-chemical oxygen demand (BOD) at 20°C	80	-
Chemical oxygen demand (COD)	150	–
Total suspended solids (TSS)	200	50
Total dissolved solids (TDS)	3,500	–

Parameter	*SEQS (Into Inland Waters)*	*IFC Guidelines*
Grease and oil	10	10
Phenolic compounds (as phenol)	0.1	–
Chlorides (as Cl')	1,000	–
Fluorides (as F')	10	–
Cyanide total (as CN')	1.0	–
Anionic detergents (as MBAS)	20	–
Sulfates (SO_4)	600	–
Sulfides (s')	1.0	–
Ammonia (NH_3)	40	–
Pesticides	0.15	–
Cadmium	0.1	0.1
Chromium (trivalent and hexavalent)	1.0	0.5
Copper	1.0	0.5
Lead	0.5	0.5
Mercury	0.01	0.005
Selenium	0.5	–
Nickel	1.0	–
Silver	1.0	–
Total toxic metals	2.0	–
Zinc	5.0	1.0
Arsenic	1.0	0.5
Barium	1.5	–
Iron	8.0	1.0
Manganese	1.5	–
Boron]	6.0	–
Chlorine	1.0	0.2

Notes:

1. For additional parameters and explanation, see complete **Appendix 1** and IFC Guidelines in **Appendix 2**.
2. A "-" in the third column indicates that IFC has not provided any guidelines for the parameter or they are to be established by the environmental assessment.
3. IFC General Guidelines describes "temperature of wastewater prior to discharge does not result in an increase greater than 3 °C of ambient temperature at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use and assimilative capacity among other considerations".

Table 3-6: Comparison of SEQS and for Noise

No.	Category of Area/Zone	SEQS		IFC Guidelines	
		Limit in dB(A) Leq*		Limit in dB(A) Leq*	
		Day time 06:00 - 22:00	Night time 22:00 - 06:00	Day time 07:00 - 22:00	Night time 22:00 - 07:00
1.	Residential are (A)	65	50	55	45
2.	Commercial are (B)	70	60	70	70
3.	Industrial area (C)	80	75	70	70
4.	Silence zone (D)	55	45	55	45

Notes:

1. [SEQS] Silence zone: Zones which are declared as such by the competent authority. An area comprising not less than 100 meters around hospitals, educational institutions and courts and courts.
2. [SEQS] Mixed categories of areas may be declared as one of the four above-mentioned categories by the competent authority.
3. [SEQS] dB(A) Leq: time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.
4. [IFC Guidelines] For acceptable indoor noise levels for residential, institutional, and educational settings refer to WHO (1999).

CHAPTER 4. THE PROPOSED PROJECT

The proposed power plant will be installed adjacent to and primarily on the land currently owned by the Lakhra Power Generation Company Ltd. (LPGCL). However, it will be an independent power plant, with its own fuel source, storage, utilities and operations.

4.1 Existing Lakhra Power Station

4.1.1 Generating Units

Several feasibility studies were conducted between 1967 and 1988 for the construction of coal fired Power Station at Lakhra for the estimated 1,300 million tons of coal reserves. Pakistan Water and Power Development Authority (WAPDA) prepared PC-1[1] for construction of 3 x 50 MW (three identical units of 50 MW each) coal power plants in 1985. Dongfang Electric Corporation (DEC) of China provided supplier's credit to the project and consequently the contracts for supply and erection of mechanical/electrical equipment and main civil works were signed in August 1989 and February 1990, respectively. The key plant features are described in **Table 4-1**.

Table 4-1: Major Characteristic of Lakhra FBC Power Station

Unit	*No. 1*	*No. 2*	*No. 3*
Location	Indus Highway, District Jamshoro, Sindh		
Current Status	Operational	Operational	Not Operational
Type of Boiler	Fluidized Bed Combustion, Sub-critical pressure		
Commissioning Date	06 Jun. 1995	14 Oct. 1995	03 Jan. 1996
Installed Capacity	50 MW	50 MW	50 MW
Steam Condition	535 °C, 9.8 MPa		
Manufacturer Boiler/Turbine	Dongfang Electric (China)		
Fuel	Type: Lignite Coal Source: Lakhra Coal Mines Consumption: 52 ton/hour Supplier: Lakhra Coal Development Company (LCDC), a public sector company		
Water Supply	Source: Indus River Quantity 0.25 m^3/s (9 cusec) Transport: Underground pipe of 0.51 m (20 inch)		
Land Area	Plant: 112.30 ha (277.5 acres) Intake facilities: 4.78 ha (11.80 acres)* Colony: 46.13 ha (114.00 acres) Others: 23.88 ha (59.02 acres)		

[1] PC-1, the Planning Commission Form 1, is the standard government Pro Forma for the stage 1 of public sector project cycle and provides information on the project justification and pre-feasibility of the proposed development project.

Unit	No. 1	No. 2	No. 3
	Total: 187.09 ha (462.32 acres)		
Power Dispatch	Through two 132 kV Lines to Jamshoro and one 132kV line to Khanot operated by NTDC		

Source: LPGCL
*Note: Intake facilities include River Intake Pump House, Road and Water Supply Pipe line

The 3x50 MW Power Station at Lakhra was an experimental power station. Fluidized Bed Combustion (FBC) is a relatively new technology for combusting low grade, high sulfur coal for power generation. In this system, the coal and limestone are suspended (fluidized) throughout the furnace by means of air entering at the bottom of furnace. FBC technology was just introduced when this plant was installed. Even the contractor did not have sufficient expertise for project of this size (50 MW), and sought assistance from Foster Wheeler & Company USA for initial designing of FBC boilers. The boilers were designed after testing of coal samples from different locations of Lakhra coal field.

The contractor faced number of problems during the guarantee period resulting in several modifications of the design. However, many problems remained mainly due to high sulfur and ash contents in the coal. Boiler Unit No. 1 has been operated and Unit No. 2 has been recently operated at 38 MW, whereas Unit No. 3 has not been operated due to deterioration since March, 2007. Consequently current power generation capacity is around 30 MW. One of the key issues is the erosion of different parts of boiler. The continuous operation of boilers for longer period, i.e., beyond 50 days has not been achieved, so far, due to heavy clinker formation after burning of coal. The boilers are therefore, stopped and are to be cleaned after operation of about 40 days.

4.1.2 Fuel and Performance

Lakhra Coal Development Company Limited (LCDC) was established for the LFPS under the administrative control of Ministry of Petroleum and Natural Resources, GoP. Since the commissioning of the plant, coal has been mined by LCDC at Lakhra coalfield located about 20 km from the LFPS.

Lakhra coal mine has a total reserve of 1,328 million tonnes of which the measured, indicated, and inferred reserves are 244, 629, and 456 million tonnes, respectively. The coal seam thickness is between 0.3 and 3.3 meters. Lakhra coal is classified as lignite with medium ash content (4.3-49%), very high sulfur (1.2-14.8%). The moisture ranges between 9.7 and 38.1%; the volatile matter between 18.3 and 38.6%; and the fixed carbon between 9.8 and 38.2%.[1] The heating value is between 3,058 kcal/kg and 5,088 kcal/kg (5,503 Btu/lb and 9,158 Btu/lb). FBC technology has been used in the boiler of the LFPS, which is suitable technology for burning coal with high sulfur content. The fuel requirement of the boiler and available coal quality (average) are given in **Table 4-2**. It indicates that the quality of Lakhra coal can meet the requirements of the boiler of the LFPS.

[1] Pakistan Energy Yearbook 2013. Ministry of Petroleum and Natural Resources, Government of Pakistan.

Table 4-2: Fuel Requirement of the Boiler and Lakhra Coal Quality

Item	*Required Parameters (Applied Basis)*	*Lakhra Coal Quality For reference (Applied Basis)*
Carbon	33.04%	34.74%
Hydrogen	2.45%	2.70%
Oxygen	7.04%	9.15%
Nitrogen	0.75%	0.62%
Sulfur	5.20%	4.98%
Ash	19.52% (max. 30%)	15.69%
Moisture	30%	25 – 30%
Volatile matter	26.00%	28.38%
Fixed Carbon	22.48%	24.47%
Calorific Value	3,195 kcal/kg	6,057 Btu/lb = 3,365 kcal/kg

Source: Lakhra Coal Development Company

4.1.3 Handling, Transportation and Storage of Fuel

LCDC has delivered the Lakhra coal to LFPS by trucks with a loading capacity of 20-30 ton. The amount of coal used for the LFPS is 800 ton per day as of March 2014. There is a coal storage yard at the premise with a capacity of 3,000 ton per day.

4.1.4 Water Supply System

The source of water for LFPS is the Indus River. An allocation of 0.25 cubic meter per second (m^3/s) or 9 cubic feet per second (cusecs) was made by the Irrigation Department of the Government of Sindh (GoS) to the power plant in 1990s. Originally, there were three intake water pumps, one for each unit, installed at the river to meet the requirements of the plant and the associated housing colony. However in the last two decades meandering of the Indus River resulted in movement of the main course of the river away from the pumping station. Consequently, the intake point has been moved twice.

Major use of water in the plant is the cooling water system. The water is first passed through the coagulator and clarifier, where coagulated silt is removed and returned back to the river as coagulator blowdown. Other uses include those for the boilers, offices, other plant and housing colony needs.

As the plant is currently operating at only 20% of its design capacity, the water abstraction from the river is currently about 5,000 m^3/day which amounts to 0.06 m^3/sec (2.1 cusecs) or less than 25% of the allocation.

4.1.5 Wastewater Generation and Disposal

The major discharge of wastewater generated from the facility is the cooling tower blowdown, which was originally designed to go into the Indus through a water discharge pipeline.

However, the stream where the pipeline reaches is not connected to the river due to change in course of the river. At present the wastewater discharge goes to a silty area situated in about 240 m north of the discharge point, where some quantity of water is evaporated.

The settled silt is removed from the coagulator (coagulator blowdown) as slurry which is also pumped into the above pipeline that carries wastewater from the plant toward the river. Wastewater generated during regeneration of demineralized water is neutralized and discharged through the above pipeline.

Low volume wastes include boiler blowdown, laboratory drains, wastewater from hydrogen and chlorine plants, and plant drains. Boiler blowdown and wastes from the water treatment system are pH-neutralized, plant drains are treated for oil and grease, and wastewater from air pre-heater washing and boiler chemical cleaning are neutralized before being discharged to the river.

Sanitary wastes from the plant are drained into wastewater treatment facility, and are pH-neutralized and discharged towards the river.

4.1.6 Cooling Water System

The cooling towers are natural draft cooling type.

4.1.7 Solid Waste Storage and Disposal

Plastic, garbage, garbage waste, recyclable paper, waste agriculture bio-mass and municipal solid waste etc. are generated from LFPS which are collected by licensed companies and disposed of at a dumping site located in 5 km from the station. Flammable material like lubricating oil, turbine oil, HSD oil, Hydraulic oil etc. are drained through specific trenches and disposed of in a separate pond.

4.1.8 Stacks and Emissions

There is one exhaust gas stack at LFPS. The stack parameters are shown in **Table 4-3**. Stack emissions from the plant have not been monitored since the commissioning as during project planning there were no national environmental quality standards. Although, at the time of project commissioning the standards were promulgated, but the monitoring guideline for air pollution and the regulatory regime to enforce the standards were introduced much later. Therefore, no monitoring has been conducted since the operation.

Ambient air quality measurement was conducted during this study.

Table 4-3: Stack Design Parameters

Parameter	*unit*	*Value*
Capacity	MW	150
Stack height	m	100
Inner diameter	m	4.5
Flue gas temperature	K	433
Exit velocity	m/s	23

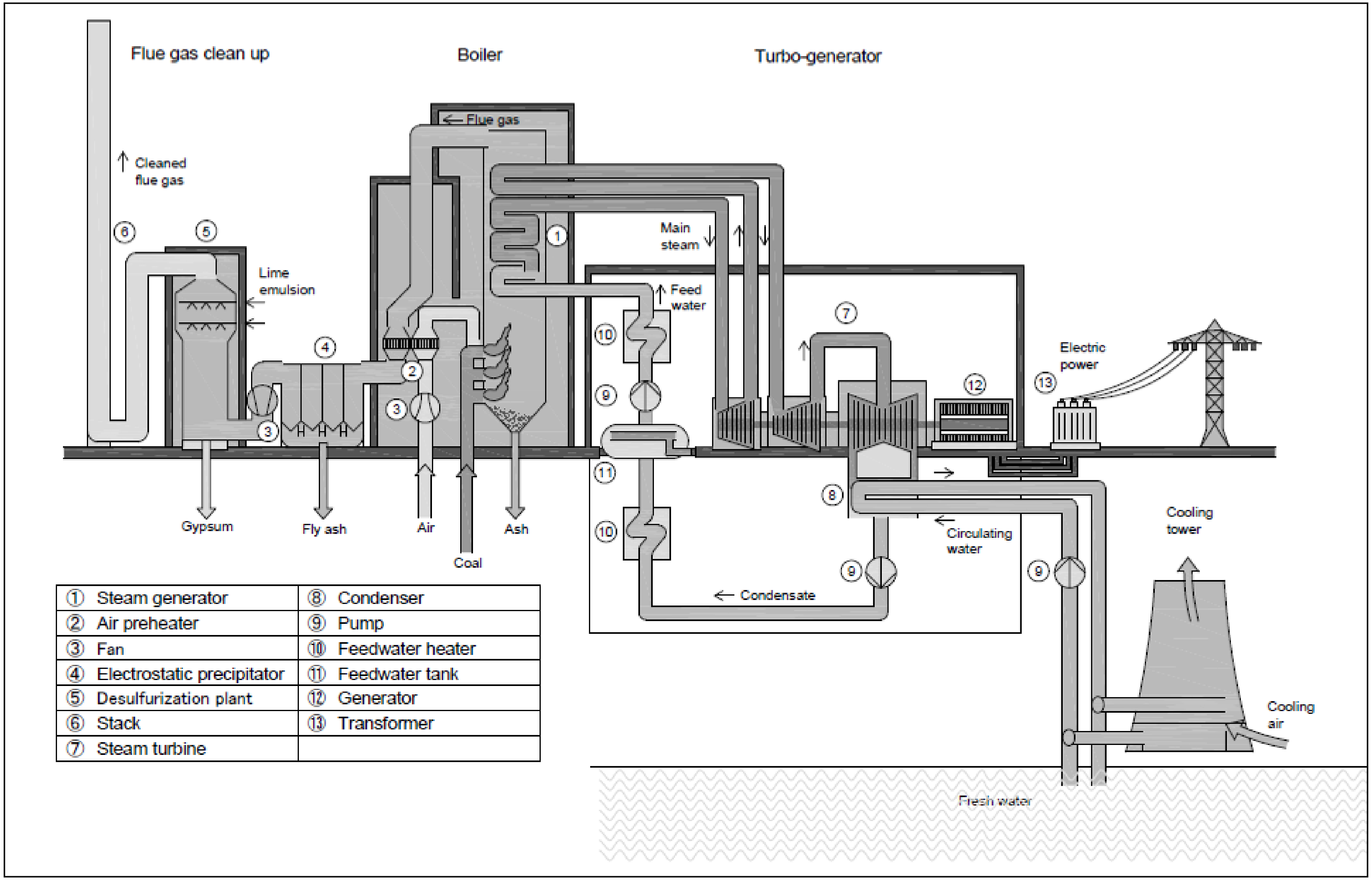
Source: EIA for Jamshoro Power Generation Project, October 2013

4.2 General Description of the Proposed Plant

4.2.1 Technical Outline

GoP is proposing to develop a 660 MW power plant. A block diagram of the power plant is shown in **Figure 4-1**. The major systems of the proposed plant include:

- Unit capacity and load operation
  - Nominal capacity of 660 MW including auxiliary power consumption
  - Net plant output of 600 MW
  - The plant is designed for base load operation
- Plant configuration
  - One Ultra-Supercritical (USC) system of a boiler, a turbine generator and auxiliaries
  - Once-through boiler with Pulverized Coal (PC) firing
  - Single reheat condensing, tandem-compound steam turbine
  - Totally enclosed, three phase, 50Hz, synchronous generator
  - Auxiliary plants; coal handling system, ash handling system, water treatment system
- Fuel to be burned
  - Blended coal with 80% sub-bituminous coal and 20% lignite
  - 100% sub-bituminous coal when lignite is not available
  - Auxiliary light fuel oil to be used for startup and supporting firing at low plant load as necessary



Source: JICA Survey Team

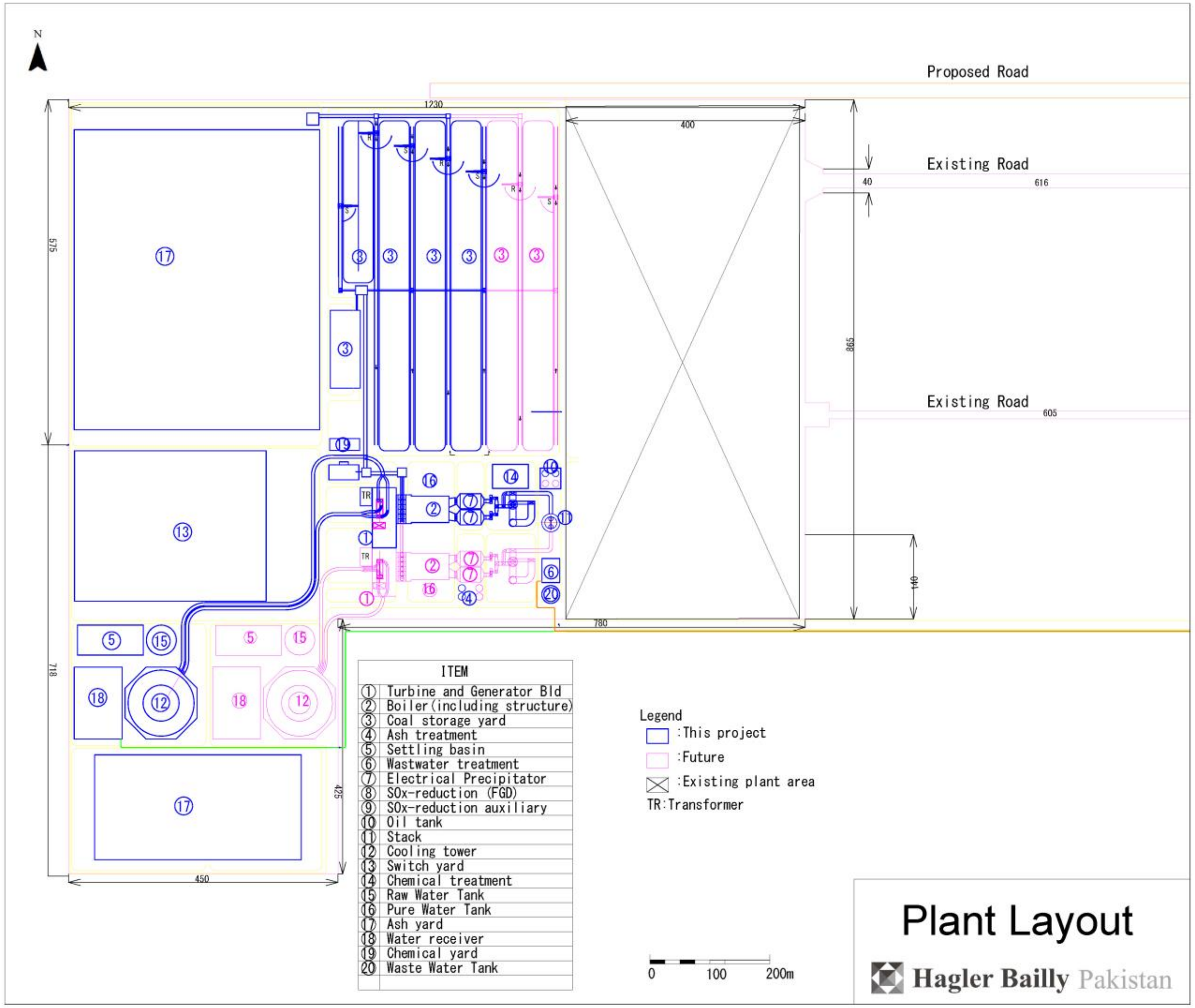
Figure 4-1: Simplified Schematic Diagram of the Proposed Power Plant

- Emission control
    - Particulate matter control: Electrostatic precipitator (ESP) with 99.7% efficiency
    - Sulfur dioxide (SO_2) control: Flue Gas Desulfurization (FGD) with 80% efficiency
    - Nitrogen oxides (NOx): Low NOx firing technology in the boiler
- Grid connection
    - Grid connection of 500 kV transmission lines
- Water supply
    - Water-cooled condenser paired with a natural draft type cooling tower

The layout of the proposed plant is shown in **Figure 4-2**. The total area of the plant is 92.3 ha which is utilized as follows:

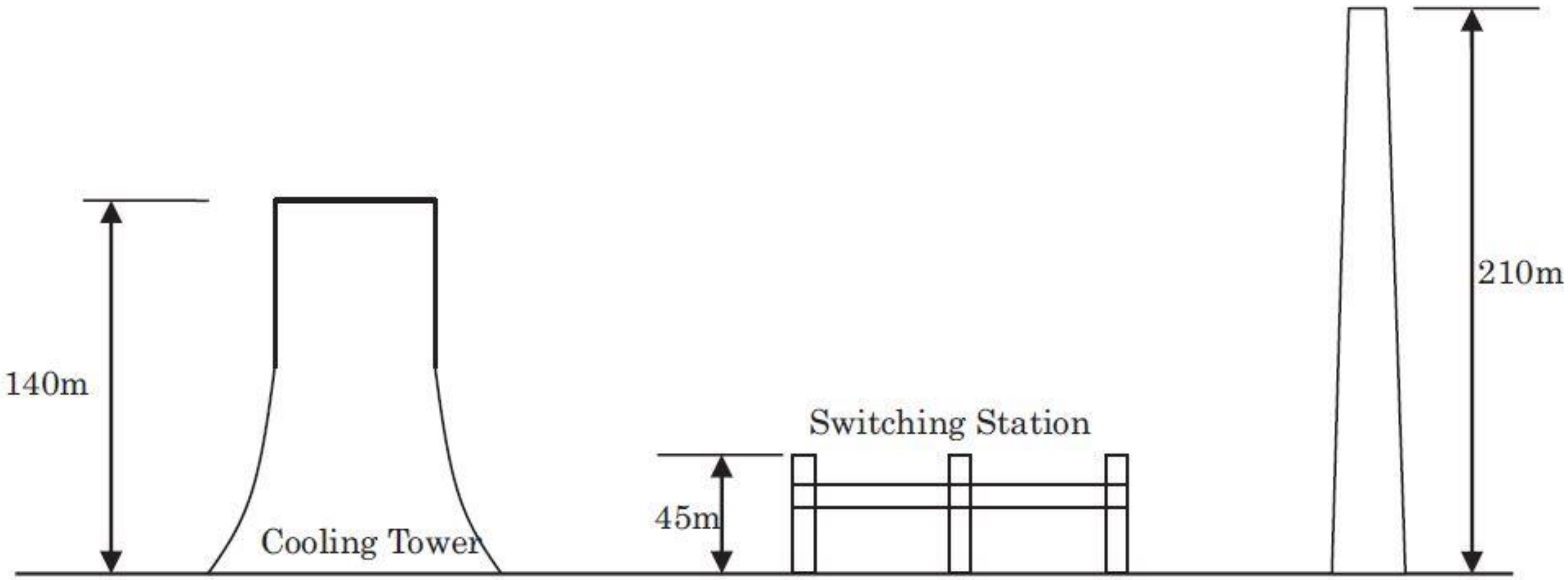
• Coal Storage Yard	15.0 ha
• Ash Yard	26.9 ha
• Switch Yard	8.0 ha
• Water Treatment	4.6 ha
• Boilers and turbines	6.3 ha
• Future Expansion	18.5 ha
• In-plant roads, and empty spaces	13.0 ha

The relative heights of the large structures are shown in **Figure 4-3**.



Source: JICA Survey Team

Figure 4-2: Plant Layout



Source: JICA Survey Team

Figure 4-3: Relative Heights of Main Components

4.2.2 Specifications for Unit Operation

1. Total Plant Condition

The net rated output of the turbine is the output measured at terminals of the transmission line. The plant is designed to continuously generate 100% gross output under the following conditions:

Table 4-4: Conditions of Rated Power Output

Parameter	*Unit*	*Value*
Unit capacity (Net)	MW	600
Main steam pressure at main stop valve inlet	MPa	24.1
Main steam temperature at main stop valve inlet	^oC	593
Reheat steam pressure at reheat stop valve inlet	MPa	4.2
Reheat steam temperature at reheat stop valve inlet	^oC	593
Condenser vacuum	kPa abs	11.1
Cooling water temperature	^oC	35.6
Turbine speed	rpm	3,000
Generator power factor	Lagging	0.85
Generator voltage	kV	22 or 24
Generator frequency	Hz	50
Unit efficiency (Gross) (LHV) (Sub-bituminous 80%, Thar 20%)	%	42.3
Unit efficiency (Gross) (LHV) (Sub-bituminous 100%)	%	42.5

Source: JICA Survey Team

2. Unit Operation

The purpose of this plant is to supply base load power to the grid. It is required to have high reliability and capability for supplying the power demand in order to respond to rapid changes in load.

- Load changes from minimum to base load. Minimum load is the condition in which the boiler can be operated without support of liquid fuel and it shall not be more than 35% of rated load
- Load changing rates (i) from 50% load to 75% load and (ii) from 75% load to rated load are to be 3%/min in the case of only sub-bituminous coal
- Sliding pressure operation shall be applied during load, ranges from 50% to 90%

In case of power grid failure, this plant should be transferred to house load operation, which is a stand-by condition for synchronizing immediately after the recovery from an electrical failure.

The bypass system should have the function to override the house load operation from the rated load when triggered by a grid accident. If some mills can be stopped and the pressure peak of the main pipe system can be controlled within the design pressure, the capacity of the bypass system may be decreased. A practical approach is necessary for decreasing the capacity and about 70% will be the minimum capacity.

4.3 Power Generation Technology

4.3.1 Unit Size

The unit size of a power plant is determined by the following criteria.

Table 4-5: Criteria for Determination of Unit Size

Criteria	Explanation
1	[Economic aspect] The economies of scale, including lower capital cost in $/kW and lower operating costs ($/MWh), favor the larger sizes.
2	[Stability of the power network system] A power plant has the probability of being shut down due to trouble in the power plant itself or for other reasons. The power system stability depends on the power loss magnitude. If the magnitude of the power loss due to plant outage is large, the whole power system might be shut down. It is said that, in general, an abrupt loss of 10% or less in the whole network is regarded safe. In the case of Pakistan, the total generation power is about 20,000 MW, and so 600 MW (net) is regarded less than the 10% of the whole network in the above criteria. As for the individual network stability condition, however, a safety margin is necessary.
3	[Track record of foreign countries] There are a number of 600 MW class operating plants in the world.

Considering the above criteria, 660 MW is regarded as the most suitable capacity in Pakistan.

4.3.2 Steam Condition

3. Selection of Pulverized Coal Combustion Technologies

A coal fired power system consists of the following types:

- Pulverized coal combustion (PC)
- Fluidized bed combustion (FBC)
- Integrated gasification combined cycle (IGCC)

The power generation facilities are very public in nature and must be designed to minimize the occurrence of any problems that would disrupt operation or restrict power supply. As Pakistan has few coal-fired experiences; it is considered that the technical risks in adopting this immature technology, i.e. IGCC, should be avoided.

The vital criteria in selecting which type to be used for the Project are shown below:

- Reliability for continuous production of power -- good commercial record

- Modern and economical design -- high plant performance and low long-term project costs
- Plant operation and maintenance -- matured control system and minimum maintenance
- Environmental impact -- stable emission control

The most vital item above is the reliability, and it is discussed in three types.

As for the PC fired power plant, there are three types in commercial operation; Subcritical (Sub-C), Super Critical (SC) and Ultra Super Critical (USC). Although detailed comparison will be shown later, a PC-fired power technology has been developed long ago with a stable operation record.

As for the FBC boiler, there are two types, namely, Atmospheric FBC (AFBC) and Pressurized FBC (PFBC). AFBC has been used in many occasions for the range of 350 MW; however, there are little operation records for the 600 MW class. Besides this, the units are more complicated in terms of operation and maintenance. The PFBC is still under development; therefore, it is not considered for the Project even though it will give high thermal efficiency in the future. It is judged that both types of FBC are not suitable for the Project.

The IGCC type has been developed and in commercial operation since 1996; however, the technology was not considered to be matured enough. Most of IGCC plants are under the process of improvement and so this type is not suitable for the Project.

(1) Selection of Steam Condition

In order to achieve high net plant efficiency of fossil fuel-fired power plants, materials and metallurgy technology have been developed, and the thermal cycle main steam pressure and temperature have been raised over the years.

As shown in **Table 4-6,** recent large-scale fossil power plants are divided into three categories, i.e., subcritical, supercritical, and ultra-supercritical.

Table 4-6: Categories of Thermal Power Plants

Category	*Boiler type*	*Pressure*	*Temperature*
Subcritical	Drum type	under 22.1 MPa	538–566 °C
Supercritical	Once-through boiler	22.1 MPa and higher	566 °C
Ultra-supercritical	Once-through boiler	22.1 MPa and higher	566 °C and higher

Source: JICA Survey Team

The definition of SC and USC is sometimes different between associations or institutes. In this report the definition by US Electric Power Research Institute (EPRI) is used, where steam condition of 593°C / 593°C is regarded as USC[1]. The comparison of these three categories of power plants are presented in **Table 4-7**.

Table 4-7: Comparison of Three Categories of Thermal Power Plants

Items	*Subcritical*	*Supercritical*	*Ultra-supercritical*
Plant efficiency	Base	Better	Best
Technology expansively	Base	Better	High technology
Construction cost	Base	Higher	Much higher
Maintenance cost	Base	Higher	Much higher (in case of damaged)
Plant operation	Base (manual operation available)	Vulnerable (automation required)	Vulnerable (automation required)
Water quality management	Base	Be cautious	Be cautious
Technical summary	Stable operation but low efficiency	Step up to higher efficiency	Jump up to highest efficiency
Recommendation			Appropriate

Source: JICA Survey Team

As a once-through boiler does not have reserve tank like drum, the boiler has a small time constant for its plant dynamic characteristics, which require quick response on disturbance. Wide range of the highly automatic boiler and turbine control is required. In addition to that, feed water quality should be strictly managed. Otherwise, the boiler tubes would easily corrode and the steam turbine blades would also suffer from scale damage. In spite of difficulties, a once-through boiler is recommended to achieve high efficiency and technical development.

Recently, supercritical units have become the standard selection for large fossil power plants of 600 - 660 MW units in Asia. They are supercritical with pressure of 24 - 25 MPa and temperature of 566 °C / 566 °C. The steam condition of 24.1MPa/ 593°C / 593°C, regarded as USC here, is actually the boundary between SC and USC, and this type also has been established and reliable.

USC is the highest in performance ratio, however, it should be managed with cautious operation and maintenance. The repair cost due to operational errors might be high owing to the use of highly advanced materials and the welding process for the plant's boiler and turbine, which have high temperature and high pressure tolerance.

In terms of power system instability, load fluctuation or load shedding might occur more in Pakistan than in Japan or Europe, hence, thermal stress might be induced into the boiler and

---

[1] Updated Cost and Performance Estimates for Clean Coal Technologies Including CO_2 Capture—2005 Chapter 4, EPRI

turbine materials due to drastic change in temperature thus resulting in the shortened life of materials.

Nevertheless, the high efficient steam condition of 24.1MPa/593°C is recommended for the Project. In addition, it is better to introduce and install advanced technology for the equipment maintenance.

4.3.3 Boiler Design Parameters

For the new Lakhra 660 MW coal fired project, it is recommended to use an USC thermal cycle with main steam pressure at 24.1 MPa and main steam/reheat temperature of 593 ºC. This will enable efficient use of the imported sub-bituminous coals, lower greenhouse gas emissions, as well as reduction in SO_2, NO_x and ash production.

The boiler system with single reheat can attain an efficiency of not less than 83.0% HHV while firing blended coal of 80% sub-bituminous and 20% Thar lignite. The boiler will be sized to deliver 600 MW net power. The steam generator will be designed based on the following:

- Main steam pressure (at turbine inlet): 24.1 MPa
- Main steam temperature: 593 ºC
- Reheat steam pressure: 4.2 MPa
- Hot reheat temperature: 593 ºC
- Main steam flow @ boiler maximum continuous rating (BMCR): 2,200 t/h
- Feedwater temperature: 300 ºC

4.3.4 Coal Feeding and Pulverizer System

The boiler will have six coal bunkers. Capacity of bunkers will be established such that the boiler can be operated with one bunker is out of service at the boiler maximum continuous rating (BMCR) operation. The bunkers will be cylindrical vessels with a conical hopper or rectangular vessels with pyramid hopper. The hopper will have a minimum 70º slope from the horizontal. The capacity of five bunkers shall be determined for 16-hours BMCR operation. The bunkers will be made of steel plate lined with stainless steel. The bunkers will be supported by steel structures with adequate bracing and reinforcing members. The bunkers will be fed with coal on the top by a traveling tripper conveyor. Each bunker will be provided with devices to transmit signals to advise when filling is needed and when to stop. Alarms will be provided to indicate malfunctions in the systems. Provisions will be made for injecting the bunkers with CO_2 gas for firefighting. Besides the main discharge opening leading to a gravimetric coal feeder to the pulverizer units, each bunker will have an emergency door that will allow for dumping the coal on the floor in case of a fire in the bunker.

Coal feeders will be of gravimetric type, with two coal monitors for each feeder with microprocessors to control delivery of the required tonnage of coal to each pulverizer. The gravimetric coal feeders will have an accuracy of 0.25% or better and will be explosion-proof type. All parts in contact with the coal will be fabricated with stainless steel. The electric motor driving for the coal feeders will have variable frequency drive controls.

The pulverizer with vertical shaft type will consist of the shaft and three steel rollers, and electric motor drive, a gearbox velocity reducer, lubricating system, hydraulic system for creating pressure on the roller assembly, hydraulic pump and accumulators. Each pulverizer will receive coals in pebble form, about 2 cm x 2 cm, and will grind them to a powder, about 90% of which will pass through the 200 mesh. Air from the primary air fans heated by the tri-sector regenerative air heater will provide for coal drying and conveying to the burners.

The pulverizers will have a pyrite (pyrite, rock, metal, etc.) rejection system. Rejected pyrites will be collected and conveyed to the ash handling system. Each pulverizer will have a classifier which will collect oversized coal particles and return them to the pulverizer grinding area for further pulverization. Steam or CO_2 will be used for injecting into the pulverizer in the event of overheating that could lead to an explosion. Instruments and controls will be provided to monitor and protect the equipment and personnel from danger.

The burners will be of the staged combustion, low NO_x type. Additional air for combustion will be the secondary air stream and the over-fire air. Shutoff gates will be provided on each pulverizer for separation from unit operation or repair.

Wall-fired units employ self-contained individual burners. Tangential-fired boilers have burners arranged in a package of vertically placed individual nozzles for firing. The flame is produced in the form of a fire ball in the center of the furnace. With tilt burner assemblies, the furnace fire ball can be adjusted upwards or downwards.

In addition to the design measures, following measures will be taken to prevent dust emission:

- Dust extraction/suppression system will be provided at transfer points of conveyor system and ventilation system to supply fresh air;
- Roof extraction fans will be provided in essential areas like crusher house and boiler bunker floors.
- Conveyor belt will be enclosed to prevent dust generation;
- Water sprinkling system will be provided at material handling and storage yard;
- Road within the plant will be asphalted to reduce dust emission; and
- Greenbelt will be developed around the plant to arrest the fugitive dust emissions.

4.3.5 Furnace

The furnace is the chamber where combustion occurs, with the hot gas transmitting heat by radiation to the water walls and by radiation and convection to the pendant surfaces located in the upper zone of the furnace. The burners are located either on the front or front and rear walls, or on corners of the furnace in a tangential-firing system. Hot flue gases flow upwards in the furnace, then to the back pass with convective heat exchange surfaces.

Finer ash particles (fly ash) will be entrained by the flue gas flow. Heavier particles (bottom ash) fall into the bottom hopper below the furnace where they are collected and removed. The front, rear and sides of the furnace are of membrane walls with fully welded fins with tubes. The roof is also of membrane walls. Openings will be provided on the water walls for observation of furnace conditions and for soot blower penetration. The bottom hopper will be entirely water cooled; with two sides inclined and so arranged that no obstruction exists that can impede the discharge of bottom ash

Pendant heat exchange surfaces are placed in upper zone of the furnace and the cross-over section to the back pass. The back pass contains horizontal tube sections of primary superheater, reheater and economizer. The main air heaters will be vertical shaft, regenerative trisector type with flue gases flowing downward through one section, and the primary and the secondary air flowing upward through the other two sections. To meet environmental requirements, the primary means of reducing NO_x emissions will be low-NO_x burners, over-fire air injection and, if required, gas recirculation.

4.3.6 Superheater and Reheater

The superheaters and reheaters will be arranged such as to uniformly distribute the steam temperature at all loads. Consideration will be given to the thermal expansion of headers, spacers and supports, and to accessibility for maintenance work. Pendant and horizontal tube sections will be arranged parallel to the direction of flue gas flow to minimize slag buildup.

There will be sufficient surface provided in the platen and pendant sections to maintain the furnace exit temperature bellow 1,100 ºC at boiler continuous maximum rating (BMCR) and all other loads.

4.3.7 Economizer

The economizer will be of continuous loop type arranged for upward flow of water and downward flow of flue gases. The tubes will be bare type or finned type. The economizer will be arranged with tube banks of not more than 2 m depth, with steam soot blowers between banks.

A pyramidal watertight hopper will be arranged under the economizer to collect the coarse economizer fly ash.

4.3.8 Boiler Setting and Insulation

The boiler will be balanced draft for outdoor installation with a roof cover and local roofs at the burner level. The furnace inside surfaces will partially be covered by refractory insulation, and outer surfaces are covered by insulation and lagging. Furnace and rear pass enclosure walls will be suitable for water washing.

Hinged access doors, arranged to permit convenient and safe access for maintenance work will be provided at main platform levels. The furnace, back pass, fans, air heaters, flue ducts, hoppers and piping will be firmly insulated and provided, as needed, with lagging so that the outside surface temperature will not exceed the ambient air temperature by more than 20 ºC. All thermal insulation will be made from non-corrosive and non-asbestos materials.

4.3.9 Air Heaters

Two 50% capacity each vertical shaft regenerative-type air heaters will be provided to heat the primary and secondary air, taking heat from the boiler flue gas. The air heater rotor will be driven by an electric motor, through a totally enclosed speed reduction drive unit. The rotor shell will be constructed of steel plates.

The air heater will have an automatically adjustable sealing system designed to keep the maximum air heater leakage below 5% of the air flow entering the heater at all loads. The heater shaft will be made of corrosion-resistant steel, and the heating elements will be readily removable. Platforms at air heater level will be provided for basket lay down area. The hot and intermediate sections will be made of carbon steel plate and the cold end of low alloy corrosion-resistant steel plate.

The air heater radial bearings will be self-aligning anti-friction type and the thrust bearing will be pivotal segmental and anti-friction type with flat cylindrical rollers. Bearing housings are oil-tight and readily accessible. An oil lubricating system, including oil reservoir pump with motor, oil coolers, instrumentation and controls, will be provided for each air heater. The air heaters will be provided with stationary soot blower, water deluge system for fire protection and a fire detection and alarm system.

A steam air heater will be provided to prevent acid corrosion of the regenerative air heater cold end baskets and housing.

4.3.10 Air and Flue Gas Fans

The boiler will be provided with two primary air (PA) fans, two secondary air forced draft (FD) fans, and two induced draft (ID) fans. The PA fans will take outside air, pass it through the tri-sector air heater, and discharge it into the coal pulverizers to dry the coal and to convey the pulverized coal to the burners. The secondary air FD fans will take outside air, pass it through the tri-sector air heater, and then discharge it to the wind boxes to support the combustion process.

The ID fans will draw flue gases from the boiler, cool them in the tri-sector air heaters, and pass them first to the electrostatic precipitator (ESP) to remove suspended particles and then to the flue gas desulfurization (FGD) equipment for removal of sulfur dioxide, before discharging to the atmosphere through the stack. The PA fans will be centrifugal type, while the FD and ID fans will be axial flow type. The PA and FD fans will be located inside the boiler area with sound attenuating screens at their inlets, and the ID fans will be located outside of the boiler area. All fans will be designed for continuous operation over their entire operating range without excessive vibration, surging or other undesirable characteristics.

The PA, FD and ID fans will be designed so that both pairs of fans operate in parallel to produce the flow and pressures required for the boiler operating. The design margins are 1.2 times for the flow and 1.3 times for the pressure head of the BMCR condition. Fans will be connected with their electric motor drives via flexible couplings, which will all be provided with guards. Each fan will be provided with a lubricating oil system, oil coolers, and vibration monitor.

4.3.11 Soot Blowers

The boiler will be provided with soot blowers to maintain the cleanliness of the heat transfer surfaces. These will include rotary wall blowers in the furnace water walls and retractable soot blowers where flue gas temperature is above 540 ºC, and partially retractable blowers at gas temperatures of 540 ºC and below. Where gas temperatures are 300 ºC or lower, fixed soot blowers will be used. The blowing medium of the blowers will be steam at pressure and temperature not less than 1.7 MPa and 230 ºC, respectively.

Rotation speeds of the retractable blowers will be adjustable in the field to provide some latitude if experience shows that the original choices require corrections. A completely automatic programmable control system with monitor and keyboard panel will be provided for the remote control of blower operations.

4.3.12 Fuel Burning Equipment

A boiler typically uses the following equipment in its fuel burning system:

- Main burners
- Warm-up burners
- Remote control igniters
- Flame detectors
- Burner throat ceramic tiles

The main burners will be of staged combustion, low NO_x type. The main burners will be sized and located so that the boiler can be stably operated in the load range from the boiler maximum continuous rating (BMCR) to partial loads of 30% when burning the specified blended coal without the use of oil burners. The burners should have a stable turndown minimum ratio of 3 to 1. The main burners will have a peek door with tinted glass to permit flame observation. Registers will be equipped with register drives and position indicators arranged for remote operation and from burner platform.

Warm-up burners will be designed for light fuel oil with mechanical or steam atomized construction. The warm-up burners will be retractable along with all piping, including emergency shut-off valves. Warm-up burner operation will be subject to all protection requirements of the burner control system.

The remotely controlled igniters will be electrically initiated, retractable type designed to burn light fuel oil and to be disconnected for rapid replacement. The igniters will be Class 1, as defined by NFPA 85E. Flame detectors with associated controls will be provided to shut off fuel automatically and actuate alarms on loss of flame, as required by NFPA 85D and 85E. Flame detector controls will interface with the DCS burner management system.

4.3.13 Ducts and Wind Boxes

Flue ducts and wind boxes will be designed to withstand internal transient pressures in accordance with NFPA 8502. Ducts will be constructed of steel plates not less than 6 mm thick and reinforced with steel angles and straps. Expansion joints in the ducts will be installed to permit free movement of ducts and expansion. Dampers of the balanced multiple leaf type will be provided in flanged duct sections with rigid shaft mounted on ball or roller bearings.

4.3.14 Coal bunker Design

The boiler coal bunkers will be cylindrical with conical hoppers or rectangular with pyramid hoppers. The hopper funnel will be angled at 70º to the horizontal to ease flow. The bunker will be made of stainless steel-clad steel, with a corrosion allowance of 2 mm or more. Discharge from the bunkers will be through gate valves and gravimetric coal feeder to the respective pulverizer.

Coal fire in the bunkers should be recognized at once and dealt with. The pulverizer will be provided with an inert gas system (nitrogen, carbon dioxide or steam) which will be injected upon activation of the temperature-based alarm system. The coal bunkers discharge piping should have an additional emergency system that allows for rapid dumping of the bunker contents onto the ground to be dealt with by fire extinguishers.

4.4 Steam Turbine and Auxiliaries

(1) Turbine System

In a large-scale thermal power unit, the steam turbine is one of the most important equipment. A steam turbine must ensure the reliability, stability, and economic performance. Therefore, the steam turbine and auxiliary equipment for nominal gross power of 660 MW for the new power plant must have stable design and be practically proven through operation in other similar-capacity units. For the Project, the tandem compound type is selected (**Table 4-9**).

Table 4-8: Main Design Specifications for the Turbine Plant

Equipment		*Specification*
Main Turbine		
Basic Specification	Type	Tandem Compound Condensing Turbine
	Rated speed	3,000 rpm
	Main steam pressure	24.1 MPa
	Main steam temperature	593 ^oC
	Hot reheat steam pressure	4.2 MPa
	Hot reheat steam temperature	593 ^oC
	Main steam flow	1,900 t/h
	Exhaust steam pressure	11.1 kPa abs

Source: JICA Survey Team

(2) Main Steam Turbine Auxiliary Systems

In the turbine system, the following main equipment/systems will be provided:

- Steam turbine and generator
- Turbine-generator control system
- Hydraulic oil system
- Lubricating oil system
- Gland seal steam system
- Main steam and hot/cold reheat systems
- HP bypass and LP bypass systems
- Extraction steam system and Feedwater drain systems
- Condenser
- Condensate system
- Deaerator
- Boiler feedwater system
- Condensate make-up system
- Cooling water system

4.5 Condenser and Condensate System

Steam turbines extract power from steam as it passes from high pressure and high temperature conditions at the turbine inlet to low pressure and lower temperature conditions at the turbine outlet. Steam exiting the turbine goes to the condenser, where it is condensed into water.

The condensation process creates the low pressure conditions at the turbine outlet. Lower exhaust pressure results in greater generation of energy that is available to drive the turbine, which in turn increases the overall efficiency of the system.

The exhaust pressure of the steam turbine (or vacuum) is a function of the temperature maintained at the condensing surface which is dependent on the design and operating conditions within the condensing system (e.g., surface area, materials, cooling fluid flow rate) and especially the temperature of the cooling water used to absorb heat and reject it from the condenser.

In addition to the above main purposes, the condenser has following functions:

- Conserve the high purity water (condensate) for reuse in the boiler - turbine cycle that minimizes water treatment costs for makeup water.
- Receive and condense the exhaust steam from the boiler feed pump turbine drives.
- Serve as a collection point for all condensate drains, steam vents and dumps.

- Deaerate the condensate to reduce corrosion potential in the cycle system components.
- Serve as a heat sink for the turbine by-pass steam during startup, shut-down and emergency unit trip.

The condenser air evacuation system will consist of two mechanical vacuum pumps one of which will hold the vacuum in the condenser during operation. A mechanical hogging pump will be provided to evacuate air from the condenser shells during unit startup. A sponge rubber ball condenser tube cleaning system will be used to maintain and clean the condenser tubes. The balls will generate contact pressure on their way through the condenser tube, by which fouling will be removed from the inner tube. The process will work automatically, and the tubes will be continuously cleaned of mud, algae and scaling. The condensate pumps will take suction from the condenser hotwell and pass the condensate through low pressure feedwater heaters, the condensate ion-exchange polishing unit, and into the deaerating heater. The purpose of the condensate polisher is to remove any impurities and chemical contamination that may have leaked into the condensate stream from the circulating water system. It will consist of three parallel ion exchanger trains, two in operation and while the third is on standby or regenerating the resin using hydrochloric acid and caustic soda. The wastewaters from regeneration process will be piped to the waste collection basin for further treatment.

Four-stage low pressure (LP) feedwater heaters will take extraction steam from the low pressure turbine cylinders and heat the condensate passed through them. The flow required to maintain the deaerator storage tank level will be controlled by modulating control valves upstream of the LP feed water heaters. The deaerating feedwater heater is where the extraction steam gets in contact with the sprayed-in condensate. The deaerator will be provided with a condensate storage tank in which the heated and deaerated condensate is to be stored. The deaerator will be vented to the atmosphere to reject the noncondensibles separated from the condensate. The deaerated water at any load will have a residual oxygen content not to exceed 7 ppb.

4.6 Generator and Electrical System

4.6.1 Main Generator System

The main generator will be a totally enclosed, three-phase, 3,000 rpm, synchronous machine with hydrogen direct cooled rotor and water direct cooled stator. The generator will be connected to the main transformer by an isolated phase bus duct system. The unit auxiliary transformer receives power from the main generator through a tap into the isolated phase duct system.

The main characteristics of the main generator will be:

- Rated output: 660 MW, 776 MVA
- Power factor: 0.85
- Rated voltage: 22 kV or 24 kV, 3 phase, 50 Hz
- Winding connection: Wye-connection with neutral connected Terminal bushings:

- Terminal bushings basic impulse insulate level (BIL): 110 kV
- Cooling system: Stator coil － Direct water cooling
- Cooling system: Rotor coil － Direct hydrogen cooling (with hydrogen gas pressure of 400 kPa (58 psig) or higher)
- Excitation system: Static excitation system
- Short circuit ratio: 0.55
- Winding insulation: Class F
- Efficiency: 99% or higher.

The generator will be suitable for operation in parallel with other electric generating equipment. The housing will be fabricated to withstand the pressure generated by an explosion of a mixture of hydrogen and air within the housing. All leads, including power, control and instrumentation will be brought out of the casing through gastight seals.

The hydrogen cooling system will consist of four hydrogen coolers, a seal oil unit, and instrumentation and controls. Generator rotor mounted fans will provide hydrogen circulation through the closed system. The carbon dioxide displacement system will be provided to permit purging of the hydrogen within the generator using carbon dioxide and vice versa. The hydrogen coolers will be cooled with water from the closed cooling water system. A hydrogen seal oil system will be provided to maintain hydrogen pressure and purity within the generator casing. The stator water cooling system will be completely independent of any other system and use high purity demineralized water in a closed circulation loop.

The generator bearings will be lubricated by the turbine-generator lube oil system. Heat will be removed by heat exchangers cooled by the plant closed circuit cooling water system.

4.6.2 Excitation System

An excitation system for the main generator will be provided of a static excitation type with automatic voltage regulator and power system stabilizer. Excitation transformer will provide power to the generator excitation system (rotor exciting field). They will be connected to the generator via isolated bus ducts.

4.6.3 Main Transformer

The main transformer will transmit electric power from the main generator to the high voltage transmission system. The transformer will be a three phase, oil filled two-winding unit and will be located outdoors. The transformer will be designed to operate in an environment characterized by an ambient air temperature range of between 10 ^{o}C and 45 ^{o}C. The transformer will be connected to the main generator by an oil insulated/cooled phase bus ducts. The transformer rating and design features will be as follows:

- Rating: 720 MVA
- Cooling: Forced oil and Forced air cooling (OFAF)

- Input voltage: 22 kV or 24 kV (LV)
- Output voltage: 500 kV with on-load tap changer (OLTC at HV side)
- Phase: 50 Hz, 3 phase
- Winding: HV wye, LV delta
- Grounding system: High voltage neutral point direct grounding
- Winding temperature rise: 60 ^{o}C (at OFAF)

The transformer core will be made of high grade, non-aging silicon steel of low hysteresis loss and high permeability. The coils will be wound with copper and the coil isolation designed for continuous operation at 60 ºC rise without deleterious effect. The transformer will be provided with two complete independent groups of cooling equipment. Each group will comprise of an air cooled radiator heat exchanger and cooling pump.

4.6.4 Auxiliary Transformers

A unit auxiliary transformer will be installed to supply all unit auxiliary loads to permit the maximum output capacity of the plant. It will take power from the main generator via the isolated bus duct tap-in ducts. The unit auxiliary transformer will be located outdoors, and its rating will be:

- Rating: 70 MVA
- Cooling: Oil natural circulation and Forced air cooling (ONAF)
- Input voltage: 22kV or 24 kV
- Output voltage: 6.6 kV
- Frequency: 50 Hz, 3 phase
- Winding: HV delta, LV wye x2
- Grounding system: Low voltage neutral point transformer/resistance combination
- Winding temperature rise: 55 ^{o}C (at ONAF)

4.6.5 Start-up Transformers

For start-up, electric power for auxiliaries is taken from the electrical grid via the start-up transformer. The start-up transformer has the same MVA rating as the unit auxiliary transformer, so that it could serve as a back-up in case the unit auxiliary transformer had an emergency outage or is taken off line for maintenance or repairs. The start-up transformer is located outdoors, and its rating will be

- Rating: 70 MVA
- Cooling: Oil natural circulation and Forced air cooling (ONAF)
- Input voltage: 500 kV (HV)

- Output voltage: 6.6 kV (LV)
- Frequency: 50Hz, 3 phase
- Winding: HV wye, LV delta x2 with embedded delta
- Grounding system: Low voltage neutral point transformer/resistance combination
- Winding temperature rise: 55 ^{o}C (at ONAF).

4.6.6 Medium Voltage Switchgear

The medium voltage 6.6kV auxiliary system will consist 2(two) groups by dividing the LV winding of the auxiliary transformer and the start-up transformer into two winding respectively. The medium voltage 6.6kV auxiliary system will distribute power to the low voltage load centers and to the 6.6kV motors from either the unit auxiliary transformer or the unit startup transformer. The 6.6kV switchgear will be rated to withstand and interrupt the maximum short-circuit current 40kA. The full load current rating of the 6.6kV bus will be 3,000 A.

The system will use a fast bus transfer system in the event of a unit trip or loss of the unit auxiliary transformer. The transfer will utilize a contact of the incoming feeder breaker from the unit auxiliary transformer to initiate the closing of the start-up transformer supply breaker. The transfer will be blocked in the event of a 6.6 kV bus fault, loss of voltage at the start-up transformer, or a protective relay trip of the 6.6kV main breaker.

Protective relaying and metering will be provided to prevent equipment damage. The protective relaying is such that the breaker closest to the fault will trip first. The 6.6 kV buses will be metal-clad switchgear and utilize vacuum circuit breakers, which will be of the draw-out, electrically operated and stored energy type. The 6.6kV switchgear will be located indoors. Open/close time of the breakers will be 0.2 sec.

4.6.7 Low Voltage Load Centers and Control Centers

This will consist of 6.6 kV/440V dry-type power transformers and 440V switchgear and motor control centers. The transformers will be located indoors with two-winding, three phase, 50 Hz, insulation Class F, forced air or natural circulated air (AF/AN) cooling and LV grounding via resistance.

The low voltage auxiliary system load centers will be arranged a split bus type and double-ended, with two bus sections connected by a normally open bus tie breaker. Each bus section will be fed from a separate power transformer and the tie breaker will be connected the 6.6kV auxiliary system and transformer secondary main breaker by cable through a disconnect link. During normal operation, each bus section will be fed from its associated power transformer. Upon loss of a transformer or its feed, the load will be manually transferred to the alternative source by bus tie breaker closing. The 6.6kV main bus tie and the 440V load centers bus tie breakers and the motor feeder circuit breakers will be operable from the main control room.

4.6.8 Electrical Motors

All medium and low voltage motors will be designed to start fully loaded by the driven equipment and to accelerate their connected loads to rated speed with a minimum of 80% of rated terminal voltage. Motors of 200 kW and larger size will be fed from the 6.6kV switchgear.

Motors smaller than 199kW will be fed by the low voltage load centers and motor control centers. All motors will be built with class F insulation. Motors that smaller than 0.75 kW will be single phase, 220V AC. Direct current motors will be powered by the 110V DC system.

4.6.9 DC Power System

The direct current (DC) system will consist of batteries, battery chargers, DC switchboard and distribution panel boards. The batteries will be sized to supply emergency power for two hours in the event of loss of AC power, and have sufficient current to feed all critical plant loads at the nominal voltage level.

The DC system will provide power to circuit breaker control circuits, DC motors and all DC plant loads. The batteries will be lead-acid, low maintenance sealed cell type. Two DC power systems will be installed, one for the generating unit and one for the switchyard.

4.6.10 Un-interruptive Power Supply Equipment (UPS, CVCF)

The AC110V un-interruptive power supply equipment will supply a high quality stable power with constant voltage and constant frequency appropriate to the demand of the load side. The UPS system will comprise two inverter/static switch modules, connected in a parallel redundant mode, such that they normally share the load. Upon the failure of one module, it will automatically shut down and the other module will take the full load.

Under normal operation, the UPS power will be supplied from AC 110V line to be rectified DC 110V feeding to AC inverter. If AC power is lost, the station battery will feed into the inverter of UPS.

4.6.11 Emergency Generator System

The emergency diesel generator system will be utilized to supply AC power to selected plant loads following a loss of station AC power. The diesel generator and its auxiliaries will be independent operated and capable meet all power requirements in the power plant.

The diesel will receive a start single from an under-voltage relay from the emergency bus. Following a brief time delay, the diesel will start and come up to rated frequency and voltage. The operator will then close the breaker to energize the diesel to the emergency service bus of power unit.

4.6.12 Cable Systems

Cable systems connect the power sources to the electrical equipment and devices. The voltage ratings of cables and wiring will be:

- Medium voltage power cables: 10 kV

- Low voltage power cables: 600 V
- Lighting and small power cables: 600 V
- Control and instrument cables: 600 V

Medium and low voltage power cables will consist of soft-drawn copper conductor and cross-linked polyethylene (XLPE) insulation and polyvinyl chloride (PVC) jacket. The jacketing material will be rodent-proof with good flexibility and long-term resistance to sunlight, moisture and oils, and will not propagate combustion flames. Outdoor above-ground cables will be installed in conduits and cable trays. Underground cables will be installed in underground duct banks or in trenches. Cables of different types will be grouped and routed separately for safety. Medium voltage cables will be routed separately from other cables.

4.7 Circulation Water and Cooling System

4.7.1 System Description

The circulating water system—the main heat rejection system—consists of structures and mechanical equipment which serve the main condensers and cooling water systems to reject plant heat to the atmosphere. The makeup water to the system will be taken from the Indus river and treated by clarifiers with the addition of chemicals to reduce hardness. The main components of the circulating water system are cooling towers, circulating water pumps, condenser and its associated valves, and instrumentation and controls.

4.7.2 System Design Basis

The closed circulating water system flow through the condenser will be about 60,000 m^3/h per unit, based on a design wet bulb temperature of 28.6 ºC, cooling tower range of 10 ºC (difference between the temperatures of the hot water entering the cooling tower and the cold water collecting in the tower basin), and a cooling tower approach of 7 ºC (difference between the temperature of the cold water leaving the cooling tower and the ambient air wet bulb temperature of the water entering it). Makeup water required by the system will be about 1,650 m^3/h per unit, with 300 m^3/h for blowdown. The circulating makeup water will keep the water chemistry at an acceptable level to prevent salt deposition. The water characteristics are shown in **Table 4-9**.

Table 4-9: Circulating Water Chemistry

Parameter	*Makeup Water*	*Circulating Water*
Temperature, ºC	35	35.6 - 45.6
pH	7 - 8.5	7 - 8.5
Conductivity, µmhos/cm	350 - 500	1,500 - 2,200
Suspended solids, mg/l	15 - 50	40 - 90
Total hardness, mg/l as CaCO3	80 - 150	250 - 500
Total dissolved solids, mg/l	200 - 500	1,000 - 1,600

In order to maintain chemical levels as indicated above, water from the cooling tower basin will be continuously removed through blowdown and dumped into the wastewater collection basin for reuse in various plant services, such as ash handling and coal dust suppression.

4.7.3 Cooling Tower

The cooling towers cool the heated circulating water by evaporation process that occurs when water droplets are brought into direct contact with the upwards-flowing ambient air, i.e., the wet-type cooling tower process. In general, there are two types of wet-type cooling towers operated by the power industry: mechanical draft and natural draft.

Mechanical draft towers use motor and fans to create an upward air flow. This type of system has lower construction costs but is complicated to maintain and consumes significant electrical power to operate. On the other hand, natural draft cooling towers achieve the desired air flow using the hyperbolic shape of the concrete tower that creates a ‘chimney’ effect. The size of the tower generally is larger and it therefore requires higher construction cost, yet no electricity is needed for its operation. Either mechanical draft or natural draft cooling towers can be used for the new Lakhra 660 MW coal fired project; however, the advantage of the natural draft cooling tower over the mechanical draft design is the fact that it does not consume electric power to drive the fans, nor require constant repair, maintenance and replacement of the fans. For this reason, the natural draft cooling tower is recommended for the proposed Lakhra project. Most large power units where no once-through cooling system is available use natural draft cooling towers for cooling circulating water. The natural draft cooling tower is constructed as a hyperbolic concrete shell and filled with certain materials in the interior. Atmospheric air is sucked in by the natural draft created by the concrete structure shape, ambient air flows upwards against the splashing water droplets and exits at the top of the tower. The cooling tower for one 660 MW coal-fired unit will have a base diameter of about 110 m and a height of about 140 m.

The tower structure is generally constructed of a combination of reinforced concrete and FRP, the tower fill PVC or treated wood. The hyperbolic natural draft tower is extremely dependable and predictable in its thermal performance. Air flow through this tower is produced by the density differential that exists between the heated (less dense) air inside the tower and the relatively cool (more dense) ambient air outside. Although hyperbolic towers are more expensive to build than mechanical towers, they are used extensively in the field of electric power generation where long amortization periods allow sufficient time to recover the capital cost of the tower.

4.7.4 Circulating Water Pumps

Water cooled by the cooling tower will be collected in the cooling tower concrete basin, which will have an extension that serves as the pumps’ intake structure. For the natural draft hyperbolic tower, a common intake structure for all pumps will be provided. There will be four 25% capacity vertical wet pit-type circulating water pumps. Their discharge head will be 30 m of water column, necessary to overcome the pressure drop through the condenser, piping system and to raise the water to the elevation required for water distribution.

The pump pit will be designed to be deep enough so that the water level in the pit satisfies the pump's required NPSH (net positive suction head). In order to reduce the required NPSH, the pumps will be operated at a relatively low speed not to exceed 500 rpm, and will be designed with a first stage that requires a low suction head. Stop logs will be provided to facilitate isolation of a pump pit for dewatering, cleaning and/or repair. A pair of removable cleaning screens will be provided to filter out any debris flying into the tower. Each circulating water pump will be equipped with an automatically-controlled, motor-operated butterfly discharge valve that will be fully closed when the pump is stopped and fully opened during pump operation.

4.7.5 Closed Cooling Water System

The closed cooling water system will remove heat from various plant equipment and reject it to the service water system and then to the cooling tower. The system will operate as a closed system of clean water with makeup from the water storage basin. It will provide cooling water at 40 ºC under all operating conditions.

The system will supply cooling water to the following:

- Steam turbine lubricating oil coolers
- Generator hydrogen coolers
- Generator seal oil cooler
- BFP turbine lubricating oil cooler
- Condensate pump motor cooler
- Boiler auxiliaries coolers
- Air compressor, inter- and after-coolers
- Sampling coolers.

4.7.6 Chemical Treatment System

Chemical treatment of the circulating water system will consist of periodic chlorination through diffusers placed in the circulating water pump infrastructure. pH control will consist of sulfuric acid injection into the cooling tower basin. Chlorination is to be achieved by injection of sodium hypochlorite produced on site. The sodium hypochlorite generator will consist of a salt storage tank, salt dissolver tank, two full-capacity saltwater transfer pumps, a circulation tank, two full-capacity circulation pumps, and a sodium hypochlorite storage tank. Two full-capacity sodium hypochlorite injection pumps, one operating when needed and the other on standby, will be provided to control algae and bacterial grow in the circulating water system. A control and monitoring system will be installed to provide control of chemical dosage, so as to assure safe operation of the system and its components.

4.8 Freshwater System

The freshwater system will take water from the Indus River (**Figure 4-4**). Permission from the Irrigation Department of the Government of Sindh will be required to obtain water from the Indus River.

The additional water intake facility will be installed in the Indus River which will be located approximately 3 km downstream of the existing water intake tower. The additional water conveyance pipeline will be installed along the existing road, which is approximately 6.5 km in length.

The required quantity is about 2,200 m^3/hr for the 660 MW unit. The historical water levels of the Indus near the Kotri Barrage are as follows:

- Flood level (FL): 23.2 m
- High water level (HWL): 20.8 m
- Low water Level (LWL): 18.9 m
- Low-Low water level (LLWL): 14.8 m

The river flow velocity ranges from 0.2 m/s to about 0.4 m/s. River bottom soundings show shifting in the riverbed. The suspended sediment concentrations range from 680 to 3,500 ppm. Lowest water levels usually occur during the winter season.

In locating the intake structure for the units, consideration will be given to the existence of the water intakes for and the scouring of the river bed. The concrete intake structure is to be built on pile supports. Water will be pumped to the power plant, where it will be first stored in a raw water retention basin or storage tanks and then pretreated for distribution to various plant water uses. The total storage capacity of the retention basin will be about 80,000 m^3. At the river shore, a concrete intake structure is to be built with three pump bays. Water flowing to the intake will pass through the fixed rake bars that will stop any large floating debris. A trash rake that travels on rails removes debris from the trash bars and dumps them into a trash hopper for disposal.

Source: JICA Survey Team

Figure 4-4: Proposed Water Intake and Wastewater Discharge Pipelines

A set of stop logs will allow any of the intake bays to be isolated, as required. The water will be first cleaned by the traveling screen, which will have a fine screen mesh with 6 mm x 6 mm openings. The water pumps will be of vertical construction, each designed for 1/3 capacity, all in operation as needed to keep the raw water retention basin level constant. Two 100% capacity screen wash pumps will be used to periodically wash the traveling screens. Provisions will be made to allow fish to return to the river before reaching the traveling screens or being sucked into the raw water pumps. A pipe will forward the water to the plant’s raw water retention basin. From the raw water retention basin, three 50% capacity pumps will feed the pretreatment plant clarifiers. Two pumps will be in normal operation, the third on standby. The raw water river pumps will be of vertical construction, multi-stage, water lubricated and with electric motor drivers. The intake structure will have a service deck for lay down of equipment for repair, and where the electrical switchgear and motor control center will be located.

Control of microbiological organisms in the raw water system will be done by use of chlorine as a biocide. The chlorine will be injected into the intake structure between the traveling screens and the raw water pumps. A covered shed on the intake structure deck will store the chlorine and the injection control system. The pipe between the pump discharge and the raw water retention basin at the plant will be either reinforced concrete or coated steel pipe.

The pretreatment plant will consist of two reactor-clarifiers, followed by a sand filter. The pretreatment system is designed to produce an effluent containing less than 1 mg/l of suspended solids, based on treating Indus river water of the following quality:

- Temperature: 20 to 35 ºC
- pH: 7.5 to 8.5
- Turbidity: 600 to 3,500 mg/l
- Conductivity: 350 to 500 μmho/cm
- Suspended solids: 80 to 950 mg/l
- Total hardness, as CaCO3: 80 to 150 mg/l

The reactor-clarifiers will be used to remove suspended materials. Each unit will consist of two large (30 m diameter and 4.5 m height) cylindrical concrete vessels, in which a central mixing and chemical addition zone will be located. The process takes several stages, the first being coagulation. Coagulating agents, such as aluminum sulfate, ferric sulfate, polymers or others, will be mixed with the incoming raw water in the rapid mixing chamber. Additional floccules will be added to create large flocs, which will be dispersed in the water that flows to the outer circumference of the clarifier where a calmer environment will promote settling of these flocs at the bottom of the clarifier.

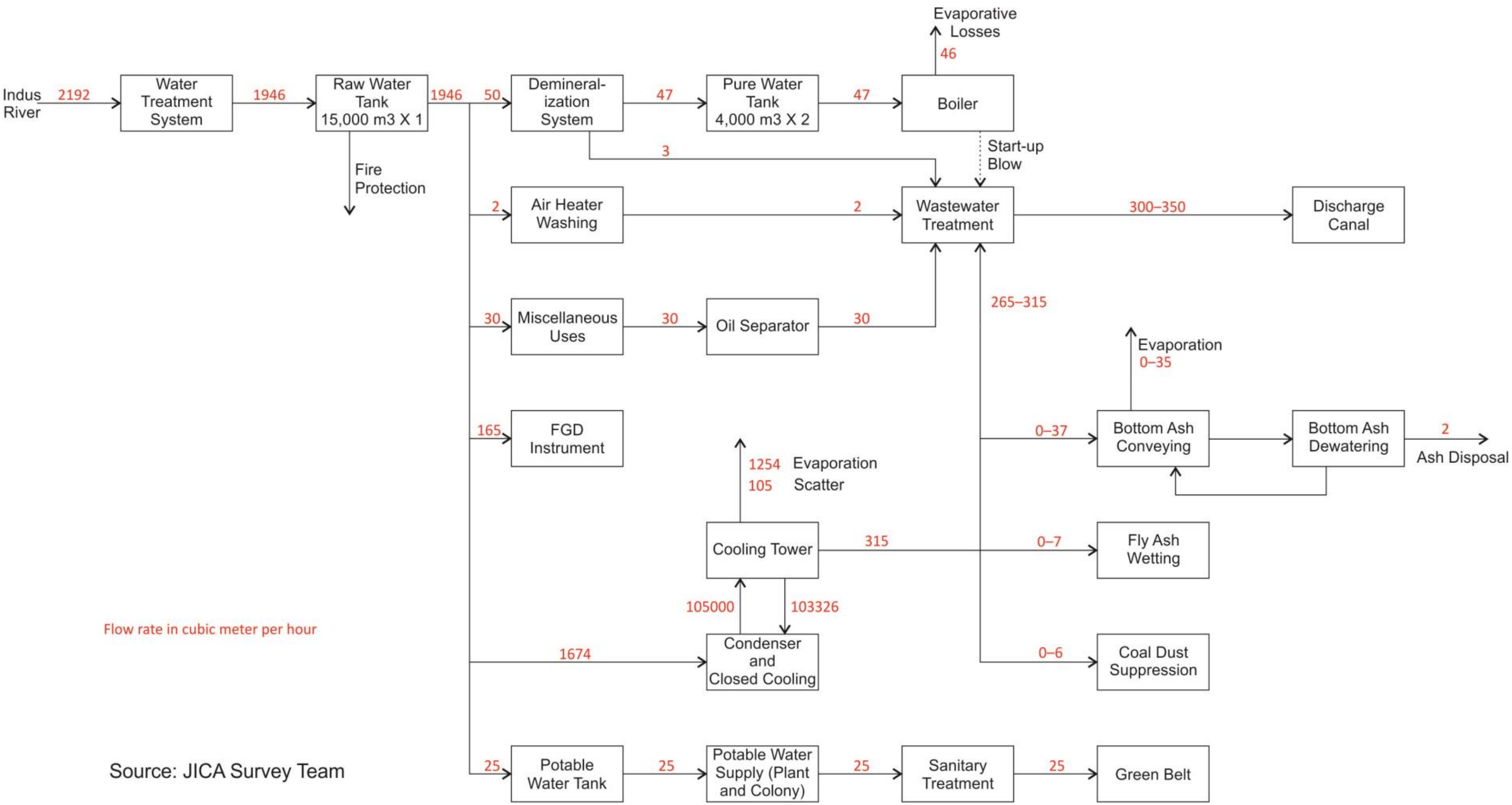
The clarification process will produce two streams: the cleaned water that flows out of the unit at the top in a trough, and sludge at the bottom that contains the solids separated from the raw water. The sludge will be periodically withdrawn from the bottom of the clarifier vessel and disposed of with the ashes. The clean water taken from the top of the clarifier will be further passed through sand filters. The pretreated product water will be stored in a 16,000 m^3 concrete basin from where it will be pumped by 3 x 50% capacity forwarding pumps to various users, the largest of which would be the cooling towers. The pretreated product water storage tank will also serve as the source of fire water, and therefore will have a fixed reserve level always available for fire extinguishing purposes. In case, the conductivity of the river water is high, the pre-treatment water after sedimentation process will be treated by two different processes. The first will be the filtration process through which water will be treated and supplied to the administration building for miscellaneous use. The second will be the deionization process (ion exchange process) through which water will be treated and supplied to the boilers.

The different users of the pretreated water and the daily flow rates for each unit are presented in the water balance diagram shown in Figure 4-5.

Steam cycle makeup will be provided from the demineralized plant. It will consist of activated carbon filter deep bed cation ion exchangers, degasifier anion exchangers and deep mixed bed polisher. There will be three parallel trains for each unit, each designed for 50% dematerialized load, with two trains in operation while the third regenerates resins or remains on standby.

Each train will consist of an activated carbon filter which will remove chlorine and other oxides. From the activated carbon filters, water will enter the deep bed cation exchanger. The resins in the cation exchanger will attach to calcium, magnesium and sodium compounds in the water. The water will then flow to the degasifier, where carbon dioxide is released, after which it will enter the deep bed anion exchanger, which will remove sulfates, nitrides, chlorides, bicarbonates and silicates from the stream. The treated water will then be passed through a mixed bed polisher, which will have both a deep cation and a deep anion bed, producing ultra-pure water for cycle makeup. The treated water will be discharged into a demineralized water storage tank and is pumped to either the condensate storage tank or directly into the condenser hot well where it will mix with the condensate. The demineralized water treatment plant will be housed in a separate building, together with all its pumps, valves, analyzers, instrumentation and programmable logic control (PLC) systems.

Reverse Osmosis (RO) plant may be considered during design stage if deemed necessary to treat the high conductivity river water in low flow conditions



Source: JICA Survey Team

Figure 4-6: Proposed Water Supply System

4.9 Wastewater

The wastewater treatment system will be installed to treat the wastewater generated from each facility in the thermal power station appropriately before discharging into public water bodies.

The additional wastewater drainage pipeline (**Figure 4-4**) will be installed at the same route as the proposed water conveyance pipeline which is approximately 3.8 km in length, and the treated wastewater will be discharged into the existing water channel.

The wastewater will be treated appropriately in accordance with the SEQS.

4.10 Design Coal Specification and Blending

The main fuel for the power plant will be imported sub-bituminous coal. Lignite in the ratio of 20% will be blended with the sub-bituminous coal. The design specification of the fuel is shown in **Table 4-10**.

Table 4-10: Quality of Design Coal

Parameter	*Sub-bituminous (e.g., Imported Coal)*	*Lignite (e.g., Thar)*
	Selected Value	*Selected Value*
Proximate Analysis (Air-dried basis)		
Moisture (%ad)	14.3	47.6
Ash (%ad)	8.9	14.9
Volatile Matter (%ad)	39.5	47.9
Caloric Value		
High Heating Value (HHV) (kcal/kg)	5,000	3,146
Ultimate Analysis (Dry Ash Free basis*)		
Carbon (%daf)	76.6	74.0
Hydrogen (%daf)	5.52	6.1
Oxygen (%daf)	16.0	18.0
Sulfur (%daf)	0.7	2.5
Nitrogen (%daf)	1.15	1.0

*Excluded all moisture and ash

Note: Total values of ultimate analysis are not 100% due to numbers under decimal points.

Source: Indonesian Coal Book 2012/2013, as of typical value of Arutmin 5000, and SECMC for Thar lignite

For the purpose of design, blending percentage of Lignite has been considered to be 20%. The fuel properties under these blending scenarios are shown in **Table 4-11**.

Table 4-11: Blended Fuel Properties

Parameter	*Coal "Singularity"* *Sub-bituminous 100%*	*Coal "Blend"* *Sub-bituminous 80%+Lignite 20%*
Proximate Analysis (Air-dried basis)		
Moisture (%ad)	14.3%	20.96%
Ash (%ad)	8.9%	10.1%
Caloric Value		
High Heating Value (HHV), kcal/kg	5,000	4,629
Ultimate Analysis (Dry Ash Free basis*)		
Carbon (%daf)	76.6%	76.1%
Hydrogen (%daf)	5.52%	5.64%
Oxygen (%daf)	16.0%	16.4%
Sulfur (%daf)	0.7%	1.06%
Nitrogen (%daf)	1.15%	1.12%

*Excluded all moisture and ash

Note: Total values of ultimate analysis are not 100% due to numbers under decimal points.

Source: JICA Survey Team

4.11 Coal Consumption

The total coal consumption will depend on the ratio of blending of sub-bituminous and Thar coals. The coal consumption for the 660 MW plant for two possible scenarios is shown in **Table 4-12**.

Table 4-12: Coal and Limestone Consumption

Coal	*Sub-bituminous*	*Lignite*	*Total*	*Limestone*
Daily Consumption (tons)				
Coal "Singularity"	6,816	0	6,816	90
Coal "Blend"	6,053	1,513	7,567	108
Annual Consumption at 80% Plant Factor (million tons)				
Coal "Singularity"	2.00	0	2.00	0.026
Coal "Blend"	1.76	0.44	2.21	0.032

4.12 Ash Handling and Disposal System

Coal combustion residuals (CCRs), commonly referred to as coal ash, are the materials that remain after burning coal for electricity. CCRs to be produced at the Project include the following:

- Fly ash;
- Bottom ash; and
- Flue gas desulfurized gypsum (FGD gypsum)

4.12.1 Production and Handling

Table 4-13 provides the estimates for the ash and gypsum to be generated for both stages of the project. Assuming worst case of design coal, a blend of 80% sub-bituminous coal and 20% lignite (Blending Coal "Blend" in **Table 4-13**), and 80% plant factor, total ash production is estimated at 223,159 t/y with fly ash at 200,843 t/y and the rest being bottom ash. Production of FGD gypsum is estimated at 46,841 t/y.

During combustion in the furnace, bottom ash will fall down to the boiler bottom hopper from where it will be conveyed into a bottom ash silo. The remainder of the ash generated during combustion will be carried over in the flue gases as fly ash. The electrostatic precipitator (ESP) installed between the boiler and the stack will remove almost all the fly ash and collect it in hoppers.

In the flue gas desulfurization (FGD) facility limestone slurry will be sprayed into the flue gas stream where sulfur dioxide will react with the limestone to form a mixture of calcium sulfite and calcium sulfate (gypsum). This mixture will be collected at the bottom where air will be injected to convert the calcium sulfite into calcium sulfate. The gypsum thus produced will be collected in a bin for disposal.

Table 4-13: Ash and Gypsum Production

	Daily Production (kg)			*Annual Product at 80% Plant Factor (t)*		
	Bottom Ash	*Fly Ash*	*Gypsum*	*Bottom Ash*	*Fly Ash*	*Gypsum*
Coal "Singularity"	61,090	549,806	96,096	17,838	160,543	28,060
Coal "Blend"	76,424	687,819	160,415	22,316	200,843	46,841

Source: JICA Survey Team

4.12.2 Ash Disposal

All the fly ash will be temporarily stored in ash silos. However, later it will be either transported in its dry form to cement companies for recycling or will be disposed in the ash ponds. Trucks will be used to transport ash from the source to the silos as well as from silos to the cement companies. Gypsum will initially be stored in silos. Gypsum that cannot be recycled will also be transferred to the ash pond for storage. The description of the potential impacts along with the mitigation measures associated with the transportation of ash to the ash pond is outlined in Table 9–1.

Ash produced will contain low concentrations of toxic metals such as arsenic, selenium, lead, and mercury. For disposal in the ash pond it is therefore important to create an impermeable layer under the disposal site that will remain impermeable under the weight of the wastes stored on top of this foundation layer. The impermeable layer will be a thick layer of compressed clay or a plastic membrane. Once a segment is filled, it will be be covered with a layer of top soil and seeded with vegetation to prevent dust generation due to wind. A new segment adjacent to the first one will then be created, and so on until the entire ash pond area is covered with vegetation.

About 29.4 ha (72.77 acres) of land are allocated as the ash disposal site with the capacity of about 5 years of ash and gypsum waste for the 660 MW project, assuming no utilization of ash for commercial purposes. Of the 29.4 ha land, about 11.4 ha (28.2 acres) is to be newly acquired whereas the remaining is owned by LPGCL. The life of the ash pond will increase If LPGCL is able to find consumers for the ash after commissioning of the proposed Power Plant. If, on average, 50% of the ash is recycled, the life of the pond will increase to 10 years. This means that LPGCL will require additional land for disposal of ash. The requirement may arise as early as 5 years after commissioning of the power plant or may be delayed as much as 10 years, if LPGCL undertakes an aggressive recycling policy. As acquisition of land may take as much as two years, LPGCL will undertake an assessment of additional land requirement three years after commissioning and initiate land acquisition process based on the assessment. If in the assessment, it is determined that no additional land will be required in the four year period following the assessment, the assessment will be repeated two years later, i.e., five years after commissioning.

4.13 Flue Gas Treatment System

4.13.1 Electrostatic Precipitators

The boiler will be equipped with a dry electrostatic precipitator (ESP) to be located between the air heater outlet and the flue gas desulfurization (FGD) unit inlet. The purpose of the ESP will be to minimize loading of particulates (fly ash and unburned carbon) at the entrance to the FGD, primarily in order to meet product quality requirements of saleable gypsum as well as to meet the stack emission limits for particulates.

The ESP may be rigid electrode or rigid frame design. Total flue gas flow will be about 2 million Nm^3/hr and particulate loading, without treatment will be about 4,629 mg/Nm^3. The ESPs will be designed to have an efficiency of not less than 99.7% and will limit the outlet flue gas particulate loading to below 44 mg/Nm^3 at all loads when burning design coal (*Note:* Particulate emission will be further reduced in the absorber and mist eliminators of the FGD system prior to leaving the stack).

The ESP will have multiple, independently powered electrical sections. The electrical sections will be arranged in at least two 50% independent load groups, such that a loss of power supply to one load group will not affect the performance capability of the electrical section served by the other load group.

The ESP will be a self-supporting structure designed for outdoor installation. It will be able to withstand all external forces simultaneously with all internal forces created due to pressure, dust loading, operating temperatures and the dynamic loading imposed by vibrators and rappers. Airtight expansion joints will be provided to accommodate the thermal expansion of the breaching and casing. The roof will be designed to support maintenance personnel and tools in addition to all other external loads. The ESPs will be designed with 10% extra plate collection area. All metal parts of the collector subject to abrasion and wear will have a 3 mm corrosion allowance, except for discharge and collecting electrodes.

A rapping system will be provided for cleaning electrodes and collecting plates. It will be capable of 50g acceleration normal to the most remote section of the plates. Rapping frequency and intensity will be adjustable to provide for variation in steam generator operating conditions. The rapping system will operate automatically, and will be such that flue gas puffs and fluctuations in the electrical load are minimized. Rapper controls will be readily adjustable for intensity and frequency, and will be independently adjustable for each electrical field. All electrical parts will be outside of the gas stream.

4.13.2 Flue Gas Desulfurization System

General

The flue gas desulfurization (FGD) system will be designed to treat the flue gas from a boiler using primarily coal and heavy fuel oil as fuel for warm-up start up. It will be designed with efficiency more than 80% to achieve performance requirements under all operating conditions between 40% and 100% of the maximum continuous rated capacity of the boiler. The flue gas flow rate will be about 2 million Nm^3/hr. SO_2 emission, without treatment, will be about 3,436 mg/Nm^3.

The FGD system will be based on the widely used limestone scrubbing technology and will produce a gypsum byproduct that is usable for wallboard production or as an additive in the manufacture of cement. This process is being offered as a process and equipment package by a number of companies.

System Description

The FGD system will consist of the following main subsystems:

- Gas cooling and quenching
- Absorption and slurry oxidation
- Slurry filtration and gypsum handling
- Limestone slurry preparation.

The flue gas will be received from the ESP relatively dust free (<30 ppm) and at the higher temperature of 130 ºC, or 10 ºC above the sulfur dioxide dew-point. It will be cooled to about 90 ºC by the gas cooling heat exchanger. Sulfur dioxide absorption will be accomplished by direct water quench. The water quench consumes a fair amount of water that is lost in the stack.

The first step of the cooling will be accomplished by indirect heat exchange between the incoming hot flue gas and the cold desulfurized flue gas leaving the absorber. The principal purpose of this step is the reheating of the cold, desulfurized flue gas leaving the absorber to about 90 ºC, or a temperature at least 10 ºC above the dew point of the gas at which it leaves the absorber. This, in turn, will achieve two objectives:

- The stack will not be a 'wet' stack with a highly visible plume of condensing water vapor as well as water droplets in the vicinity of the stack, and
- The functioning of the CEM (Continuous Emission Monitoring) system for the continuous control of the environmentally harmful emissions (SOx, NOx, CO, particulate matter) will be enhanced due to the absence of interfering water droplets.

A second cooling step will be accomplished by direct quenching with an excess of fresh pretreated water. This will saturate the flue gas with water vapor and cool it to approximately 60 ºC. The quenching will be accomplished in a vessel with sufficient vapor space and entrainment separation devices to assure good separation of liquid from vapor, in order to minimize carryover of entrained droplets of water into the absorber. Carryover of liquid droplets must be avoided to minimize the introduction of chlorides into the absorber and from there into the gypsum by-product.

After the cooling steps, the flue gas will enter the absorber. Generally, the absorption vessel is combined with the gypsum oxidation vessel, which is in the lower part of the absorber. The reactions taking place in the absorber/oxidizer may be summarized in a simplified manner as follows: The flue gas is contacted counter currently with a series of sprays of limestone slurry and gypsum. The SO_2 and calcium carbonate solution at the surface of the limestone particles form calcium sulfite, which precipitates as a solid and falls to the bottom section of the absorber. Air is sparged into the slurry at the bottom of the absorber and oxidizes the sulfite to calcium sulfate.

The process conditions will be controlled by maintaining the pH in the slurry to achieve a selected outlet SO_2 concentration in the stack. The pH will be controlled, in turn, by the addition of fresh limestone slurry to the bottom of the absorber. Excess slurry will be withdrawn on absorber vessel level control from the absorber and pumped to the filtration section.

The desulfurized flue gas will exit the absorber after passing through a multistage de-mister to reduce any entrained droplets to less than 50 mg/Nm^3. It will then be reheated by indirect heat exchange against the incoming flue gas.

A single absorption and solution oxidation train will be provided and will typically include:

- Absorber, including multiple layers of slurry spray headers
- Two- or more stage mist eliminator (integral or external to absorber) to reduce liquid carryover to less than 50 mg/Nm3

- Nominal 50% ID booster fans (if needed in addition to the boiler ID fans)
- Oxidizer vessel (may be combined with absorber) with multiple agitators
- 50% oxidation air compressors (two operating, one spare)
- 34% slurry circulation pumps (three operating, one spare)
- 100% absorber bleed pumps (slurry feed to filters)
- Instrumentation and controls.

The function of slurry filtration and gypsum handling subsystem is to separate the gypsum from the circulating slurry and to generate a transportable product with a maximum free water content of 10% or less. The expected gypsum production rate will be about 13,472 kg/hr. Because of potentially high maintenance and plant availability requirement, the filter train will be supplied with a full spare unit.

The slurry from the absorber bleed pump will be received by the gypsum filter, which typically is a belt-type vacuum filter with multiple zones to allow for multi-stage washing of the filter cake. The filter will be able to produce a product with a maximum free water content of 10% by weight, under all load conditions, while meeting product specifications.

The filtrate from various stages will be collected in a two-chamber filtrate sump. Part of the most concentrated filtrate will be pumped to waste treatment at a rate that maintains the chloride concentration of the entire system within allowable limits. The rest of the filtrate will be returned to the absorber and part of it used to prepare fresh limestone slurry.

The slurry filtration and gypsum handling system will comprise of 100% belt-type vacuum filters, each including:

- Main filter structure, filter belt, multiple filter zones
- Filtrate receiver and barometric seal leg for each zone
- Piping to vacuum system
- Liquid ring-type vacuum pumps (one operating, one spare)
- Gypsum discharge chute to gypsum conveyor
- Multi-compartment filtrate sump, with agitators for each compartment
- 100% wastewater sump pumps
- 200% filtrate sump pumps
- Gypsum belt conveyor, to receive dewatered gypsum cake from filter and convey to storage or disposal transportation
- Instrumentation and controls
- Electrical equipment associated with the above.

The limestone slurry preparation subsystem will produce limestone slurry appropriate for use in the absorber from as-delivered limestone and water and gypsum filtrate or wash water. Limestone will be received by truck or railcar, stored in storage shed of sufficient size to hold a 15-day supply at full capacity. From there, the limestone will be conveyed to the limestone feed silo and, via a feeder and feed conveyor, to one of two milling systems where the slurry will be prepared and then stored in the limestone slurry feed tank.

The milling systems will consist of a coarse limestone crusher, followed by wet milling in a rod or ball mill. The product stream from the rod or ball mill will be collected in a mixing tank, and from there pumped through wet cyclones. The overflow of the cyclones will be transferred to the limestone slurry feed tank, and the underflow recycled to the ball mill.

This subsystem will be comprised of the following:

- One covered limestone storage area (capable of holding a 15-day supply)
- One retrieval and conveying system to fill the limestone feed silos
- One limestone feed silo with a capacity of 15 hours of limestone consumption when the unit operates at full load
- Two limestone milling systems, each including a feeder/conveyor, a coarse crusher, a wet rod or ball mill, a mixing tank and a hydraulic classification system, with the product slurry discharging to the slurry feed tank
- One limestone slurry feed tank sized to hold 10 hours of slurry. The tank will be equipped with one or more agitators to keep the slurry in suspension.
- Two 100% limestone slurry feed pumps to feed the slurry to the absorber.

The materials of construction employed in the various parts of the FGD system must consider the corrosion potential of the various sections. The corrosion potential may differ slightly between different processes and may have an effect on the specific choice of materials. Appropriate materials for the different sections will be selected to ensure a minimum of five years of equipment life, with minimal corrosion-derived maintenance.

In general, Hastelloy C-276 alloy, as base material, cladding or liner, FRP, or flake glass-lined carbon steel have been successfully used for the construction of vessels, ducting and other equipment in such service.

The following equipment and interconnecting ducting and piping will be constructed of a corrosion-resistant material:

- Gas/gas heat exchanger
- Quench vessel
- Absorber and oxidation vessel
- Absorber to mist eliminator and gas/gas exchanger
- Pumps.

Lower grade alloys can be used in the filtration section. Carbon steel can be used in the limestone slurry preparation section.

All sizing criteria stated below are minimum requirements and refer to the boiler being operated at its maximum continuous rating (BMCR) with the design coal and 20% excess air and considering the leakage rate of the boiler air heater.

a. Gas/gas heat exchanger: will be sized to raise the temperature of the treated flue gas to 10 ºC above its dew point or 90 ºC, whichever is higher.

b. Quench vessel: will be designed to cool flue gas to about 60 ºC by contacting with the total makeup stream of water to the cooling tower, with minimal entrainment of liquid.

c. Flue gas superficial velocity: will not exceed 5 m/s.

d. Number of spray levels: three operating plus one spare.

e. Slurry hold up in bottom section (when used as oxidation vessel): 5 minutes in slurry circulation rate or 7 hours in solid retention time, whichever is larger.

f. Minimum vertical distance between top spray bank and first demister: 2 m.

g. Demisters will be designed to a maximum liquid carryover of 50 mg/Nm3, and will be provided with washing sprays to remove deposits.

h. Filtrate sump will be sized for 4 hours storage.

i. Ball or rod mill slurry tank will be sized for 15 minutes storage, plus sufficient freeboard to accommodate surges from the mill.

j. Limestone slurry feed tank: will be sized for 10 hours storage.

k. Slurry pumps will be sized with a margin of 20% on head and 10% on flow.

l. All slurry piping will avoid dead ends and will have hose connections to allow line flushing when the line is taken out of service.

m. Slurry piping 2 inches and less will be flanged rubber-lined carbon steel. Piping over 2 inches will be flanged FRP pipe.

n. Instrument connections in slurry service will be protected from plugging by either membrane construction or by continuous process water flushing into the process.

o. Valves: valves for slurry service will be plug valves, slide gate valves, diaphragm valves, ceramic globe valves or pinch valves, as appropriate for the application.

p. Isolation valves in slurry service will be packing-less knife gate.

q. Valves will be provided with an easily visible position indicator.

r. Flue gas ductwork: the flue gas ductwork includes the ductwork from the gas/gas exchanger (untreated flue gas) outlet to the stack.

All flue gas ducting will be fabricated from steel plates not less than 6 mm thick and will be of welded construction, and will be suitably protected against corrosion.

System Performance Requirements

The FGD system will be designed and guaranteed to achieve the following performance, when the boiler is operated anywhere between 40% and 100% of its MCR using design coal with 20% excess air:

- Remove at least 95% of the sulfur oxides in the flue gas.
- The desulfurized flue gas will be reheated to the higher of 10 ^{o}C above its dew point or 90 ^{o}C, whichever is higher.
- Achieve a limestone utilization rate of less than 1.1 moles of calcium in the limestone per mole of sulfur removed.

System Operation and Controls

The FGD system will be furnished and equipped for fully automated operation, controlled by the overall plant distributed control system (DCS). Critical operational parameters will be indicated via the DCS system in the central control room. Remotely controlled operations will include switching of pumps (shutting down the operating unit and the starting of the spare), washing of mist eliminators, and other periodical intermittent operations.

Should an unscheduled outage of the regenerative air heater occur, the FGD system will experience a rapid increase in flue gas temperature, which may be partially offset by increased evaporation in the quench tower. This situation may prevail for 15 minutes, after which time the unit will be tripped if the air heater cannot be restarted. The FGD system will be designed to withstand such an event without damage or increased maintenance.

The FGD system will be designed to withstand, without damage, an internal pressure equal to the shutoff pressure of the ID fans. This condition may occur due to partial or complete blockage of the mist eliminators after the absorber stage and could also last for several minutes until the unit is tripped.

4.13.3 Control of Oxides of Nitrogen

General

During combustion in boiler, nitrogen in the coal and in the air will be combined with the oxygen in the air to form oxides of nitrogen (NOx). Pakistani and international regulations have established limits of NOx emissions from power generating plants. The nitrogen that originates from the air produces thermal NOx, while the nitrogen compounds from the coal produce fuel NOx. The factors that affect the amount of thermal NOx produced are combustion temperature and duration of the combustion process. The NOx produced by coal combustion is affected by the availability of oxygen to react with the fuel nitrogen compounds in their gaseous state. In order to reduce formation of both thermal and fuel NO_2 for pulverized coal firing, the following measures have to be considered:

- The fuel NOx can be minimized by controlling the quantity of air permitted to mix with the fuel in early stages of the combustions
- The thermal NOx contribution to the total NOx can be reduced by operating at low excess air percentages, as well as lowering the gas temperature throughout the furnace by using low-turbulent diffusion flames.

(1) NOx Control Methods

There are several ways to reduce NOx emissions from a power plant and are categorized into two major groups, (i) reduction of the amount of NOx within the furnace, and (ii) reduction of NOx after the flue gases have left the furnace by chemical treatment methods.

Combustion process method: The reduction of the NOx generated inside the furnace is the most economic and the preferred choice. If these means prove insufficient to meet the regulatory requirement, then the post combustion method is additionally adopted.

Among the combustion methods used to reduce the amount of NOx generated include:

- Flue gas recirculation: It is used primarily with low nitrogen fuels and reduces NOx formation by lowering the gas temperature in the furnace.
- Fuel re-burning: It consists of injecting fuel above the main combustion zone. It affects furnace temperature profile and provides moderate NOx reduction.
- Low NOx burners (LNB): It produces staged combustion, impacts flame length and turn-down stability. LNB can reduce NOx formation by 50% or more. There are many LNB designs which have been utilized in large pulverized coal fired power plants.
- Over fire air (OFA): It consists of fuel rich combustion in the main burners and addition of fresh air atop the burners to compel additional combustion process in the furnace. It can reduce NOx formation by about 30% with good operation records.
- Combination of LNB with OFA: This is the application that optimizes the two methods and has a potential to achieve up to 70% NOx reduction.

Post-combustion methods: Among the methods used for post-combustion NOx reduction, the most practical methods for pulverized coal fired large boilers are the following:

- Selective catalytic reduction (SCR): It consists of installing in the boiler convective zone a set of catalytic baskets and injection of ammonia in the flue gas stream before the catalysts. The ammonia reacts with the NOx in the presence of the catalyst to form nitrogen and water vapor. This method can achieve a very high NOx reduction efficiency of up to 85%, but it requires high capital cost and high operating costs. The catalyst be easily plugged by the fly ash particles in the flue gas and generally requires replacement every 5 to 7 years. The SCR is being used where very stringent NOx limits are imposed.

- Selective Non-catalytic Reduction (SNCR): It is a method that consists of injecting urea in the flue gas stream. It reacts with the NOx to form water and nitrogen. The NOx reduction is moderate and is limited to a small flue gas temperature range. It requires small capital cost and modest operating costs. The NOx reduction ranges between 15 to 40% and varies with the load.

(2) Low NOx Issues

The use of low NOx burners and several other methods that address the NOx formation during the combustion process have revealed some side effects. These include the presence of pyrites, sulfur and chlorine. These manifest during combustion where fire side corrosion on water walls has been observed. Ignition loss is another problem, and so is the increased carbon content which makes fly ash unusable as a cement additive.

To resolve the above, the boiler manufacturer has to provide injection of air at the water walls. This will prevent potential future damage. Most boiler manufacturers have combined low NOx burners, over fire air and gas recirculation that reduce NOx formation. It is recommended that the potential boiler manufacturer will make computational fluid dynamics (CFD) modeling to assess impact on boiler performance to assure that NOx level meets local and international environmental regulations.

(3) Recommended Approach for the Project

The combined technology of low NOx burners and over fire air or gas recirculation is recommended for the project. It is also recommended that the potential boiler manufacturer will make computational fluid dynamics (CFD) modeling to assess impact on boiler performance to assure that NOx level meets local and international environmental regulations.

For the Project, the low NOx firing technology would be applied to meet the national emission standard.

4.14 Gaseous Emission and Waste

Pollutants in the gaseous emissions from the power plant will consist of carbon dioxide, sulfur dioxide, particulates, and oxides of nitrogen. Plant emissions, with and without treatment, are shown in **Table 4-14**.

Table 4-14: Emission of Gaseous Pollutants

	Without treatment (mg/Nm^3)			*With treatment (mg/Nm^3)*		
	SO_2	*NOx*	*PM*	*SO_2*	*NOx*	*PM*
Coal “Singularity” Subbituminous 100%	2,269	N/A[1]	12,982	454	≤ 261	39
Coal “Blend” Subbituminous 80% + Lignite 20%	3,436	N/A[1]	12,209	687	≤ 261	37

Assumed efficiencies: FGD 80%, ESP 99%, NOx reduction 80%

Note:

1. NOx value after treatment is targeted 200 ppm (261 mg/Nm^3) or less. So the value for without treatment condition is not calculated.

4.15 Transportation of Equipment for the Project

The equipment for the power plant will be imported via Karachi Port or Port Qasim (**Figure 7-3** in **Chapter 7**). It will then be moved to LFPS via one of the main highways, M-9 or N-5. The load will comprise dozens of 40-feet (12.2 m) flat-bed trucks. In addition some large equipment will be carried on over-sized articulated trucks.

4.16 Port Handling and Transportation of Coal

Imported coal will be brought by ships and then by train to the Plant Site. The major ports in the country include Karachi Port and Port Qasim. These ports, located close to Karachi city, serve as major hubs for the import and export of commodities to and from the county. Both ports have facilities to handle fuel oil and coal. Port Qasim is the preferred choice for the Project, as railway transportation out of this port avoids the congested routes out of Karachi. Further discussion on port and transportation options is included in **Chapter 7**.

CHAPTER 5. DESCRIPTION OF THE ENVIRONMENT

5.1 Area of Influence

The potential impacts of the Project on its surrounding physical and biological environments include air and water quality impacts, noise generation, land transformation and changes to soil. These are expected to reduce with the increased distance from the Project facilities, affecting more the areas located closer, up to five kilometers, to the Project facilities. For this, a study area of five kilometers around the site was delineated, to assess the baseline conditions in the areas likely to be affected by the Project due to its proximity to the Project site (**Figure 5-1**). This is referred to as the Study Area in this report.

For other impacts, such as, changes due to project water intake and water outfall, some primary data was also collected from the Indus River. Assessment of traffic was based on data collected in baseline survey.

5.2 Physical Environment

5.2.1 Geology

Pakistan geologically overlaps both with the Indian and the Eurasian tectonic plates. Sindh province lies on the north-western corner of the Indian plate. The Study Area lies on the southeastern fringe of the Kirthar range, a hill range that runs in the north to south direction for about 400 km along the Sindh-Balochistan provincial boundary.[1] Primary lithology in the Study Area is of sedimentary origin, consisting of limestone with occasional shale and sandstone of Laki Formation. Laki Formation is very rich in fossils of Eocene age (56-34 million years ago). Study area mostly consists of flood plain deposits. Two major active fault lines located near the Study Area are Surjam Fault, about 50 km to the southwest and the Jhimpir Fault, about 45 km to the south. Maximum recorded earthquakes on the Surjam and Jhimpir Faults were 6.1 and 5.6 on the Richter scale, respectively.[2]

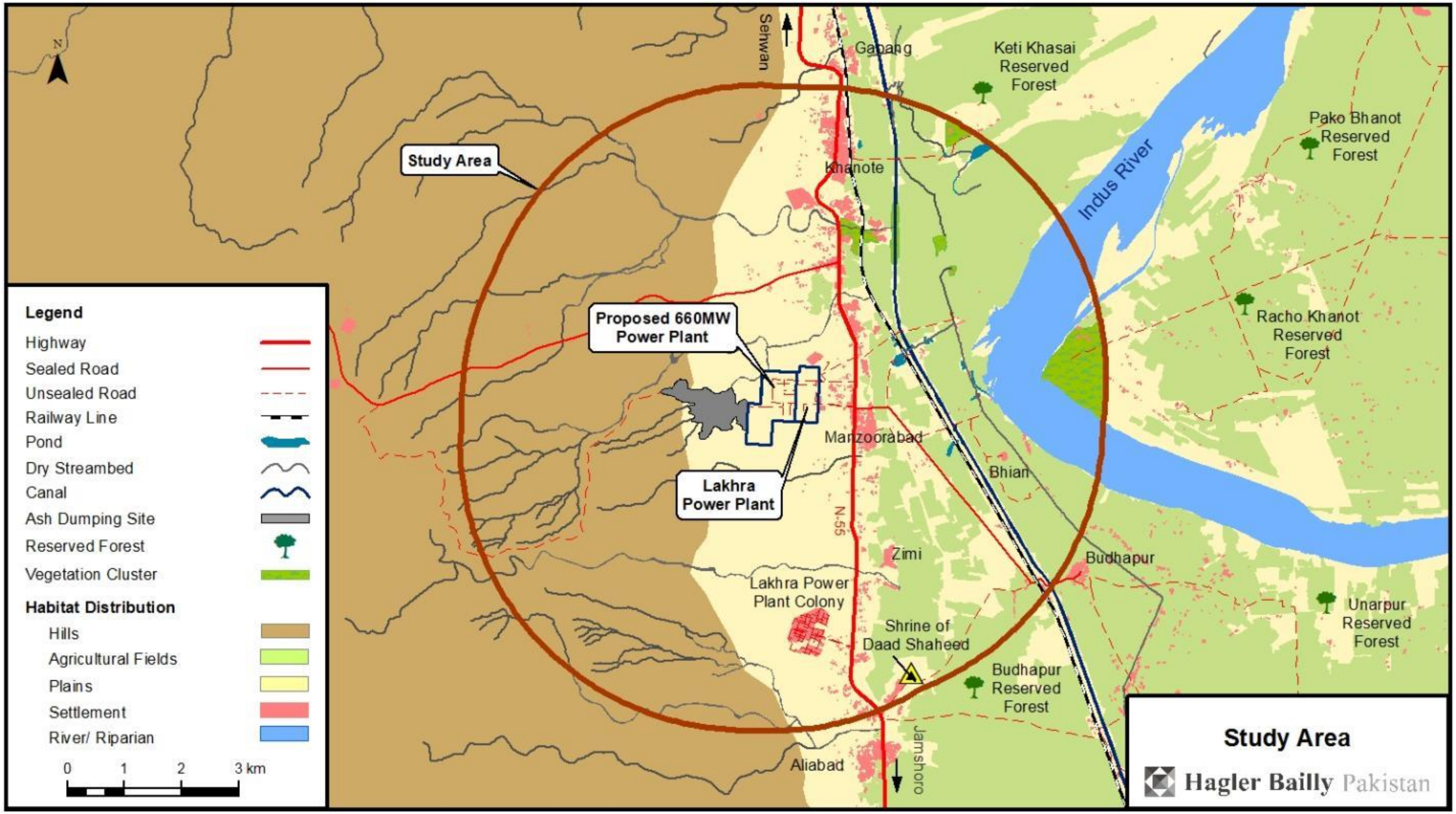
5.2.2 Topography and Land Use

The elevation of the Study Area generally ranges between 20 and 45 m above mean sea level. It slopes towards the Indus River which runs along the eastern boundary of the Study Area. There are small sedimentary hills in the western and southwestern side of the Study Area that rise to an elevation of about 100 meters. The western side of the Study Area is gravel plain with very little natural vegetation cover. The eastern half of the Study Area is part of the Indus River flood plain.

---

1 Geology and tectonics of Pakistan, Kazmi. A. H and Jan. M. Q, 1997

2 Sindh Provincial Monsoon/Floods contingency Plan 2011 (Draft Version), provincial disaster management authority, Government of Sindh



Source: Hagler Bailly Pakistan

Figure 5-1: Study Area Lakhra FBC Power Station

There are two main land uses in the Study Area other than the Lakhra Plant. These are the agricultural land in the east and semi urban areas in the southeast and northeast. The Indus River floodplain has good alluvium soil and has been converted to productive farmlands. About 51% of the Study Area falls in this category of land use. The semi-urban areas are located in southeast and northeast of the Study Area. These include Manzurabad, Aliabad and some more villages. Other minor land uses include the road network, the canal network, the under-construction Right Bank Outfall Drain (RBOD) and about eight small rural settlements spread around the Study Area.

5.2.3 Soil

General Description of Soil

The Study Area has a very shallow soil cover. The soil map of Sindh[1] categorizes the area of the LFPL and its surrounding as 'rough mountainous land' whereas the area close to Indus River is categorized as loamy and seasonal flooded soil of river plains. The dominant soil group in both areas is Calicisols[2], which are loamy soils with accumulation of secondary calcium carbonates.

Soil sampling

The sampling locations were chosen considering wind direction of current ash disposal site. One sample was collected from agriculture land to check top soil fertility characteristics.

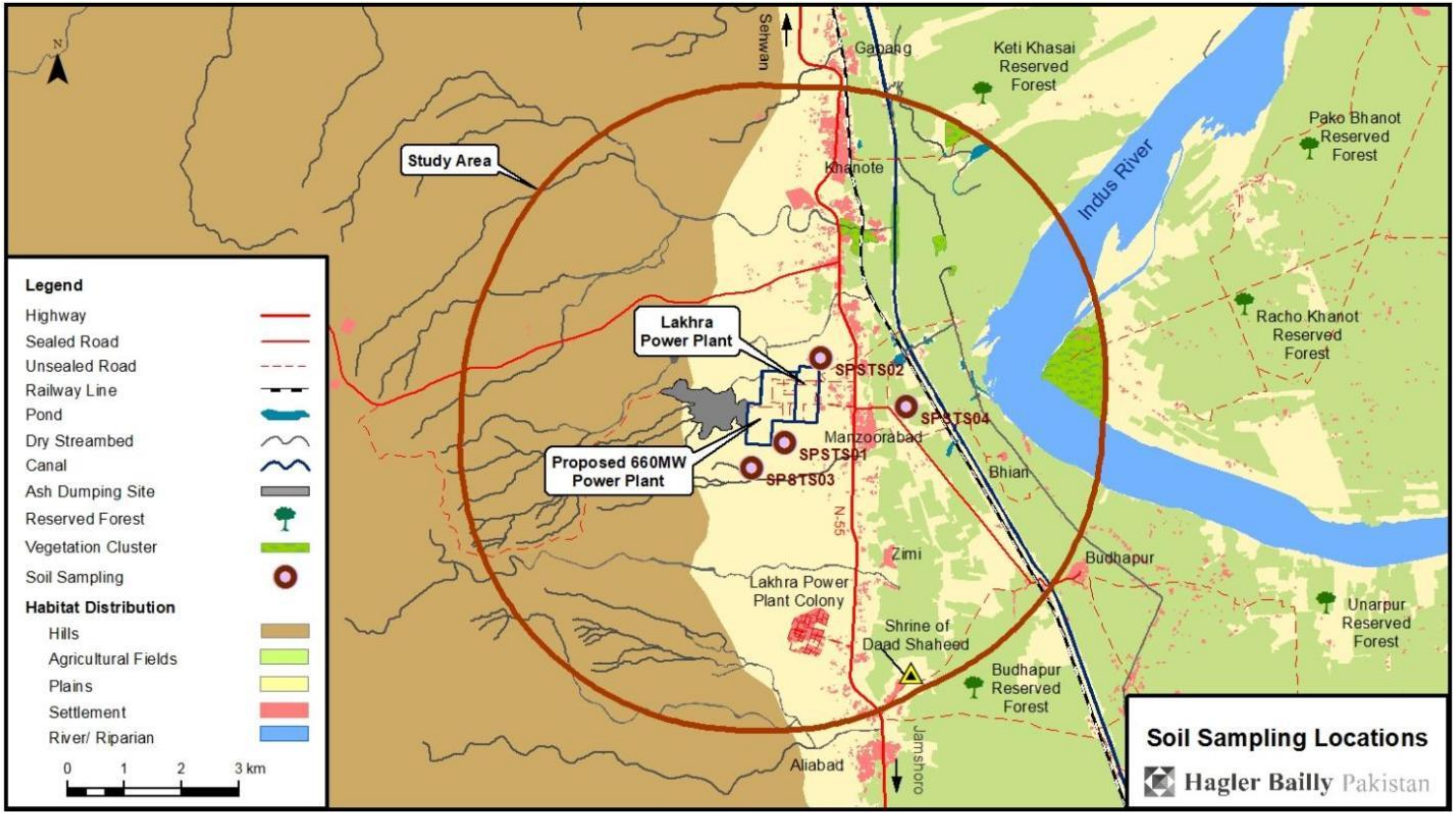
Total four surface soil samples were collected form the Study Area. The sampling locations are listed in **Table 5-1** and shown in **Figure 5-2**. Sampling methodology is shown in **Appendix 3**.

Table 5-1: Soil Quality Sampling Locations

Sample ID	*Coordinates*	*Site Description*	*rationale*
SPSTS01	25° 41' 54.1"E 68° 17' 00.9"N	500 m south of the plant, flat barren land, gravel and sandy laom	Upwind (downwind in summer) of the existing plant
SPSTS02	25 42' 42.0"E 68° 17' 23.0"N	500 m north of the plant, flat barren land, gravel and sandy laom	Downwind (Upwind in summer) of the existing plant
SPSTS03	25° 41' 39.5"E 68° 16' 40.0"N	750 m southwest of the plant, flat barren land, gravel and sandy laom	Near ash disposal site of the existing plant
SPSTS04	25° 42' 14.7"E 68° 18' 16.8"N	1000 m east of the plant, flat agricultural land, sandy loam	To check agricultural productivity

1 Soil Map of Sind 1:1,000,000. Soil Survey of Pakistan, Lahore. 1978.

2 Calicisols is a soil with substantial accumulation of lime.



Source: Hagler Bailly Pakistan

Figure 5-2: Soil Sampling Locations

Results and Conclusions

There are no national standard or international guidelines for screening of soil parameters. An approach is to compare the concentration of various parameters with the three times the corresponding value of average crustal abundance (the target value). The summary of sample analysis reports is presented in **Table 5-2** and laboratory provided results are provided in **Appendix 4**.

Metals

Metals were analyzed in four samples from the Study Area. Key observations on the results are as follows:

- Boron was detected higher than target value in Sample S03.
- Cadmium was detected higher than three times its average crustal abundance in Samples S01 and S02.
- Selenium was detected higher than three times its average crustal abundance in all samples (S01 to S04).
- Silver was detected higher than three times its average crustal abundance in Sample S04.

The higher values of above metals may have occurred due to the spread of bottom and fly ash with the wind from existing plant. No disposal mechanism is adopted at the plant for end management of bottom ash and fly ash. Currently, the bottom and fly ash from the plant is being disposed of mainly to an open barren land located west of the existing plant. During the scoping and feedback consultations, complaints were voiced on ash dumped near residences and a hilly catchment.

Agricultural Productivity

One sample (S04) was collected and analyzed for soil agricultural productivity. Based on the sample results, topsoil soil existing conditions are suitable for agricultural purposes (**Table 5-3**).

Quality Assurance

One sample (S05) was analyzed as quality control duplicate sample. The real identity was unknown to the testing laboratory. Upon receipt of results, relative percentage difference (RPD) was detected with the corresponding sample (**Table 5-4**) and found below 10% for most of the parameters.

Table 5-2: Summary of Soil Samples Analysis Results

Parameter	*Units*	*Analytical Method*	*LOR*[1]	*SPSTS01*	*SPSTS02*	*SPSTS03*	*SPSTS04*	*3 x Crustal Abundance*
Arsenic	mg/kg	US EPA 200.8	0.001	0.964	0.810	0.429	0.720	6.3
Barium	mg/kg	US EPA 200.8	0.001	116.009	97.280	76.176	107.552	1,020
Boron	mg/kg	US EPA 200.8	0.001	10.564	14.338	28.529	9.358	26.1
Cadmium	mg/kg	US EPA 200.8	0.001	0.725	0.501	0.230	0.057	0.45
Chromium	mg/kg	US EPA 200.8	0.001	74.518	46.118	78.412	52.998	420
Copper	mg/kg	US EPA 200.8	0.001	17.375	16.225	18.036	13.572	204
Iron	mg/kg	US EPA 200.8	0.001	76.218	67.142	215.653	133.795	189,000
Lead	mg/kg	US EPA 200.8	0.001	2.284	3.052	4.057	4.711	30
Manganese	mg/kg	US EPA 200.8	0.001	328.172	465.106	551.246	618.837	3,300
Nickel	mg/kg	US EPA 200.8	0.001	14.162	13.952	24.765	19.655	270
Selenium	mg/kg	US EPA 200.8	0.001	3.657	1.826	1.925	4.290	0.15
Silver	mg/kg	US EPA 200.8	0.001	0.094	0.195	0.147	0.725	0.24
Zinc	mg/kg	US EPA 200.8	0.001	27.171	21.943	16.333	14.605	237
Mercury	mg/kg	US EPA 200.8	0.001	0.072	0.019	0.048	0.037	0.201
Potassium	mg/kg	US EPA 200.8	0.001	–	–	–	192.472	45,000
PO_4 (P)	mg/kg	US EPA 200.8	0.001	–	–	–	9.355	–
NO_3 (N)	mg/kg	US EPA 300.1	0.001	–	–	–	43.068	–
pH	–	US EPA 300.1	1.0	–	–	–	8.020	–

[1] LOR refers to the "minimum level at which a laboratory report analytical data in mg/l or ppm or any other unit with confidence in the quantitative accuracy. The defined concentration cannot be lower than the concentration of lowest calibration standard for analyte being used for that specific parameter".

Parameter	*Units*	*Analytical Method*	*LOR[1]*	*SPSTS01*	*SPSTS02*	*SPSTS03*	*SPSTS04*	*3 x Crustal Abundance*
EC	□C020	CSSS[1]	1.0	–	–	–	5,350	
Organic Matter	%	CSSS	0.1	–	–	–	0.9	–
Organic Carbon	mg/kg	CSSS	0.050	–	–	–	0.54	–

Note: In the above table dash (–) means information not available or not applicable

Table 5-3: Generalized Guidelines for Interpretation of Soil Analysis Data

Criteria A: *Nitrate Nitrogen, Phosphate Phosphorus and Potassium*			
Measurement	*Low mg/kg*	*Marginal mg/kg*	*Adequate mg/kg*
Nitrate (NO3-N)*	< 11	11 - 20	> 20
Phosphate (PO4-P)*	< 4	4 - 7	> 7
Potassium (K)*	< 60	60 - 120	> 120
*Land Resources Research Institute National Agricultural Research Center Islamabad- Pakistan			

Criteria B: pH							
Denomination	*Strong acid*	*Moderate acid*	*Slight acid*	*Neutral*	*Slightly alkaline*	*Moderately alkaline*	*Strongly alkaline*
pH range*	5.1–5.5	5.6–6.0	6.1–6.5	6.6–7.3	7.4–7.8	7.9–8.4	8.5–9.0
*The United States Department of Agriculture Natural Resources Conservation Service classifies soil pH in the ranges. Soil pH is in the range 6.0 to 7.0 for most plants but some prefer acid or alkaline conditions[2].							

Criteria C: Salinity or Electrical Conductivity[3]				
EC (mS/cm)	*Degree of salinty*	*Hazard for crop growth*	*Plant Response*	*Relative tolerance of crops*
0-2	Non-saline	very low	Negligible	
2-4	Slightly saline	restricted yield of sensitive crops	Restricted yield of sensitive crops	Beans, peas, corn, soybean, sunflowers, clovers and timothy
4-8	moderately saline	Medium	Restricted yield of many crops	canola, flax, oats, wheat, rye, barley, bromegrass, alfalfa, sweet clover and trefoil

1 CSSS: Canadian Society of the Soil Science

2 http://www.nrcs.usda.gov/wps/portal/nrcs/search/?ss=16&navtype=SEARCH&cid=null&navid=260000000000000&pnavid=null&ttype=search&pname=NRCS – Search , Results 1

3 http://www.gov.mb.ca/agriculture/soilwater/nutrient/fbd02s14.html

8-16	Severly saline	High	Only a few tolerant crops yield satisfactorily	Slender and tall wheatgrass, Russian and Altai wildrye
>16	Very serverly saline	very high	Only a few tolerant forage grasses grow satisfactorily	

Table 5-4: Quality Control Duplicate Sample Results

Parameter	*Units*	*Duplicate Sample (SPSTS05)*	*Corresponding Sample (SPSTS02)*	*Relative Percentage Difference (RPd) (%)*
Arsenic	mg/kg	0.779	0.810	3.90%
Barium	mg/kg	96.711	97.280	0.59%
Boron	mg/kg	15.017	14.338	4.63%
Cadmium	mg/kg	0.458	0.501	8.97%
Chromium	mg/kg	45.498	46.118	1.35%
Copper	mg/kg	16.018	16.225	1.28%
Iron	mg/kg	69.178	67.142	2.99%
Lead	mg/kg	2.881	3.052	5.76%
Manganese	mg/kg	470.244	465.106	1.10%
Nickel	mg/kg	14.017	13.952	0.46%
Selenium	mg/kg	1.900	1.826	3.97%
Silver	mg/kg	0.204	0.195	4.51%
Zinc	mg/kg	22.501	21.943	2.51%
Mercury	mg/kg	0.016	0.019	17.14%

5.2.4 Climate

Climate is the average course or condition of the weather at a place usually over a period of years as exhibited by temperature, wind velocity, and precipitation. The climate of the Study Area is broadly hot and dry summer mild winter and rainfall in monsoon.

The weather station closest to the Study Area is located at Hyderabad (25° 38’ N, 68° 42’ E), approximately 42 km east of the plant site. The climatic description of the Study Area presented in this section is based on the 30-year climatic data of Hyderabad. The hottest month is June in which the maximum average monthly temperature exceeds 40 ºC. The winters are mild with temperature dropping to 20 ºC in January. The Study Area receives approximately 178 mm of rain annually. Almost 65 % of the rain is concentrated in the monsoon months of July and August. Monthly temperature, rainfall and wind data are provided in Table 5-3 to Table 5-5.

The annual and seasonal wind-roses are shown in **Figure 5-3**.

- Winter (December to early March): The winters have mild weather with minimum temperatures ranging between 11 to 19 ºC with January being the coldest month. Winter is mostly dry with accumulative rainfall of about 10 mm similarly relative humidity is around 50%. The Wind direction is mostly from North to South in entire winter with an average speed of 1.4 meters per second (m/s) and shift to Northeast direction in the month of March and remains there for the rests of the year

- Summer (April to June): The summers are hot with average temperature reaching 35 ºC with June being the hottest month where temperate may cross 40 ºC. Summer is also dry with rainfall of less than 14 mm in the month of June relative humidity ranges between 50% in April to 64% in June. The wind direction is towards Northeast with average wind speed of 3 m/s.

- Monsoon (July to August): Monsoon is the characteristic feature of the subcontinent with hot average temperature reaching 36 ºC and heavy rainfall. From the historic climatic data (1961-1990) almost 65% of the rainfall occurs in this season with slightly higher rainfall in august than July. The relative humidity reaches monthly average of more than 65%. The wind direction is still towards Northeast with average wind speed of 3.6 m/sec.

- Post-Monsoon summer (September to November): In Post Monsoon temperatures starts dropping and reaches 24 ºC by November, although in month of September the recorded rainfall is of 16 mm but rest of season is mostly dry with humidity of around 50%. Wind direction is from Southwest to Northeast which changes its course towards north in the end of season.

According to Koppen climate classification the climate in the Study Area is arid desert hot climate which is broadly hot and dry summer with mild winter rainfall. Broadly speaking, there are four seasons in Pakistan. These seasons are defined on the basis of temperature and the changes associated with the southwest monsoon. The southwest monsoon is a wind system that prevails from April to October in the Indian Ocean, and is characterized by a reversal in wind direction and heavy rainfall over most of the Indian Subcontinent. Within Pakistan, considerable variation is found in temperature and monsoonal changes. Thus, the specific characteristics and duration of seasons depend on geographic location. The general characteristics of the season in the Study Area on the basis of climatic data of Hyderabad are presented below:

- Winter (December to early March): The winters have mild weather with minimum temperatures ranging between 11 to 19 ºC with January being the coldest month. Winter is mostly dry with accumulative rainfall of about 10 mm similarly relative humidity is around 50%. The Wind direction is mostly from North to South in entire winter with an average speed of 1.4 meters per second (m/s) and shift to Northeast direction in the month of March and remains there for the rests of the year.

- Summer (April to June): The summers are hot with average temperature reaching 35 ºC with June being the hottest month where temperate may cross 40 ºC. Summer is also dry with rainfall of less than 14 mm in the month of June relative humidity ranges between 50% in April to 64% in June. The wind direction is towards Northeast with average wind speed of 3 m/s.

- Monsoon (July to August): Monsoon is the characteristic feature of the subcontinent with hot average temperature reaching 36 ºC and heavy rainfall. From the historic climatic data (1961-1990) almost 65% of the rainfall occurs in this season with slightly higher rainfall in august than July. The relative humidity reaches monthly average of

more than 65%. The wind direction is still towards Northeast with average wind speed of 3.6 m/sec.

- Post-Monsoon summer (September to November): In Post Monsoon temperatures starts dropping and reaches 24 ºC by November, although in month of September the recorded rainfall is of 16 mm but rest of season is mostly dry with humidity of around 50%. Wind direction is from Southwest to Northeast which changes its course towards north in the end of season.

Table 5-5: Temperature of the Study Area

ºC

Month	*Mean of Monthly*		*Highest Recorded*		*Lowest Recorded**	
	Maximum	*Minimum*	*Value*	*Date*	*Value*	*Date*
Jan	29.8	20.1	35	20/1/1902	-1	31/1/1929
Feb	33.7	22.1	39	27/2/1943	2	1/2/1929
Mar	39.1	27.2	47	28/3/1949	5	2/3/1898
Apr	43.5	33.2	48	26/4/1986	12	3/4/1903
May	46.1	37.4	49	25/5/1932	17	2/5/1916
Jun	45.0	35.6	50	9/6/1941	20	26/6/1902
Jul	41.5	32.1	46	23/7/1951	21.4	26/7/1989
Aug	40.5	31.7	44	20/8/1958	22	2/8/1884
Sep	40.8	33.2	45	22/9/1974	18	29/9/1923
Oct	41.0	32.6	45	11/1/1941	11	31/10/1949
Nov	37.0	26.6	41	4/11/1977	6	29/11/1938
Dec	31.4	21.0	35	11/12/1963	3	23/12/1945
Annual	39.1	29.4	50	9/6/1941	-1	31/1/1929

* Highest and lowest recorded temperatures are based on data collected at the Hyderabad station since it was established in 1877

Source: Pakistan Meteorological Department

Table 5-6: Rainfall in the Study Area

Month	*Mean Monthly (mm)*	*Wettest Month **		*Mean Number of Rainy Days*
		Value (mm)	*Year*	
Jan	1.2	49.0	1888	0.2
Feb	3.9	55.1	1906	0.4
Mar	5.1	92.2	1911	0.4
Apr	5.8	46.7	1963	0.3
May	3.5	56.4	1889	0.3
Jun	13.9	149.8	1964	0.6
Jul	56.7	401.6	1908	0.6
Aug	60.8	276.6	1944	2.4

Month	Mean Monthly (mm)	Wettest Month *		Mean Number of Rainy Days
		Value (mm)	Year	
Sep	21.4	286.0	1962	0.9
Oct	1.5	26.2	1956	0.1
Nov	2.1	48.3	1890	0.1
Dec	2.0	28.8	1979	0.2
Annual	177.7	546.7	1913	8.5

* Based on data collected at the Hyderabad station since it was established in 1877

** ‘Rainy day’ is defined as a day on which at least 0.1 mm of rain is recorded

Source: Pakistan Meteorological Department

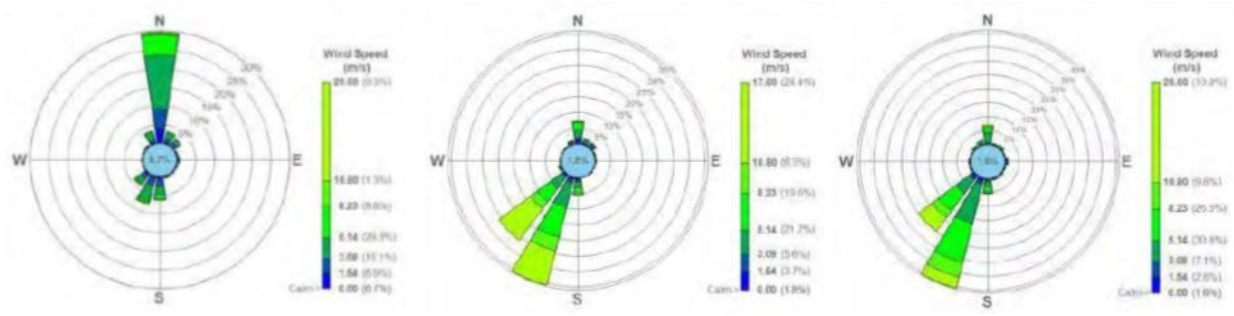
Table 5-7: Mean Wind of the Study Area

Month	Wind Speed(m/s)	Wind Direction
Jan	1.2	N
Feb	1.3	N
Mar	1.3	SW
Apr	2.2	SW
May	3.5	SW
Jun	3.9	SW
Jul	3.7	SW
Aug	3.6	SW
Sep	2.8	SW
Oct	1.4	SW
Nov	1.3	N
Dec	1.2	N
Year	2.3	SW

Based on data collected at the Hyderabad station between 1975 and 1979

Source: Pakistan Meteorological Department

Oct. 2010 to Feb. 2011	Mar. to Jun. (2011)	Jul. to Sep. (2011)



Source: Hagler Bailly Pakistan

Figure 5-3: Wind Rose for 2011

5.2.5 Water Resources

(1) General Description of Water Resources

Major water bodies in the Study Area include the Indus River and the under construction RBOD (Right Bank Outfall Drain). Groundwater is not major source of drinking water in the Study Area due to high amount of salinity in the groundwater. The water resources are briefly described below.

Surface Water

The Indus River flows at a distance of about 4 km to the east of the plant site (**Figure 5-4**). The river has an average width of about 500 m during normal flow which increases to several kilometers during high floods. The width of the river at Kotri Barrage is one kilometer. Kotri Barrage, built in 1955, is used to divert water to irrigation canals and to provide protection against flood. The barrage has 44 bays and has the maximum design capacity to discharge 24,777 cumec (cubic meters per second). The average annual flow of Indus River at Kotri barrage is 1,085 cumec. The 10-year monthly averaged flow data for the Indus River recorded from 2005 season to 2014 season at the upstream of Kotri barrage is presented in **Table 5-8**.

Five water samples in total were collected and analyzed. Out of these, two were collected and analyzed from water bores, two from the Indus River and one from plant effluent.

The summary of sample analysis report is presented in **Table 5-9** and **Table 5-12** and laboratory provided results are provided in **Appendix 4**.

Table 5-8: Indus River Monthly Flow at Kotri Barrage

Month	*Flow (cumec)*
Jan	195
Feb	198
Mar	196
Apr	360
May	430
Jun	768
Jul	1,670
Aug	4,592
Sep	3,470
Oct	664
Nov	296
Dec	177
Annual	1,085

Source: Irrigation & Power Department, Government of Sindh

Part of the under-construction RBOD is also located in the Study Area. The channel is designed to carry saline water from water logged farmlands on the right back of Indus River to the sea. The channel is partly excavated and various excavated sections are not connected. Rainwater and seeped water from surrounding land has accumulated in the excavated channels.

Groundwater

Total five groundwater extraction wells found in nearby village of Manzurabad (**Table 5-9**). All weels are borehole type driven by electric motor. Depth to groundwater, as reported by the owners, varies from 40 to 50 m in these wells. There is no significant groundwater resource in other villages in the Study Area found. In Manzurabad, groundwater uses restrict to washing and ablution needs due to high salinity.

Table 5-9 Description of the Groundwater Wells in the Study Area

No	*Location*	*Coordinates*	*Total Depth*	*Water Table*	*Owner*	*Uses*
WB-1	Manzurabad	25 42 03.0 68 17 55.1	50 m	40 m	Installed in Mosque	Cleaning purposes
WB-2	Mosque near Habibullah More on Indus Mines Road	25 43 35.6 68 17 25.5	70 m	50 m	Installed in Mosque	Cleaning purposes
WB-3	Manzurabad	25 42 03.3 68 17 55.1	50 m	40 m	Installed in a house	Washing purposes
WB-4	Manzurabad	25 42 02.9 68 17 51.6	50 m	40 m	Installed in a house	Cleaning purposes
WB-5	Manzurabad	25 42 13.1 68 17 42.1	50 m	40 m	Installed in a house	Cleaning purposes

Source: Hagler Bailly Pakistan

(1) Water Sampling

Selection of Sampling Sites

A total of five water samples were collected from water resources in the Study Area.

Surface water and groundwater samples were collected from:

- both surface water and groundwater sources
- both shallow and deep wells groundwater sources where available

The sampling locations were chosen to cover:

- River- Upstream and downstream of Water Intake and Effluent fall point of Lakhra Plant (WPSTW01 and WPSTW02)
- Lakhra Plant effluent (WPSTW05)
- Shallow and deep wells in residential areas of the Study Area (WPSTW03, WPSTW04)

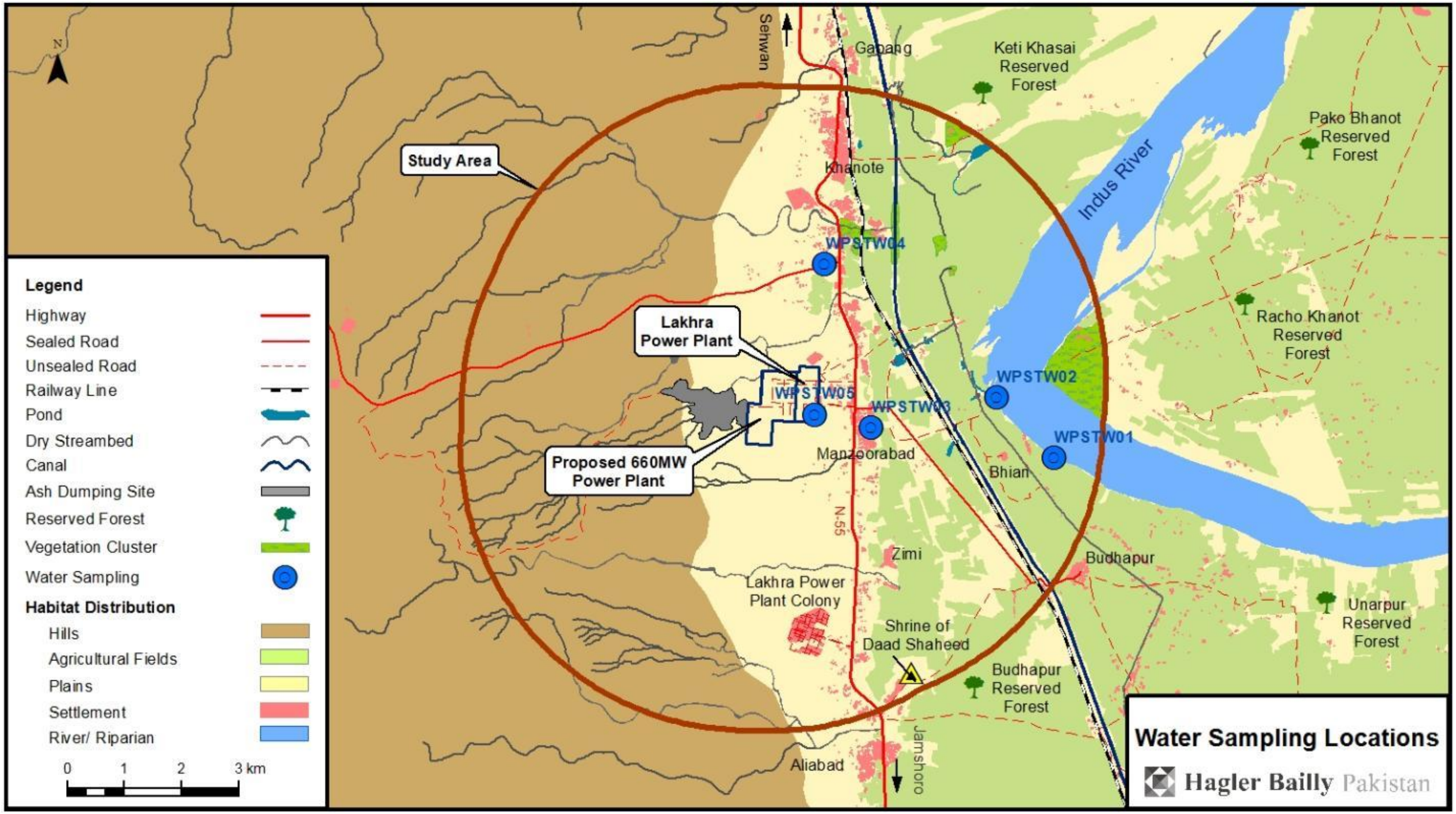
The sampling locations are listed in

Table 5-10 and shown in **Figure 5-4.**

Table 5-10: Water Quality Sampling Locations

Sample ID	*Coordinates*	*Description*	*Justification*
WPSTW01	25° 41' 46.4"E 068° 19' 50.2"N	Surface water sample, 4 km in southeast	Indus River: Downstream to Plant Intake
WPSTW02	25 42 ' 20.5"E 068° 19' 13.7"N	Surface water sample , 4 km in southeast	Indus River: Upstream to Plant Intake
WPSTW03	25° 42' 03.0"E 068° 17' 55.1"N	Groundwater from 50 m shallow well located 1000 m east of the Plant	Shallow Well: Mosque, Manzurabad
WPSTW04	25° 43' 35.6"E 068° 17' 25.5"N	Groundwater from 70 m deep well located 1500 m north of the Plant	Deep Well: Mosque, Habibullah More on Indus Mines Road
WPSTW05	25° 42' 10.3"E 068° 17' 20.0"N	Sample from Plant Effluent which constitutes mainly water from coooling towers	Near Plant Waste Water Collection Pit

Source: Hagler Bailly Pakistan



Source: Hagler Bailly Pakistan

Figure 5-4: Surface Water Resources in the Study Area

(1) Results and Conclusion

Five water samples in total were collected and analyzed. Out of these, two were collected and analyzed from water bores, two from the Indus River and one from plant effluent.

The summary of sample analysis report is presented in **Table 5-9** and **Table 5-12** and laboratory provided results are provided in **APPENDIX 4**.

Portable Water Source Samples Results Compliance with NEQS

Samples from river and groundwater were evaluated with NEQS for drinking water. Key observations are as follows:

- Results for TDS are higher than the NEQS for samples W03 (Groundwater) and W04 (Groundwater).
- Chloride in W04 was also found higher than the NEQS.
- Results for analyzed metals are within permissible levels of NEQS in all samples.
- Other major ions in analyzed samples are within permissible levels of NEQS.

Effluent Water Source Samples Results Compliance with NEQS

The sample from effluent water assessed with NEQS for waste/effluent water and all parameters analyzed were found within the permissible levels of NEQS.

Quality Assurance

- One sample (W06) was analyzed as quality control duplicate sample. The real identity was unknown to the testing laboratory. Upon receipt of results, relative percentage difference (RPD) was detected with the corresponding sample **(Figure 5-10**) and found less than 8% for major ions and varies up to 20% for metals. However, RPD for three metals (Ag, Zn, B) ranges from 40-65%.

Table 5-11: Sample Analysis Results from Water Resources

Parameter	*Unit*	*Level of Reporting, LOR*[1]	*NEQS Guideline Values for Drinking Water*	*Sample ID: WPSTW01*	*Sample ID: WPSTW02*	*Sample ID: WPSTW03*	*Sample ID: WPSTW04*
Temperature	ºC	1.0	–	19.5	19.5	30.5	30.4
DO	mg/l	1.00	–	9.30	9.27	4.00	3.80
Conductivity	µS/cm	1.0	–	539.0	525.0	6,710.0	5502.0
TDS	mg/l	10.0	<1000	480.0	470.0	5,070.0	4,028.0
pH		0.1	6.5 – 8.5	7.79	7.82	7.2	7.1
TSS	mg/l	4.0		11.67	–	–	–
Fluoride	mg/l	0.1	1.5	<0.1	<0.1	–	<0.1
Sulfate	mg/l	10		88	–	–	–
Chloride	mg/l	5.0	<250	58.49	54.95	–	1352
Color	CU	1.0	<15	–	<1.0	–	<1.0
Turbidity	NTU	0	5	–	<0	–	<0
Nitrate	mg/l	0.001	50	–	0.703	–	0.492
Nitrite	mg/l	0.010	3	–	<0.010	–	<0.010
Residual Chlorine	mg/l	0.1	0.2 – 0.5	–	<0.1	–	<0.1
Total Hardness	mg/l	1.0	<500	–	120	–	1308
Ammonia	mg/l	0.5	–	<0.5	–	–	–
Calcium	mg/l	1.0	–	28.22	–	–	–
Magnesium	mg/l	1.0	–	11.87	–	–	–
Cadmium	mg/l	0.001	0.01	<0.001	0.002	<0.001	0.002
Chromium	mg/l	0.001	0.05	0.041	0.030	0.046	0.047
Copper	mg/l	0.001	2	0.054	0.036	0.097	0.136

Parameter	*Unit*	*Level of Reporting, LOR*[1]	*NEQS Guideline Values for Drinking Water*	*Sample ID: WPSTW01*	*Sample ID: WPSTW02*	*Sample ID: WPSTW03*	*Sample ID: WPSTW04*
Lead	mg/l	0.001	0.05	0.009	0.007	0.008	0.009
Mercury	mg/l	0.001	0.001	<0.001	<0.001	0.001	<0.001
Selenium	mg/l	0.001	0.01	<0.001	<0.001	0.003	0.005
Nickel	mg/l	0.001	0.02	0.016	0.011	0.018	0.019
Silver	mg/l	0.001	–	<0.001	<0.001	0.010	0.002
Zinc	mg/l	0.001	5.0	0.028	0.023	0.025	0.052
Arsenic	mg/l	0.001	0.05	<0.001	<0.001	0.009	0.006
Barium	mg/l	0.001	0.7	0.127	0.131	0.073	0.260
Iron	mg/l	0.001	–	0.023	0.020	0.058	0.049
Manganese	mg/l	0.001	0.5	0.109	0.097	0.178	0.125
Boron	mg/l	0.001	0.3	0.040	0.015	0.064	0.053
Sodium	mg/l	0.001		66.961	–	–	–
Potassium	mg/l	0.001	–	4.206	–	–	–
Phosphate	mg/l	0.001	–	0.019	–	–	–

[1] LOR is the minimum concentration of a substance that can be measured with the procedure adopted.

Note: In the above table dash (–) means information not available or not applicable

Table 5-12: Analysis Results of Sample from Plant Effluent

Parameter	*Unit*	*Level of Reporting, LOR*	*NEQS Guideline Values for Waste Water*	*Sample ID: WPSTW05*
Temperature	ºC	1.0	–	20.2
DO	mg/l	1.00	–	6.91
Conductivity	µS/cm	1.0	–	850.0
TDS	mg/l	10.0	3500	684
pH		0.1	6 - 9	7.0
TSS	mg/l	4.0	200	13.0
Fluoride	mg/l	0.1	10	<0.1
Sulfate	mg/l	10.0	600	231
Chloride	mg/l	5.0	1000	179
Ammonia	mg/l	0.5	40	<0.5
Calcium	mg/l	1.0	–	38
Magnesium	mg/l	1.0	–	20
Cadmium	mg/l	0.001	0.1	<0.001
Chromium	mg/l	0.001	1.0	0.037
Copper	mg/l	0.001	1.0	0.026
Lead	mg/l	0.001	0.5	0.005
Mercury	mg/l	0.001	0.01	<0.001
Selenium	mg/l	0.001	0.5	<0.001
Nickel	mg/l	0.001	1.0	0.009
Silver	mg/l	0.001	1.0	<0.001
Zinc	mg/l	0.001	5.0	0.012
Arsenic	mg/l	0.001	1.0	<0.001
Barium	mg/l	0.001	1.5	0.120
Iron	mg/l	0.001	8.0	0.020
Manganese	mg/l	0.001	1.5	0.057
Boron	mg/l	0.001	6.0	0.036
Sodium	mg/l	0.001	–	150.837
Potassium	mg/l	0.001	–	5.891
Phosphate	mg/l	0.001	–	0.024

Note: In the above table dash (–) means information not available or not applicable

Table 5-13: Quality Control Duplicate Sample Results

Parameter	*Unit*	*Duplicate Sample (WPSTW04)*	*Corresponding Sample (WPSTw01)*	*Relative Percentage Difference (RPD) (%)*
Temperature	ºC	30.4	30.4	0%
DO	mg/l	3.8	3.8	0%
Conductivity	µS/cm	5520	5502	0%
TDS	mg/l	4066	4028	1%
pH		7.1	7.1	0%

Parameter	*Unit*	*Duplicate Sample (WPSTW04)*	*Corresponding Sample (WPSTw01)*	*Relative Percentage Difference (RPD) (%)*
Fluoride	mg/l	ND	ND	–
Chloride	mg/l	1352.420	1348.870	0%
Color	CU	ND	ND	–
Odor	TON	Acceptable	Acceptable	–
Turbidity	NTU	0.000	0.000	–
Nitrate	mg/l	0.492	0.456	8%
Nitrite	mg/l	ND	ND	–
Residual Chlorine	mg/l	ND	ND	–
Total Hardness	mg/l	1308	1300	1%
Cadmium	mg/l	0.002	ND	–
Chromium	mg/l	0.047	0.049	4%
Copper	mg/l	0.136	0.110	21%
Lead	mg/l	0.009	0.009	0%
Mercury	mg/l	ND	ND	–
Selenium	mg/l	0.005	ND	–
Nickel	mg/l	0.019	0.019	0%
Silver	mg/l	0.002	0.003	40%
Zinc	mg/l	0.052	0.032	48%
Arsenic	mg/l	0.006	ND	–
Barium	mg/l	0.260	0.234	11%
Iron	mg/l	0.049	0.041	18%
Manganese	mg/l	0.125	0.116	7%
Boron	mg/l	0.053	0.027	65%

5.2.6 Air Quality

Other than the LFPS, there are no major stationary sources of gaseous emission in the Study Area. The main non-stationary source is the N-55 (Indus Highway) that passes close to the Plant. Beyond the Study Area, the main sources of emission are:

- Jamshoro Thermal Power Station (JTPS) is 25 km south of LFPS
- Lakhra Coalfield to the west and northwest of the plant site at a distance of 10 - 25 km

Emissions from these sources consist of oxides of nitrogen (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO) and particulate matters.

(1) Measurement of Pollutants in Ambient Air

Ambient air quality was sampled and analyzed at five locations from February 14, 2014 to March 8, 2014. These locations were selected considering their proximity to the Project site and surrounding settlements. The sampling locations are listed in **Table 5-14** and shown in **Figure 5-5**. The sampling methodology is presented in **APPENDIX 3**.

Table 5-14: Ambient Air Quality Sampling Locations

Sample ID	*Coordinates*	*Description*	*Justification*
APSTA01	25° 51' 15.3"N 68° 11' 40.7"E	Located in Haji Mir Dost Khosa village, 18 km north of the existing plant boundary.	Location identified to check background ambient air conditions (no impact from plant)
APSTA02	25 39' 57.4"N 68° 17' 13.2"E	Located in Wapda colony, 4 km south of the existing plant boundary	Main residential area in winter downwind direction
APSTA03	25° 44' 45.0"N 68° 17' 34.2"E	Located in Khanote village, 4 km north of the existing plant boundary	Main residential area in summer downwind direction
APSTA04	25° 42' 03.1"N 68° 17' 55.2"E	Located in Manzoorabad village, 1 km east of the existing plant boundary	Nearest main settlement
APSTA05	25° 42' 16.2"N 68° 15' 02.3"E	Located in Manzoorabad village, 2.5 km west of the existing plant boundary	To provide some data of the impact of the open dumping of coal ash

(2) Results and Conclusion

Summary of results are presented in **Table 5-15**.

Table 5-15: Summary of Results

All values in μg/m³

Point No.	*Sulfur Dioxide (SO_2)*	*Nitrogen Dioxide (NO)*	*Nitrogen Dioxide (NO_2)*	*Particulate Matter*	
				Less than 10 Microns (PM_{10})	*Less than 2.5 Microns ($PM_{2.5}$)*
APSTA01	6.67	5.33	1.55	139.47	55.56
APSTA02	22.67	2.84	8.56	152.14	82.64
APSTA03	7.95	0.79	18.59	210.97	112.52
APSTA04	13.96	11.61	6.26	250.00	172.41
APSTA05	[a]	8.46	10.50	153.42	55.79
SEQS					
24 hours Average	120	40	80	150	75
Annual Average	80	40	40	120	40
IFC Guidelines					
24 hours Average	125	[b]	200	150	75
Annual Average	[b]	[b]	40	70	35

Notes:

a Tube was installed but was found damaged later and could not be analyzed by the laboratory

b IFC has not prescribed any guidelines for these parameters for the corresponding averaging period.

Quality Assurance

The Relative Percentage Difference (RPD) of the duplicate sample with corresponding sample (APSTA02) is provided in **Table 5-16** and results reported have minimal difference for the both samples exposed in similar conditions.

Table 5-16: Quality Control Duplicate Sample Results

Parameter	*Duplicate Sample ($\mu g/m^3$)*	*Corresponding Sample ($(\mu g/m^3$)*	*RPD (%)*
Sulfur Dioxide (SO_2)	21.02	22.67	7.55
Nitrogen Dioxide (NO_2)	8.24	8.56	3.81
Nitrogen Dioxides (NOx)	12.93	11.39	12.66

Discussion on Results

The following are the key observations on the results presented in **Table 5-15**.

Comparison with ambient standards and guidelines

- The observed values of all gaseous pollutants (SO_2, NO, and NO_2) are well within the corresponding maximum value set by the NEQS for ambient air quality and the ambient air quality guidelines of the IFC.
- Particulate matter, both PM_{10} and $PM_{2.5}$, at most of all locations generally exceed SEQS and IFC Guidelines values.
- Sulfur Dioxide (SO_2)
- Compared to other locations, the observed values SO_2 at A02 is high, which is downwind of the Lakhra Plant. This may indicate contribution from the Plant.

Oxides of Nitrogen (NO_X)

- The results of NO and NO_2 do not show any particular spatial pattern.

Particulate Matter

- PM_{10} appears to be higher near large settlements (Khanot and Manzurabad) by about 60-100 $\mu g/Nm^3$ as compared to the other locations. This indicates contribution from local traffic particularly on unsealed roads.
- $PM_{2.5}$ appears to show similar pattern. Its levels are higher in large settlements by about 60-100 $\mu g/Nm^3$ as compared to the other locations. Cooking in the houses using biomass as fuel is the possible source of higher levels of $PM_{2.5}$.
- Contribution from the power plant cannot be discerned from the measured data as the data was collected for 24-hour at each site. During such short intervals, wind direction and speed may change frequently shielding any wind-related pattern.
- Other than the contribution from the anthropogenic sources, the source of the higher levels of particulate matter is natural. The desert and dry conditions in the area results in stirring up of particulate matter by wind.

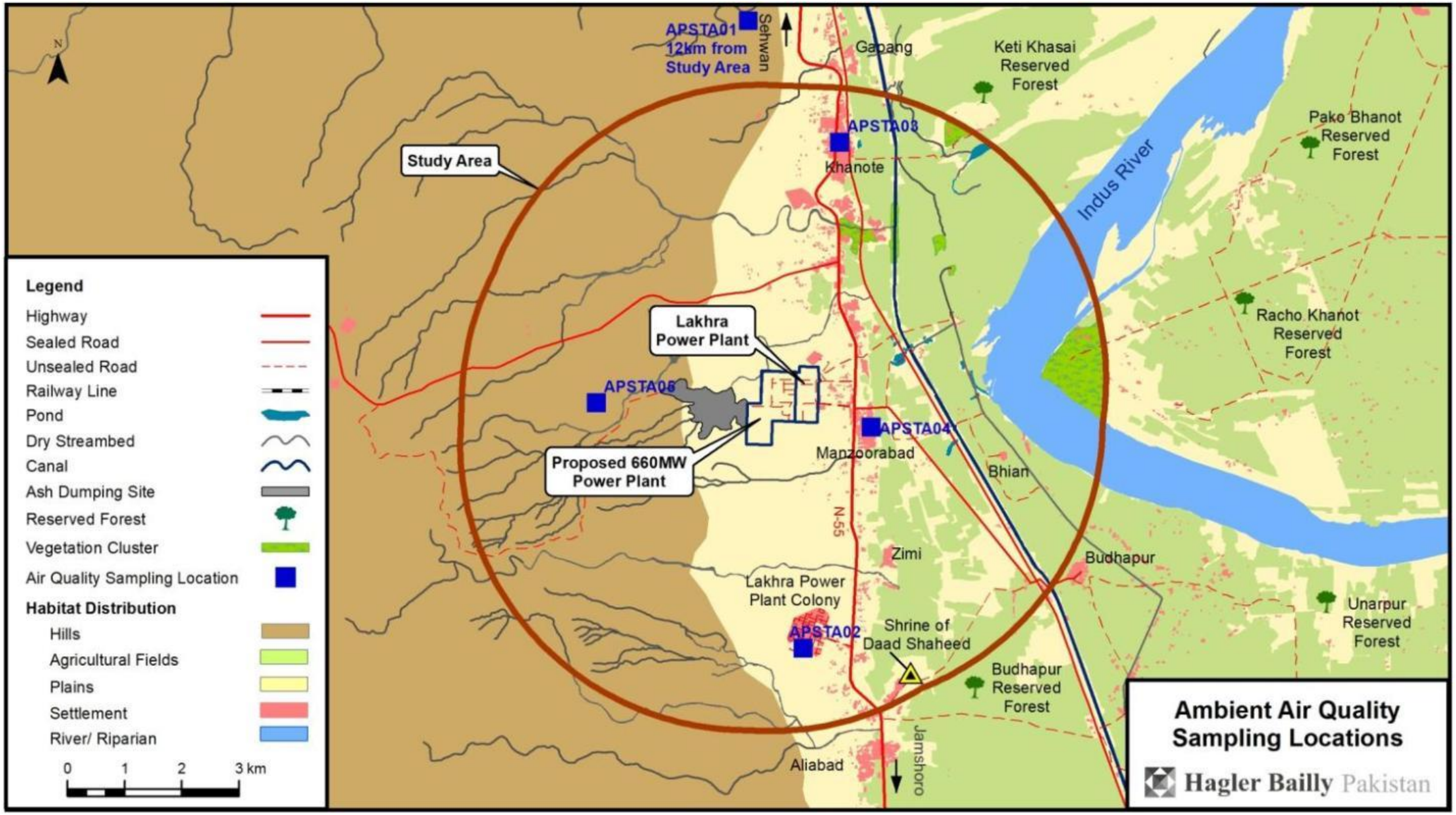
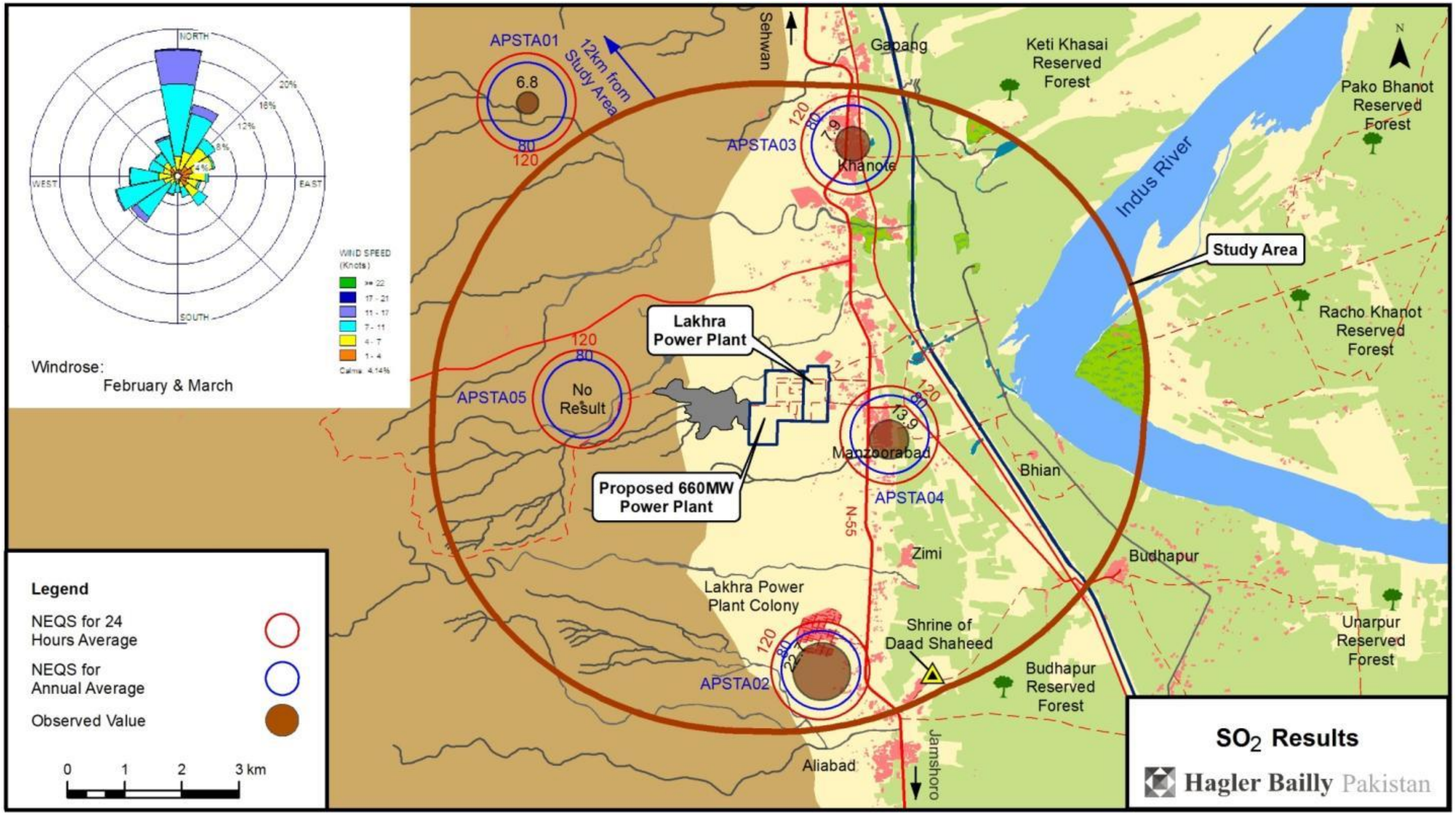
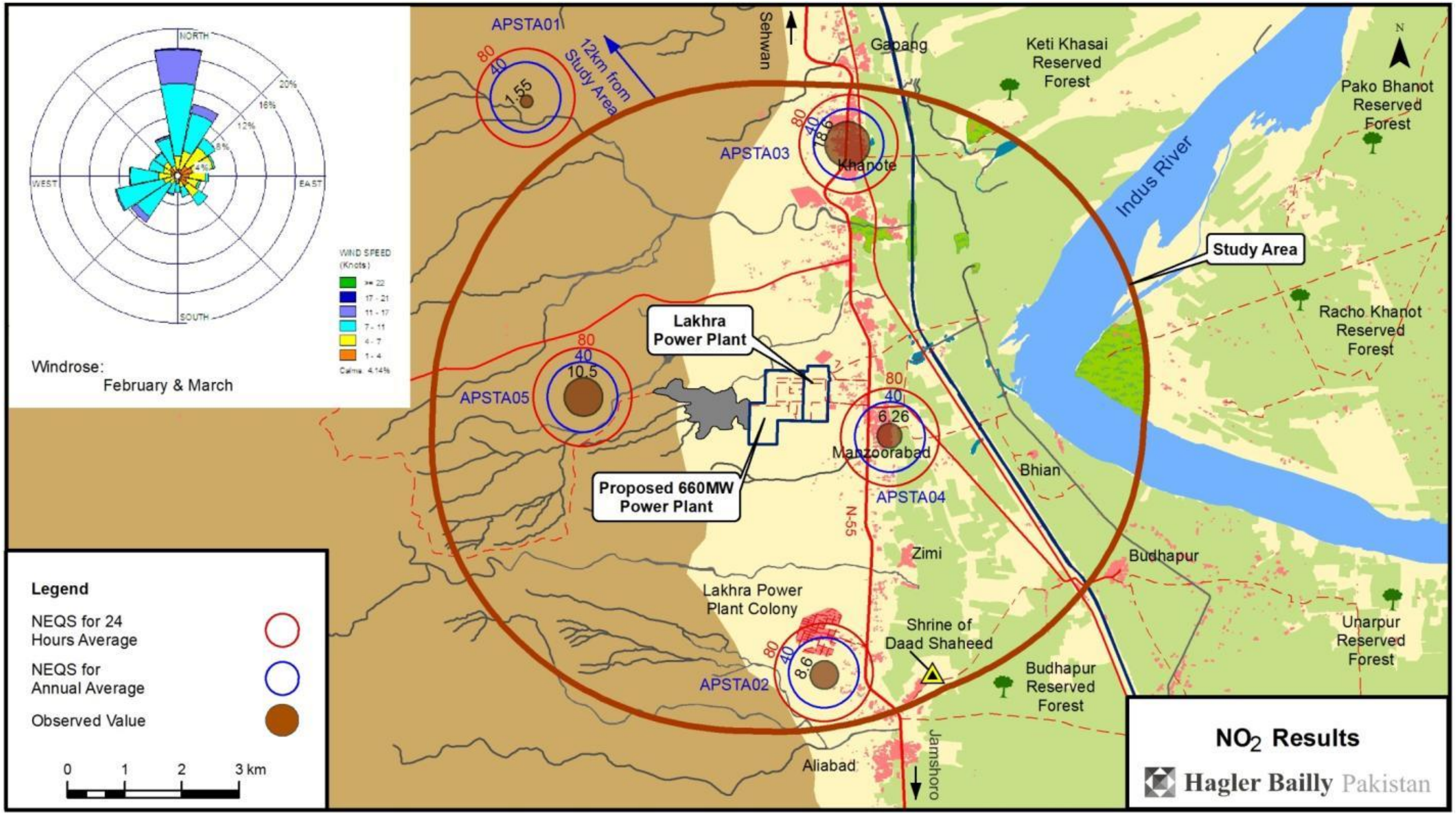


Figure 5-5: Air Quality Measurement Conditions



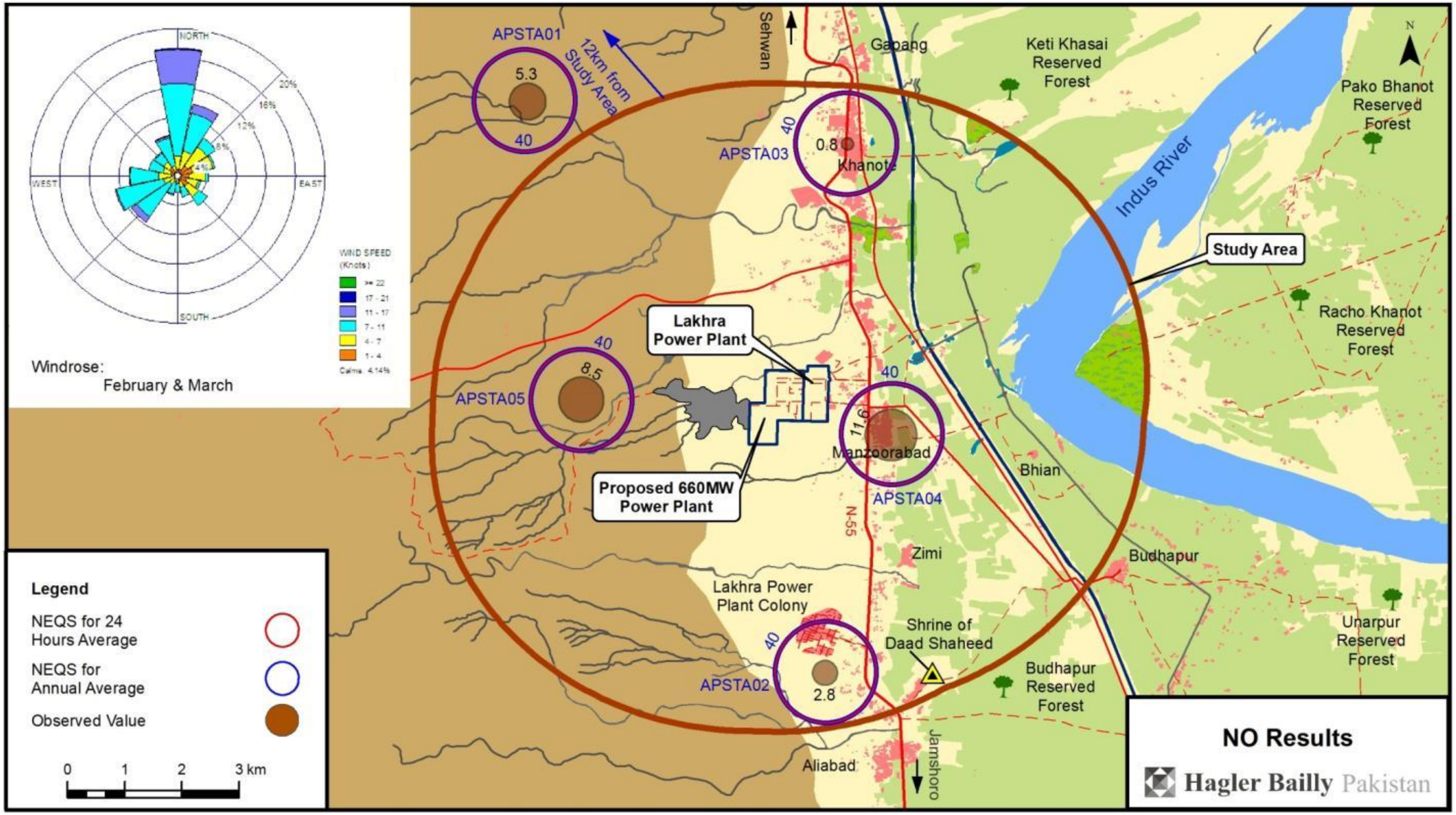
Source: Hagler Bailly Pakistan

Figure 5-6: Sulfur Dioxide Results



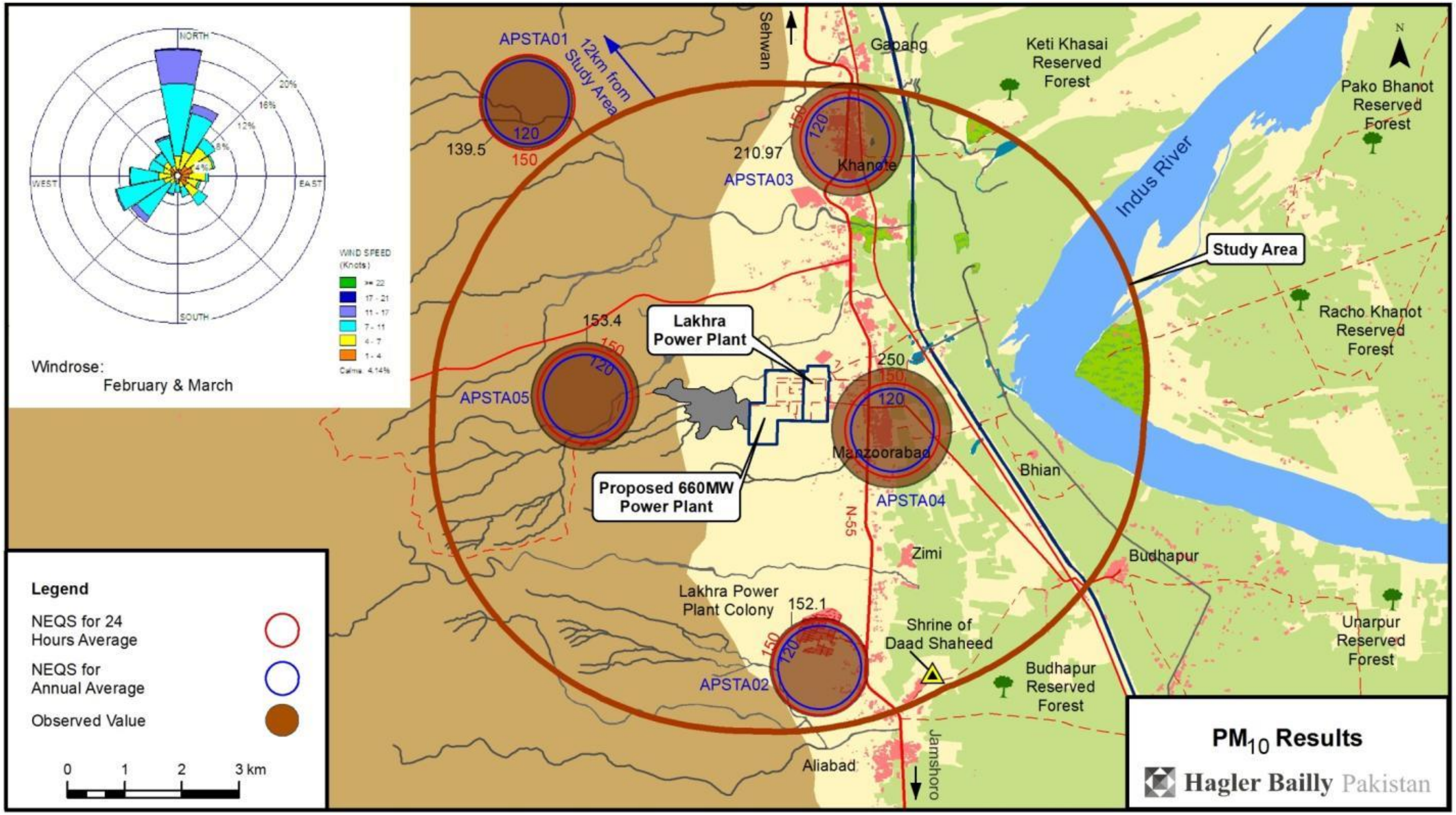
Source: Hagler Bailly Pakistan

Figure 5-7: Nitrogen Dioxide Results



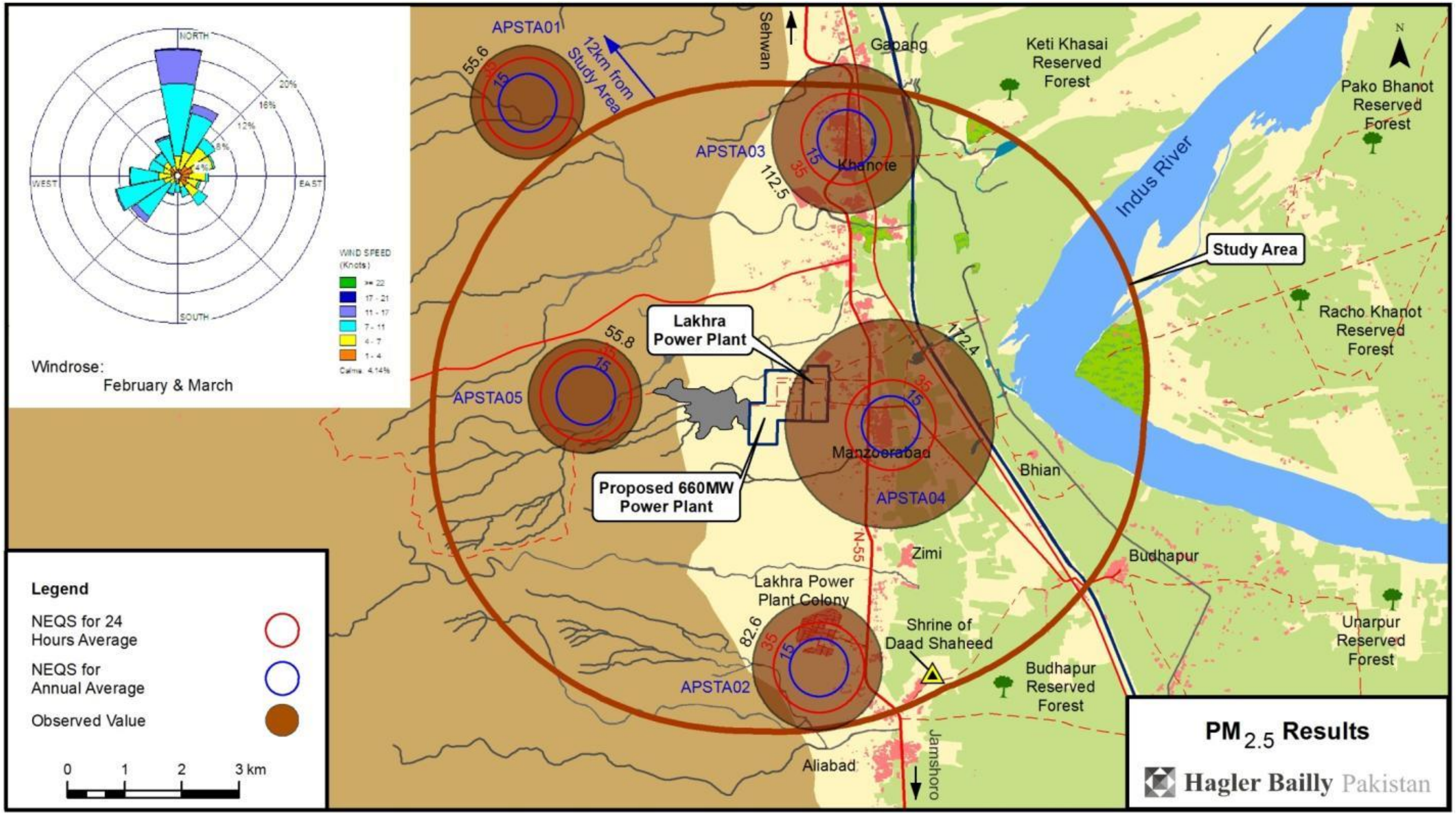
Source: Hagler Bailly Pakistan

Figure 5-8: Nitrogen Oxide Results



Source: Hagler Bailly Pakistan

Figure 5-9: PM_{10} Results



Source: Hagler Bailly Pakistan

Figure 5-10: $PM_{2.5}$ Results

5.2.7 Noise

There is no industrial source of noise within the Project vicinity other than the plant. To determine the baseline noise, measurements were taken at three locations. The locations were selected considering the nearest community to the Project. Total three representative locations were selected in the Study Area.

The measurement locations are listed in **Table 5-17** and shown in **Figure 5-12**. The survey was conducted in in the month of February 2014.

Table 5-17: Noise Measurement Locations

Measurement Location ID	*Coordinates*	*Site Description*	*rationale*
NPSTN01	25° 42º 17.1"E 68° 17º 35.5"N	350 m east of the plant, residential huts, primary school	Noise (nearest settlement in east)
NPSTN02	25° 42º 03.0"E 68° 17º 55.1"N	950 m east of the plant, Manzorabad settlement	Noise (nearest settlement to road route
NPSTN03	25° 40º 29.8"E 68° 19º 44.8"N	5 km m south of the plant, rail station, residential houses	Noise (nearest settlement to rail route near plant)

General Noise Level

A summary of results is provided in **Table 5-18.** The minimum and maximum noise levels are reported as L_{10} and L_{90}, respectively. L_{10} and L_{90} refer to percentile noise levels that are exceeded 10% and 90% of the time, respectively. A percentile score tells us what percent of other scores is less than the data point we are investigating. This means that the data averaging is made through excluding of 10% upper and lower extreme ranges of the noise data.

The average noise levels (L_{eq}) measured at noise sampling locations compared with the environmental design criteria for community Noise[1] (**Table 5-18** and **Figure 5-11**).

The noise levels in the daytime are within the guideline values. However, the nighttime values are exceeding the guideline values for point N01 and N02. This may be attributed due to the location of the measurement points nearer the highway (N-55) and existing plant.

[1] National Environmental Quality Standards (NEQS) for noise for residential area

Table 5-18: Summary of Noise Levels during the Survey

Measurement Point	*Noise Levels (dB A)*			
	Time	*L_{10}*	*L_{eq}*	*L_{90}*
NPSTN01	Daytime	46.9	51.7	56.1
	Nighttime	48.3	53.8	56.1
NPSTN02	Daytime	48.3	55.4	61.4
	Nighttime	48.3	53.0	61.4
NPSTN03	Daytime	31.7	45.5	51.3
	Nighttime	31.6	38.3	51.3
NEQS Ambient Quality Limits				
Daytime (06:00 - 22:00 hours)	–		55	–
Nighttime 22:00 - 06:00 hours	–		45	–

Rail Route Noise

Existing rail track is located about 1.5 km east of the Plant. Noise levels on the rail route were recorded at Budhapur Railway Station, located 5 km southeast of the Plant. The station master of the Budhapur Railway Station reported that daily four trains pass through this station. All four trains pass through the night and all of them are passenger trains. However, currently none of the trains stop at this station. The noise meter was placed at about 30 m from the rail track and was place on the roof of single story building.

During the noise survey near the railway track, two trains passed through the Budhapur Station. Analysis of the train noise is presented in **Table 5-19.**

Table 5-19: Train Noise Analysis

Train	*Time of Day (hours)*	*Time Taken to Pass the Station (Minutes)*	*Peak Noise Level (d BA)*	*Leq During the Passage (d BA)*	*Leq for 5 Minutes before the Passage*	*Leq for 5 Minutes after the Passage*
1	22:09	4	80.9	67.8	37.7	36.4
2	23:54	5	83.3	68.1	33.1	36.3

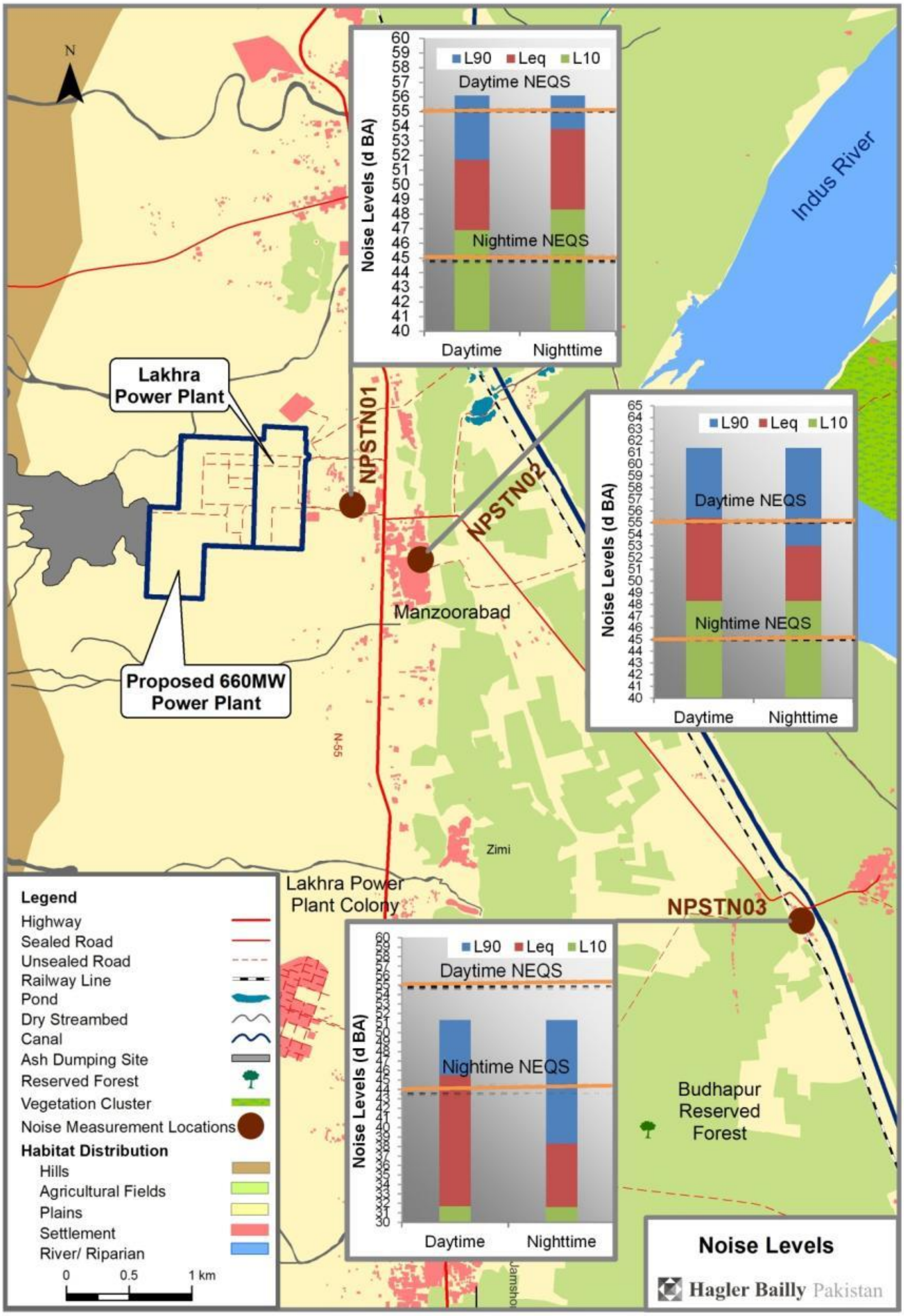


Figure 5-11: Comparison of Measured Noise Levels with NEQS

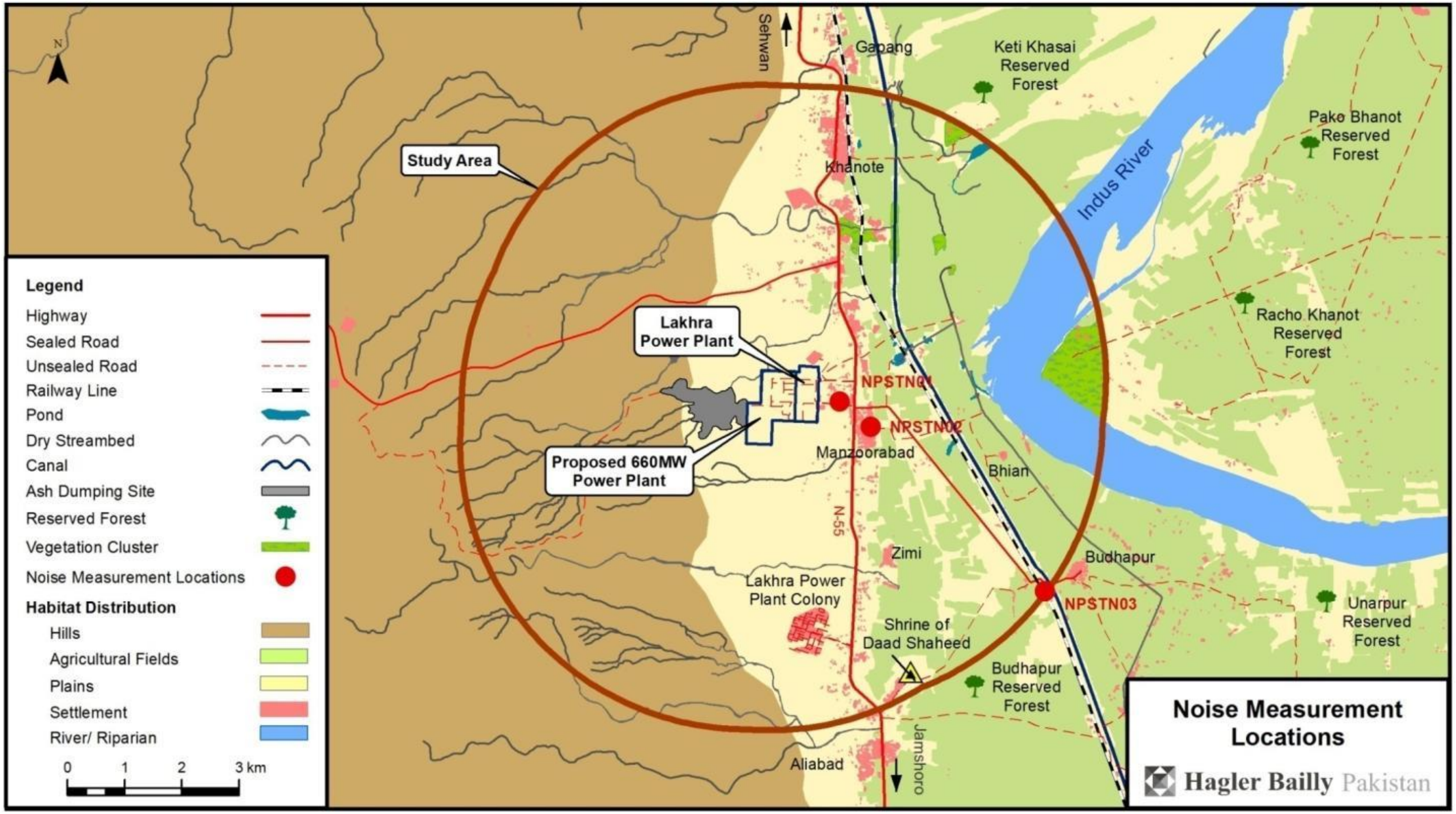


Figure 5-12: Noise Measurement Locations

5.3 Ecology

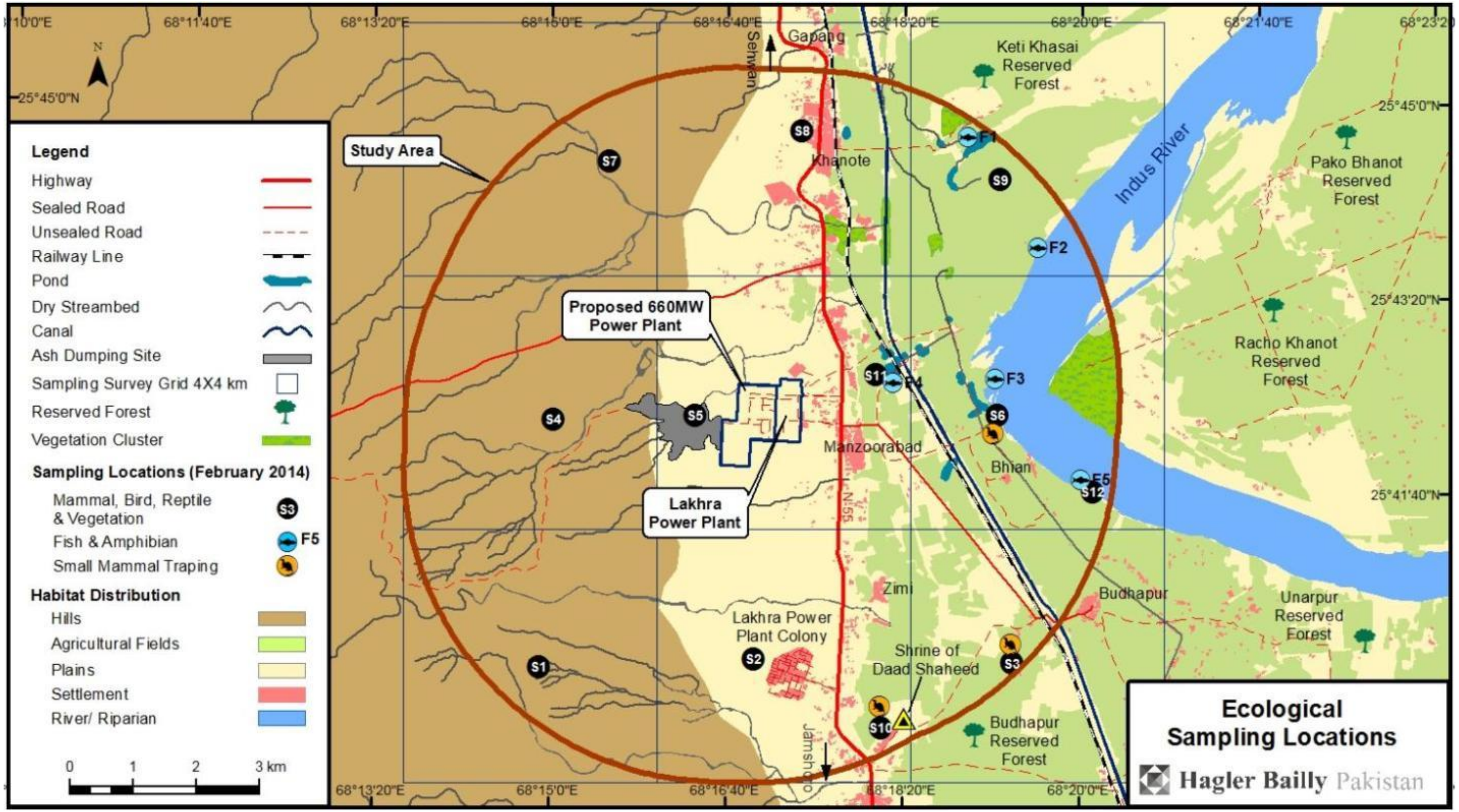
The Study Area consists of the existing Lakhra Plant, the proposed site for the 660 MW Power Plant and a 5 km potential impact zone around them to account for an area in which the ecological resources may be impacted by the Project related activities including sound, vibrations, and air quality. A map of the Study Area is shown in **Figure 5-13**.

The specific tasks covered under this ecological baseline study include:

- Review and compilation of issues relating to biodiversity and ecology raised by stakeholders during the consultation process (see **Section 1.4**).
- A review of the available literature on the biodiversity of the Study Area.
- Field surveys including:
    - Qualitative and quantitative assessment of flora, mammals, reptiles, birds and fish
    - Identification of key species, their population and their conservation status in the country and worldwide.
    - Reports of wildlife sightings in the Study Area by the resident communities.
- Analysis of ecological interaction of selected species with the environment.
- Analysis to further develop the basis for evaluating the potential impacts of Project related activities on the biodiversity, specifically seeking any potential critical habitat[1] and ecosystem services in the Study Area.

Methodology for the ecological surveys is shown in **Appendix 3**. The field data is included as **Appendix 5**.

[1] Policy on Social and Environmental Sustainability, January 2012. Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, International Finance Corporation. The World Bank Group.



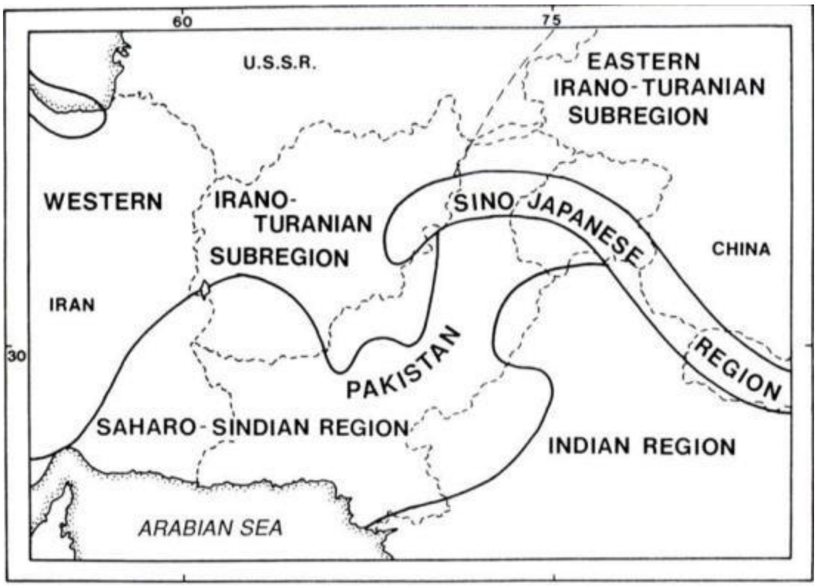
Source: Hagler Bailly Pakistan

Figure 5-13: Ecological Sampling Locations

5.3.1 Vegetation

Pakistan has a rich and varied flora. There are about 4,940 native species of flowering plants, which are found in a variety of habitats from seashore and deserts to high mountainous areas to the north. These include about 372 species which are endemic, mostly found in the north and western mountainous regions of Pakistan.[1]

Phytogeographically, the Study Area falls into the Saharo-Sindian region (**Figure 5-14**). The vegetation of this region is typical of arid regions and consists of xerophytic species that are adapted to extreme seasonal temperatures and moisture fluctuation. These perennial plants[2] have adapted to the desert environment by growing long roots, allowing them to acquire moisture at or near the water table.[3] Perennial plants often survive by remaining dormant during dry periods of the year, then springing to life when water becomes available. The vegetation of this region is highly influenced by the edaphic factors.[4] The nature of the surface soil is an important factor determining the nature and density of vegetation.



Source: Rafiq, Rubina A., and Nasir, Yasin J. 1995. Wild Flowers of Pakistan, Oxford University Press.

Figure 5-14: Phytogeographical Regions in Pakistan

The Study Area is mostly flat land with an average altitude ranging between 20 m to 45 m above mean sea level. Both sides of the Indus River bank are composed of agricultural fields. Smaller sedimentary hills are located in the west and south-west of the Study Area. Two small wetlands or ponds can be observed on the eastern side of the Project site that have been

---

1 Rafiq, Rubina A., and Nasir, Yasin J. 1995. Wild Flowers of Pakistan, Oxford University Press.

2 The flowering plants, that grow and bloom over the spring and summer, die back every autumn and winter, and then return in the spring from their root-stock, are known as perennial plants

3 Rafiq, Rubina A., and Nasir, Yasin J. 1995. Wild Flowers of Pakistan, Oxford University Press.

4 Edaphic factors refers to the physical and chemical components (temperature, pH, mineral composition etc) of the soil in a particular area.

created by flood water from the Indus River (**Figure 5-16**). The central part of the Study Area is dominated by plains. A vegetation clusters can also be seen in the plains. This is located approximately 4 km north-east of the Project. Drainage channels cut through the plains to drain the rain water. There are no protected or reserve forests in the Study Area. There are some reserve forests outside the Study Area but are not likely to be impacted by Project activities.

A survey was conducted in February 2014 to observe the vegetation and floral diversity in the Study Area during the spring season.

Sampling Points are indicated in **Figure 5-13**.

A total of 25 plant species were observed in the Study Area. During the field survey, most of the observed plant species were common and found in more than one habitat. These included *Acacia senegal, Prosopis cineraria, Aerva javanica, Leptadenia pyrotechnica, Salvadora oleoides, Ziziphus nummularia* and *Calotropis procera.* The vegetation of the Indus River bank and mostly composed of perennial shrubs of *Tamarix dioica* and *Alhagi camelorum*.

Geomorphic landforms provide correlates for predicting habitat, especially in arid lands where they capture the unique complexity of the ecosystem. Geomorphic landforms define the ranges of vertebrate species.[1] They affect abiotic conditions, the flow of organisms, propagules,[2] energy and material, and the frequency and spatial pattern of disturbance regimes, as well as constraining the very geomorphic processes that create them.[3,4] Within the Study Area, habitats were classified relying primarily upon geomorphology, vegetation and soil texture. Based on geomorphology, soil characteristic and vegetation communities observed, the Study Area can be classified into four main habitats: agricultural fields, plains, hills, river/riparian. *Google Earth*[TM] images were used to initially delineate spatial distribution of habitat types within the Study Area.

Habitat classification approaches are subjective in nature, devised to assist in the understanding of ecological systems, the functions of those systems, and the interrelationship with species. Classically, wildlife habitat is described as containing three basic components: cover, food, and water[5] with vegetation as the core descriptive component.

Table 5-20 shows the spatial distribution of the habitat types. **Figure 5-15** provides representative photographs of the habitats. Habitat distributions within the Study Area are shown on a map in **Figure 5-16**.

---

1 Forman, R.T.T., and Godron, M. 1986. Landscape Ecology. Wiley, New York.

2 A propagule is any of various usually vegetative portions of a plant, such as a bud or other offshoot, that aids in dispersal of the species and from which a new individual may develop

3 Swanson, F.J., Kratz, T.K., Caine, N., and Woodmansee, R.G. 1988. Landform effects on ecosystem patterns and processes: geomorphic features of the earth's surface regulate the distribution of organisms and processes.

4 McAuliffe, J.R. 1994. Landscape evolution, soil formation, and ecological patterns and processes in Sonoran Desert bajadas. Ecological Monographs 64:111–148.

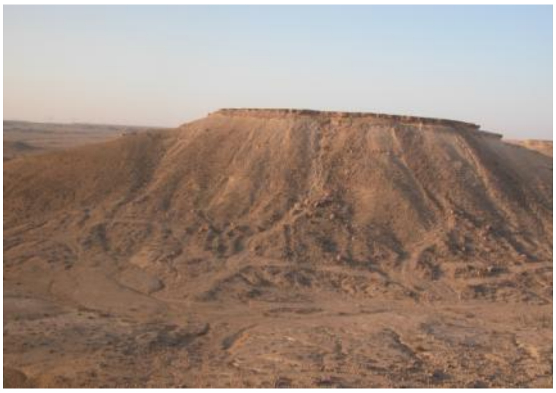
5 Morrison, M.L, Marcot, B., Mannan, W. 2006. *Wildlife-Habitat Relationships: Concepts and Applications*. Island Press, Washington, D.C.

Table 5-20: Distribution of Habitat Types in the Study Area

No	*Habitat Types*	*Area (square km)*	*Percentage Distribution*
1.	Agricultural Fields	20.9	20%
2.	Plains	31.5	31%
3.	Hills	45.1	44%
4.	River/riparian	4.8	5%
	Total	102.3	100%

a. Agricultural Fields

b. Plains



a. Hills

b. Riparian (pond)

c. Indus River bank

d. Vegetation Cluster

Figure 5-15: Photographs of Habitats in the Study Area

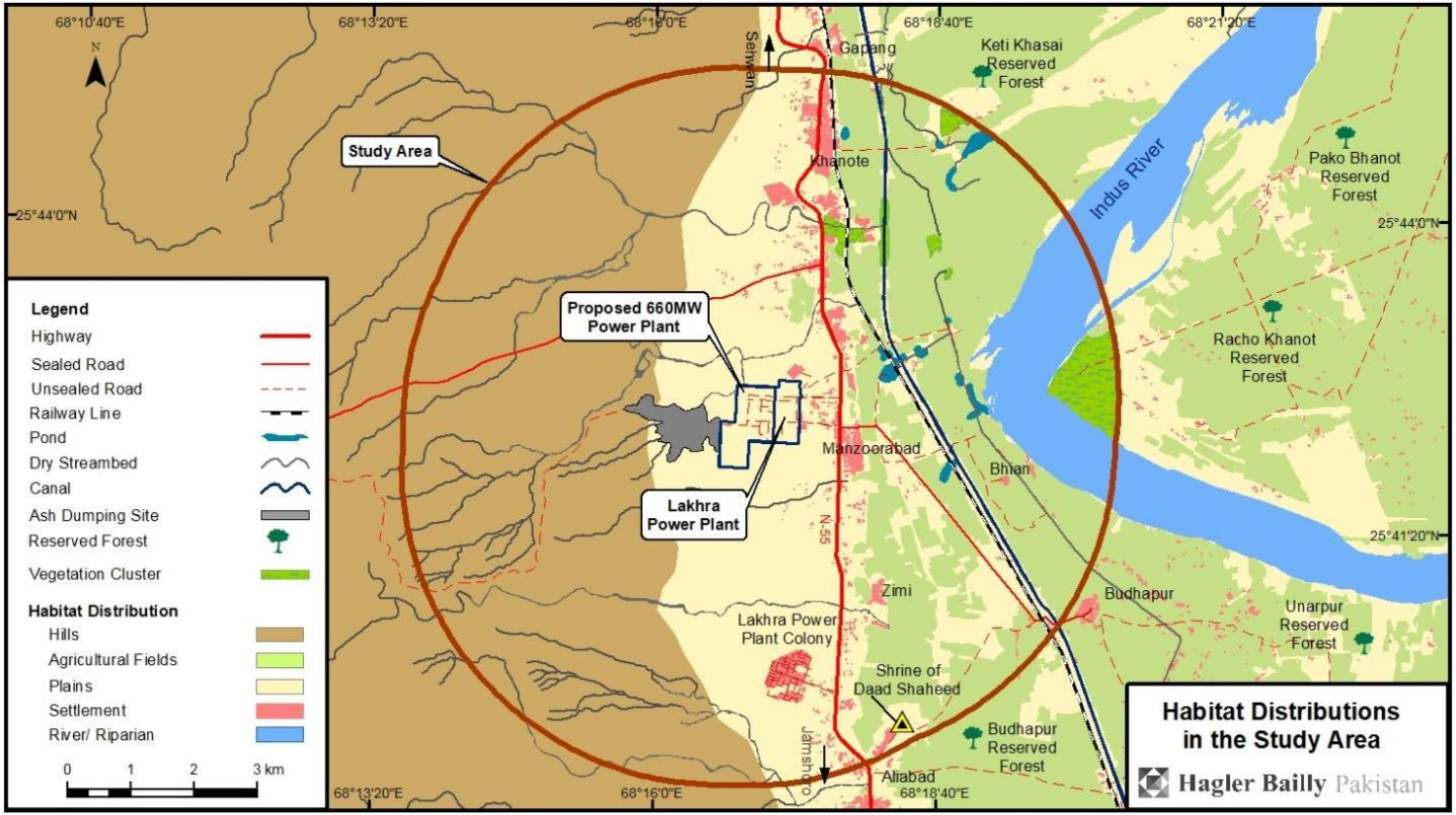


Figure 5-16: Habitat Distributions in the Study Area

Table 5-21 summarizes the vegetation cover, species count, and species diversity by habitat types for the February 2014 survey.

Phytosociological attributes of the plant species in the habitats are given in **Table 5-22**. Three values were developed from sampling individual vegetation density, cover and frequency. These values were averaged to provide the Importance Value Index (IVI)[1] which is a measure to assess the overall significance (dominance) of a species in a vegetation community since it takes into account several properties of the species in the vegetation.

Table 5-21: Vegetation Cover, Species Count and Species Diversity by Habitat Types

Habitats	*Vegetation Cover*			*Plant Count*			*Species Diversity*
	Average	*Maximum*	*Minimum*	*Average*	*Maximum*	*Minimum*	
Agricultural Fields	0.65%	1.29%	0.01%	15	22	7	1.50
Plains	2.55%	6.72%	0.01%	19	36	4	3.00
Hills	0.04%	0.06%	0.02%	34	48	18	1.67
River/riparian	4.09%	11.04%	0.37%	45	75	19	1.67

Table 5-22: Phytosociological Attributes of Plant Communities in Habitats

Habitat	*Scientific Names*	*D1*	*D3*	*C3*	*F1*	*F3*	*IVI*
Hills	Rhazya stricta	0.37	23.81	0.20	0.11	17.65	13.89
	Salvadora oleoides	0.11	7.14	65.12	0.11	17.65	29.97
	Fagonia indica	0.70	45.24	0.19	0.19	29.41	24.95
	Acacia Senegal	0.04	2.38	24.14	0.04	5.88	10.80
Agricultural fields	Tamarix dioica	7.67	85.98	87.78	0.42	50.00	74.59
	Cassia italica	0.42	4.67	0.04	0.08	10.00	4.90
	Prosopis juliflora	0.17	1.87	2.17	0.17	20.00	8.01
	Typha sp.	0.58	6.54	0.00	0.08	10.00	5.52
	Acacia nilotica	0.08	0.93	10.02	0.08	10.00	6.98
River/riparian	Tamarix dioica	0.33	11.11	3.12	0.33	25.00	13.08
	Saccharum sp.	1.67	55.56	60.93	0.33	25.00	47.16
	Prosopis juliflora	1.00	33.33	35.95	0.67	50.00	39.76
Plains	Salvadora oleoides	0.04	2.63	76.88	0.04	7.69	29.07
	Rhazya stricta	0.37	23.81	0.20	0.11	17.65	13.89
	Fagonia indica	0.70	45.24	0.19	0.19	29.41	24.95
	Cassia italica	0.19	11.90	0.03	0.07	11.76	7.90
	Prosopis juliflora	0.07	4.76	7.12	0.04	5.88	5.92

[1] Mueller-Dombois, Dieter, and Ellenberg, Heinz. 1974. Aims and methods of vegetation ecology. New York: John Wiley & Sons. 547pp.

Habitat	Scientific Names	D1	D3	C3	F1	F3	IVI
	Ziziphus mauritiana	0.07	4.76	3.20	0.07	11.76	6.58
	Acacia nilotica	0.04	2.38	24.14	0.04	5.88	10.80

D1: Density
The number of individual of a species counted on a unit area.

D3: Relative density
The proportion of a density of a species to that of a stand as a whole.

C3: Relative cover
The proportion of the total frequency of a species to sum of the frequency of all the species in area.

F1: Frequency
Percentage of sampling plots in which a given species occurs.

F3: Relative frequency
The proportion of the total of a species to the sum of the cover of all the plants of all species in the area.

IVI: Importance value index
It can be obtained by adding the values of relative density, relative cover and relative frequency and dividing it by three will give the importance value IVI of the species

Agricultural Fields

Agricultural fields constitute 20% of habitats of the Study Area (**Table 5-20)** and mostly lie in the flood plains along the Indus River. The natural vegetation of this habitat is mostly replaced by cultivated varieties of crops. However, some natural vegetation in the form of hedges and bushes was observed along the edges of the fields. The range of vegetation cover in this habitat was from 0.01% to 1.29%. The species diversity of this habitat was 1.5 species per sampling point (**Table 5-21). T**he dominant plant species in this habitat as reflected by the Importance Value Index were *Tamarix dioica* 74.59, *Prosopis juliflora* 8.01 and *Acacia nilotica* 6.98 (**Table 5-22**)**.**

Plains

The plains habitat constitutes 31% (including 2% of the settlements area) of the total habitat of the Study Area (**Table 5-20**). The average vegetation cover observed was less that observed in the river/riparian habitat but more than observed in the hills and plains. Species diversity was higher than all the habitats, with species count in the range of 3 species per sampling point (**Table 5-21**). Vegetation degradation in this habitat was observed due to grazing and browsing by domestic livestock. The vegetation cover in this habitat ranged from 0.01% to about 6.72%. Based on Importance Value Index the dominant plants were *Salvadora oleoides* 29.07*, Fagonia indica* 24.95, *Rhazya stricta* 13.89 and *Acacia nilotica* 10.80 (**Table 5-22**)**.**

A small vegetation cluster was also observed in this habitat (**Figure 5-16**). The vegetation cover in this vegetation cluster was relatively intact and thick. Locals were observed to cut trees and shrubs for use as fuel, firewood and fodder. The dominant species observed in the vegetation cluster included *Salvadora oleoides, Ziziphus mauritiana and Acacia nilotica*.

Hills

This is the most dominant habitat and constitutes about 44% of the Study Area (**Table 5-20**). The vegetation cover in this habitat was relatively thin and sparse due to browsing and over grazing, with total cover ranging from 0.02% up to 0.06%. The species diversity observed in this habitat was 1.67 species per sampling point (**Table 5-21**). The dominant species in hills, based on Importance Value, consisted of *Acacia Senegal* 47.69, *Rhazya stricta* 25.80*,* *Fagonia indica* 26.88 (**Table 5-22**).

River / Riparian

This habitat constitutes 5% of the Study Area (**Table 5-20**). It includes the banks of the main Indus River as well as wetlands and water channels located mostly in the agricultural fields. The vegetation cover observed was highest among all the habitats and ranged from 0.37% to 11.04%. Grazing pressure was prominent. The species diversity observed was 1.67 species per sampling point (**Table 5-21**). The dominant plant species in this habitat as reflected by the Importance Value Index are *Saccharum sp* 47.16, *Prosopis juliflora* 39.76 and *Tamarix dioica* (**Table 5-22**).

Conservation and Protection Status

No threatened or endemic plant species were observed in the Study Area during the survey nor reported from the literature survey.

5.3.2 Mammals

The present varied and interesting composition of the mammalian fauna of Pakistan is largely due to its role as transitional zone between two of the world's six major zoogeographical regions, the Palearctic and the Oriental, and further species have apparently also come from as far as the Ethiopian region.[1]

The province of Sindh is rich in diversified wildlife species. The natural habitat of wildlife found in various ecological zones of the province include coast line (sandy bays to mangrove forests), riverine forests along both banks of Indus River, the Indus River plains and inland brackish and fresh water wetlands, arid areas and deserts (Thar and Nara deserts) as well as the Kirthar Range.

A total of 21 mammal species have been reported from the Study Area and its vicinity.[2] These include members from Family Canidae, Ericinaceidae, Felidae, Herpestidae, Hystricidae and Leporidae. Among the river mammals, a dolphin species from Family Platanistidae[3] and an otter from Family Mustellidae[4] have been reported from the Indus

1 Roberts, T.J. 1997. *The Mammals of Pakistan.* Oxford University Press Karachi. 525 pp

2 Ghalib, SA.,Hasnain, SA. and Khan, AR. 2004. Current status of the Mammals of Sindh.J.Nat.Hist.Wildl. 3(1):16.

3 Gachal, G. S. and Slater, F. M. 2004.Barrages, Biodiversity and the Indus River Dolphin.*Pakistan J.Biol. Sci*., **7**(5):797-801.

4 Khan, W. A., Akhtar, M., Ahmad, M. S., Abid M., Ali H. and Yaqub A. Historical and Current Distribution of Smooth-coated otter(*Lutrogale perspicillatasindica*) in Sindh, Pakistan. Pakistan J. Wildl., vol. 1(1): 5-15, 2010

River mostly upstream of Kotri barrage. Small mammals reported from the Study Area include species from Family Muridae, Vespertilionidae, Sciuridae, Viverridae, Soricidae.[1]

An ecological survey was conducted in June 2012 in Jamshoro district about 25 km from the Project site.[2] Signs of four (4) mammalian species were observed. These included the signs of Asiatic Jackal Jackal *Canis aureus*, Indian Crested Porcupine *Hystrix indica*, Desert Hare or Indian *Hare Lepus nigricollis* and signs of a fox species *Vulpes sp.* During same study signs of small mammals were also observed in the study area. These included the signs of Balochistan Gerbil *Gerbillus nanus*, House Rat *Rattus rattus*, Indian Gerbil *Tatera indica* and Soft-furred Metad *Millardia meltada.*

A survey was conducted in the Study Area to study mammalian abundance and diversity in February 2014. Sampling Points are indicated in **Figure 5-13** in the Methodology section of this report. The mammal species known to occur in the Study Area are listed in **Table 6-2** in **Appendix 6**.

Table 5-23 provides a summary of Sampling Points by habitat type. It presents the sign data for mammals (excluding rodents), abundance and diversity by habitat type for survey 2014. Sampling was conducted at 12 points, of which three (3) were in agricultural fields, three (3) in plains three (3) in hills and three (3) in river/riparian. On the basis of the topographical features, habitats of the Study Area were divided into four types, i.e. agricultural fields, hills, plains and river/riparian. **Figure 5-** presents species accumulation curves (SAC) (SAC is a curve built upon the total number of species counted for incremental number of individuals recorded),3 for the February 2014 survey for the four habitat types: agricultural fields, plains, hills and river/riparian. The curves for all four habitats show a decreasing rate of discovery of new species and level off indicating adequacy of sampling effort.

Table 5-23: Signs Data for Mammals Excluding Rodents, Abundance and Diversity by Habitat Type, Surveys Conducted February 2014

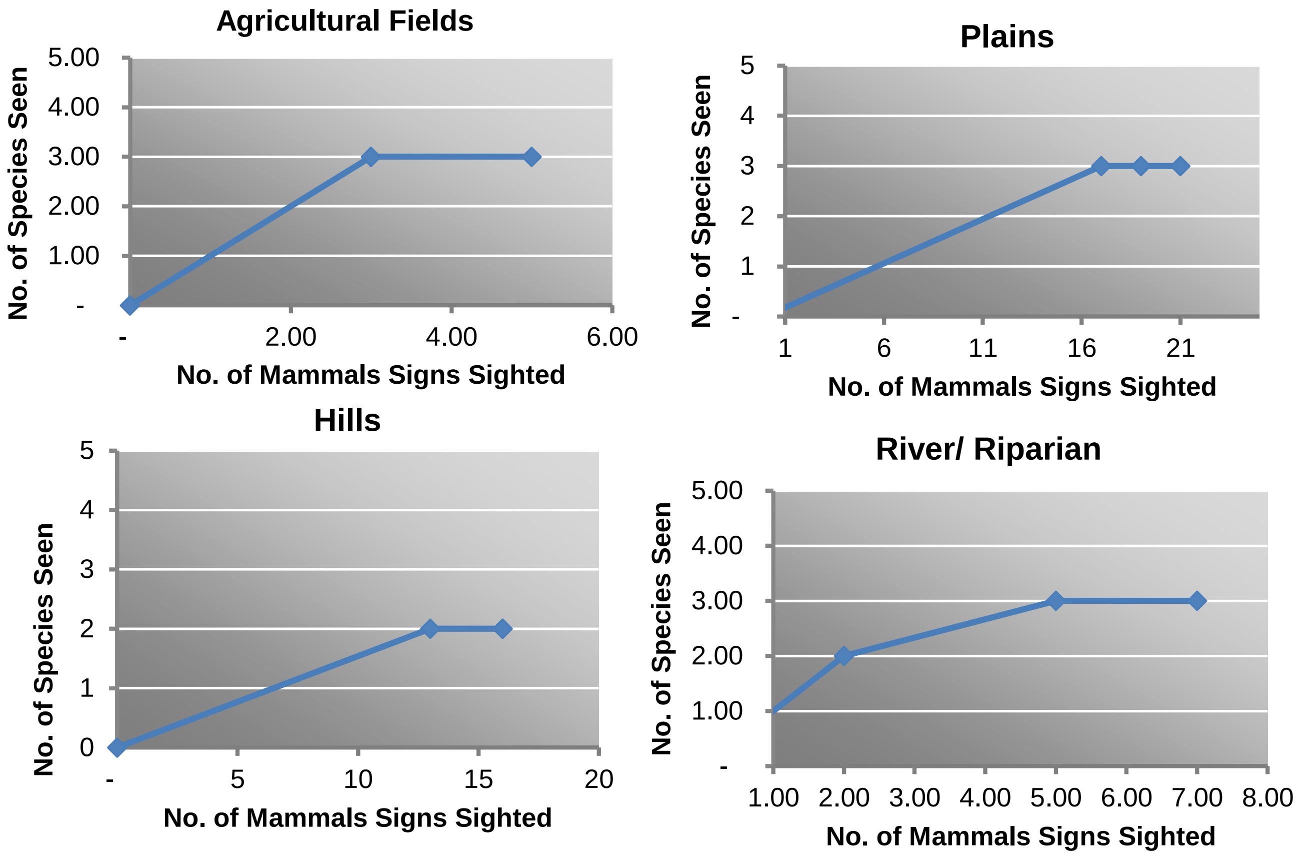
Habitat	*No. of Sampling Points*	*Total Sightings and Signs*	*Density*	*No. of Species*
February 2014				
Agricultural Fields	3	5	1.67	3
Plains	3	16	5.33	2
Hills	3	21	7.00	3
Rivers/ripirian	3	7	2.33	3
Total	**12**	**49**		

[1] Roberts, T. J. 1997. The Mammals of Pakistan.Revised Edition, Oxford University Press, 5-Bangalore Town, Sharae Faisal, Karachi.525 pp.

[2] Asian Development Bank (ADB), July 2012, Environmental Impact Assessment of Rehabilitation of Thermal Power Station Jamshoro. Report prepared for Engconsult Ltd.

[3] Thompson, G.G., and Thompson, S.A. 2007. Using species accumulation curves to estimate trapping effort in fauna surveys and species richness. Austral Ecology: Volume 32, Issue 5, Pages 564 -569 (Published Online: 20 June 2007).

Figure 5-17: Species Accumulation Curves for February 2014 Survey



Large Mammals

Table 5-24 presents the abundance of mammals in the Study Area for the February 2014 survey.

Two fox species are known to occur in the Study Area: the Bengal Fox *Vulpes bengalensis* and Common Red Fox *Vulpes vulpes.* Signs of a fox species *Vulpes sp*. species were observed in three habitats during February 2014 survey i.e. agricultural fields, plains and river/riparian. Even though it is not possible to identify the species from the signs alone, keeping in view the geographical location, it is most likely to be the Bengal Fox *Vulpes bengalensis*.

The Asiatic Jackal *Canis aureus* is known to inhabit the deserts and plains of Sindh.[1] Signs of this species were observed in all four habitats included agriculture fields, plains, hills and river/riparian. Though occurring, it is usually relatively scarce in extensive desert tracts where the Fox species *Vulpes sp* is a more abundant carnivore.

Other large and medium sized mammals reported from the Study Area include the Indian Wild Boar *Sus scrofa* and Jungle Cat *Felis chaus*.

[1] Roberts, T.J. 1997. *The Mammals of Pakistan.* Oxford University Press Karachi. 525 pp

Error! Reference source not found. shows habitat preference of the three common mammal species of the Study Area, namely Fox *Vulpes sp.*, Asiatic Jackal *Canis aureus*, Desert Hare *Lepus nigricollis*.

Table 5-24: Abundance of Mammals in the Study Area (for both signs and sightings) Survey Conducted February 2014

Common Names	*Scientific Names*	*Habitats*				*Total*	*No of Habitats in which occuring*
		Agricultural Fields	*Hills*	*Plains*	*River/ Riparian*		
Asiatic Jackal	*Canis aureus*	2	3	7	4	**16**	**4**
Desert Hare or Indian Hare	*Lepus nigricollis*	–	13	11	–	**24**	**2**
Indian Crested Porcupine	*Hystrix indica*	1	–	–	1	**2**	**2**
Bengal Fox	*Vulpes bengalensis*	2	–	3	2	**7**	**3**

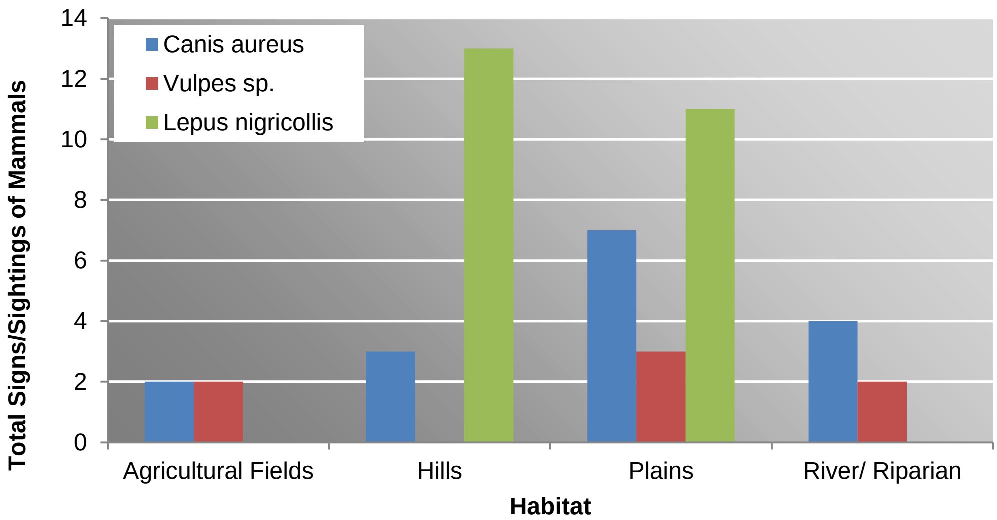


Figure 5-18: Distribution of Mammal Signs and Sightings in Habitat Types in the Study Area. Surveys Conducted February 2014

Aquatic Mammals

The Smooth-coated Otter *Lutrogale perspicillata* has been reported from the vicinity of the Study Area[1] but the population recorded is low in number.[2] It is listed as Vulnerable in the IUCN Red List 2014. This is essentially a plains' species found throughout the lower Indus riverine system and up to the outer foothills of the Punjab.[3] Its distribution range in Sindh was along Nara canal, Keenjhar and Haleji lakes, Guddu barrage, Sukkur barrage and coastal area of Keti Bunder in Thatta District especially at the time of high and low tides.[4] However, it has become progressively rare even in these regions, largely because of increased human settlement on the banks of the Indus River as well as destruction of its habitat caused by vegetation removal, water pollution, fish depletion, forest fires and construction of irrigation barrages across the Indus.[5] High demand for otter skins in the international markets[6] and weak enforcement of wildlife laws have encouraged the poor local communities to carry out otter hunting. It was not observed in the Study Area during the February 2014 survey.

The Indus Blind Dolphin *Platanista minor* is listed as Endangered in both the IUCN Red List 2014 as well as Pakistan's Mammals National Red List 2006. A high abundance of this river dolphin has been reported from the area between Guddu and Sukkur Barrage[7] (**Figure 5-19**). About 130 years ago, the Indus dolphin was found throughout approximately 3,400 km of the Indus river and its tributaries from the estuary to the base of the foothills of the mountains.[8] In 2001 a comprehensive survey of the entire range was conducted. The total population size

---

[1] Gachal, G. S., Memon, Z., Qadir, A. H., Yusuf, S. M. and Siddiqui, M. 2007. Ecological Impact on the status of Otter (Lutrogaleperspicillata). Sindh Univ. Res. J., 39(2): 19-26.

[2] Rais, M., Khan, MZ.,Ghalib, SA., Abbas, D., Khan, WA., Islam, S. and Husnain, A. 2009. Recent records of Smooth-coated (Lutrogaleperspicillata) Otter form Sindh, Pakistan. Pakistan Journal of Zoology. 41(5): 413-414

[3] Roberts, T. J. 1997. The Mammals of Pakistan.Revised Edition, Oxford University Press, 5-Bangalore Town, Sharae Faisal, Karachi.525 pp.

[4] Ahmad, M. 1998. *Wildlife of Pakistan* (In Urdu).National Language Authority, Pakistan, PatrasBukhari Road, H–8/4, Islamabad.504 pp

[5] Roberts, T.J. 1997. The Mammals of Pakistan. Oxford University Press Karachi. 525 pp

[6] Khan, W. A. , Akhtar M., Ahmad, M. C., Abid, M. Ali, H. and A, Yaqub. 2010. Historical and Current Distribution of Smooth-coated otter (*Lutrogale perspicillata sindica*) in Sindh, Pakistan. Pakistan J. Wildl., vol. 1(1): 5-15, 2010

[7] Khan M. Z. 2006, Current status and biodiversity of Indus Dolphin reserve and Indus Delta wetlands (ramsar sites). Proceedings 9th International Riversymposium, Brisbane, Australia, 2006, pp 1-17

[8] Anderson, J. 1878, Anatomical and Zoological Researches: comprising an account of the zoological results of the two expeditions to Western Yunnan in 1868 and 1875 and a Monograph of the two cetacean genera *Platanista* and *Orcella*. Bernard Quaritch, Piccadilly, London.

was estimated as 1,100 in approximately 1,000 km of river.[1] Nearly the entire population (99% of the animals) occurred in only 690 linear km, which implies roughly an 80% reduction in the area of occupancy since the 1870's.[2] The factors for decline include water pollution, poaching, fragmentation of habitat due to barrages, and dolphin strandings in the irrigation canals.[3] The survey was repeated in 2006 and an increase in the population was observed. Abundance was estimated as 121 between Chashma and Taunsa barrages, 52 between Taunsa barrage and Ghazi Ghat and 1293 between Guddu and Sukkur barrages. Including an estimate for unsurveyed areas, the Indus dolphin subspecies was determined to number 1,600-1,750 animals in 2006.[4] A small population of 4 – 6 specimens was recorded near Kotri barrage.[5] The Indus Blind Dolphin *Platanista minor* was not seen in the Study Area during the survey of February 2014.

Small Mammals

Desert Hare or Indian Hare *Lepus nigricollis* sings were observed from the Study Area in only two habitats included hills and plains during the February 2014 survey.

Signs of the Indian Crested Porcupine *Hystrix indica* were observed from the Study Area in two habitats including agriculture land and river/riparian

The Palm Squirrel *Funambulus pennantii* belonging to Family Sciuridae is reported from the Study Area. It is common in large cities, villages and semi-desert regions. In extensive sand hill desert areas such as Cholistan, Thal and Tharparkar, the squirrels have penetrated wherever there is human habitation.[6] It was not observed during the February 2014 survey.

The Small Asian Mongoose *Herpestes javanicus* is well adapted to living in the outskirts of villages and towns and avoids mountainous areas.[7] It was not seen in the Study Area during the February 2014 survey.

The Long-eared Desert Hedgehog *Hemiechinus collaris* and Small Indian Civet *Viverricula indica* were reported from the Study Area but were not seen during the February 2014 Survey.

---

1 **Braulik, G. T.** 2006. Comprehensive status assessment of the Indus River dolphin (*Platanistagangetica minor)*. Biological Conservation 129(4): 579-590.

2 Gill Braulik, 2004, Indus river dolphins in Pakistan, Whale and Dolphin Conservation Society

3 Roberts, T. J. 1997. The Mammals of Pakistan, Oxford University Press, 448 pp.

4 Khan U., Bhagat H. B., Braulik G. T., Khan A. H (2010) Review of the conservation and establishment of protected areas for the Indus River dolphin Platanista gangetica minor. In: Final workshop Report Establishing protected area for Asian freshwater cetaceans Edited by Daneille Kreb, Randall R. Reeves Peter O. Thomas, Gillian T Braulik and Brian D. Smith, Yasi Indonesia

5 WWF-Pakistan. 2006. Abundance of Indus river Dolphin in 2006, 35 pp:

6 Roberts, T.J. 1997. *The Mammals of Pakistan.* Oxford University Press Karachi. 525 pp

7 Ibid.

Rodents: The habitats of the Study Area have diverse species of rodents. Common rodent species in the Study Area include Indian Gerbil *Tetra indica*, House Mouse *Mus Musculus,* Indian Mole Rat *Bandicota bengalensis,* Roof Rat Rattus rattus and Short Tailed Mole Rat *Nesokia indica*.

Locations for trapping of rodents are indicated on the map in **Figure 5-13**.

Table 5-25 provides the results for rodents trapped in the Study Area (using Sherman Live Traps).[1]

For the February 2014 survey, House Mouse was the most common species with a trapping success of 44% followed by House Rat (33%) and House Shrew (22%)**.**

Table 5-25: Trapping Success for Rodents in the Study Area Survey Conducted July and October 2011

Scientific Names	*Common Names*	*Captured/100 Trap Nights*	*Percent of Trapping*
February 2014			
Mus Musculus	House Mouse	3.33	44%
Rattus rattus	House Rat	2.50	33%
Suncus Murinus	House Shrew	1.67	22%
Total		7.50	100%

Conservation and Protection Status

Among the terrestrial mammals, two species belonging to *Vulpes* genus, Family Canidae, are known to occur in the Study Area: the Bengal Fox *Vulpes bengalensis* and the Common Red Fox *Vulpes vulpes*. They are both listed as Near Threatened in the Pakistan's Mammals National Red List 2006 and also included in the Appendix III of CITES Species List.[2] Another member of the Family Canidae, Asiatic Jackal *Canis aureus* is listed as Near Threatened in the Pakistan's Mammals National Red List 2006 and also included in Appendix III of the CITES Species List. One member of the Family Felidae reported from the Study Area includes Jungle Cat *Felis chaus.* The species is included in the Appendix II of CITES Species List.[3] Other small and medium sized mammals of conservation importance reported from the Study Area include Indian Crested Porcupine *Hystrix indica* Grey Mongoose *Herpestes edwardsii,* Small Indian Mongoose *Herpestes javanicus* and Small Indian Civet *Viverricula indica*.

---

[1] EIAO Guidance Note No. 10/2004. Methodologies for Terrestrial and Freshwater Ecological Baseline Surveys, Environment Protection Department, Hong Kong.

[2] UNEP-WCMC. 04 March 2014. UNEP-WCMC Species Database: CITES-Listed Species

[3] Ibid

Among the river mammals, Smooth Coated Otter *Lutrogale perspicillata* is listed as Vulnerable in the IUCN Red List[1] and also included in the Appendix II of CITES Species List.[2] The species is listed as Near Threatened in Pakistan's Mammals National Red List 2006.[3] The Indus Blind Dolphin *Platanista minor* is listed as Endangered in both the IUCN Red List and Pakistan's Mammals National Red List 2006. It is included in Appendix I of CITES Species List.[4]

Asiatic Jackal *Canis aureus:* It is generally accepted that the population occurring throughout Pakistan belongs to the nominate sub-species *Canis aureus aureus*.[5] It is found throughout the plains, as well as areas of Balochistan and the Khyber Pakhtunkhwa. This is a very adaptable animal, readily entering mountainous areas, forest plantations, and riverine thickets. In the irrigated colonies, there is some evidence that jackals have decreased in number in recent years, which might be the result of increased human disturbances, as well as the effect of chemical pesticides, which are usually highly toxic to mammals. The Asiatic Jackal *Canis aureus* is included in Appendix III of the CITES Species List and listed as Near Threatened in Pakistan's Mammals National Red List 2006. Signs of this species were observed at Sampling Points S9, S10, S1, S5, S8, S11, S6 and S12 during the February survey 2014.

Bengal Fox *Vulpes bengalensis:* is noticeably smaller than any of the races of the Common Red Fox. It can be readily distinguished in the field by the prominent black tip to its tail. This fox is generally associated with open country having a scattering of trees and is not found in extensive sand dune area or in forests. It hunts mainly at night and also supplements its diet with fruits whenever available. It is listed as Near Threatened in the Pakistan's Mammals National Red List 2006 and is included in Appendix III of CITES Species List.[6] Signs of the species were observed at Sampling point S9, S10, S5 and S11.

Common Red Fox *Vulpes vulpes:* The Common Red Fox is a very variable species both in size and coloration and has several sub-species, at least three of which are known to occur in Pakistan. It occurs throughout the mountainous areas of Balochistan, North West Frontier Province, and the Himalayas, both in the valleys and higher mountain slopes as well .[7] The Common Red Fox is hunted in other countries for its valuable pelt, yet it is still widespread in Pakistan. It is placed in Appendix III of the CITES list and listed as Near Threatened in the Pakistan's Mammals National Red List 2006. It was not seen in the Study Area during the February survey 2014.

---

1 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 10 March 2014.

2 UNEP-WCMC. 04 March 2014. UNEP-WCMC Species Database: CITES-Listed Species

3 Status and Red List of Pakistan Mammals. 2006. Biodiversity Programme IUCN Pakistan

4 UNEP-WCMC. 04 March 2014. UNEP-WCMC Species Database: CITES-Listed Species

5 Roberts, T.J. 1997. *The Mammals of Pakistan.* Oxford University Press Karachi. 525 pp

6 UNEP-WCMC. 04 March 2014. UNEP-WCMC Species Database: CITES-Listed Species.

7 Roberts, T.J. 1997. *The Mammals of Pakistan.* Oxford University Press Karachi. 525 pp

Jungle Cat *Felis chaus:* This is the most widely distributed and adaptable of the smaller cats inhabiting Pakistan.[1] It can be encountered in extensive sand-hill desert, barren hilly country at low elevations, as well as in the fertile cultivated plains of the Indus River. It is widespread and relatively common in Punjab and Sindh Provinces and less common in southern Balochistan. It is placed in Appendix II of the CITES Species List. It was not seen during the February Survey 2014.

Indian Grey Mongoose *Herpestes edwardsii:* The Grey Mongoose is easily distinguished in the field by its longer contour hairs which form almost a cape along the flanks and over the hind quarters. It is adapted to arid conditions and is, consequently, widespread in Pakistan. It is common throughout the central and northern parts of Sindh, but sparse in southern Balochistan.[2] It is included in Appendix III of the CITES Species List. The species was not observed in the Study Area during the February Survey 2014.

Small Asian Mongoose *Herpestes javanicus:* The Small Asian Mongoose is a small ferret-like animal with a long tapered tail and a sharp pointed conical face. The Small Asian Mongoose is particularly plentiful in southern Sindh, extending throughout Tharparkar, Thatta and Dadu districts. It occurs sparsely in Bahawalpur Division.[3] It is included in Appendix III of the CITES Species List. The species was not observed in the Study Area during the February Survey 2014.

Indian Crested Porcupine *Hystrix indica:* The lower parts of this large rodent's body are covered with short brown bristle like hairs. From the fore part of the crown to behind the shoulders, the hairs on the top of the body are modified into very long slender spines, generally of an all-black color, which can be erected when the animal is excited or angry. The porcupine is remarkably adaptable ecologically, and is found in most parts of Pakistan.[4] A gradual destruction in wilderness area is responsible for the decline in its numbers. It is listed as Near Threatened in Pakistan's Mammals National Red List 2006. Signs of this species were observed at Sampling Point S9 and S6 in the Study Area during the February 2014 survey.

Small Indian Civet *Viverricula indica*: The Small Indian Civet is cat-like in general appearance, having relatively long fore-legs and conspicuous rounded ears. This is the best adapted of all the civets in the sub-continent to semi-desert conditions and is found in a variety of habitats including riverine jungle and extensive sand-dune desert regions.[5] It is listed as Near Threatened in Pakistan's Mammals National Red List 2006 and is included in Appendix III of the CITES Species List. It was not seen during the February 2014 Survey.

Smooth Coated Otter *Lutrogale perspicillata*: Smooth-coated Otters are relatively large and weigh between 7 to 11 kilograms and have a body length of 23 to 25 inches. They can be

---

[1] Ibid

[2] Ibid

[3] Roberts, T.J. 1997. *The Mammals of Pakistan.* Oxford University Press Karachi. 525 pp

[4] Ibid

[5] Ibid

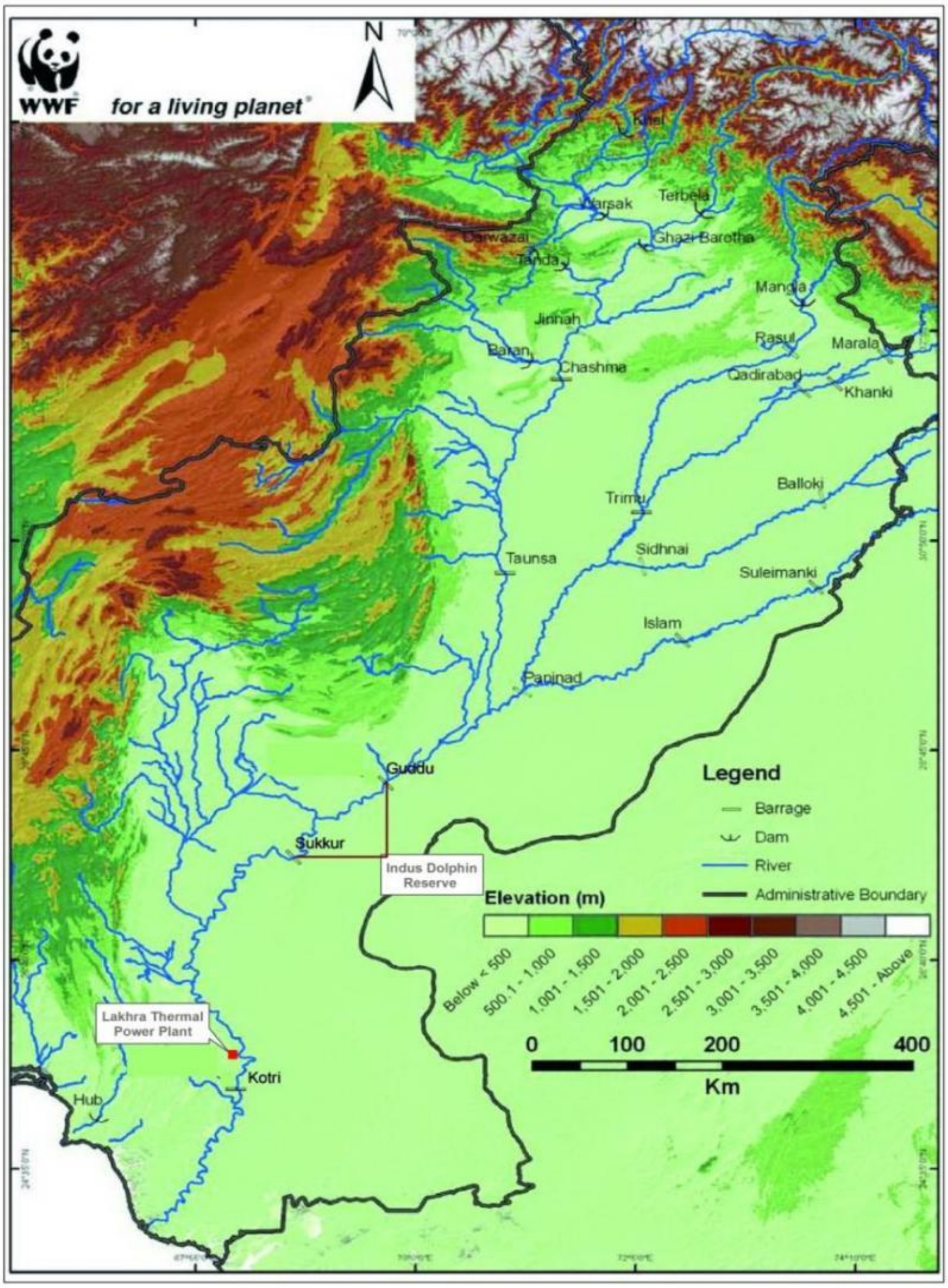
distinguished from other species of otters by a more rounded head and a hairless nose in the shape of a distorted diamond. The tail is flattened, the legs are short and strong, with large webbed feet bearing strong claws. As their name suggests, they have unusually short and sleek fur; this is dark to reddish brown along the back, while the underside is light brown to almost grey in color.[1] It is listed as Vulnerable in the IUCN Red List and Near Threatened in Pakistan's Mammals National Red List 2006. It is included in Appendix II of the CITES Species List. The species was not observed during the survey of February 2014.

Indus Blind Dolphin *Platanista minor*: The Indus Dolphin is probably one of the most specialized of the world's fresh-water dolphins, being confined to the fluvial, not tidal, water which is heavily turbid and silt laden. In outline, it is a typical dolphin with a sleek fusiform body, the caudal region being laterally compressed and very slim. It differs from most other dolphins in the broad spade-shaped flipper and rostrum, or beak, which is relatively long and very slender. In color, this dolphin is pinkish or purplish grey-brown, being only slightly paler ventrally. Like other cetaceans, the skin is soft and satiny to the touch in surprising contrast to the harsh granulated skin of a shark or slippery feel of true fishes.[2] It is listed as Endangered in the IUCN Red List and Endangered in the Pakistan's Mammals National Red List 2006. It is included in Appendix I of the CITES Species List. It was not observed during the February 2014 survey.

---

[1] Hawang, Y. T. and Lariviere, S. 2005. *Lutrogale perspicillata*. Mammalian Species (786)

[2] Roberts, T.J. 1997. *The Mammals of Pakistan.* Oxford University Press Karachi. 525 pp



Map Source: WWF-Pakistan and Sindh Wildlife Department, 2010, Ecological Impact of Floods: Indus Dolphin survey Sukkur to Kotri Barrages

Figure 5-19: The Indus River System with Major Head Works

5.3.3 Reptiles and Amphibians

Pakistan has a high diversity of reptiles and amphibians comprising 24 species of amphibians and about 200 species of reptiles, represented by 26 families.[1]

---

[1] Khan, M.S. 2006. *Amphibians and Reptiles of Pakistan,* Krieger Publishing Company, Malabar, Florida, 2006, 310 pp.

Minton[1] and Mertens[2] made significant contributions to herpetological studies in Pakistan, primarily in the southern parts of the country, including Sindh and Balochistan. Minton[3] reported 144 species of amphibians and reptiles from Pakistan, whereas Mertens[4] not only documented 178 species but also corrected some of the systematic anomalies adapted by the former scientist. The herpeto-fauna (reptiles and amphibians) of the Study Area is only marginally reported in the literature. There are few fragmentary reports that contain observations of amphibians and reptiles from the adjacent areas of Jamshoro, Dadu and Kirthar Range .[5,6,7,8,9,10] However, the information currently available about the amphibians and reptiles of the Study Area is an extension of generalized distribution of the herpeto-fauna of the district, and is partly based on the earlier work of Minton[11] and Mertens. [12]

An ecological survey was conducted in June 2012 in Jamshoro district about 25 km from the Project site.[13] Signs of four (4) reptile species were observed. These species included the Indian Fringe-toed Sand Lizard *Acanthodactylus cantoris,* Cholistan Desert Lacerta, *Eremias cholistanica,* Brilliant Ground Agama *Trapelus agilis* and the Indian Spiny-tailed Ground Lizard *Saara hardwickii.*

A survey was conducted in the Study Area from February 14th to February 16th, 2014 to study herpeto-faunal abundance and diversity in the spring season. This was a good time for sampling the reptiles and amphibians that come out of winter hibernation in spring.

Sampling points are indicated in **Figure 5-13**.

Data collected during this study is included in **Table 5-4** in **Appendix 5**.

Figure 5-20 presents Species Accumulation Curves (SAC is a curve built upon the total number of species counted for incremental numbers of individuals recorded) for the February 2014 survey in the Study Area for the habitats sampled (agricultural fields, hills,

---

1 Minton, S.A. 1966. A Contribution to the herpetology of W. Pakistan. Bull. Am. Mus. Nat. Hist., 134(2): 28-184.

2 Mertens, R. 1969. Die Amphibiens und Reptiliens West Pakistan. Stutt. Beit. Naturkunde, 197:1-96.

3 Minton, S.A. 1966. A Contribution to the herpetology of W. Pakistan. Bull. Am. Mus. Nat. Hist., 134(2): 28-184.

4 Mertens, R. 1969. Die Amphibiens und Reptiliens West Pakistan. Stutt. Beit. Naturkunde, 197:1-96.

5 Murray, J.A., (1884). Vertebrate Zoology of Sindh: A systematic account. Richard & Co., London. 415 pp.

6 Murray, J.A., (1886). Vertebrate Zoology of Sindh: A systematic account: 1-92. Richard & Co., London.

7 Boulenger, G.A., 1890. The Fauna of British India including Ceylon and Burma: Reptilia and Batrachia. Taylor & Francis, London, pp 541.

8 Smith, S.A., (1933). The Fauna of British India including Ceylon and Burma, vol. I. Taylor & Francis, London.

9 Smith, S.A., (1935). The Fauna of British India including Ceylon and Burma, vol. II. Taylor & Francis, London

10 Smith, S.A., (1943). The Fauna of British India Ceylon and Burma including the whole of Indo-Chinese sub-region, vol. III. Taylor & Francis, London. 240 pp.

11 Minton, S.A. 1966. A Contribution to the herpetology of W. Pakistan. Bull. Am. Mus. Nat. Hist., 134(2): 28-184.

12 Mertens, R. 1969. Die Amphibiens und Reptiliens West Pakistan. Stutt. Beit. Naturkunde, 197:1-96.

13 Asian Development Bank (ADB), July 2012, Environmental Impact Assessment of Rehabilitation of Thermal Power Station Jamshoro. Report prepared for Engconsult Ltd.

plains and river/riparian). For each habitat type, Species Accumulation Curves[1] are presented for all reptile and amphibian species to represent sample adequacy in the February 2014 survey. The curves for hills, plains, and river/riparian habitats levelled off showing adequacy of sampling effort. The curve for agricultural fields did not level off showing inadequate sampling in this habitat. To compensate for this, a literature review of the reptiles and amphibians of the Study Area was carried out.

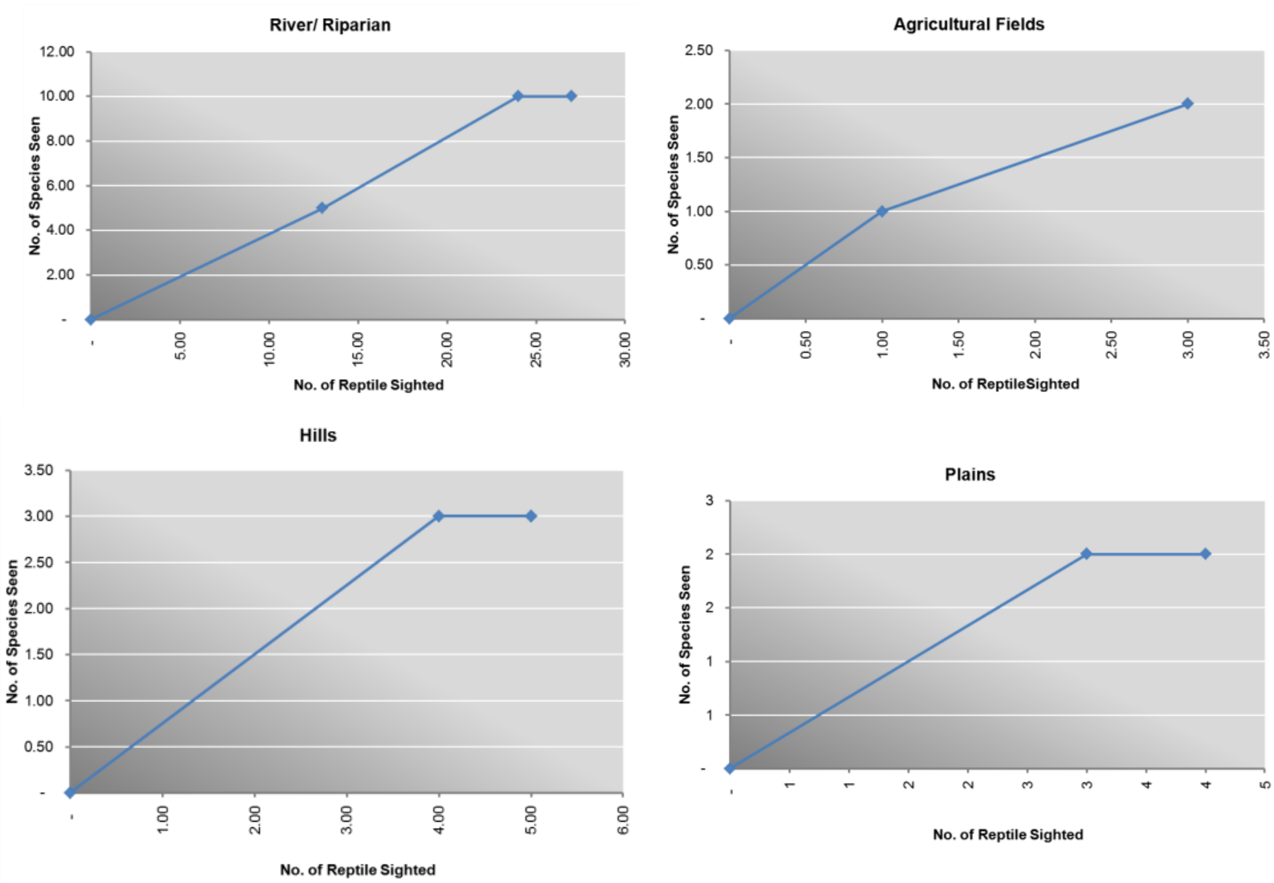


Figure 5-20: Reptiles and Amphibians, Species Accumulation Curves for 2014 Survey

Table 5-26 provides a summary of sampling points by type of habitat, number of sightings, and the number of species sighted.

Table 5-26: Reptile and Amphibian Abundance and Diversity by Habitat Type, Survey Conducted February 2014

Habitat	*Sampling Points*	*Total Sightings*	*Density*	*No. of Species*
February 2014				
Agricultural fields	3	3	1.0	2
Hills	3	5	1.6	3
Plains	3	4	1.3	2
River / Riparian	3	27	9.0	10
Total	**12**	**39**		

[1] Thompson, G.G., and Thompson, S.A. 2007. Using species accumulation curves to estimate trapping effort in fauna surveys and species richness. Austral Ecology; Volume 32 Issue 5: 564 -569 (published online: 20 June 2007).

Table 5-27 shows the abundance of reptiles and amphibians in the Study Area for all habitat types.

Table 5-27: Abundance of Reptiles and Amphibians in the Study Area Survey Conducted February 2014

No	Common Name	*Scientific Name*	*Habitats*				***Total***	***No of Habitats***
			Agricultural Fields	*Hills*	*Plains*	*River/ Riparian*		
1.	Rough Bent-toed Gecko	*Cyrtopodion scabrum*	–	3	2	–	**5**	**2**
2.	Striped Grass Skink	*Eutropis dissimilis*	2	–	–	1	**3**	**2**
3.	Brilliant Ground Agama	*Trapelus agilis*	–	1	2	–	**3**	**2**
4.	Bengal Monitor	*Varanus bengalensis*	1	–	–	2	**3**	**2**
5.	Indian Fringe-toed Sand Lizard	*Acanthodactylus cantoris*	–	–	–	2	**2**	**1**
6.	Garden Lizard	*Calotes v. versicolor*	–	–	–	3	**3**	**1**
7.	Skittering Frog	*Euphlyctis cyanophlyctis*	–	–	–	3	**3**	**1**
8.	Black Cobra	*Naja naja*	–	–	–	2	**2**	**1**
9.	Indian Softshell Turtle	*Nilssonia gangetica*	–	–	–	4	**4**	**1**
10.	Brown Roofed Turtle	*Pangshura smittii*	–	–	–	1	**1**	**1**
11.	Indian Roofed Turtle	*Pangshura tecta*	–	–	–	8	**8**	**1**
12.	Glossy-bellied Racer	*Platyceps v. ventromaculatus*	–	1	–	–	**1**	**1**
13.	Royal Snake	*Spalerosophis atriceps*	–	–	–	1	**1**	**1**
		Total Sightings	**3**	**5**	**4**	**27**	**39**	

Table 6-1 in **Appendix 6** provides a list of species observed and reported from the Study Area.

Photographs of the common species observed during the surveys are included in **Figure 5-21.**

a. *Acanthodactylus cantoris* (Indian *fringe*–toed sand lizard)

b. *Trapelus agilis* (Brilliant ground agama)

c. *Varanus bengalensis*

d. *Calotes versicolor* (Asian garden lizard)

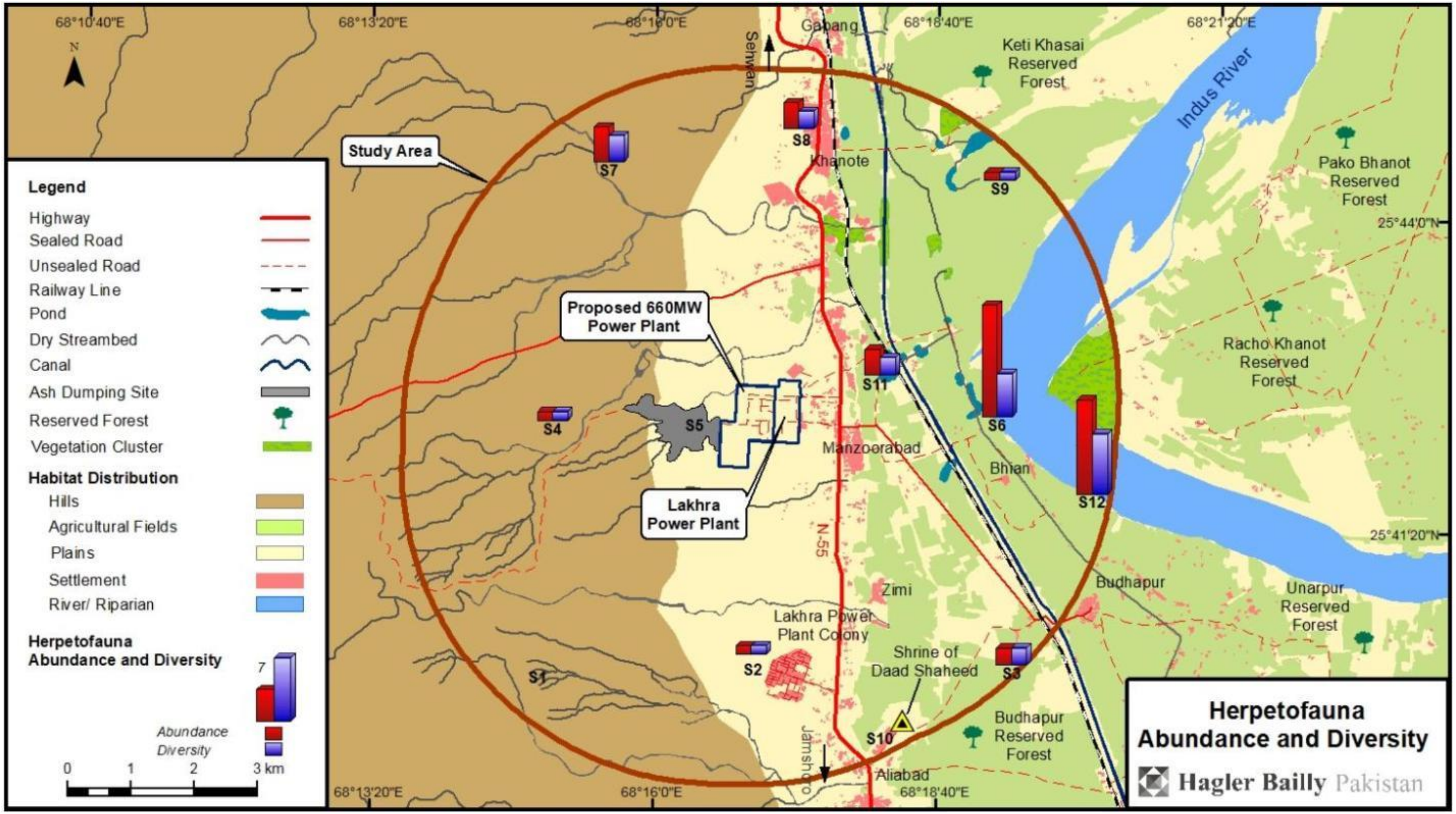
Figure 5-21: Photographs of Common Reptilian Species of the Study Area

Overview of Reptile Abundance and Diversity

Table 5-26 gives the reptile and amphibian abundance and diversity by habitat type for surveys conducted in February 2014. During the February 2014 survey, a total of 39 individuals belonging to 13 species were seen at 12 sampling points. The average number of sightings per sampling point (density) during the February 2014 survey was 1.0, 1.6, 1.3 and 9.0 in agricultural fields, hills, plains and river/riparian respectively.

The abundance and diversity of reptiles and amphibians in the Study Area for the February 2014 surveys is illustrated in **Figure 5-16**. The maximum abundance was seen at Sampling Point S6 in river/riparian habitat where 13 individuals belonging to 5 species were sighted. The most abundant species seen at this sampling location was the Indian Roofed Turtle *Pangshura tecta* followed by Skittering Frog *Euphlyctis cyanophlyctis*. This sampling location is located on the banks of the Indus River and provides conducive habitat for turtle and frog species. The second highest herpeto–faunal abundance was seen at Sampling Point S12 also located along the bank of the Indus River, where 11 individuals were seen. The Indian Roofed Turtle *Pangshura tecta* was the most abundant species seen here. The least abundance of herpeto–fauna seen during the February 2012 survey was at Sampling Point S9, S4 and S2 located in agricultural fields, hills and plains respectively where only a single individual was seen. No reptile or amphibian species was seen at the following sampling points S10, S5 and S1.

The highest reptile diversity was recorded at Sampling Points S12 on the banks of the Indus River where seven (07) herpeto–faunal species were observed. Species seen here included Indian Roofed Turtle *Pangshura tecta*, Indian Softshell Turtle *Nilssonia gangetica*, Bengal Monitor *Varanus bengalensis*, Garden Lizard *Calotes v. versicolor*, Black Cobra *Naja naja*, Royal Snake *Spalerosophis atriceps*, Striped Grass Skink *Eutropis dissimilis.* The second highest herpeto–faunal diversity was seen at Sampling Point S6 where five (05) species were observed including Indian Roofed Turtle *Pangshura tecta*, Skittering Frog *Euphlyctis cyanophlyctis*, Indian Softshell Turtle *Nilssonia gangetica,* Indian Fringe-toed Sand Lizard *Acanthodactylus cantoris* and Brown Roofed Turtle *Pangshura smittii*.



Source: Hagler Bailly Pakistan

Figure 5-22: Herpeto-fauna Abundance and Diversity

Species Sighted and Habitat Affinities

Table 5-4 in **Appendix 5** gives the data collected for the reptile and amphibian species observed in the Study Area during the surveys of February 2014.

A total of 39 individuals belonging to 13 species were seen during the February 2014 survey. The most abundant herpeto-faunal species seen was Indian Roofed Turtle *Pangshura tecta.* It was seen exclusively in the river/riparian habitat. This is a quiet-water turtle, occurring in streams, canals, oxbows, ponds, and man-made water tanks. It also occurs in brackish coastal waters.[1] Other abundant herpeto-faunal species seen during the February 2014 survey included Rough Bent-toed Gecko *Cyrtopodion scabrum* and Indian Softshell Turtle *Nilssonia gangetica.*

Reptiles and amphibians are highly habitat specific, and therefore, occupy small niches spread all over the Study Area. Unlike birds and mammals that have very wide foraging ranges, reptiles and amphibians have a restricted home range. Except Monitor Lizards and large snakes, other species usually stay within an area of one square km for feeding and breeding.[2] Geckos or Skinks may occupy microhabitats spread over even smaller areas. The breeding ground for a reptile or amphibian species cannot be marked at one or two places; these are spread all over the area within suitable habitats at several scattered places, provided other climatic factors remain conducive.

Information from the February 2014 survey was used to study habitat affinities. No species was observed in all four or even three habitats of the Study Area. Species observed in two habitats included Rough Bent-toed Gecko *Cyrtopodion scabrum*, Striped Grass Skink *Eutropis dissimilis*, Brilliant Ground Agama *Trapelus agilis* and Bengal Monitor *Varanus bengalensis*. All other species were seen in only one habitat including the Garden Lizard *Calotes v. versicolor*, Skittering Frog *Euphlyctis cyanophlyctis*, Indian Softshell Turtle *Nilssonia gangetica*, Indian Roofed Turtle *Pangshura tecta*.

The distribution of some common reptiles in the habitats of the Study Area is shown in **Figure 5-23**.

---

1 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 10 March 2014.

2 Mertens, R. 1969. Die Amphibiens und Reptiliens West Pakistan. Stutt. Beit. *Naturkunde*, 197:1-96.

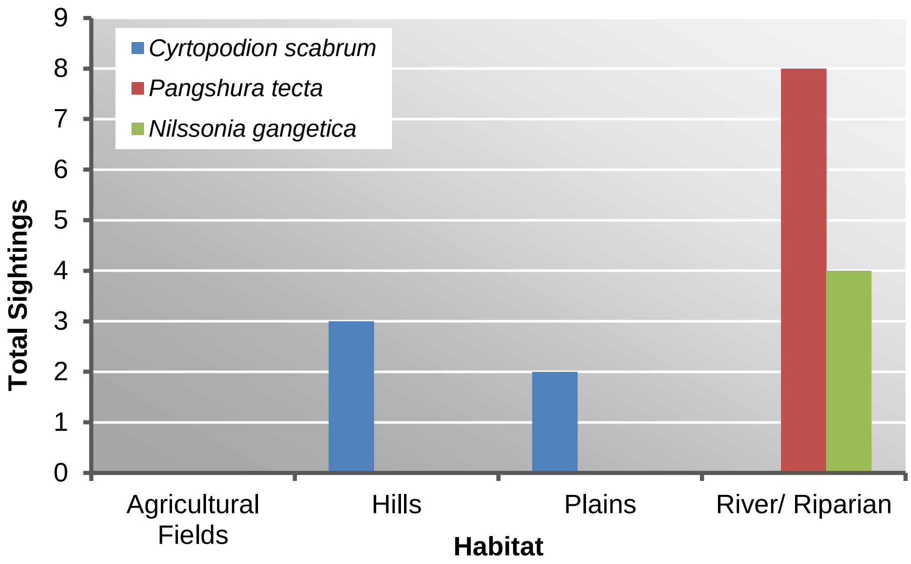


Figure 5-23: Distribution of Some Common Reptiles in Habitat Types in Study Area Survey Conducted February 2014

Conservation Status

Six of the reptiles reported to occur in the Study Area are included in the IUCN Red List.[1] The Narrow-headed Soft-shell Turtle *Chitra indica* listed as Endangered while the Spotted Pond Turtle *Geoclemys hamiltonii*, Indian Softshell Turtle *Nilssonia gangetica*, Peacock Soft-shell Turtle *Nilssonia hurum* and Common River Turtle *Hardella thurji* are listed as Vulnerable. The Brown Roofed Turtle *Pangshura smithii* is listed as Near Threatened.

Only one species, Cholistan Desert Lacerta *Eremias cholistanica* is Endemic. The species included in Appendix I in the CITES Species List[2] include Spotted Pond Turtle *Geoclemys hamiltonii,* Indian Roofed Turtle *Pangshura tecta*, Narrow-headed Soft-shell Turtle *Chitra indica,* Peacock Soft-shell Turtle *Nilssonia hurum,* Indian Softshell Turtle *Nilssonia gangetica,* the Spotted Pond Turtle *Geoclemys hamiltonii,*Indian Monitor Lizard *Varanus bengalensis and* Indo-Pak Desert Monitor *Varanus griseus koniecznyi.*

The species included in Appendix II of the CITES Species List[3] include Common Sand Boa *Eryx johnii,* Dhaman *Ptyas mucosus,* Indian Cobra *Naja naja,* Indian Flap Shell Turtle *Lissemys punctata,* Bull Frog *Hoplobatrachus tigerinus,* Common River Turtle *Hardella thurji,* Indian Flap Shell Turtle *Lissemys punctata* , Brown Roofed Turtle *Pangshura smithii,* Russell's Sand Boa *Gongylophis conicus* and Indian Spiny-tailed Ground Lizard *Saara hardwickii.*

---

1 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 10 March 2014.

2 UNEP-WCMC. 27 February 2014. UNEP-WCMC Species Database: CITES-Listed Species.

3 Ibid

Indian Spiny–Tailed Lizard *Saara hardwickii*

The Indian Spiny–Tailed Lizard *Saara hardwickii* is a characteristic diurnal ground lizard that lives in vast tracts of hard soil with moderate to sparse xerophytic vegetation throughout the deserts of Cholistan, Thar, Thal, and Nara, as well as portions of southern Balochistan including Lasbela.[1] It is a herbivore and its diet consists of leaves, flowers, and grasses. This reptile species usually occurs around scattered bushes and its burrows have a wide opening. This species is included in CITES Appendix II[2] because of its attractiveness in global wild pet trade. However, there is no reliable figure available concerning the extent of illegal trade of this species from Pakistan. It was not seen in the Study Area during the February 2014 survey.

Common Sand Boa *Eryx johnii*

This boid snake is characteristic of moderate deserts of loose soil with sparse vegetation; it becomes rare in sandy, stony and damp soil. It readily invades human habitations, attracted by rodents, where it resides in their burrows.[3] It is a powerful constrictor; the prey is killed by pressing against the walls of the burrows. This species is included in Appendix II of CITES species list. The skin of this snake is extremely valuable and used in making purses, bags, shoes and other items that are sold at high prices in the international market. It is sought after and caught from the wild for its skin. Moreover, it is used in public shows by snake charmers. It was not seen in the Study Area during the February 2014 survey.

Cholistan Desert Lacerta *Eremias cholistanica*

The species constitutes the first record of the genus *Eremias* from the Oriental (Indian) region.[4] The species has been named *Eremias cholistanica*, after the Cholistan Desert of Pakistan and is endemic to the country. It lives in the sandy area with sparse vegetation, mainly consisting of *Calligonum polygonoides, Haloxylon salicornicum, Aerva persica.* The species is exclusively insectivorous and feeds on ant–lions, beetles, termites and spiders. It was not observed in the Study Area during the February 2014 survey.

Black Cobra *Naja naja*

The Black Cobra *Naja naja* frequents various habitats including grasslands, vegetation along tilled fields, along water courses, semi–desert forests, barns, ruins with grassy growths, and growths around villages. The Cobra, through diurnal, usually prefers coming out at the time of least disturbance. It is particularly shy of human beings. It is a restless creature moving from place to place with agility in search of its prey, which are mainly mice, rats, poultry, frogs and

---

1 Minton, S.A. 1966. A Contribution to the herpetology of W. Pakistan. Bull. Am. Mus. Nat. Hist., 134(2): 28-184.

2 UNEP-WCMC. 27 February 2014. UNEP-WCMC Species Database: CITES-Listed Species.

3 Khan, M.S. 2006. Amphibians and Reptiles of Pakistan, Krieger Publishing Company, Malabar, Florida, 2006, 310 pp

4 Baig, K.J. and Masroor, R. 2006. A new species of Eremias (Sauria: Lacertidae) from Cholistan Desert, Pakistan. Russian Journal of Herpetology, 13 (3): 167-174.

snakes.[1] It is included in Appendix II of the CITES Species List. The species was seen in the Study Area at Sampling Points S11 and S12 during the February 2014 survey.

Bengal Monitor *Varanus bengalensis*

Bengal Monitor *Varanus bengalensis* is large monitor lizard which inhibits moderately dry forests and extends into the cultivated areas where it lives in tracts of barren lands. It lives in burrows and often invades inhibited houses, attracted by poultry and rodents. It is also a good tree climber. During the rainy season it lives in tree holes feeding on birds and eggs. The breeding season of this reptile extends from April to June and it lays 6–12 eggs.[2] It is included in CITES Appendix I. It was seen in the Study Area at Sampling Point S12 during the February 2014 survey.

Indian Desert Monitor *Varanus griseus koniecznyi*

The Indian Desert Monitor *Varanus griseus koniecznyi* prefers sandy fields of uneven surfaces with tracts of hard soils with sparse vegetation.[3] It excavates burrows in the roots of trees and bushes, and also inhabits the crevices in trees and boulders. It feeds on rodents, lizards, snakes, birds, and eggs. The breeding season extends from late March to late May. Monitor lizard skins have high commercial value and earn high prices in both national and international markets. However, there is little information available on the illegal trade and killing of this species from Pakistan. It is included in Appendix I[4] of the CITES Species List. It was not seen in the Study Area during the February 2014 survey.

Dhaman or Rope Snake *Ptyas mucosus*

This is a large snake with an elongated head, distinct from neck and a blunt snout. The color is usually dorsum gray to dark olive brown. The diet of the Dhaman consists mainly of lizards, birds, eggs, rodents, and frogs. It is known to press the struggling prey against the ground with its body while devouring it.[5] This species breeds from March through August and hibernates from December to February. It is included in Appendix II of the CITES Species List. It was not seen in the Study Area during the February 2014 survey.

Spotted Pond Turtle *Geoclemys hamiltonii*

This turtle is mainly black with small yellowish spots, and a much–elevated carapace. A large shield, sometimes divided into three, covers the upper surface of the snout and the crown. Its digits are webbed to the claws. The tail is extremely short. The shell is dark brown or blackish,

---

1 Khan, M.S. 2006. Amphibians and Reptiles of Pakistan, Krieger Publishing Company, Malabar, Florida, 2006, 310 pp

2 Ibid

3 Ibid

4 UNEP-WCMC. 12 March 2014. UNEP-WCMC Species Database: CITES-Listed Species.

5 Khan, M.S. 2006. Amphibians and Reptiles of Pakistan, Krieger Publishing Company, Malabar, Florida, 2006, 310 pp

5 Ibid

elegantly marked with yellow spots and radiating streaks.[1] It is listed as Vulnerable in the IUCN Red List and included in Appendix I of the CITES Species List. It was not seen in the Study Area during the February 2014 survey.

Brown Roofed Turtle *Pangshura smithii*

This turtle is native to India, Pakistan and Bangladesh (IUCN Red List). The carpace (shell) is depressed and feebly keeled and usually pale olive brown in color.[2] It is listed as Near Threatened in the IUCN Red List and included in CITES Appendix II. It was observed in the Study Area during the February 2014 survey at Sampling Point S6 located on the banks of the Indus River.

Indian Flapshell Turtle *Lissemys punctata*

This turtle is plentiful in the riparian system of the upper and lower Indus valleys and frequents muddy ditches, lakes and marshes with considerable marginal vegetation .[3] The shell is light olive brown, with scattered bright yellow round dashed spots. The diet includes adult frogs, tadpoles, fishes, crustaceans, fishes, crustacean, fish larvae, water plants and mollusks. It hibernates from November to February. The species is included in CITES Appendix II. It was not seen in the Study Area during the February 2014 survey.

Indian Softshell Turtle *Nilssonia gangetica*

This is a soft shelled turtle found in the rivers of South Asia. The upper part is olive while the lower part more yellowish in color. It is listed as Vulnerable in the IUCN Red List and included in Appendix I of the CITES Species List. It was seen in the Study Area during the February 2014 survey at Sampling Point S6 and S12.

Common River Turtle *Hardella thurjii*

The Brahminy River Turtle or Crowned River Turtle *Hardella thurjii* is a species of turtle found in northern India, Pakistan, and Bangladesh. This species has a shell with a large, moderately flat, dark brown or black carapace (dorsal surface) and a yellow or black plastron (ventral surface). The lower jaw is heavily dented.[4] It is listed as Vulnerable in the IUCN Red List and included in CITES Appendix II. It was not seen in the Study Area.

---

1 Boulenger, G.A., 1890. The Fauna of British India including Ceylon and Burma: Reptilia and Batrachia. Taylor & Francis, London, pp 541.

2 Ibid

3 Khan, M.S. 2006. Amphibians and Reptiles of Pakistan, Krieger Publishing Company, Malabar, Florida, 2006, 310 pp

4 Fritz Uwe; Peter Havaš (2007). "Checklist of Chelonians of the World". *Vertebrate Zoology* **57** (2): 223–224. ISSN 18640-5755. Archived from the original on 2010-12-17. Retrieved 29 May 2012.

Indian Roofed Turtle *Pangshura tecta*

This is found in most major rivers of South Asia but can occur in brackish coastal waters as well. A soft bottom and abundant aquatic vegetation are preferred conditions for its habitat.[1] It is included in CITES Appendix I. It was not observed in the Study Area.

Narrow-headed Soft-shell Turtle *Chitra indica*

Indian Narrow-headed Softshell turtle (*Chitra indica*) is a species of turtle found in the major rivers of Pakistan and India. The color is usually olive to deep olive green .[2] The species is listed as Endangered in the IUCN Red List and included in CITES Appendix I. It was not seen in the Study Area during the February 2014 survey.

Peacock Soft-shell Turtle *Nilssonia hurum*

Peacock Softshell Turtle *Nilssonia hurum* is a species of turtle found in Nepal, India, Bangladesh and Pakistan.[3] The species is listed as Vulnerable in the IUCN Red List and included in CITES Appendix I. It was not seen in the Study Area during the February 2014 survey.

Chain Sand Boa Gongylophis conicus

The Chain Sand Boa or Russell's Sand Boa is usually found in moist sandy and silty soil. The snake is shy and usually forages at night. Its primary reflex in the face of danger is to bury itself in the soil. When captive it remains buried for several days, keeping its head close to the surface. When provoked, it throws itself in a coiled ball and if touched flinches, occasionally slashing to strike with the whole body. The snake is of uncertain temperament, and its bite is painful. Lizards, rats and mice are the main food items but nestlings and eggs are occasionally consumed. It is included in CITES Appendix II. This species was not observed in Study Area.

Bull Frog *Hoplobatrachus tigerinus*

This species is found throughout most wetland areas of India, Bangladesh and much of northern Pakistan, and is recorded from the southern parts of Nepal, and from upper and northern central Myanmar.[4] It was once heavily collected for the international frog legs trade. Legal export of this species from the range states of India and Bangladesh has been banned since the mid-1990's. It is included in CITES Appendix II.

---

1 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 10 March 2014.

2 Fritz Uwe; Peter Havaš (2007). "Checklist of Chelonians of the World". *Vertebrate Zoology* **57** (2): 223–224. ISSN 18640-5755. Archived from the original on 2010-12-17.

3 Ibid

4 Anand Padhye, Kelum Manamendra-Arachchi, Anslem de Silva, Sushil Dutta, Tej Kumar Shrestha, Sabitry Bordoloi, Theodore Papenfuss, Steven Anderson, Sergius Kuzmin, Muhammad Sharif Khan, Ronald Nussbaum 2004. *Hoplobatrachus tigerinus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on **06 March 2014**.

5.3.4 Birds

Pakistan is bounded by Iran and Afghanistan to the West and China to the north and India to the east. The country is bisected by Indus River, which flows the entire length of the country before entering the Arabian Sea via the sprawling Indus delta in the south. Pakistan has a rich diversity of bird habitats, from the dry alpine and moist temperate forests of the western Himalayas to the deserts of Baluchistan and Sind. The Indus basin is extensively irrigated and cultivated providing a variety of man-made habitats. This diversity of habitats supports a wide variety of bird species, and some 669 have been recorded. More than 60% of the country, land lying to the west of the Indus River and south from Peshawar to the Arabian Sea coasts, is Palaearctic in character, with a steppic dry mountain habitat, and is very different from the rest of Indian subcontinent. Pakistan's avifauna is thus a fascinating mix of Palearctic and Oriental, blending species that are at the western and eastern limits of their distribution.[1]

River Indus and its associated tributaries provide an important habitat for both resident and migratory birds. Vegetation on both sides of the river and agricultural areas offer ample habitat and food for many bird species. Common resident bird species reported from the River Indus and tributaries include Indian Pond Heron *Ardeola grayii*, Common Moorhen *Gallinula chloropus*, Little Egret *Egretta garzetta*, Black-shouldered Kite *Elanus caeruleus*, Little Grebe *Tachybaptus ruficollis,* Little Cormorant *Phalacrocorax niger,* Black Kite *Milvus migrans*, Red-wattled Lapwing *Hoplopterus indicus*, Eurasian Collard Dove *Streptopelia decaocto*, White-throated Kingfisher *Halcyon smyrnensis*, Pied Kingfisher *Ceryle rudis*, Common Kingfisher *Alcedo atthis*, Hoopoe *Upupa epops*, Striated Babbler *Turdoides earlei*, Black Drongo or King Crow *Dicrurus macrocercus*, House Crow *Corvus splendens*, Common Myna *Acridotheres tristis*, Bank Myna *Acridotheres ginginianus* etc.[2]

An ecological survey was conducted in June 2012 in Jamshoro district about 25 km from the Project site.[3] A total of 451 bird individuals belonging to 25 species were observed in the Study Area. The most abundant bird species seen in the Study Area included the Rock Pigeon *Columba livia* and the Great Cormorant *Phalacrocorax carbo* followed by the Little Egret *Egretta garzetta* and House Crow *Corvus splendens.*

Both resident and migratory birds have been reported from the Study Area as listed in **Table 6-3** in **Appendix 6** and these can be observed in a variety of habitats including agricultural fields, hills, plains and river/ riparian

A survey was conducted in February 2014 to gain information about the abundance and diversity of the avifauna of the Study Area in spring. Sampling points are indicated in the map in **Figure 5-13**.

Data collected during this study is included in **Table 5-5** in **Appendix 5**.

---

1 Grimmett, R., Roberts, T., and Inskipp, T. 2008. Birds of Pakistan, Yale University Press.

2 Ibid

3 Asian Development Bank (ADB), July 2012, Environmental Impact Assessment of Rehabilitation of Thermal Power Station Jamshoro. Report prepared for Engconsult Ltd.

On the basis of the topographical features, habitats of the Study Area were divided into four types, i.e. agricultural fields, hills, plains and rivers/riparian.

Table 5-28 provides a summary of sampling points by habitat type, number of sightings, and number of species sighted during the February 2014 survey. Sampling was conducted at 12 points, of which three (3) were in agricultural fields, three (3) in hills, three (3) in plains and three (3) in rivers/riparian.

Figure 5-23 presents species accumulation curves (SAC) from the February 2014 survey for the four habitat types: agricultural fields, plains, hills and rivers/ riparian. The curves for all four habitats did not level off and reach saturation indicating that more sampling was needed in each habitat type. To compensate for any inadequacy in sampling, a literature review of the avian-fauna reported from the Study Area and surroundings was completed. Special emphasis was given to the birds of conservation importance.

Table 5-28: Bird Abundance and Diversity by Habitat Type

Surveys Conducted February 2014

Habitat	*No.of Sampling Points*	*Total Sightings*	*Density*	*No. of Species*
Februry 2014				
Agricultural Fields	3	79	26.33	11
Plains	3	48	16.00	4
Hills	3	14	4.67	3
River/ Riparian	3	282	94.00	17
Total	**12**	**423**		

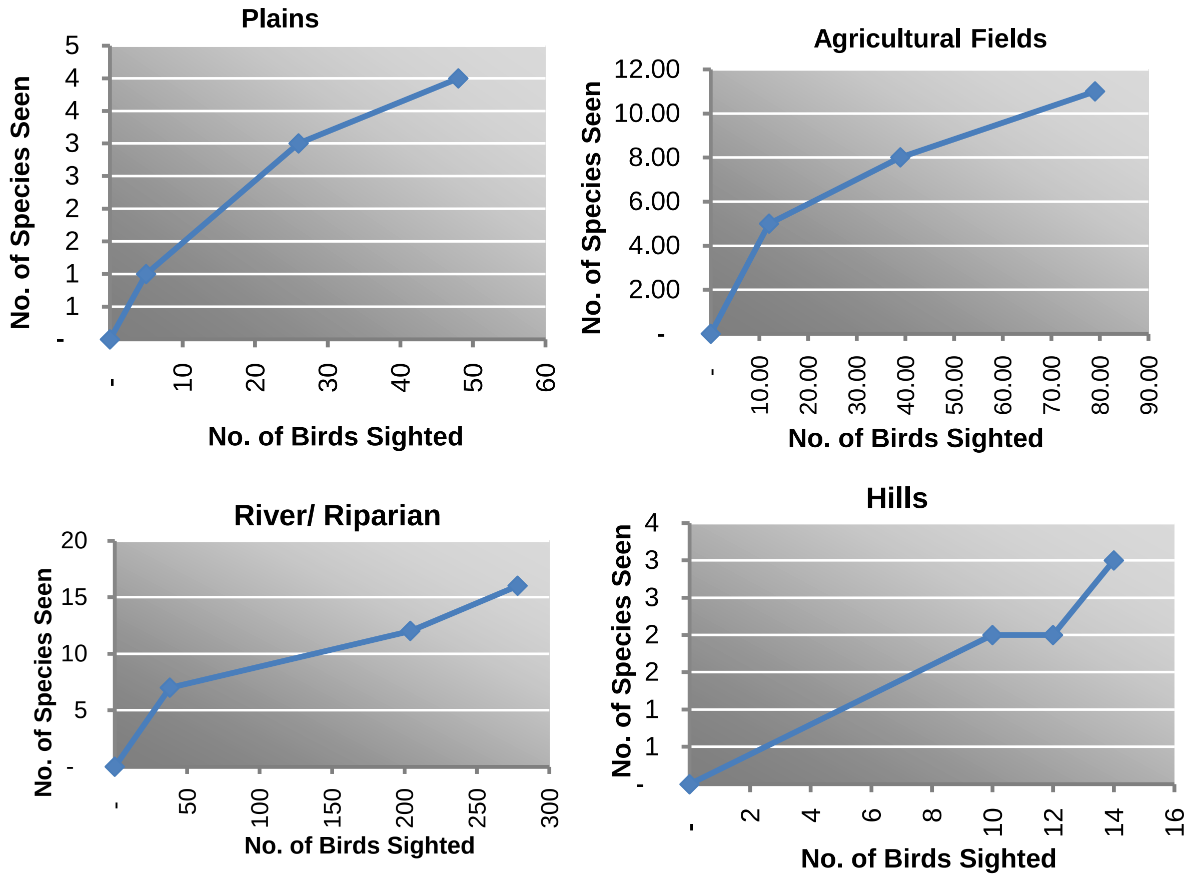


Figure 5-24: Birds, Species Accumulation Curves for February 2014 Survey in Study Area in Habitat Types

Overview of Bird Diversity and Abundance

A total of 65 birds species have been reported from the study Area. Most of the reported species are resident in the Study Area, while some winter migrant and passage migrant species have also been reported (**Table 6-3, Appendix 6**).

During the February 2014 ecological survey a total of 423 birds belonging to 27 species were observed (**Table 6-3**, **Appendix 6**). Dominant bird species seen in the Study Area included Red-rumped Swallow *Hirundo daurica* with 150 individuals observed, followed by Blue Rock Pigeon *Columba livia*, Common Swift *Apus apus*, House Sparrow *Passer domesticus,* and Little Grebe *Tachybaptus ruficollis* with 49, 40, 20 and 20 individuals observed respectively.

The spatial distribution of the bird abundance in the Study Area is shown in **Figure 5-25**. The highest bird abundance seen during the February survey was at Sampling Point S12 located on the banks of the Indus River. A total of 166 birds were seen at this sampling point located near the Indus River. The sampling point is located on the river bank and surrounded by agriculture land. The presence of adequate food and shelter were the likely reasons for the high bird abundance seen here. The Red-Rumped Swallow *Hirundo daurica,* was the most commonly seen bird at this location. High bird abundance was also seen at some other sampling points during the February 2014 survey including Sampling Point S11, S10 and S6. Generally bird abundance was higher for those sampling points that were present in the vicinity of river/riparian habitat. The least abundance during February survey was seen at Sampling Point S1 in hills where only two (2) birds were sighted.

The spatial distribution of the bird diversity seen in the Study Area is shown in **Figure 5-25**. The highest bird diversity seen during the February 2014 survey was at Sampling Point S11 located in the river/riparian habitat where 9 bird species were observed. This sampling point was located in the vicinity of a pond near an agricultural field and the adequate food and water supply for the birds led to the high bird diversity. The Common Swift *Apus apus* and Little Gerbe *Tachybatus ruficolus* were the most commonly observed birds at this location. The second highest bird diversity was observed at Sampling Point S6 where 7 bird species were observed. The Common Swift *Apus apus* was most commonly seen bird at this location. The least diversity observed during the February 2014 survey was at Sampling Points S2 and S4 where only 2 bird species were sighted at each sampling point.

Species Sighted and Habitat Affinities

Table 6-3 in **Appendix 6** provides a list of birds observed in the Study Area during the February 2014 survey.

Table 5-29 provides details of the number of birds of each species sighted in each habitat type in the Study Area during February 2014 surveys.

Information from the February 2014 survey was used to study habitat affinities. No species was observed in all four habitats. Species that were observed in three habitats included Desert Lark *Ammomanes deserti* and Rock Pigeon *Columba livia.* Four species were recorded in two habitats. These include Ashy Prinia *Prinia socialis*, Cattle Egret *Bubulcus ibis*, Common Hoopoe *Upapa epops* and Little Stint *Calidris minuta*. All the other bird species were observed in one habitat though the possibility of their presence in other habitats cannot be ruled out.

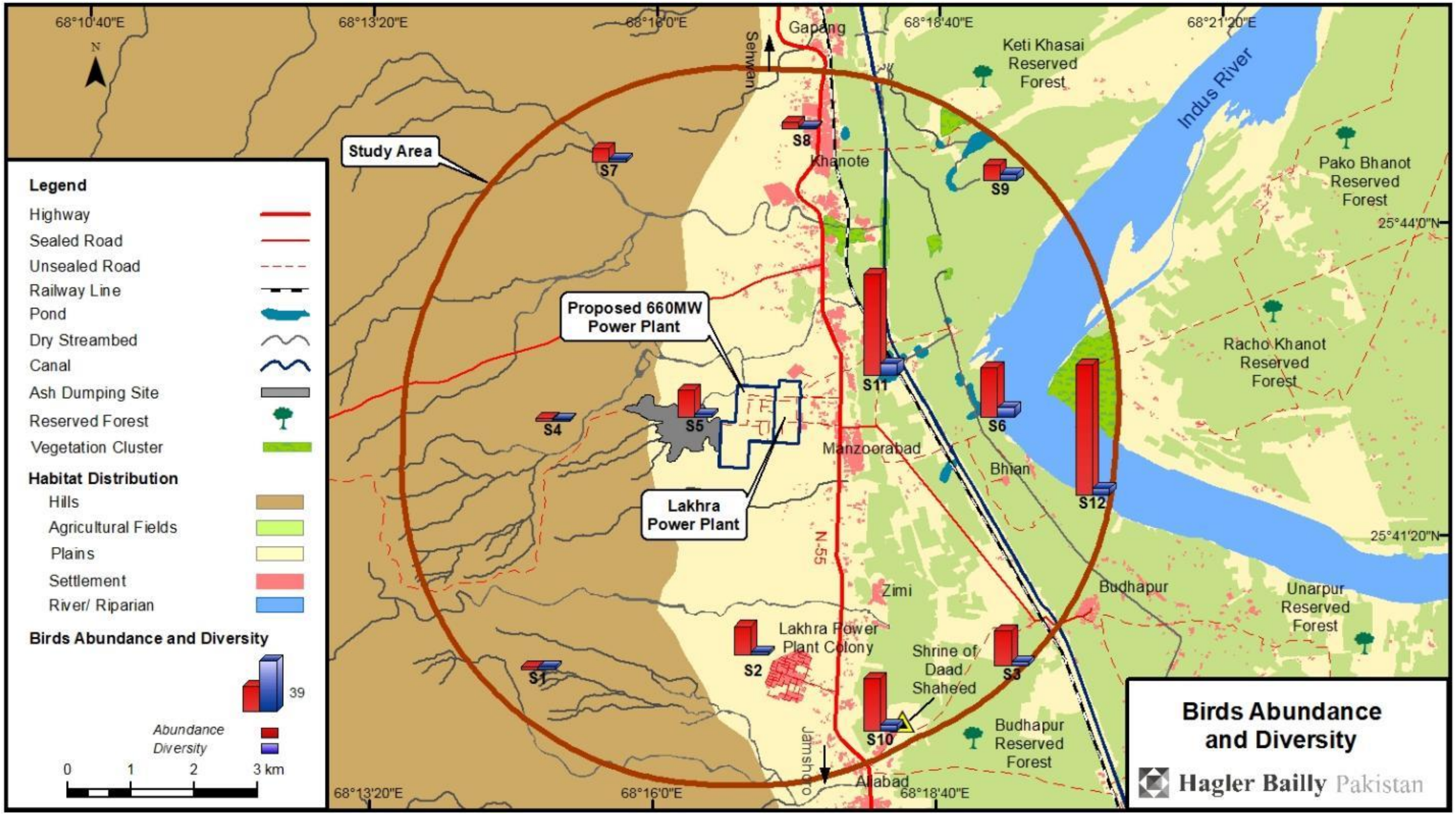
Agricultural Fields

A total of 79 individuals belonging to 11 bird species were observed in the agricultural fields (**Table 5-28**). Of the observed species, 6 were unique to the agricultural fields and not seen in other habitats. Density observed (26 individuals sighted/sampling point) was less than that seen in rivers/ riparian habitat but more than that seen in the plains and hills (**Table 5-28**). The most abundantly seen bird was the House Sparrow *Passer domesticus* with a total of 20 individuals observed followed by Blue Rock Pigeon *Columba livia,* Laughing Dove *Streptopelia senegalensis*, House Crow *Corvus splendens,* River Tern *Sterna aurantia* and Cattle Egret *Bubulcus ibis* with counts of 15, 15, 10, 5 and 5, respectively. The House Sparrow *Passer domesticus,* Blue Rock Pigeon *culumba livia,* House Crow *Corvus splendens*, Desert Lark *Ammomanes deserti,* are resident species in the Study Area and can be seen throughout the year, while Eurasian Marsh Harrier *Circus aeruginosus* and River Tern *Sterna aurantia* are winter migrant*.* The species unique to the agricultural fields and not observed in other habitats were Eurasian Marsh Harrier *Circus aeruginosus,* Great Egret

Casmerodius albus, House Crow *Corvus splendens,* House Sparrow *Passer domesticus,* Laughing Dove *Streptopelia senegalensis* and River Tern *Sterna aurantia.*

Plains

A total of 48 individuals belonging to 4 birds species were recorded in this habitat (**Table 5-28**). Out of 4 recorded species 2 were unique to this habitat. The density (16 individuals/sampling point) was higher than hills, but lower than both river/riparian and agriculture fields. Blue Rock Pigeon *Columba livia* was the most abundant species recorded in this habitat with 27 counts, followed by Black-bellied Sandgrouse *Pterocles orientalis* with 15 counts. The species unique to this habitat included Steppe Eagle *Aquila rapax nipalensis* and Black-bellied Sandgrouse *Pterocles orientalis*. Both these species are winter visitors to the Study Area.



Source: Hagler Bailly Pakistan

Figure 5-25: Bird Abundance and Diversity

Hills

A total of 14 individuals belonging to 3 bird species were observed in the hills (**Table 5-28**). Density (4 individuals/sampling point) was the lowest observed among all the habitats (**Table** 5-28). Blue Rock Pigeon *Columba livia* was the most abundant species with a total count of 7 birds in the habitat. This was followed by Desert Lark *Ammomanes deserti* with 6 counts. Both species are year-round residents in the Study Area. No bird species were unique to this habitat. Ashy Prinia *Prinia socialis* was the least common bird species observed only once in the hills.

Rivers/ Riparian

A total of 282 individuals belonging to 17 bird species were observed in the (**Table 5-28**). Of these, 12 species were unique to the rivers/ riparian habitat. The bird density observed (94 individuals/sampling points) was the highest observed among all the habitats (**Table 5-28**). Red-Rumped Swallow *Hirundo daurica* and Common Swift *Apus apus* were the most abundant species observed in this habitat with total counts of 150 and 40 birds respectively. Red -Rumped Swallow *Hirundo daurica* is a winter migrant to the Study Area, while the Common Swift *Apus apus* is a summer visitor. The unique species observed only in the rivers/ riparian habitat include Black Wing Stilt *Himantopus himantopus,* Black Drongo *Dicrurus macrocercus,* Common Swift *Apus apus,* Greater Coucal *Centropus sinensis,* Indian Pond Heron *Ardeola grayii,* Little Cormorant *Phalacrocorax niger,* Little Egret *Egretta garzetta,* Little Grebe *Tachybaptus ruficollis,* Pied Kingfisher *Ceryle rudis,* Red-rumped Swallow *Hirundo daurica,* Red-Wattled Lapwing *Vanellus indicus,* Small Skylark *Alauda gulgula* and White Wagtail *Motacilla alba.*

Important Bird Areas

The Important Bird Areas (IBAs)[1] are designated by Birdlife International in different countries of the world and are key sites for conservation—small enough to be conserved in their entirety and often already part of a protected-area network. They do one (or more) of three things:

- Hold significant numbers of one or more globally threatened species
- Are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species
- Have exceptionally large numbers of migratory or congregatory species

The locations of some of the IBAs identified in Sindh[2] are indicated on a map in **Figure 5-26**. There is no IBA in the vicinity of the Study Area. The closest IBA is the Kirthar National Park that is located at least 40 km away from the Study Area.

---

[1] Birdlife International official website. http://www.birdlife.org/action/science/sites/index.html. Downloaded on 5 March 2014.

[2] Birdlife International Official Website http://www.birdlife.org/datazone/userfiles/file/IBAs/AsiaCntryPDFs/Pakistan.pdf

Table 5-29: Number of Birds Sighted of Each Species by Habitat Type in the Study Area. Surveys Conducted During February 2014.

No	*Scientific Name*	*Common Name*	*Habitats*				*Total*	*No of Habitats*
			Agricultural Fields	*Plains*	*Hills*	*River/ Riparian*		
1.	Ammomanes deserti	Desert Lark	2	5	6	–	13	3
2.	Columba livia	Rock Pigeon	15	27	7	–	49	3
3.	Prinia socialis	Ashy Prinia	–	–	1	2	3	2
4.	Bubulcus ibis	Cattle Egret	5	–	–	2	7	2
5.	Upapa epops	Common Hoopoe	2	–	–	1	3	2
6.	Calidris minuta	Little Stint	1	–	–	12	13	2
7.	Himantopus himantopus	Balck Wing Stilt	–	–	–	1	1	1
8.	Dicrurus macrocercus	Black Drongo	–	–	–	1	1	1
9.	Pterocles orientalis	Black-bellied Sandgrouse	–	15	–	–	15	1
10.	Apus apus	Common Swift	–	–	–	40	40	1
11.	Circus aeruginosus	Eurasian Marsh Harrier	2	–	–	–	2	1
12.	Casmerodius albus	Great Egret	2	–	–	–	2	1
13.	Centropus sinensis	Greater Coucal	–	–	–	1	1	1
14.	Corvus splendens	House Crow	10	–	–	0	10	1
15.	Passer domesticus	House Sparrow	20	–	–	0	20	1
16.	Ardeola grayii	Indian Pond Heron	–	–	–	7	7	1
17.	Phalacrocorax niger	Little Cormorant	–	–	–	5	5	1
18.	Egretta garzetta	Little Egret	–	–	–	11	11	1
19.	Tachybaptus ruficollis	Little Grebe	–	–	–	20	20	1
20.	Ceryle rudis	Pied Kingfisher	–	–	–	8	8	1

No	*Scientific Name*	*Common Name*	*Habitats*				*Total*	*No of Habitats*
			Agricultural Fields	*Plains*	*Hills*	*River/ Riparian*		
21.	Hirundo daurica	Red-rumped Swallow	–	–	–	150	150	1
22.	Vanellus indicus	Red-Wattled Lapwing	–	–	–	7	7	1
23.	Streptopelia senegalensis	Laughing Dove	15	–	–	–	15	1
24.	Sterna aurantia	River Tern	5	–	–	–	5	1
25.	Alauda gulgula	Small Skylark or Oriental Skylark	–	–	–	10	10	1
26.	Aquila rapax nipalensis	Steppe Eagle	–	1	–	–	1	1
27.	Motacilla alba	White Wagtail	–	–	–	4	4	1
		Total	79	48	14	282	423	

Importance of Study Area for Migratory Birds

Pakistan gets a large number of guest birds from Europe, Central Asian States and India every year. These birds that originally reside in the northern states spend winters in various wetlands and deserts of Pakistan from the high Himalayas to coastal mangroves and mud flats in the Indus delta. After the winter season, they go back to their native habitats.

This famous route from Siberia to various destinations in Pakistan over Karakorum, Hindu Kush, and Suleiman Ranges along Indus River down to the delta is known as International Migratory Bird Route Number 4. It is also called the Green Route or more commonly the Indus Flyway, one of the important migratory routes in the Central Asian - Indian Flyway[1] (**Figure** 5-27). The birds start on this route in November. February is the peak time and by March they start flying back home. These periods may vary depending upon weather conditions in Siberia and/or Pakistan. As per an estimate based on regular counts at different Pakistani wetlands, between 700,000 and 1,200,000 birds arrive in Pakistan through Indus Flyway every year.[2] Some of these birds stay in the lakes but majority migrate to coastal areas.

The Study Area is not declared as a protected wetland Ramsaar site.[3] Even though some migratory birds have been reported from the Study Area and vicinity, (**Table 6-3** in **Appendix 6)**, investigations reveal that most of the migratory birds do not use the Study Area and vicinity as a breeding and nesting area but merely as a resting ground on their way to coastal areas where there is greater food and habitat available.

Birds of Conservation Importance

Appendix 6 gives a list of birds reported from the Study Area and observed during the February 2014 survey. A total of two bird species reported from Study Area are included in the IUCN Red List.[4] The River Tern *Sterna aurantia* is listed as Near Threatened while Indian Skimmer *Rynchops albicollis* is listed as Vulnerable in the IUCN Red List. Species included in CITES Appendix II include White Wagtail *Motacilla alba,* Common Crane *Grus grus*, Black-shouldered Kite *Elanus caeruleus,* Black Kite *Milvus migrans* and Steppe Eagle *Aquila rapax nipalensis*.

River Tern Sterna aurantia

This is a common resident in Sindh breeding on the sandbars along major rivers, wandering widely to forage over island lake sand larger irrigation canals (Grimmet 2008).[5] The species

---

1 Convention on the Conservation of Migratory Species. 1 February 2006. Central Asian Flyway Action Plan for the Conservation of Migratory Waterbirds and their Habitats. New Delhi, 10-12 June 2005: UNEP/CMS Secretariat.

2 Pakistan Wetlands Programme. 2012. Migratory Birds Census Report.

3 The Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

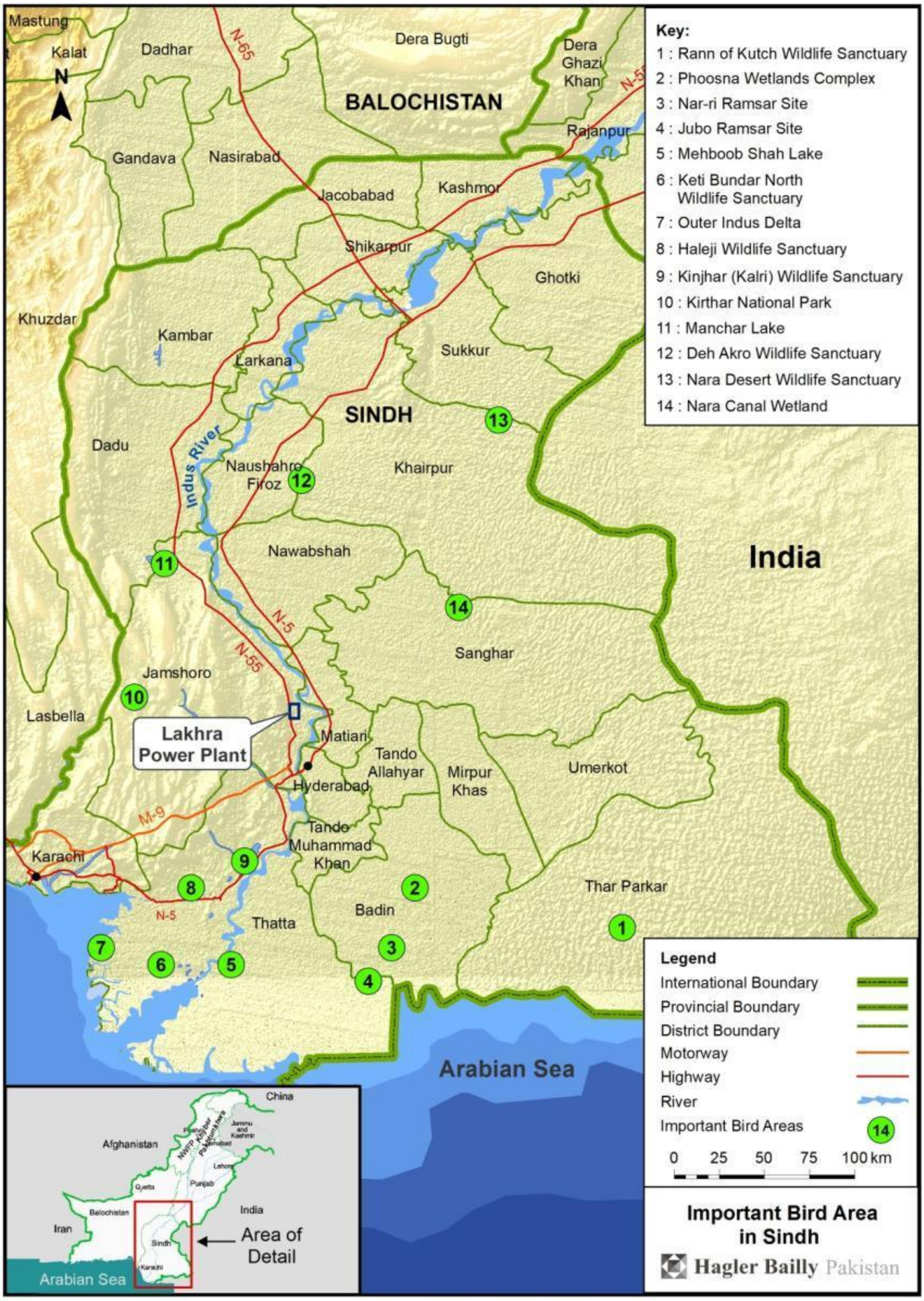
4 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 10 March 2014..

5 Grimmett, R., Roberts, T., and Inskipp, T. 2008. Birds of Pakistan, Yale University Press.

is listed as Nearly Threatened in the IUCN Red List. It was observed at Sampling Point S9 during the February 2014 survey.

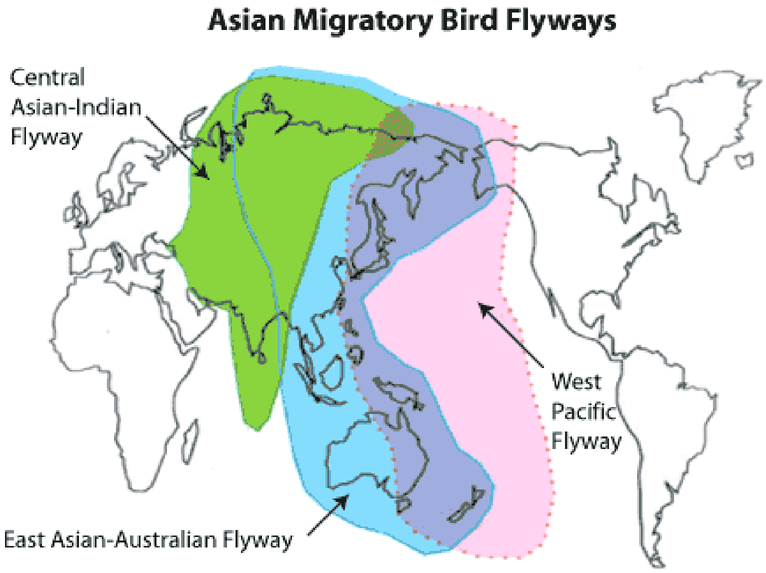
Indian Skimmer Rynchops albicollis

Indian Skimmer *Rynchops albicollis* is a rare summer breeding visitor to the Study Area. It is confined to sandbars along the River Indus and its main tributaries, arriving around the delta from mid-February through to April (Grimmett 2008). Adult have a large, drooping orange-red bill, black upper and contrasting under parts. The species is listed as Vulnerable in the ICUN Red List. It was not observed in the Study Area during the February 2014 survey.



Source: Map adapted from Birdlife International Official Website
http://www.birdlife.org/datazone/userfiles/file/IBAs/AsiaCntryPDFs/Pakistan.pdf

Figure 5-26: Important Bird Areas in Sindh



Source: http://alaska.fws.gov/media/avian_influenza/ak-flyway2.gif U.S. Fish and Wildlife Service/Alaska] |Author=U.S. Fish and Wildlife Service |Date=2008.

Figure 5-27: Asian Migratory Bird Flyways

White Wagtail Motacilla alba

The White Wagtail is a slender bird, 16.5–19 cm in length, with a characteristic long, constantly wagging tail. Its average weight is 25 g and the maximum lifespan in the wild is about 12 years.[1] It is a winter migrant throughout the Indus plains and less common throughout Baluchistan. It prefers to breed on gravelly streams.[2] The species is included in Appendix II of the CITES Species List. It was not observed during the February 2014 Survey.

Common Crane Grus grus

Adults of this species have a black head and fore-neck, with a white stripe behind the eye extending down the side of the neck. The population of this bird is declining due to heavy hunting pressure.[3] The species is included in Appendix II of the CITES Species List. It was not observed in the Study Area during the February 2014 Survey.

Black-shouldered Kite Elanus caeruleus

The species has brownish-grey upper parts with a less distinct shoulder patch. The bird is resident in most parts of the Indus basin throughout the year. It can be seen in deserts though

---

1 Wasser, D. E.; Sherman, P. W. (2010). "Avian longevities and their interpretation under evolutionary theories of senescence". *Journal of Zoology* **280**.

2 Grimmett, R., Roberts, T., and Inskipp, T. 2008. Birds of Pakistan, Yale University Press.

3 Ibid

it avoids the mountainous areas.[1] The species is included in Appendix II of the Species CITES List. It was not observed in the Study Area during the February 2014 Survey.

Black Kite Milvus migrans

The colour of this bird species is dark reddish brown, with a white variable whitish crescent at the primary base of the under wings. It is a common resident species throughout low-lands.[2] The species is included in Appendix II of the CITES Species List. It was not observed during the February Survey 2014.

Steppe Eagle Aquila rapax nipalensis

The species has broad wings with pronounced and spread fingers, and a protruding head and neck. The species is included in Appendix II of the CITES Species List. It was observed at Sampling point S5 in the Study Area during the February 2014 Survey.

5.3.5 Fish

This section provides information about the fish fauna of the Study Area from literature review and field surveys conducted during February 2014 survey. A survey was conducted from 14th February 2014 to 16th February, 2014 (February 2014 survey).

Data collected during this study is included in **Table 5-6** in **Appendix 5**.

A list of fish species observed in the Study Area is given in **Table 6-4** in **Appendix 6**.

Overview of Fish Fauna

The fish fauna of the Study Area has not been intensively studied but there are a few reports of the fish fauna of adjacent sections of the Indus River. Major publications representing fish fauna of the area in general are those of Rafique,[3] Hussain,[4] Khan,[5] Siddiqui *et al.* [6] and Sufi.[7]

At least 49 fish species have been recorded from the reaches of the River Indus near the Study Area and its environs.[8] These include members from the Family Clupeidae, Cyprinidae, Bagridae, Schilbeidae, Chandidae etc. Common fish species found in the Study Area include Mrigal *Cirrhinus mrigal*a (Morakha), Kurialabeo *Labeo gonius* (Seereha), Spotfin Swamp Barb *Puntius sophore* (Popra), Pabdah Catfish *Ompok pabda* (Dimmon), Freshwater Shark *Wallago attu* and the Zig-zag Eel *Mastacembelus armatus* (Goj).

---

1 Grimmett, R., Roberts, T., and Inskipp, T. 2008. Birds of Pakistan, Yale University Press.

2 Ibid

3 Rafique, M. 2009. Fish Fauna of Haleji Lake, Sindh, Pakistan. Rec. Zool. Surv. Pak. (19):61-65.

4 Hussain, Z., (1973) Fish and fisheries of the lower Indus basin (1966-67), Agric. Pakistan, (**24**): 170-188

5 Khan, H., (1946) A fishery surveys of River Indus. J. Bombay, Nat. His. Soc., (**46**): 529-535.

6 Siddiqui P. A., I. U. Baquai and M. Iqbal (1973) Check list of fishes of Keenjhar (Kalri) Lake with notes on environmental conditions and fisheries potential. Agri. Pak., **24** (**2**): 201-220.

7 Sufi, S. M. K., (1957) Fish fauna of the Kinjhar Lake (West Pakistan) with an account of the major fishing implements employed by local fisher man. Agri. Pakistan, **8** (**3**): 208-229.

8 Hussain, Z., (1973) Fish and fisheries of the lower Indus basin (1966-67), Agric. Pakistan, (**24**): 170-188

Out of these, 10 species have very high commercial value such as Mori (*Cirrhinus mrigala*), Thaila (Gibelion catla), Rohu (Labeo rohita), Common Carp (*Cyprinus carpio*), Singhari (*Sperata sarwari*), Fauji Khagga (*Bagarius bagarius*), Malli (Wallago attu), Thalli (*Clupisoma garua*), Thalli (*Clupisoma naziri*) and Soul (*Channa marulias*).[1]

Distribution and Abundance of Fish Fauna in the February 2014 survey

A total of five sampling locations were selected for sampling of fish during the February 2014 survey. Three of these sampling locations were in the main Indus River while two were located in the ponds located in the Study Area. The location of these sampling points is shown in **Figure 5-13.**

The fish species observed in the Study Area during the February 2014 survey are listed in **Table 5-30**. Fish abundance and diversity observed during the survey is presented in **Figure** 5-28. Principal observations are summarized below. Photographs of some fish species observed in the Study Area are given in **Figure 5-29**. Photographs of fishing activities in the vicinity of the Study Area are given in **Figure 5-30**. A total of 160 fish specimens belonging to 40 fish species were observed.

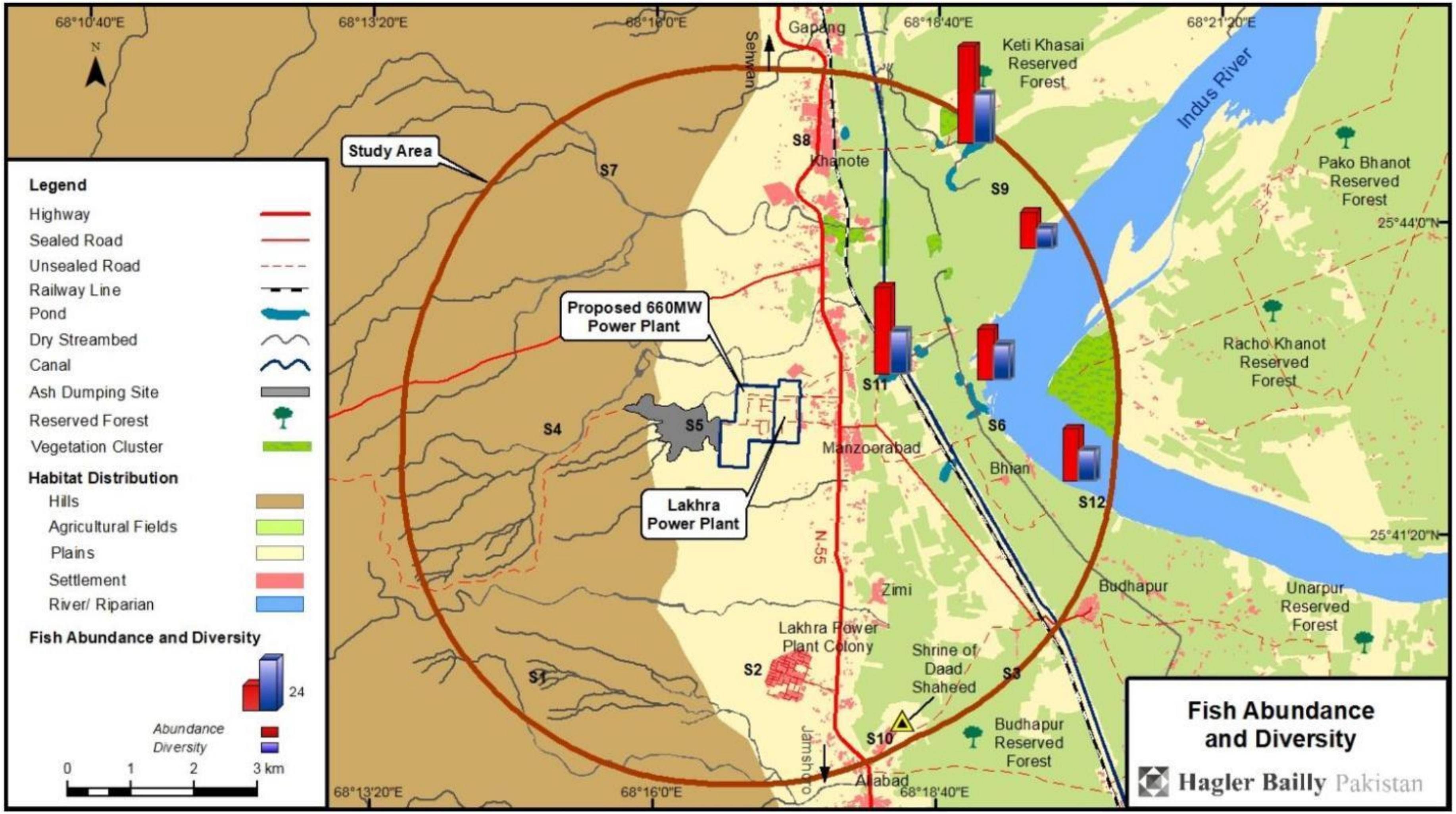
- Maximum fish abundance and diversity was observed at Sampling Point F1 where 48 fish specimens belonging to 24 fish species were observed. Large Razorbelly Minnow *Salmophasia bacaila* was the most abundant species observed at this sampling point with total count of five (5), followed by Day's *Mystus Mystus bleekeri*, Mozambique Tilapia *Oreochromis mossambicus* both having a total count of 4 and Spotfin Swamp Barb *Puntius sophore* with total count of 3.
- The most abundant fish species observed was the Day's *Mystus Mystus bleekeri* with 14 specimens caught. The second most abundant fish species observed was *Cotio Osteobrama cotio* followed by Elongate Glass Perchlet *Chanda nama* and Silver Hatchet *Chela Chela cachius* with ten (10), eight (8) and eight (8) specimens caught respectively.
- The least abundant fish species with only one individual observed included Hilsa Shad (Palla) *Tenualosa ilisha*, Humped Featherback *Chitala chitala*, Catla *Gibelion catla*, Carplet *Aspidoparia morar* and Garua Bachcha *Clupisoma garua*.

Generally the fish abundance and diversity observed was higher in the ponds than in the Indus River (**Figure 5-28**).

1 Rafique, M. 2009. Fish Fauna of Haleji Lake, Sindh, Pakistan. Rec. Zool. Surv. Pak. (19):61-65.

Table 5-30: Fish Fauna Observed During February 2014 Survey of the Study Area

Scientific Name	*Common Name*	*Sampling Point*					*Total*
		F1	*F2*	*F3*	*F4*	*F5*	
		Habitat					
		Pond	*Indus River*	*Indus River*	*Pond*	*Indus River*	
Gudusia chapra	Indian River Shad	2	–	2	–	–	4
Tenualosa ilisha	Hilsa Shad (Palla)	–	–	–	–	1	**1**
Chitala chitala	Humped Featherback	1	–	–	–	–	**1**
Notopterus notopterus	Grey Featherback	1	–	1	–	2	**4**
Chela cachius	Silver Hatchet Chela	3	2	1	2	–	**8**
Salmophasia bacaila	Large Razorbelly Minnow	5	–	–	2	–	**7**
Securicula gora	Gora Chela	–	1	–	–	1	**2**
Amblypharyngodonmola	Mola Carplet	1	–	–	2	–	**3**
Aspidoparia morar	Carplet	–	–	1	–	–	**1**
Barilius vagra	Vagra Baril	2	–	–	–	–	**2**
Esomus danricus	Flying Barb	1	–	–	1	–	**2**
Cirrhinus mrigala	Mrigal	3	–	1	–	–	**4**
Cirrhinus reba	Reba Carp	–	2	–	1	2	**5**
Gibelion catla	Catla	–	–	–	1	–	**1**
Labeo calbasu	Orange Fin Labeo	2	1	1	2	2	**8**
Labeo gonius	Kuria Labeo	1	–	1	–	3	**5**
Labeo rohita	Rohu	1	–	1	–	–	**2**
Osteobrama cotio	Cotio	2	3	1	2	2	**10**
Puntius sophore	Spotfin Swamp Barb	3	–	–	4	–	**7**
Puntius ticto	Scarlet Barb	2	–	–	5	–	**7**
Cyprinus carpio	Common Carp	2	–	–	–	–	**2**
Mystus bleekeri	Day's Mystus	4	2	3	1	4	**14**
Mystus cavasius	Gangetic Mystus	1	1	–	–	2	**4**
Mystus vittatus	Striped Dwarf Catfish	–	–	–	3	–	**3**
Bagarius bagarius	Gangetic Goonch	–	–	–	–	2	**2**
Ompok pabda	Pabdah Catfish	2	–	–	2		**4**
Wallago attu	Freshwater Shark	–	–	2	–	1	**3**
Heteropneuste sfossilis	Stinging Catfish	–	–	–	2	–	**2**
Ailia coila	Gangeti Cailia	–	–	3	–	1	**4**
Clupisoma garua	Garua Bachcha	–	–	1	–	–	**1**
Eutropiichthys vacha	Batchwa Vacha	–	1	3	–	–	**4**
Xenentodon cancila	Freshwater Garfish	1	–	1	–	–	**2**
Channa marulia	Great Snakehead	–	–	–	–	1	**1**
Channa punctata	Spotted Snakehead	–	–	–	2	–	**2**
Chanda nama	Elongate Glass Perchlet	2	3	1	2	–	**8**
Parambasis baculis	Himalayan Glassy Perchlet	1	2	1	1	1	**6**
Parambasis ranga (Hamilton, 1822)	Glassy Fish	1	–	–	2	1	**4**
Glossogobius giuris	Tank Goby	–	–	–	2	–	**2**
Oreochromis mossambicus	Mozambique Tilapia	4	–	–	3	–	**7**
Mastacembelus armatus	Zig-Zag Eel	–	–	–	1	–	**1**
	Abundance	**48**	**18**	**25**	**43**	**26**	**160**
	Species Count	**24**	**10**	**17**	**21**	**15**	



Source: Hagler Bailly Pakistan

Figure 5-28: Fish Abundance and Diversity

Reba Carp *Cirrhinus reba*

Kuria Labeo *Labeo gonius*

Mozambique Tilapia *Tilapia mosambiqa*

Rohu *Labeo rohita*

Freshwater Shark *Wallago attu*

Hilsa Shad *Tenualosa ilisha*

Humped Featherback *Chitala chitala*

Source: Hagler Bailly Pakistan

Figure 5-29: Photographs of some Fish Species observed in the Study Area Survey conducted February 2014

Source: Hagler Bailly Pakistan

Figure 5-30: Photographs of fishing activities upstream of Kotri Barrage

Fishing Activities

A number of fish species reported from the Study Area have a high commercial importance (**Table 6-4** in **Appendix 6**) and are used as food fish. These include the Mrigal *Cirrhinus mrigala*, Catla *Gibelion catla*, Rahu *Labeo rohita*, Garua Bachcha *Clupisoma garua* and Great Snakehead *Channa marulia* that are common species in the Study Area. The Hilsa Shad (Palla) *Tenualosa ilisha* has a very high commercial value in the market. It is rare in the Study Area. The Freshwater Shark *Wallago attu* and Common Carp *Cyprinus carpio* have a high commercial value as well as conservation importance. They are listed as Near Threatened and Vulnerable in the IUCN Red List respectively.

Kotri barrage is located at a distance of about 36 km from the Project site. It is the last water reservoir on the River Indus. Below Kotri, the water level fluctuates tremendously and the influence of brackish water is increasing to variable extents and therefore aquatic diversity is comparatively lower. Several fresh-water faunal species have been reported from the river upstream of Kotri including fish species, amphibians and turtles. The fish abundance is high but being overexploited due to high fishing pressure.

Field surveys and interviews conducted with the fishermen community and fish whole sale sellers in July 2012[1] shows that 500-600 boats are operating in the area (about 15 km upstream and 10 km downstream of Kotri barrage). Approximately, 2,000-4,000 people are engaged in the fishing business. An average catch for a small boat is 8-10 kg of fish per day during the summer season with 2-4 people working on a boat. The major catch is during the flood season (July – August) and minimum during the winter season (December – February). Large boats that involve 4-10 fishermen catch 10-20 kg of fish per day mainly during the summer season (May – August).

---

[1] Asian Development Bank (ADB), July 2012, Environmental Impact Assessment of Rehabilitation of Thermal Power Station Jamshoro. Report prepared for Engconsult Ltd.

Conservation and Protection Status

Among the fish species reported from the Study Area, seven (7) fish species are included in the IUCN Red List. Of these fish, the Humped Featherback *Chitala chitala,* Pabdah Catfish *Ompok pabda,* Gangeti Cailia *Ailia coila,* Freshwater Shark *Wallago attu,* and Gangetic Goonch *Bagarius bagarius* as well as the exotic fish Mozambique Tilapia *Oreochromis mossambicus* are listed as Near Threatened in the IUCN Red List[1] while Common Carp *Cyprinus carpio,* is listed as Vulnerable.

Other than the Humped Featherback *Chitala chitala,* all the other fish species of conservation importance are common in the Study Area.

Humped Featherback *Chitala chitala*

This species has been reported from several countries but is likely restricted to the Indian subcontinent. Populations have declined significantly across much of its range in Pakistan, Bangladesh, India and Nepal due to pollution and over-harvesting. The species is assessed as Near Threatened[2] in the IUCN Red List.

Pabdah Catfish *Ompok pabda*

The species inhabits habitats such as rivers and larger streams and can sometimes be found in lakes and ponds.[3] It has undergone significant population decline due to overexploitation as a food fish. The species is listed as Near Threatened in the IUCN Red List.

Gangeti Cailia *Ailia coila*

Gangeti Cailia *Ailia coila* inhabits large rivers and lakes with turbid water and a substrate of sand or mud. It attains a total length of 30 cm. It is a surface to mid-water fish which lives in shoals. Habitat degradation is considered a major driving force for the decline of this species. It is listed as Near Threatened in the IUCN Red List.[4]

Freshwater Shark *Wallago attu*

This species inhabits freshwater and tidal waters, in rivers, tanks, channels reservoirs etc. It is one of the largest, voracious and predatory of the local catfish. It is rather sluggish and stays

---

1 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 10 March 2014.

2 IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on **14 March 2014**.

3 Tenzin, K. & Ng, H.H. 2010. *Ompok pabda*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on **14 March 2014**.

4 Ng, H.H. & Dahanukar, N. 2011. *Ailia coila*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on **14 March 2014**.

at the bottom of water in search of food. The species is listed as Near Threatened in the IUCN Red List.[1]

Gangetic Goonch Bagarius bagarius

This species inhabits a variety of fluviatile habitats, although it is typically associated with swift, clear rivers with a substrate of rocks and sand. As a large, predatory fish that is actively caught for food, this species is in some danger of being overexploited. Even though current indications are that this species is still relatively abundant, the current fishing pressure on this species is likely to be unsustainable. It is listed as Near Threatened in the IUCN Red List.[2]

Mozambique Tilapia Oreochromis mossambicus

The species occurs in all but fast-flowing waters and thrives in standing waters. It is common in blind estuaries and coastal lakes where it tolerates brackish and marine environments. It feeds on algae, especially diatoms, and detritus. Large individuals also eat insects and other invertebrates. The species is listed as Near Threatened in the IUCN Red List.[3]

Common Carp *Cyprinus carpio,*

The species is found in almost all kinds of water; warm, deep, slow-flowing and still waters, lowland rivers and large, well vegetated lakes. It is listed as Vulnerable in the IUCN Red List.[4]

5.3.6 Critical Habitats

Critical habitat is designated by the International Finance Corporation (IFC) Performance Standards[5] found below:

Critical habitat is described as having a high biodiversity value, as defined by:

- Areas protected by the International Union for Conservation of Nature (Categories I-VI);[6]
- Wetlands of international importance (according to the Ramsar Convention);[7]

---

1 Ng, H.H. 2010. *Wallago attu*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on **14 March 2014**.

2 Ng, H.H. 2010. *Bagarius bagarius*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on **14 March 2014**.

3 Cambray, J. & Swartz, E. 2007. *Oreochromis mossambicus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on **14 March 2014**.

4 Freyhof, J. & Kottelat, M. 2008. *Cyprinus carpio*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on **14 March 2014**.

5 Policy on Social and Environmental Sustainability, January 2012. Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, International Finance Corporation. The World Bank Group.

6 IUCN. 1994. Guidelines for *Protected Areas* Management *Categories*. *IUCN*, Cambridge, UK.

7 Ramsar Convention, or Convention on the Wetlands of International Importance, Administered by the Ramsar Secretariat, Geneva, Switzerland

- Important bird areas (defined by Birdlife International);[1] and
- Biosphere reserves (under the UNESCO Man and the Biosphere Programme;[2]

The Study Area does not meet the criteria. The following additional characteristics were used in determining whether the Study Area lies in a critical habitat.

Habitat of significant importance to Critically Endangered and/or Endangered species: An aquatic mammal species, the Indus Blind Dolphin *Platanista minor* is reported from the Study Area that is listed as Endangered in the IUCN Red List. However, the dolphin population in the vicinity of the Study Area is small in number and not restricted to the stretch of the Indus River in the Study Area. Therefore, the Study Area does not hold significant importance for survival of this species.

The Narrow Headed Soft-Shell Turtle *Chitra indica* listed as Endangered in the IUCN Red List is reported from the Study Area. However, the turtle is widely distributed in the river systems of the Oriental region, right from Thailand to Pakistan, where it is common in the Indus and its tributaries.[3] Therefore, the habitats in the Study Area are not critical for the survival of this species.

Habitat of significant importance to endemic and/or restricted-range species: The habitats found on Study Area are homogenous and widespread. They hold no significance for the survival of endemic or restricted range species; or

Habitat supporting globally significant concentrations of migratory species and/or congregatory species: Even though some migratory birds have been reported from the Study Area and vicinity, investigations reveal that most of the migratory birds do not use the Study Area and vicinity as a breeding and nesting area but merely as a resting ground on their way to coastal areas where there is greater food and habitat available. Moreover, no mammal species depends on the area for its migration. No significant concentration of congregatory species is present in the Study Area.

Highly threatened and/or unique ecosystems: There are no threatened or unique ecosystems in the Study Area.

Areas with unique assemblages of species or which are associated with key evolutionary processes or provide key ecosystem services. This situation is not present in the Study Area. While all species are functioning components of ecosystems, there are no unique assemblages of species or association of key evolutionary processes in the Study Area.

Areas having biodiversity of significant social, economic or cultural importance to local communities. Although the area is of importance to residents in terms of ecosystem

---

1 Birdlife International, UK

2 Administered by International Co-ordinating Council of the Man and the Biosphere (MAB), UNESCO.

3 Khan, M.S. 2006. Amphibians and Reptiles of Pakistan, Krieger Publishing Company, Malabar, Florida, 2006, 310 pp.

services (such as water and vegetation for grazing), it has no unique biodiversity value of social, economic or cultural importance to the community.

Determination: There is no Critical Habitat present on the Study Area.

5.3.7 Limitations of the Study

Carnivores: Large carnivore species (e.g. Common Red Fox *Vulpes vulpes* Asiatic Jackal *Canis aureus,* cats *Felis sp.,* etc) are highly elusive and predominantly nocturnal, which make their detection difficult. These species also have large home ranges and exist in sparse populations (or primarily individually), which further reduce chances of encountering them or their signs. Intensive sign surveys were conducted and local informants were consulted to evaluate survey findings. However, it is recognized that sign surveys have limitations; for example, tracks are especially difficult to determine on hard substrates making it confusing to differentiate between signs of related species.

5.4 Socioeconomic Environment

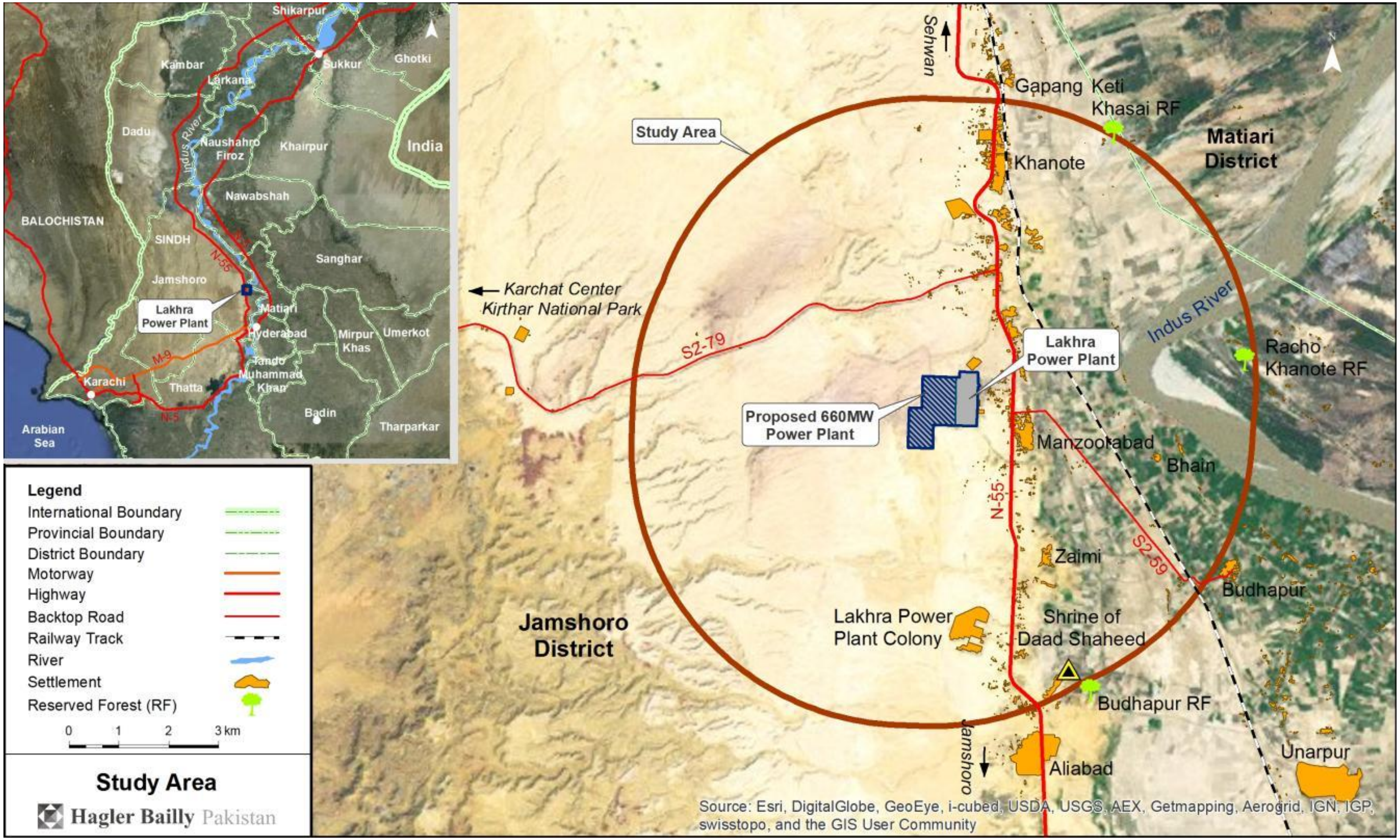
Baseline investigations were undertaken to document the existing socioeconomic conditions of the population that can be affected by the Project activities. The results of the socioeconomic baseline investigations are documented in this section of the report.

5.4.1 Delineation of Study Area

The population likely to be affected by the Project activities was identified based on an understanding of the potential impacts of the Project. The potential socioeconomic impacts of the Project fall into two categories: the direct socioeconomic impacts, such as, employment generation and skill and technology transfers, and the indirect socioeconomic impacts resulting due to the physical environmental impacts of the Project, such as, land transformation resulting in physical and economic displacement. Project induced changes to the physical environment are expected to reduce with the increased distance from the Project facilities, affecting the settlements located closer, up to 5 km, to the proposed Project facilities.

For this, a study area of 5 km around the proposed coal-fired power plant was delineated, to assess the baseline conditions in the areas likely to be affected by the Project due to its proximity to the Project site. This is referred to as the Socioeconomic Study Area in this report. The Socioeconomic Study Area is shown in **Figure 5-31**.

Direct socioeconomic impacts of the Project will not only affect the immediate socioeconomic environment of the Project but also diffuse to other parts of Jamshoro district and possibly Sindh province. The baseline conditions in these areas will be studied through the district and, where available, taluka level published data.



Source: Hagler Bailly Pakistan

Figure 5-31: Socioeconomic Study Area

5.4.2 Overview

The province of Sindh is the second largest province of Pakistan according to population (42.4 million people in 2014) and the third largest according to area (140,914 sq. km).[1] It is divided into 25 districts. Jamshoro district was bifurcated from the Dadu district in December 2004.[2] The district is situated on the right bank of River Indus and consists of four talukas: [3] Sehwan, Manjhand, Kotri and Thano Bula Khan. The District Headquarter for Jamshoro district is Jamshoro city (hereafter referred as 'Jamshoro'), popularly known as 'Educational City'.

District borders Dadu district in the North, Thatta district in the South, Karachi district in the South west and Kirthar Range in the west, which separates Sindh and Lasbela district of Balochistan. In the East, the River Indus separates it from Nawabshah, Matiari and Hyderabad districts.

Proposed coal-fired power plant is located north of Jamshoro, in the Jamshoro district of Sindh province. The site is about 38 km north of Hyderabad and about 200 km northeast of Karachi. It is located about 1.5 km from N-55 (National Highway) which is one of the main highways that connect Karachi with the rest of the country. The river Indus flows about four km to the east of the site. The socioeconomic Study Area falls within the taluka Manjhand of Jamshoro district in Sindh Province. The administrative boundaries of the Jamshoro district are shown in **Figure 5-31**.

5.4.3 Data Collection and Organization

The 1998 District Census Report (DCR), Dadu was used to gather information for this report. The Jamshoro district was bifurcated from Dadu district in 2004. Within the Jamshoro district, taluka Kotri was further bifurcated into Kotri and Manjhand talukas. Therefore, information from the 1998 DCR was used where applicable. The list of information sources and the level of information provided in each of these reports is given in **Table 5-31**.

Table 5-31: Sources of Information

Information Source	*Province Level Information*	*District Level Information*	*Taluka Level Information*
1998 District Census Report, Dadu	×	✓	✓
Development Statistics of Sindh, 2011	✓	✓	×
Pakistan Social and Living Standards Measurements (PSLM), 2011-12	✓	×	×
Pakistan Demographic and Health Survey 2012-13	✓	×	×

1 Population Welfare Department, Government of Sindh. *Home.* n.d. http://www.pwdsindh.gov.pk/ (accessed March 27, 2014).

2 District Government Jamshoro. *http://www.jamshoro.com.pk/.* 2011. http://www.jamshoro.com.pk/Population.htm (accessed March 27, 2014).

3 Taluka is an administrative subdivision of a district. The term taluka is specific to Sindh and is referred to as tehsil elsewhere in Pakistan.

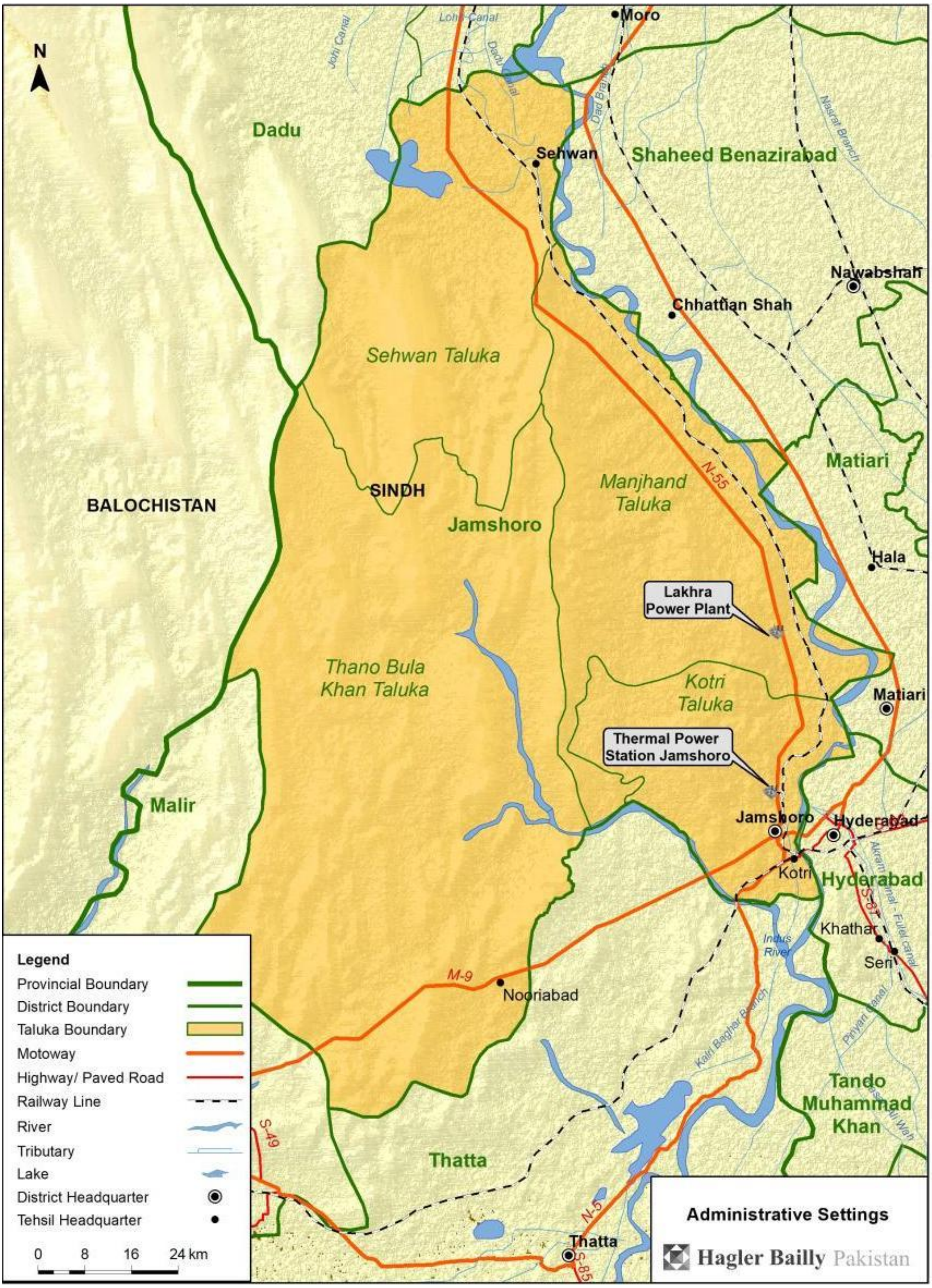


Figure 5-32: Administrative Setting

5.4.4 Demography

The population of Jamshoro district in 2013 is 752,741 (**Table 5-32**). About 92% of this population is rural, whereas the remaining eight percent is urban1.

Table 5-32: Population of Jamshoro district

Name	*Population*
Kotri Taluka	279,104
Manjhand Taluka	118,458
Sehwan Taluka	220,498
TBK Taluka	134,681
Total in Jamshoro District	**752,741**

Source: Data obtained from Jamshoro Coordination Office

The locations of settlements in the Study Area are shown in **Figure 5-33.** In addition to the 18 rural settlements and one colony there is one commercial area, Habibullah Mor. There is no resident population in the commercial area and therefore it is not included in the settlement survey.

Table 5-33 gives a list of the settlements in Study Area. Total population of Study Area is 38,685, which is approximately 25% of the total population of Manjhand taluka in 2014. Rural population is 37,020 persons and colony population is 1,665 persons. Population in colonies constitutes 4% (1,665 persons) of the total population of the Study Area and the remaining 96% (37,020 persons) is rural[2].

Table 5-33: Estimated Population in the Study Area

Name of Settlement	*Union Council*	*Taluka*	*District*	*Total HH*	*Estimated Population of Settlement*	*HH Size*
Rural Settlements						
Manzurabad	Manzurabad	Manjhand	Jamshoro	1,150	8,500	7.4
Zimi	Manzurabad	Manjhand	Jamshoro	300	2,400	8.0
Imdad Ali Khoso	Manzurabad	Manjhand	Jamshoro	138	1,300	9.4
Shuja Muhammad Khoso	Manzurabad	Manjhand	Jamshoro	50	400	8.0
Bhuro Khan Rind	Manzurabad	Manjhand	Jamshoro	300	1,500	5.0
Jan Muhammad Khoso	Manzurabad	Manjhand	Jamshoro	500	4,000	8.0
Khanot	Manzurabad	Manjhand	Jamshoro	1,200	9,500	7.9

1 Population Census Organization, Government of Pakistan, *District Census Report, 1998*, Islamabad, April 2000

2 Socioeconomic Settlement Survey held in the Study Area from 8 April 2014 to 15 April 2014 by HBP team.

Name of Settlement	*Union Council*	*Taluka*	*District*	*Total HH*	*Estimated Population of Settlement*	*HH Size*
Thehbo	Manjhand	Manjhand	Jamshoro	200	1,000	5.0
Paryo Khan Dia Dano	Manzurabad	Manjhand	Jamshoro	40	320	8.0
Koreja	Manzurabad	Manjhand	Jamshoro	250	2,500	10.0
Allah Dino Baricho	Manzurabad	Manjhand	Jamshoro	100	800	8.0
Esab Khan Khoso	Manzurabad	Manjhand	Jamshoro	100	900	9.0
Murid Khan Rind	Manzurabad	Manjhand	Jamshoro	90	900	10.0
Abdul Ghani Bandwani	Manzurabad	Manjhand	Jamshoro	200	1,600	8.0
Dodo Mithano	Manzurabad	Manjhand	Jamshoro	50	400	8.0
Mir Dost Khoso	Manzurabad	Manjhand	Jamshoro	30	240	8.0
Faqir Dad Khoso	Manzurabad	Manjhand	Jamshoro	50	360	7.2
Pehlwan Khoso	Manzurabad	Manjhand	Jamshoro	50	400	8.0
Colony						
Wapda Colony	Manzurabad	Manjhand	Jamshoro	333	1,665	5.0
Total:				**5,131**	**38,685**	**7.5**

Note: HH abbreviates for Household.

Source: Hagler Bailly Pakistan

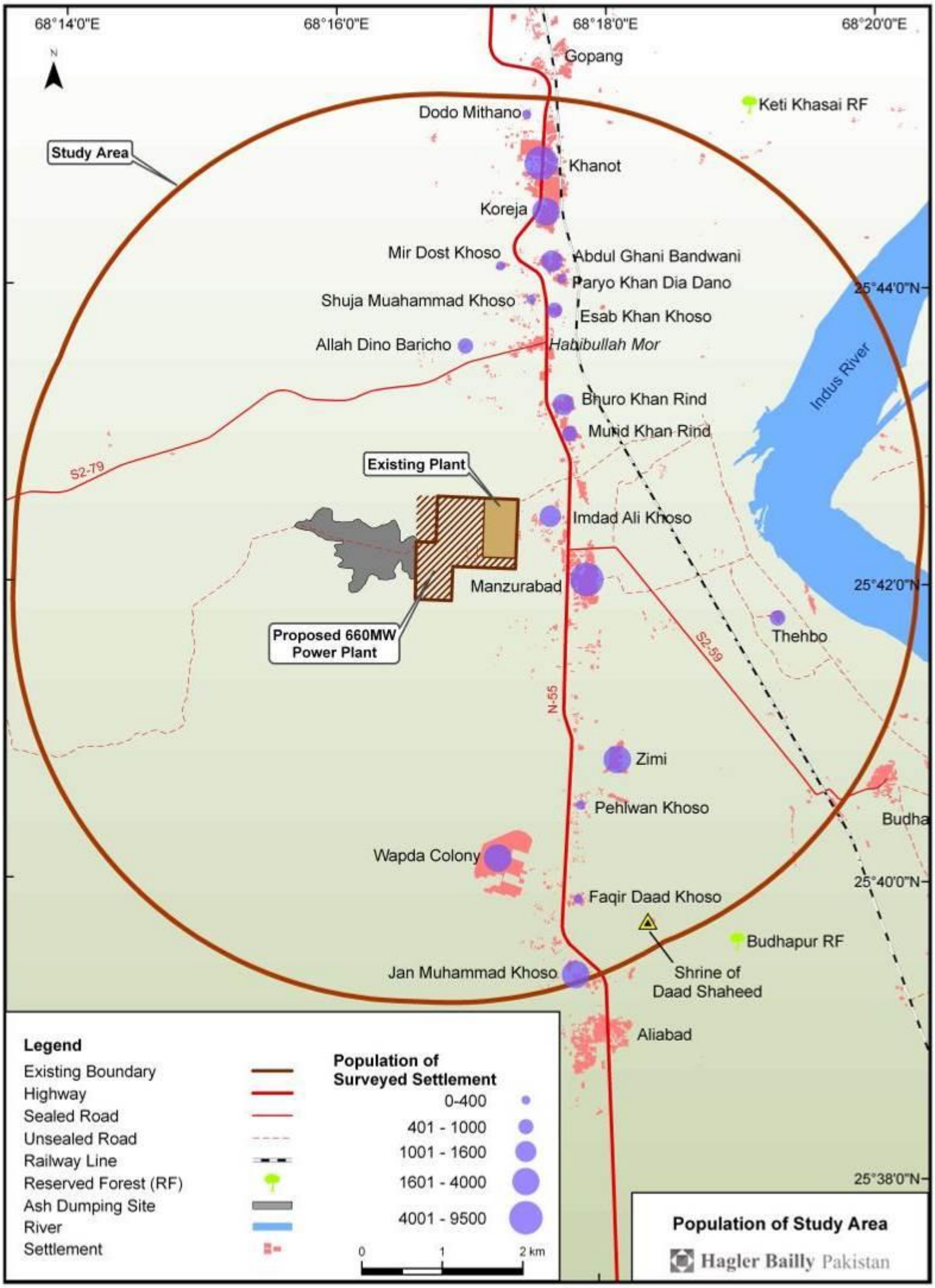
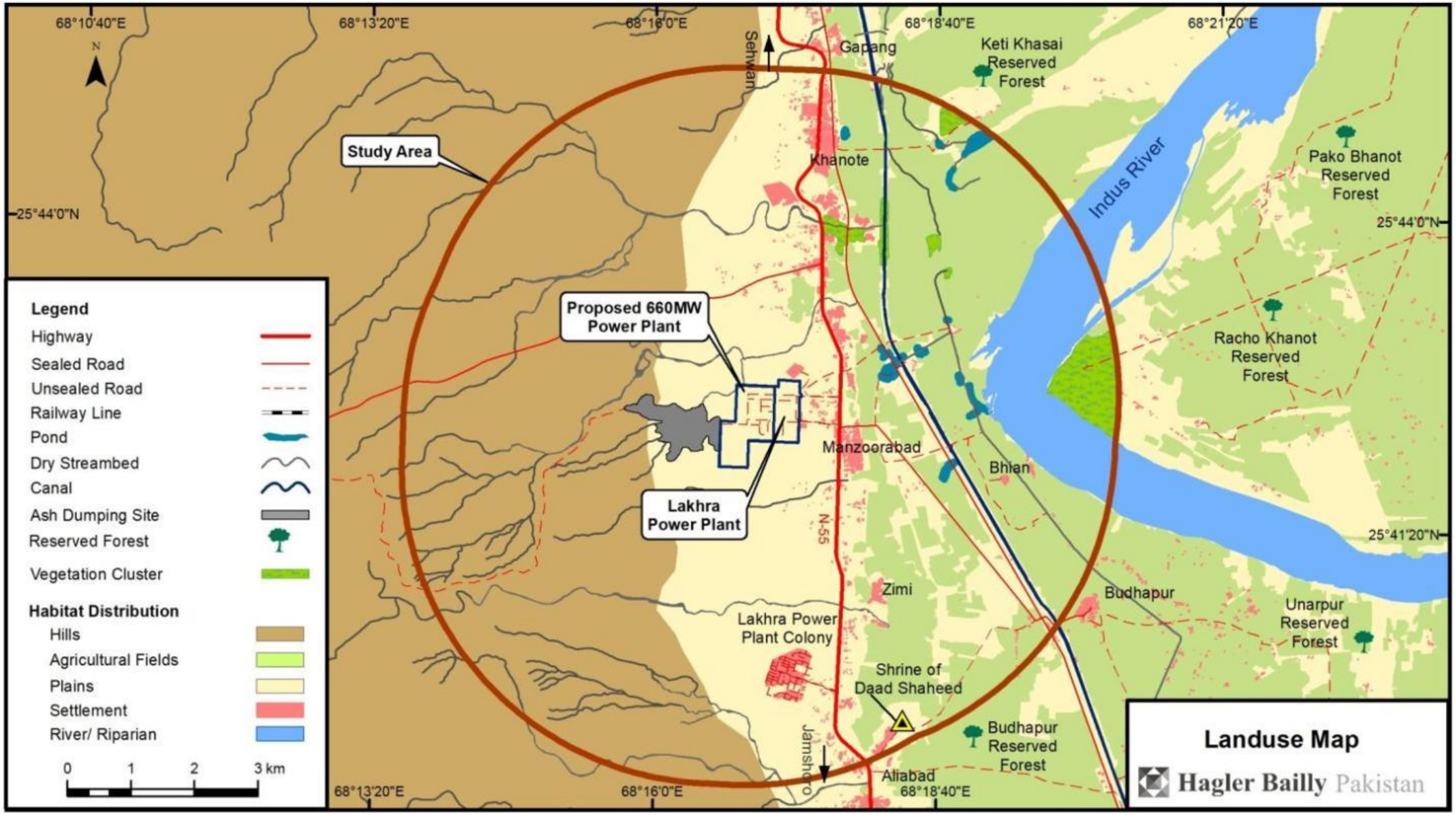


Figure 5-33: Study Area of the Lakhra Project Candidate Site

5.4.5 Land Use

Sindh province occupies land area of 14.091 million ha (34.81 million acres). Out of this, the total geographical area of Jamshoro district is 12,350 km2. Based on the analysis using a Google Earth satellite image, the total area of the study area is approximately 102.5 km^2. Within the study area, about 38% of the area constitutes hills, 32% is barren land, 20% is cultivated, 1% is covered by the settlements/colony and the remaining 7% area includes the Indus River, flood plain and Lakhra Power Plant.

As a result of field survey, the barren land has little natural vegetation cover (small trees, shrubs and grasses). The settlements are mainly colonized along the Indus Highway. The agricultural field is spread in the flood plain of the Indus River. In the agricultural field, livestock grazing (e.g., goats and cattle) were observed. In the Indus River, fishing activities were observed.

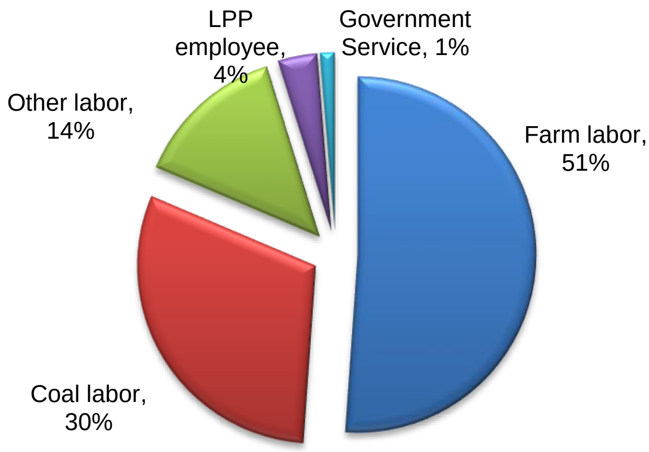


Source: Hagler Bailly Pakistan

Figure 5-34: Land Use in the Study Area

5.4.6 Economy and Income Levels

Agriculture and coal labor are the two major sources of income in the Study Area. About 51% of the total surveyed population is engaged in farm labor either on their own land or as a laborer on others' land. Another 30% population is involved in coal labor with the coal mining companies working in the area. Fourteen percent population earns income through other labor works including daily wage labor, masonry, wood cutting and selling, shop ownership and shop keeping etc. Only one percent population in the area is employed in government services including teaching and driving.[1] The percentage of occupations observed in surveyed settlements of Study Area is given in **Figure 5-35**.



Note: Information for Faqir Dad Khoso and Pehlwan Khoso villages is not available as surveys could not be conducted in these settlements.

Source: Hagler Bailly Pakistan

Figure 5-35 Percentage of Occupations Observed in Study Area

The average monthly household income is Rs. 5,667 in rural area of Sindh province. Of the Sindh working population, 37.61% of total monthly income is sourced by agriculture, 27.04% by wages and salaries, 14.99% by self-employment such as grazing and other business, and 7.14% by property management (land owning).

Industry

Industries including the Jamshoro, Lakhra and Kotori Power Stations, Lakhra Coal Mine and other mining (e.g., Limestone, Salika Sand, Gravels, Silt, Marbal, Sui Gas) involve manpower and sustain a part of the Jamshoro regional economy. According to the hearing during the socioeconomic survey, 58 locals of the eight settlements[2] are employed in the existing Lakhra Plant. These employees are usually laborers, drivers or security guards at the LPP.

---

[1] Socioeconomic Settlement Survey held in Study Area from 8 April 2014 to 15 April 2014 by HBP team.

[2] Eight settlements incclude Manzurabad, Zimi, Imdad Ali Khoso, Bhuro Khan Rind, Khanot, Paryo Khan Dia Dano, Koreja, Murid Khan Rind. Information for Faqir Dad Khoso and Pehlwan Khoso villages is not available as surveys could not be conducted in these settlements.

Two government-owned companies and 20 - 25 private companies are engaged in mining in the Lakhra Coal Field, which is located approximately 16 km west of the candidate site. The largest company of coal mining is Hussain Mining Company in Lakhra, which produces coal according to customer demands, whereas Lakhra Coal Development Company (LCDC) produces about 800 tons of coal per day and supplies only to Lakhra power plant.1 Majority of the labor working in LCDC belongs to Northern Areas (NA) of Swabi and Mangora. Labor from the NA is normally hired on contract basis for six months, during the winter season. Laborers migrate back to native areas in the summers. Only two private companies hire people from local communities.[2] In the settlements of the Study Area, 32% of the total workforce was involved in coal mining labor. The photographs of LCDC coal field are shown in **Figure 5-36**.

Figure 5-36: Photographs of the LCDC Coal Mining Area

Fishery

The Department of Livestock and Fisheries controls the fisheries departments of all the districts in Sindh. The district office of concerned department issues an annual license for fishing in a specific area for Rp.12,000 per person per boat. Fishing is only permitted in the allotted area which is normally within the stretch of the river or a water body within the registered district. The project site is located in the river stretch under jurisdiction of Nwabsha, Hyderabad, Jamshoro and Matiari districts office. The number of registered fishermen and boats, and annual fish production are as shown in the table below. In general, the livelihood of fishermen strongly depends on the income from fish sales. The fishermen sell their catch in local market. Jamshoro is the main market for fish. Other small markets exist in Sehwan and Bhan areas[3].

[1] Data has been provided to HBP by the LCDC, Lakhra, on February 24, 2014.

[2] Ibid.

[3] Information was shared with HBP by Mr Abdul Latif, Deputy Director of Department of Livestock and Fisheries, Hyderabad.

Table 5-34: Inland Fish Production by Districts

Province/District	*Fish Production (Million Tones)*	*Total Numbers of Registered Fishermen*	*Total Numbers of Registered Boats*
Nawabshah/ Shaheed Benazirabad	5,175	1,100	363
Hyderbad	5,408	1,032	152
Jamshoro	11,180	2,130	597
Matiari	3,378	501	152
Total	25,141	4,763	1,264

Source: Department of Livestock and Fishery of Sindh

5.4.7 Agriculture

Sindh's diversified economy comprises of a well–developed agricultural base supported by an effective irrigation network on the Indus. Around 14% wheat, 30% rice, 30% sugar cane, 25% cotton and 30% vegetable crops grown in Pakistan are from Sindh.[1]

In the Study Area, agriculture forms the major income generating activity with 51% surveyed population pursuing farm labor either on their own lands or on other agricultural land.[2] Major crops produced in Study Area and their estimated production is given in **Table 5-35**.

Table 5-35: Major Crops and their Production in Study Area[3]

Average Production (kg/hectare)						
Summer		*Winter*				
Cotton	Sesame Seeds	Wheat	Chickpeas	Lentil	Sorghum	Cluster bean
2,700	1,000	2,300	2,100	1,500	1,900	1,900

Note**:** Information for Faqir Dad Khoso and Pehlwan Khoso villages is not available as surveys could not be conducted in these settlements.

Source: Hagler Bailly Pakistan

Nine of the 17 surveyed settlements reported that agriculture is dependent on rain and flood events. Settlement of Thehbo however, reported that land was cultivated every year as the settlement is located less than one kilometer from River Indus. In this settlement, irrigation channels bringing water from the river, have been dug to irrigate the land using the river water (**Figure 5-37**). Such irrigation channels were observed in a few other rural settlements. In some agricultural lands, where available, underground water wells have been dug to irrigate the land. Some village locals reported that storm water runoff carrying coal ash deposited near their settlements caused damage to agricultural lands.

1 Sindh Board of Investment. http://www.sbi.gos.pk/sindh–economy.php (accessed March 27, 2014).

2 Socioeconomic Settlement Survey held in Study Area from 8 April 2014 to 15 April 2014 by HBP team.

3 Ibid.

Figure 5-37: Photos of Agricultural Field and Irrigation Channel

5.4.8 Culture and Traditions

Languages

The main languages spoken in Jamshoro District are Sindhi, Balochi, Pashto, Punjabi and Saraiki. [1] Other languages spoken include Hindko, Saraiki, Marvari and Jabli.

Ethnicity and Religion

About 95% of Jamshoro district's population is Muslim. The remaining five percent comprise of Hindus, Christians, scheduled castes and others. Similar to the overalls district, the population in the socioeconomic study area is predominantly Muslim, with less a one percent non-Muslim minority. No community has been legally defined as indigenous or protected by the State. The religious minority population in the area is culturally integrated with the rest of the population. According to the information available, there is no religious or social conflict that makes the minority population vulnerable.

Handcraft

Sindh is known all over the world for its handicrafts and artifacts. The ajrak has existed in Sindh since the birth of its civilization. The color blue is predominantly used for ajraks. The ajrak is a mark of respect when it is given to an honored guest or friend. In Sindh, it is most commonly given as a gift at Eid, at weddings, or on other special occasions like homecoming. The Sindhi Topi Day is celebrated in Sindh on 6 December every year. Traditional ajrak and Sindhi topi are shown in **Figure 5-38.**

---

[1] District Government Jamshoro. *http://www.jamshoro.com.pk/.* http://www.jamshoro.com.pk/Glance.htm (accessed March 27, 2014).

Sindhi Topi

Sindhi Ajrak

Figure 5-38: Sindhi Topi and Ajrak

Gender Roles

A household usually contains two gender-based positions of authority; the first is the position of the head, the oldest, the able-bodied male member of a household. The society in rural Sindh is male-dominated. The second is the position of the senior woman, ideally the wife of the eldest resident male, who is subordinate of the household head. The male members govern household decision making process and are responsible to represent the household in the neighborhood and larger society.

Child

There are about 50 million children aged between 5 and 19 years old in Pakistan[1]. While, almost 25 million children and adolescents are out of school, out of which 7 million children aged between 3 and 5 years have yet to receive primary schooling. It is reported that there were 12 million child laborers in Pakistan in 2012. Another report revealed that 5,659 cases of violence against children were reported from January to October 2012.[2]

The child labor is employed mainly in the informal and small-scale industry and trade. Government organizations such as the GENCO, LPGCL and NTDC do not employ children at their facilities.

Crime Incidence, Law Enforcement and Conflict Resolution

There are 18 police stations, 19 police posts and 23 chowkis in Jamshoro district. In the rural areas, the leader or wadera and the spiritual leaders hold influence in resolving conflicts and maintaining peace.

The society in rural Sindh is male-dominated. A household usually contains two gender-based positions of authority; the first is the position of the head of the household, the oldest, able-bodied male member of a household. The second, which is subordinate to that of the household head, is the position of the senior woman, ideally the wife of the eldest resident

---

1 Pakistan Bureau of Statistics, Government of Pakistan, Population Census 1998

2 Daily Times, Pakistan (2013 May 29) Report on State of Pakistan's Children 2012, United Nations Educational, Scientific and Cultural Organization (UNESCO) (2013) Financing for Global Education

male. The male members govern household decision making process and are responsible to represent the household in the neighborhood and larger society.

5.4.9 Physical Infrastructure

Roads and Transportation

Total length of roads in the Jamshoro district is 360 km which only include roads maintained by the High Ways, Communication & Works Department, Government of Sindh.[1] There are three major roads in the Jamshoro District namely Super Highway, National Highway and Indus Highway. The National Highway N-5 is one of the main highways that connect Karachi with the rest of the country. The district houses 13 railway stations. Access to taluka Manjhand is possible by blacktop road. The closest airport is located in Hyderabad city, which is situated at a distance of 38 km from Jamshoro.

Housing

According to the 1998 District Census Report of Dadu, there are 25% masonry dwellings and 75% adobe households in taluka Manjhand (**Figure 5-39**).

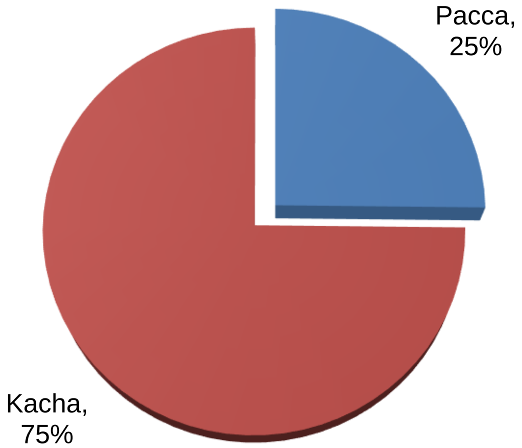


Figure 5-39: Distribution of Housing Structures by Housing Type

Water Supply and Sanitation

According to the Pakistan Social and Living Standards Measurements Survey in 2011-2012, 73% of rural population of Sindh province used hand pumps for drinking purposes while the rest used sources including tap water, motor pump, dug wells and water tankers. The average monthly water bill in rural Sindh is Rs 120, paid by approximately 62% of the population.[2]

The main source of drinking water in the Jamshoro district is tap water, which is used by 30% of the households. Almost 22% households have access to hand pumps and 12% through

---

[1] Planning & Development Department, Sindh. *Development Statistics of Sindh 2011.* Karachi: Bureau Of Statistics, 2011.

[2] Pakistan Bureau of Statistics, Government of Pakistan. *Pakistan Social and Living Standards Measurements (PSLM).* Government Report, Islamabad: Pakistan Bureau of Statistics, 2013.

motor pumps. Remaining 21% use groundwater wells and 15% are dependent on other sources.[1]

Only 22% of rural Sindh has flush toilet facility compared to 58% overall rural average in Pakistan. About 83% of rural Sindh has no sanitation system. Open drains are provided in only 15% of the rural areas of the province. There is no garbage collection system in the rural areas of the province.[2]

Health

Health services in Jamshoro district are mainly provided through basic health units (BHUs), Rural Health Centers (RHCs) and District Head Quarter Hospital (DHQ) in Jamshoro. These facilities are equipped for primary health care services and to some extent comprehensive emergency obstetric care services. [3] There are four hospitals in the district (one located in each taluka), five RHCs, 16 BHUs and six government dispensaries.[4]

There is one private and functional hospital called Zainab Trust which opens every Friday, Saturday and Sunday located in Habibullah Mor. One BHU is located in Khanot and one private clinic at Habibullah Mor. There are three government dispensaries in Manzurabad, Zimi and WAPDA Colony but the dispensary in Zimi is not functional and WAPDA Colony dispensary is exclusively for colony residents only. Communities indicated that the government health facilities are insufficient and inefficient, mainly because of lack of qualified doctors and quality medicines.

Education

The provincial education department runs primary, middle; secondary schools in district Jamshoro, however, there are very few middle, secondary and higher secondary school facilities for both boys and girls. Jamshoro district has 926 educational institutions including primary, middle, higher and higher secondary institutions. Out of these 753 are located in urban areas and the remaining 173 are in rural areas. About 74% of the total enrolment in Jamshoro district is in Primary schools. [5] This shows a high drop-out rate of students in the entire district.

In 2011, the literacy rate in Jamshoro district was lower (44%) compared to overall literacy rate for Sindh (59%) in the same year. Of the total population, 57% male and 28% female

---

[1] Ibid.

[2] Pakistan Bureau of Statistics, Government of Pakistan. *Pakistan Social and Living Standards Measurements (PSLM).* Government Report, Islamabad: Pakistan Bureau of Statistics, 2013.

[3] Emergency obstetric care (EmOC) refers to the care of women and newborns during pregnancy, delivery and the time after delivery

[4] District Government Jamshoro. *http://www.jamshoro.com.pk/.* http://www.jamshoro.com.pk/Glance.htm (accessed March 27, 2014).

[5] National Education Management Information System (NEMIS) Academy of Educational Planning and Management (AEPAM). (2012). *District Education Profile 2011-12.* Islamabad: Ministry of Education, Trainings and Standards in Higher Education, Government of Pakistan.

population was reported literate.[1] In Sindh province, 58% women and 38% men have had no education while 11% women and 17% men are enrolled in higher education (Grade 11 and above).[2]

Table 5-36: Educational Institutions in Jamshoro District [3]

	Primary	*Middle*	*High*	*Higher Secondary*	***Total***
Boys	553	28	25	4	**610**
Girls	284	17	11	4	**316**
Total	**837**	**45**	**36**	**8**	**926**

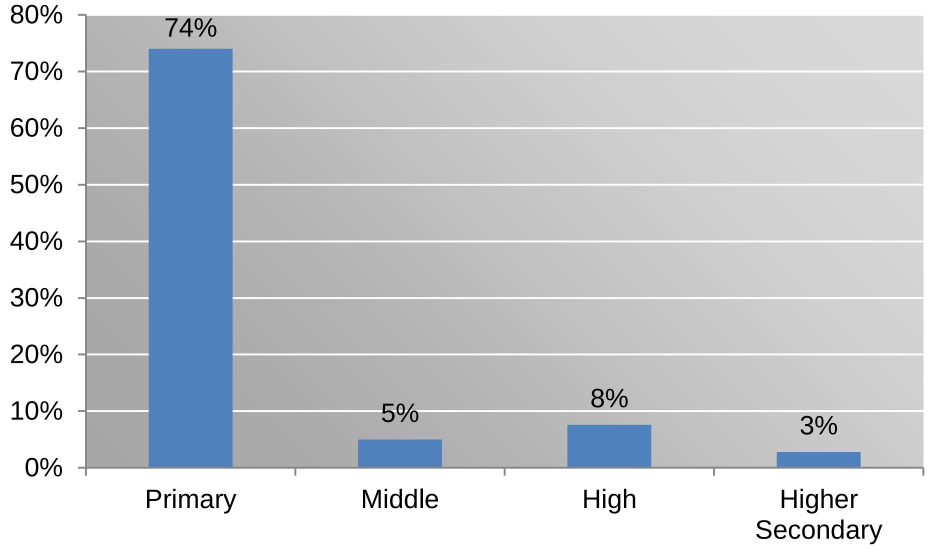


Figure 5-40: Sector-wise Percentage of Enrolment in Jamshoro District[4]

Twenty–three educational institutes are identified in the surveyed settlements, five of which were private schools and the rests are run by the Sindh Government. There are 10 government primary schools offering co-education but the five schools which locate in small settlements are not functional due to prolonged absence of teachers. Government High Schools (from grade 6 to grade 10) offering co-education are available in larger settlements of Khanot and Manzurabad only. Nearby rural communities send their children to these schools.

Indus Resource Center (IRC) has provided one private primary school at Habibullah Mor, one elementary school in Khanot and one in Manzurabad. Sindh Education Foundation (SEF) has provided one private primary school in Paryo Khan Dia Dano and a high school in Wapda

[1] Pakistan Bureau of Statistics, Government of Pakistan. *Pakistan Social and Living Standards Measurements (PSLM) 2011-12.* Government Report, Islamabad: Pakistan Bureau of Statistics, 2013.

[2] National Institute of Population Studies (NIPS) [Pakistan] and ICF International. 2013. *Pakistan Demographic and Health Survey 2012-13.* Islamabad, Pakistan, and Calverton, Maryland, USA: NIPS and ICF International, 2013.

[3] Ibid.

[4] Ibid.

Colony. The SEF primary school in Paryo Khan Dia Dano is not functional due to unavailability of funds to run the school.

5.4.10 Heritage

There is no cultural heritage protected archeological/cultural site[1]) or landscape within the Study Area. The closest heritage site is a shrine named 'Daad Shaheed' and a grave yard are located about 6 km southeast of the candidate site (**Figure 5-41** and **Figure 5-42**). The Daad Shaheed is 700 - 750 years old and it is a holy place for local people. According to the interview with the keeper of Daad Shaheed, in a particular period of a year over 3 - 5 days, approximately 2,000 people visit the Daad Shaheed.

The closest major historical site is the 'Ranikot Fort' which is located at a distance of 45 km northwest of the candidate site, in Jamshoro district (**Figure 5-43**). The Ranikot Fort is tentatively listed as a cultural heritage under UNESCO. It is listed as a tentative believed to be the world's largest fort with a perimeter of about 26 km.

Figure 5-41: Photo of Daad Shaheed

Figure 5-42: Photo of Graveyard in the Daad Shaheed

[1] Protected sites are notified under the Antiquity Act 1975 and Sindh Cultural Heritage (Preservation) Act 1994.

Figure 5-43: Photo of Ranikot Fort

5.4.11 Conclusions

The rural segments of the Socioeconomic Study Area are more vulnerable to changes in the socioeconomic environment brought by the Project. Most of these are located adjacent to the Project site, and therefore are likely to receive most of the Project impacts. The living conditions in the rural segments are below par. The rural economy has a simplistic structure, with nearly 76% employed as laborers or farmers. Farming is the main means of sustenance of the rural people of the Socioeconomic Study Area and Project impacts on local agriculture will have significant repercussions on the lives of the rural people. In some villages, the agricultural land has become water logged, which the people believe is due to leakages from the effluent discharge channel of the power plant.

The colonies and the urban areas together constitute the more developed and better-off segments of the Socioeconomic Study Area. People residing in these areas have better access to facilities and higher incomes relative to the rural parts of the Socioeconomic Study Area. Owing to higher education and skill levels prevailing in these areas, they could offer prospective employment for the Project.

5.5 Transport Route

5.5.1 Karachi to Lakhra

Equipment for the power plant will enter Pakistan either through Karachi Port (KPT) or Port Bin Qasim. Imported coal will be transported from Port Qasim to the proposed Project site by train wagons.

For the transportation of equipment and material from the ports to proposed Project site, two road options are the M-9 (Super Highway) and the National Highway N-5. The total distance using M-9 from KPT to the proposed Project site is about 200 km and about 230 km using N5 through Makli.

While distance from Port Bin Qasim using M-9 is about 180 km and about 220 km via N-5. The routes are shown in **Figure 5-44**. The detailed traffic data is included in **Appendix 7**.

5.5.2 Thar to Lakhra

The indigenous coal, if sourced from Thar, will be transported to Lakhra by truck. Once Railway truck from Thar to Lakhra is materialized, Government of Pakistan will start Thar lignite coal transportation by rail, after proper environmental & social procedures. Studies for route selection were conducted by JST. The results are shown below.

1. General Description

Initially, four route options were evaluated by JST on the suitability from environmental and social point of view. These options are provided in **Table 5-37**. The site investigation and comparative studies were conducted by JST in February 2014, which concluded as follows;

Option 1: The route length and running time are shortest. The road improvement to be required is longer, and the estimation for construction hold second place.

Option 2: The route length and running time hold second place. <u>The road improvement to be required is longest and estimated as the most expensive.</u>

Option 3: The route length and running time hold third place. The road improvement of the existing route is unnecessary so that estimated cost is relatively low.

Option 4: <u>The route length and running time are longest</u>. The road improvement of the existing route is unnecessary.

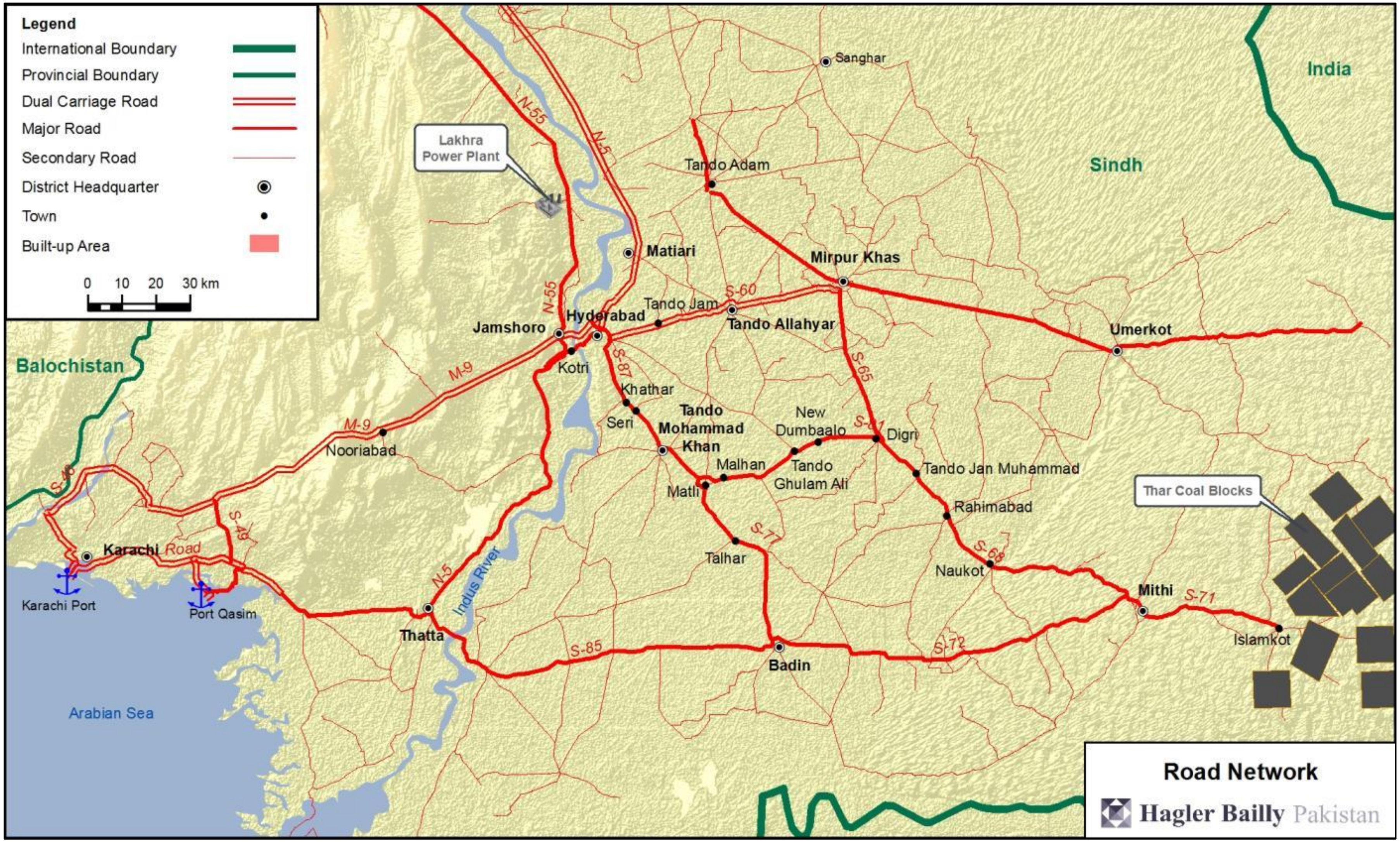
According to the above assessments, Option 1 (Figure 5-45) and Option 3 (Figure 5-46) were selected for traffic census and identification of sensitive receptors; populated townships and road conditions.

(1) Transport Route Option 1

Total length of the Route Option 1 is about 268 km. The route passes through 13 major towns (**Table 5-37**). Several of the towns on the route have bypass-roads, ‘bypasses’, constructed to deter passage of heavy traffic through the towns. The bypasses are not fully utilized and through traffic still pass through the towns. On the route, most of the road line is consisted of single carriageway.

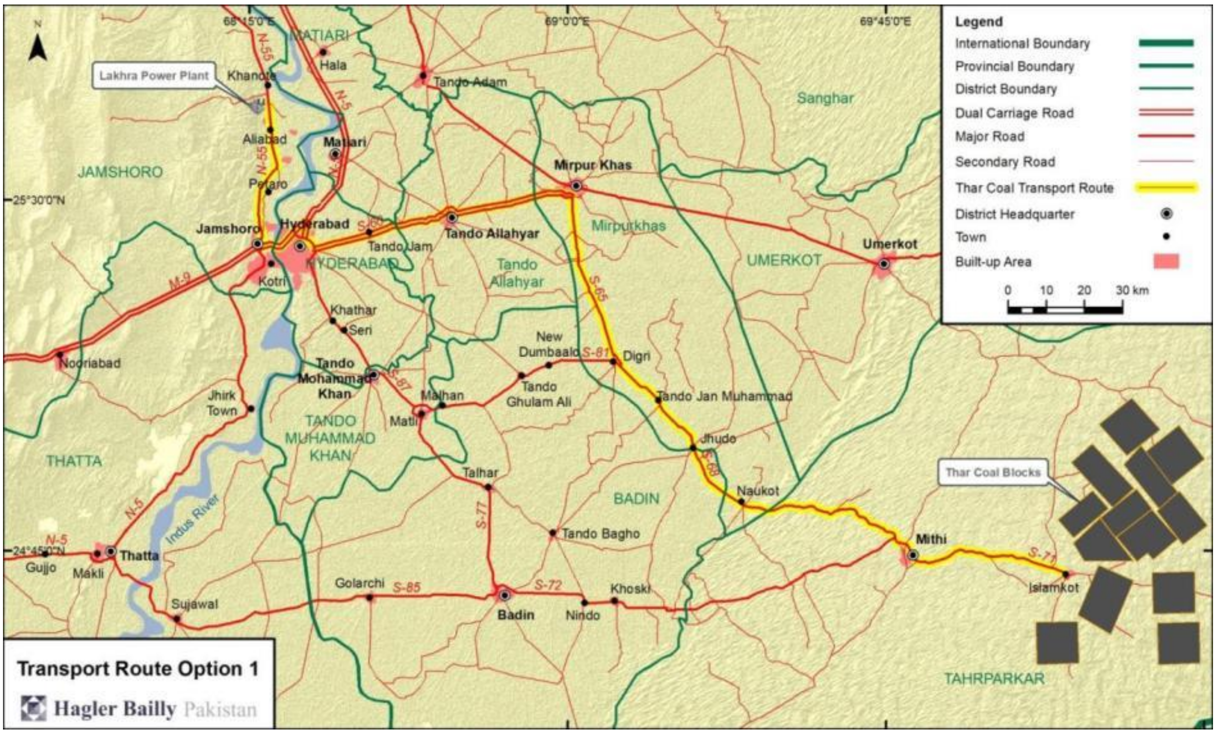
(2) Transport Route Option 3

Total length of the Route Option 1 is about 278 km. The route passes through 12 major towns (**Table 5-37**). Several of the towns on the route have bypass-roads, ‘bypasses’, constructed to deter passage of heavy traffic through the towns. The bypasses are not fully utilized and through traffic still pass through the towns. On the route, most of the road line is consisted of single carriageway.



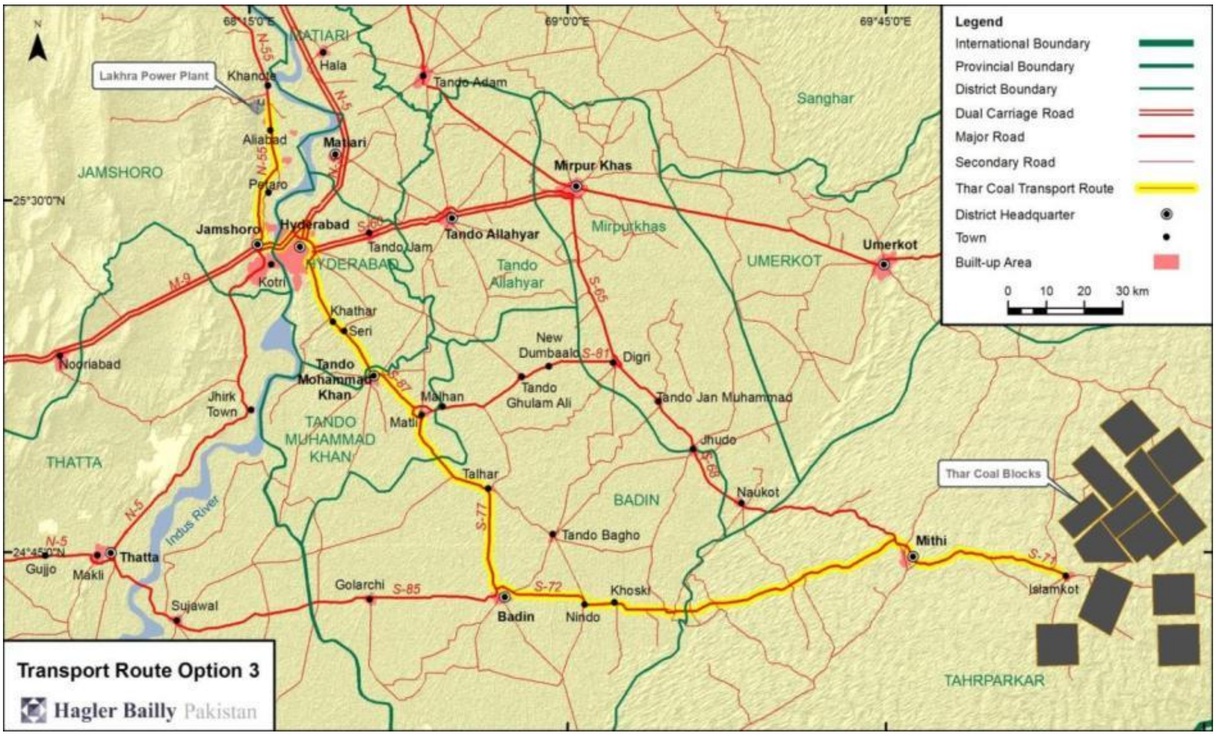
Source: Hagler Bailly Pakistan

Figure 5-44: Road Network



Source: Hagler Bailly Pakistan

Figure 5-45: Transport Route Option 1



Source: Hagler Bailly Pakistan

Figure 5-46: Transport Route Option 3

(3) Traffic Census

Traffic census was recorded at six points on the Route Option 1 and Option 3.

(4) Selection of Census Sites

The census sites were selected by JST based on their observations and available traffic data for the routes. The locations details are provided in **Table 5-38**.

(5) Vehicle Classification

For the purpose of the survey, the vehicles have been categorized into six classes. **Table 5-39** describes the classification. In the last column of the table, the *passenger car unit (PCU)* value of the classification is provided. PCU, also known as the passenger car equivalent, is a measure of the relative space requirement of a vehicle compared to that of a passenger car under a specified set of roadway, traffic and other conditions. The value may depend on a number of factors such as: dimensions, power, speed, acceleration and braking characteristics of the vehicle, road characteristics such as geometrics including gradients, curves, access controls, type of road: rural or urban, presence and the type of intersections, transverse and longitudinal clearances between vehicles moving on road, which in turn depends upon the speeds, driver characteristics and the classes of other moving vehicles, environmental and climatic conditions and traffic control methods, speed limits, and barriers.

The PCU for different classes of vehicles are not defined universally and depend on the specific purpose and the conditions for which it is to be used. The PCU values, in **Table 5-39**, depend only on the space occupied by the vehicles on the road. Trucks were further classified based on their load capacity (**Figure 5-40).**

(6) Collection Method

Collection method is shown in **Appendix 8**.

(7) Results and Conclusion

The two–way traffic at census locations along the selected route options are presented in **Table 5-41**. Light and heavy traffic was recorded at each point for 24 hour.

Key observations:

- Traffic Census Point 3: The volume of heavy and light vehicles is 19 and 81% for Direction-1 and; 16 and 84% for Direction-2 respectively of the total traffic
- Traffic Census Point 13: The volume of heavy and light vehicles is 17 and 83% for Direction-1 and; 21 and 79% for Direction-2 respectively of the total traffic.
- Traffic Census Point 4: The volume of heavy and light vehicles is 17 and 83% for both directions.
- Traffic Census Point 5: The volume of heavy and light vehicles is 34 and 66% for Direction-1 and; 27 and 73% for Direction-2 respectively of the total traffic.

- Traffic Census Point 6: The volume of heavy and light vehicles is 29 and 71% for Direction-1 and; 27 and 73% for Direction-2 respectively of the total traffic.

- Traffic Census Point 7: The volume of heavy and light vehicles is 32 and 68% for Direction-1 and; 27 and 73% for Direction-2 respectively of the total traffic.

Table 5-37: Transport Route Options

Option	*Route*	*Major towns*	*Length*	*No of roads intersection*	*No of water bodies*	*Settlement density **	*Average width ***
1	Islamkot-Mithi-Digri-Mirpur Khas-Hyderabad-Jamshoro	Islamkot, Mithi, Naukot, Jhudo, Tando Jan Mohammad, Digri, Mirwah, Gorchani, Mirpur Khas, Tando Allahyar, Tando Jam, Hyderabad, Jamshoro	268 km	99	38	13.8%	3.32 m
2	Islamkot-Mithi-Digri-Matli-Hyerabad-Jamshoro	Islamkot, Mithi, Naukot, Jhudo, Tando Jan Mohammad, Digri, Tando Ghulam Ali, Matli, Tando Muhammad Khan, Hyderabad, Jamshoro	262 km	98	54	14.5%	2.84 m
3	Islamkot-Mithi-Badin-Matli-Hyderabad-Jamshoro	Islamkot, Mithi, Shadi Large, Khoski, Nindo, Badin, Piro, Lashari, Talhar, Matli, Tando Muhammad Khan, Hyderabad, Jamshoro	278 km	89	84	11.5%	2.82 m
4	Islamkot-Mithi-Badin-Thatta-Jamshoro	Islamkot, Mithi, Shadi Large, Khoski, Nindo, Badin, Golarchi, Sujawal, Thatta, Piro Lashari, Talhar, Kotri, Jamshoro	359 km	94	82	7.9%	3.59 m

* estimated percentage of area covered by settlements and structures within 200 m of the route

** weighted average width of different segments of the route

Table 5-38: Traffic Census Locations

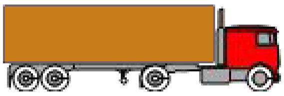
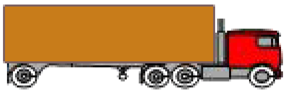
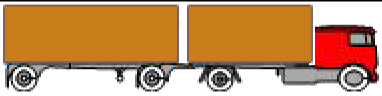
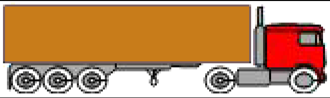
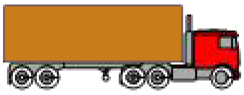
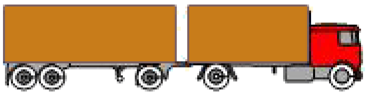
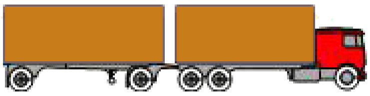
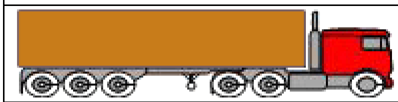
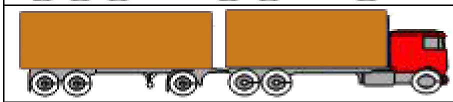
Traffic Point No.	*Nearest Major Towns*	*Date and Time of Survey*		*Coordinates*
		From	*to*	
3	Tando Allahyar and Hyderabad	March 6, 2014, 11:30 hours	March 7, 2014, 11:30 hours	25° 26' 06.2"E 68° 33' 34.2"N
13	Matli and Talhar	March 10, 2014, 08:00 hours	March 11, 2014, 08:00 hours	25° 59' 44.6"E 68° 39' 16.2"N
4	Mirpurkhas and Digri	March 11, 2014, 10:00 hours	March 12, 2014, 10:00 hours	25° 09' 48.7"E 69° 06' 32.0"N
5	Naukot and Mithi	March 12, 2014, 12:00 hours	March 13, 2014, 12:00 hours	25° 49' 59.3"E 69° 36' 35.2"N
6	Mithi and Islamkot	March 13, 2014, 08:30 hours	March 14, 2014, 08:30 hours	25° 43' 36.5"E 69° 50' 34.6"N
7	Mithi and Badin	March 12, 2014, 12:00 hours	March 13, 2014, 12:00 hours	25° 38' 28.2"E 69° 20' 47.9"N

Table 5-39: Vehicle Classification

Class	Types Included	Passenger Car Unit
Cars	Sedans, coupes, and station wagons primarily used for carrying passengers. Includes both privately owned cars and taxis	1
Trucks	Vehicles on a single frame having two or three axle used for carrying goods Tractors and tractor lorries.	2
Pick-ups	Two-axle, four-tire vehicles, other than passenger cars	1
Buses	Vehicles manufactured as traditional passenger-carrying buses with two axles and six tires. Includes traditional buses as well as minibuses with capacity of 30 or more passengers	2
Motorcycles	Two or three-wheeled motorized vehicles	0.5
Trailers/ Tractors	Vehicles with four or more axles consisting of two units, one of which is a power unit	3

Table 5-40: Truck Classification

Photograph	*Truck Type*	*Permissible Gross Vehicle Weight (in tons)*
	2 AX Single (Bedford)	17.5
	2 AX Single (Hino/Nissan)	17.5

Photograph	*Truck Type*	*Permissible Gross Vehicle Weight (in tons)*
	3 AX Tendam	27.5
	3 AX Single	29.5
	4 AX Single-Tendam	39.5
	4 AX Tendam-Single	39.5
	4 AX Single	41.5
	5 AX Single-Tridem	48.5
	5 AX Tendam-Tendam	49.5
	5 AX Single-Single-Tendam	51.5
	5 AX Tendam-Single-Single	51.5
	6 AX Tendam-Tridam	58.5
		61.5

(8) Receptors

A survey was undertaken on the transport route to identify receptors that can be potentially affected by project related activities in the transport corridor. The results are presented in this report.

(9) Methodology

Collection method is shown in **Appendix 8**.

(10) Database Description

A detailed description of the database fields is included with the database. A brief discussion follows.

Table 5-41: Two–Way Traffic at Census Points

Point Location	*Direction ID*	*Direction*	*Bikes*	*Cars*	*Pickups*	*Buses*	*Truck (2X)*	*Truck (3X)*	*Truck (4X)*	*Truck (5X)*	*Truck (6X)*	*Tractors*	***Total***	*PCU*	*Heavy Traffic*	*Light Traffic*	*Heavy Traffic (%)*	*Light Traffic (%)*
3	Direction 01	Tando Allahyar to Hyderabad	2186	2575	527	253	749	128	44	26	17	20	**6525**	8180	1237	5288	19	81
3	Direction 02	Hyderabad to Tando Allahyar	2730	2857	528	353	620	89	57	19	27	32	**7312**	8516	1197	6115	16	84
13	Direction 01	Matli to Talhar	1716	1082	386	117	312	95	31	3	8	78	**3828**	4527	644	3184	17	83
13	Direction 02	Talhar to Matli	1180	1071	343	146	323	71	34	13	20	101	**3302**	4325	708	2594	21	79
4	Direction 01	Mirpur to Digri	1012	651	147	99	181	31	1	–	6	49	**2177**	2453	367	1810	17	83
4	Direction 02	Digri to Mirpur	1003	552	138	97	127	75	1	1	4	38	**2036**	2261.5	343	1693	17	83
5	Direction 01	Noukot to Mithi	150	89	106	51	93	27	2	–	1	0	**519**	847	174	345	34	66
5	Direction 02	Mithi to Noukot	164	151	95	42	60	47	–	–	3	1	**563**	840	153	410	27	73
6	Direction 01	Mithi to Islamkot	177	80	124	47	47	44	–	–	17	2	**538**	840.5	157	381	29	71
6	Direction 02	Islamkot to Mithi	230	87	144	52	64	44	–	–	12	1	**634**	957	173	461	27	73
7	Direction 01	Badin to Mithi	107	91	112	8	57	47	–	–	29	3	**454**	792.5	144	310	32	68
7	Direction 02	Mithi to Badin	127	106	116	12	42	40	3	–	24	6	**476**	770.5	127	349	27	73

Receptor

The database records the locations and description of receptors along the traffic corridor that may have to be considered in the environmental assessment of the transportation activities. These include educational facilities, hospitals, religious places, playgrounds and water bodies.

Route Sections

For convenience of assessment, the route has been divided into sections identified by a unique number.

Location References

Locations of the receptors have been identified by GPS coordinates.[1] In addition, the location of the receptor with respect to the road has also been identified.

(11) Results

A total of 198 receptors have been identified in the transportation corridor. The results of the survey are presented in the form of a database, included as **Appendix 9** and are summarized in **Table 5-42**. Maps showing the location of the receptors are included as **Appendix 10**.

Table 5-42: Summary of Receptors

Category	*Sub Category*	*Count*	*Total*
Park/Playgrounds	Parks	0	1
	Playgrounds	1	
Educational	College/University	14	30
	School	16	
Health Facilities	Emergency Center	0	6
	Hospital	6	
Road-Rail Track Crossing	–	8	8
Religious/Cultural	Mosque	46	55
	Shrines	9	
Settlement	Various	53	53
Water Body	Channel/Pond	37	38
	Rivers	1	
Total			191

(12) Conclusion

According to this survey, the length of Route 1 is second shortest rather among the options and the average lane width of the route is relatively wide. Taking into the other conditions along each route, the Option 1 was selected as the most appropriate route for transporting Thar coal from Thar coal field to the Project site.

---

[1] Coordinates System: Longitude and latitude (dd mm ss). Datum: WGS-84

CHAPTER 6. INFORMATION DISCLOSURE, CONSULTATION, AND PARTICIPATION

As part of the Environmental Impact Assessment process, consultations are undertaken with communities and institutions that may have interest in the proposed project or may be affected by it. This section documents the consultation process for the EIA of the proposed Project.

6.1 Framework for Consultations

The EIA of the proposed Project is undertaken in compliance with relevant national legislation and in accordance with the environmental and social safeguards laid out under JICA Guidelines for Environmental and Social Considerations, April 2010 (JICA Guideline 2010) and World Bank Operational Policy 4.01 (OP 4.01) Annex B.

6.1.1 JICA Guidelines for Environmental and Social Considerations (April 2010)

Public consultation is mandated under JICA Guideline 2010[1].

- Projects must be adequately coordinated so that they are accepted in a manner that is socially appropriate to the country and locality in which they are planned.
- In the case of Category A projects[2] with a potentially large environmental impact, project proponents must consult with local stakeholders such as residences at an early stage, at which time alternatives for project plans may be examined. The outcome of such consultations must be incorporated into the contents of project plans.
- Appropriate consideration must be given to vulnerable social groups, such as women, children, the elderly, the poor, and ethnic minorities, all members of which are susceptible to environmental and social impacts and may have little access to decision-making processes within society.

6.1.2 Sindh Environmental Protection Act 2014

Public consultation is mandated under Sindh's environmental law. Regulation 6 of the IEE-EIA Regulations 2000 provides the general requirements whereas the sectoral guidelines indicating specific assessment requirements are provided in the Guidelines for Public Consultation 1997 (the 'Guidelines'). These are summarized below.

- **Objectives of Public Involvement:** 'To inform stakeholders about the proposed project, to provide an opportunity for those otherwise unrepresented to present their views and values, providing better transparency and accountability in decision making, creating a sense of ownership with the stakeholders';
- **Stakeholders:** 'People who may be directly or indirectly affected by a proposal will clearly be the focus of public involvement. Those who are directly affected may be project beneficiaries, those likely to be adversely affected, or other stakeholders. The

---

[1] "5. Social Acceptability", Appendix 1, Guidelines for Environmental and Social Considerations, April 2010, Japan International Cooperation Agency. http://www.jica.go.jp/english/our_work/social_environmental/guideline/pdf/guideline100326.pdf

[2] Guidelines for Environmental and Social Considerations, April 2010, Japan International Cooperation Agency. http://www.jica.go.jp/english/our_work/social_environmental/guideline/pdf/guideline100326.pdf

identification of those indirectly affected is more difficult, and to some extent it will be a subjective judgment. For this reason it is good practice to have a very wide definition of who should be involved and to include any person or group who thinks that they have an interest. Sometimes it may be necessary to consult with a representative from a particular interest group. In such cases the choice of representative should be left to the group itself. Consultation should include not only those likely to be affected, positively or negatively, by the outcome of a proposal, but should also include those who can affect the outcome of a proposal';

- **Mechanism of consultations:** 'Provide sufficient relevant information in a form that is easily understood by non-experts (without being simplistic or insulting), allow sufficient time for stakeholders to read, discuss, consider the information and its implications and to present their views, responses should be provided to issues and problems raised or comments made by stakeholders, selection of venues and timings of events should encourage maximum attendance';

- **Timing and Frequency:** Planning for the public consultation program needs to begin at a very early stage; ideally it should commence at the screening stage of the proposal and continue throughout the EIA process;

- **Consultation Tools:** Some specific consultation tools that can be used for conducting consultations include; focus group meetings, needs assessment, semi-structured interviews; village meetings and workshops;

- **Other Important Considerations:** 'The development of a public involvement program would typically involve consideration of the following issues; objectives of the proposal and the study; identification of stakeholders; identification of appropriate techniques to consult with the stakeholders; identification of approaches to ensure feedback to involved stakeholders; and mechanisms to ensure stakeholders' consideration are taken into account'.

6.2 Consultation Methodology

6.2.1 Stakeholder Identification and Analysis

At scoping stage, stakeholders were identified as groups and individuals that can be affected by the Project activities or that can influence the outcome of the project.

All groups and individuals that fall within the Study Area were identified as stakeholders that can be affected by the Project activities and were consulted through representatives during the scoping phase.

Groups and individuals that hold interest in the Project and can influence the outcome of the Project (latter part of the definition of stakeholders) include:

- Government and regulatory authorities directly or indirectly connected to or overseeing, the activities of the Project;

- Non–governmental organizations working in areas that can be affected by the Project;

- Academia that can be interested in transfer of skill and knowledge aspect of the Project;

The stakeholders were identified on the basis of the most recent information and understanding of the Project and its surrounding environment. Given the varying roles and educational backgrounds, stakeholders were divided into the following target groups for consultations:

- Institutional stakeholders;
- Communities.

A different consultation approach was adopted for each target group to suit their varying backgrounds, as described ahead.

The feedback consultation primarily targeted the same community that was consulted earlier in the scoping consultation. The community consultation was undertaken in the same manner described above.

6.2.2 Consultation Material

The main document for distribution to stakeholders during the consultations was the Background Information Document (BID). The BID contained information on the Project and the EIA process. The BIDs developed for Scoping Consultation and Feedback Consultation are given in **Appendix 11**. The BID was made available to stakeholders in both Sindhi and English, to accommodate their language preference.

6.3 Consultation with Institutional Stakeholders

6.3.1 Scoping Consultation

Meetings were scheduled with the institutional stakeholders at a place and time of their convenience during February and March 2014. The stakeholders were informed via telephone or email of the objective of the consultation meetings. Where possible, a copy of the BID was shared in advance of the consultation meeting to encourage understanding of Project information for discussion during meeting. The consultation sessions progressed in the following manner:

- An overview of the Project description to the community representatives;
- Description of the EIA process that will be undertaken for the Project and presentation of a structure of the EIA report to facilitate understanding of the report;
- A list of the possible environmental and social impacts of the Project.
- Stakeholders were given the opportunity to raise queries or concerns regarding the Project. Queries were responded to and concerns were documented for consideration in the EIA.

List of institutional stakeholders consulted are as shown in **Table 6-1** and Photographs of the institutional consultations are given in **Figure 6-1** and **Figure 6-2.**

Table 6-1: List of Institutional Consulted in Scoping Phase

Institutions Invited	*Date Consulted*
World Wildlife Fund (WWF), Islamabad	Feb 19, 2014
Pakistan Museum of Natural History (PMNH), Islamabad	Feb 19, 2014
International Union for Conservation of Nature (IUCN), Islamabad	Feb 19, 2014
Lakhra Coal Development Company (LCDC), Lakhra	Feb 24, 2014
Sindh Wildlife Department (SWD), Hyderabad	Feb 25, 2014
Deputy Commissioner (DC), Jamshoro	Feb 25, 2014
Sindh Forest Department, Hyderabad	Feb 25, 2014
Mehran University, Jamshoro	Feb 26, 2014
Department of Livestock and Fisheries, Hyderabad	Feb 26, 2014
Liaqat University of Health and Medical Sciences (LUMHS), Jamshoro	Feb 26, 2014
Lakhra Coal Development Company Limited (LCDC), Karachi	Feb 28, 2014
International Union for Conservation of Nature (IUCN), Karachi	Mar 04, 2014

Consultation with WWF, Islamabad

Consultation with Pakistan Museum of Natural History, Ministry of Science and Technology (PMNH)

Consultation with IUCN, Islamabad

Consultation with IUCN, Karachi

Figure 6-1: Scoping Phase Institutional Consultations in Islamabad and Karachi

Consultation with Department of Livestock and Fisheries, Hyderabad

Consultation with Sindh Wildlife Department

Consultation with Mehran University of Engineering and Technology

Consultation with Forest Department, Hyderabad

Figure 6-2: Scoping Phase Institutional Consultations in Hyderabad and Jamshoro

6.3.2 Feedback Consultation

The feedback consultation primarily targeted the same institutions that were consulted earlier in the scoping consultation. The consultation session was undertaken in the same manner described above.

Feedback Consultation meetings were scheduled with the institutional stakeholders on Sep 08, 2014. The stakeholders were informed via telephone on the objective of the feedback consultation meetings. The consultations with IUCN, Karachi, Forest Department, Hyderabad, and WWF, Islamabad could not be conducted due to their official commitments. The responses of issues raised during scoping phase consultation were provided to them in writing. The meetings progressed in the following manner:

- Stakeholders were briefed about the feedback consultation process and its objectives;
- Stakeholders were provided up-to-date information on the project design;
- Shared results on how their concerns raised under scoping consultation have been addressed under the EIA

List of institutional stakeholders consulted are as shown in **Table 6-2** and photographs of the institutional consultations are given **Figure 6-3**.

Table 6-2: List of Institutions Consulted during Feedback Consultation

Institutions Invited	*Date Consulted*
Sindh Wildlife Department (SWD), Hyderabad	Sep 8, 2014
Additional Deputy Commissioner (ADC), Jamshoro	Sep 8, 2014
Sindh Forest Department, Hyderabad	Sep 8, 2014
Mehran University, Jamshoro	Sep 8, 2014
Department of Livestock and Fisheries, Hyderabad	Sep 8, 2014
Liaqat University of Health and Medical Sciences (LUMHS), Jamshoro	Sep 8, 2014

Consultation with Sindh Wildlife Department, Hyderabad

Consultation with LUMHS, Jamshoro

Consultation with Department of Livestock and Fisheries, Hyderabad

Consultation with Mehran University, Jamshoro

Consultation with Additional Deputy Commissioner, Jamshoro

Figure 6-3: Feedback Consultations with Institutions in Hyderabad and Jamshoro

6.4 Community Consultation

6.4.1 Scoping Consultation

Total eighteen (18) rural communities are located within the Study Area. In addition, consultation also took place at Habibullah Mor, a commercial area situated about 2.5 km north of Lakhra Power Plant and at the residential colony for WAPDA staff. A visit was paid to each community a day in advance of the consultation meeting to establish contact with the representatives, to inform them of the purpose and intent to consult, and to ascertain their availability and willingness for the meeting.

Separate consultation sessions were organized for the community women bearing in mind local customs. The consultation meetings were held at a place of convenience for the stakeholders (at residences of the attendants) within the 16 settlements and WAPDA colony.

Stakeholders were introduced to the team and briefed about the consultation process and its objectives. The main points of the BID were read out to the stakeholders in Urdu and Sindhi, depending on their language preference. Through the BID an overview of the Project and EIA process was provided. Stakeholders were given the opportunity to raise queries or concerns regarding the Project. Queries were responded to and concerns were documented.

The list of communities consulted along with the geographical coordinates of the consultation locations and dates when the consultations took place are shown in **Table 6-3**, the locations are shown in **Figure 6-4.** Consultation could not take place in Pehlwan Khoso and Faqir Dad Khoso as the residents of these settlements could not attend the meeting due to unrest as a result of an incident of crime in the villages.

The consultation team recorded all discussions during the meetings as enclosed in Appendix 12. Photograph were also records for both institutional and community consultations as shown in **Figure 6-5.** However photographs of consultations with the women of the community are not presented in consideration of local customs and traditions.

Table 6-3: List of Communities Consulted during Scoping Stage

(in Chronological Order with the Geographical Coordinates of the Consultation Locations)

Location	*Union Council*	*Taluka*	*Coordinates*		*Consulted Date*
Manzurabad*	Manzurabad	Manjhand	25 42 07.0 N	68 17 51.9 E	Apr 9, 2014
Zimi*			25 40 49.0 N	68 18 06.8 E	Apr 9, 2014
Imdad Ali Khoso*	Manzurabad	Manjhand	25 42 17.1 N	68 17 36.1 E	Apr 10, 2014
Shuja Muhammad Khoso*	Manzurabad	Manjhand	25 43 49.9 N	68 17 13.3 E	Apr 10, 2014
Bhuro Khan Rind*	Manzurabad	Manjhand	25 43 49.9 N	68 17 27.9 E	Apr 10, 2014
Jan Muhammad Khoso*	Manzurabad	Manjhand	25 39 26.8 N	68 17 46.9 E	Apr 11, 2014
Khanot*	Manzurabad	Manjhand	25 44 40.4 N	68 17 39.4 E	Apr 11, 2014
Paryo Khan Dia Dano*	Manzurabad	Manjhand	25 44 05.9 N	68 17 40.9 E	Apr 12, 2013
Koreja*	Manzurabad	Manjhand	25 44 33.6 N	68 17 35.7 E	Apr 12, 2013
Thehbo*	Manjhand	Manjhand	25 41 46.7 N	68 19 14.5 E	Apr 12, 2013
Allah Dino Baricho*	Manzurabad	Manjhand	25 43 36.3 N	68 17 27.0 E	Apr 13, 2013
Esab Khan Khoso*	Manzurabad	Manjhand	25 43 47.3 N	68 17 35.4 E	Apr 13, 2013
Murid Khan Rind*	Manzurabad	Manjhand	25 42 54.1 N	68 17 46.5 E	Apr 14, 2013
Abdul GhaniBandwani*	Manzurabad	Manjhand	25 44 09.2 N	68 17 29.2 E	Apr 14, 2013
Dodo Mithano*	Manzurabad	Manjhand	25 45 06.5 N	68 17 30.2 E	Apr 14, 2013
Wapda Colony*	Manzurabad	Manjhand	25 40 04.7 N	68 17 14.9 E	Apr 15, 2013
Mir Dost Khoso*	Manzurabad	Manjhand	25 44 07.7 N	68 17 20.3 E	Apr 15, 2013
Traders (Habibullah Mor)	Manzurabad	Manjhand	25 43 35.6 N	68 17 30.7 E	Apr 15, 2013

*Note: the women stakeholders were also consulted in these 16 villages and Wapda colony.

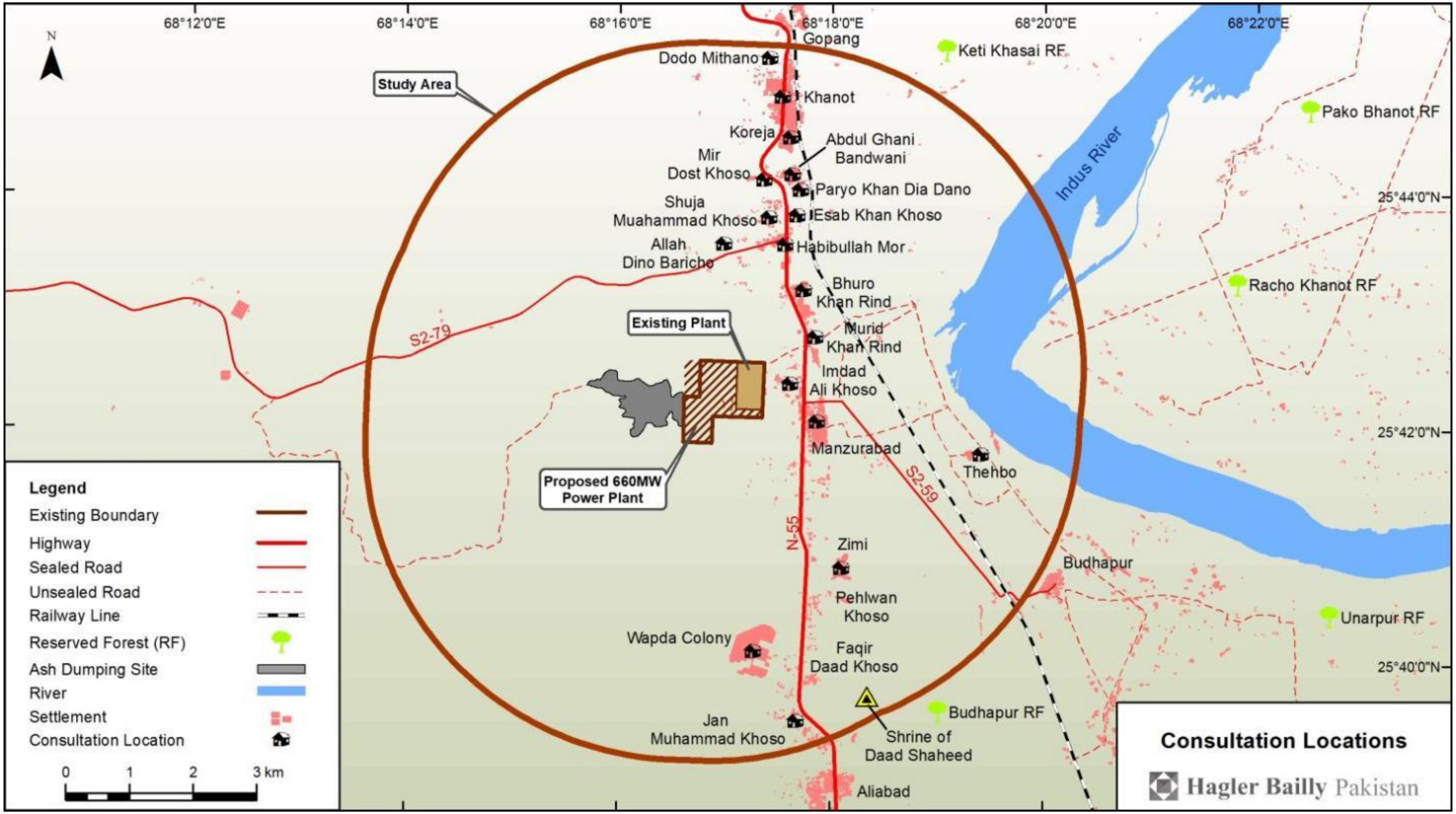


Figure 6-4: Consultation Locations near Project Site


Consultation with Manzurabad Community


Consultation with Zimi Community


Consultation with Imdad Ali Khoso Community


Consultation with Shuja Muhammad Khoso


Consultation with Bhuro Khan Rind Community


Consultation with Jan Muhammad Khoso Community


Consultation with Khanot Community


Consultation with Paryo Khan Dia Dano Community

Consultation with Koreja Community

Consultation with Thehbo Community

Consultation with Allah Dino Baricho Community

Consultation with Esab Khan Khoso Community

Consultation with Murid Khan Rind Community

Consultation with Abdul Ghani Bandwani Community

Consultation with Dodo Mithano Community

Consultation with Wapda Colony

Consultation with Mir Dost Khoso Community

Consultation with Traders (Habibullah Mor)

Figure 6-5: Photographs of the Scoping Consultations for Communities

6.4.2 Feedback Consultation for Communities

The feedback consultation primarily targeted the same community that was consulted earlier in the scoping consultation. The community consultation was undertaken in the same manner described above.

Total eighteen (18) rural communities located within the Study Area were consulted. In addition, consultation also took place at Habibullah Mor, a commercial area situated about 2.5 km north of Lakhra Power Plant and at the residential colony for WAPDA staff. Separate consultation sessions were organized for the community women and the consultation meetings were held at a place of convenience for the stakeholders (at residences of the attendants) within the 19 settlements and WAPDA colony.

Each community was informed in advance to establish contact with the representatives, to inform them of the purpose and intent of the feedback consultations, and to ascertain their availability and willingness for the meeting. Residents of the settlement of Faqir Dad Khoso could not be not consulted as the notable of the settlement failed to attend any of the mutually planned consultation sessions. The meetings progressed in the following manner:

- Provided an update of the Project design to the community representatives
- Shared results on how their concerns raised under scoping consultation have been addressed under the EIA

The list of communities consulted along with the geographical coordinates and dates when the consultations took place are shown in **Table 6-3**. Communities where stakeholder consultations were conducted are shown on a map in **Figure 6-6**. Photographic records of the consultations with the men from the communities are presented in **Figure 6-7**, whereas, photographs of consultations with the women of the community are not presented in consideration of local customs and traditions.

Table 6-4: List of Communities Consulted during Feedback Consultations

Location	*Union Council*	*Taluka*	*District*	*Coordinates*		*Consulted Date*
Imdad Ali Khoso*	Manzurabad	Manjhand	Jamshoro	25 42 17.1 N	68 17 36.1 E	Sep 5, 2014
Manzurabad*	Manzurabad	Manjhand	Jamshoro	25 42 07.0 N	68 17 51.9 E	Sep 5, 2014
Zimi*	Manzurabad	Manjhand	Jamshoro	25 40 49.0 N	68 18 06.8 E	Sep 5, 2014
Esab Khan Khoso*	Manzurabad	Manjhand	Jamshoro	25 43 47.3 N	68 17 35.4 E	Sep 6, 2014
Bhuro Khan Rind*	Manzurabad	Manjhand	Jamshoro	25 43 49.9 N	68 17 27.9 E	Sep 6, 2014
Shuja Muhammad Khoso*	Manzurabad	Manjhand	Jamshoro	25 43 49.9 N	68 17 13.3 E	Sep 6, 2014
Allah Dino Baricho*	Manzurabad	Manjhand	Jamshoro	25 43 36.3 N	68 17 27.0 E	Sep 6, 2014
Koreja *	Manzurabad	Manjhand	Jamshoro	25 44 33.6 N	68 17 35.7 E	Sep 6, 2014
Murid Khan Rind*	Manzurabad	Manjhand	Jamshoro	25 42 54.1 N	68 17 46.5 E	Sep 6, 2014
Khanot*	Manzurabad	Manjhand	Jamshoro	25 44 40.4 N	68 17 39.4 E	Sep 6, 2014
Thehbo*	Manjhand	Manjhand	Jamshoro	25 41 46.7 N	68 19 14.5 E	Sep 6, 2014
Dato Khoso*	Manzurabad	Manjhand	Jamshoro	25 40 33.9 N	68 19 33.5 E	Sep 6, 2014
Abdul Ghani Bandwani*	Manzurabad	Manjhand	Jamshoro	25 44 09.2 N	68 17 29.2 E	Sep 7, 2014
Pehlwan Khoso*	Manzurabad	Manjhand	Jamshoro	25 40 30.3 N	68 17 50.8 E	Sep 7, 2014
Mir Dost Khoso*	Manzurabad	Manjhand	Jamshoro	25 44 07.7 N	68 17 20.3 E	Sep 7, 2014
Jan Muhammad Khoso*	Manzurabad	Manjhand	Jamshoro	25 39 26.8 N	68 17 46.9 E	Sep 7, 2014
Dodo Mithano*	Manzurabad	Manjhand	Jamshoro	25 45 06.5 N	68 17 30.2 E	Sep 7, 2014
Paryo Khan Dia Dano*	Manzurabad	Manjhand	Jamshoro	25 44 05.9 N	68 17 40.9 E	Sep 7, 2014
Wapda Colony*	Manzurabad	Manjhand	Jamshoro	25 40 04.7 N	68 17 14.9 E	Sep 7, 2014
Traders (Habibullah Mor)	Manzurabad	Manjhand	Jamshoro	25 43 35.6 N	68 17 30.7 E	Sep 7, 2014

*Note: the women stakeholders were also consulted in these 19 villages and Wapda colony.

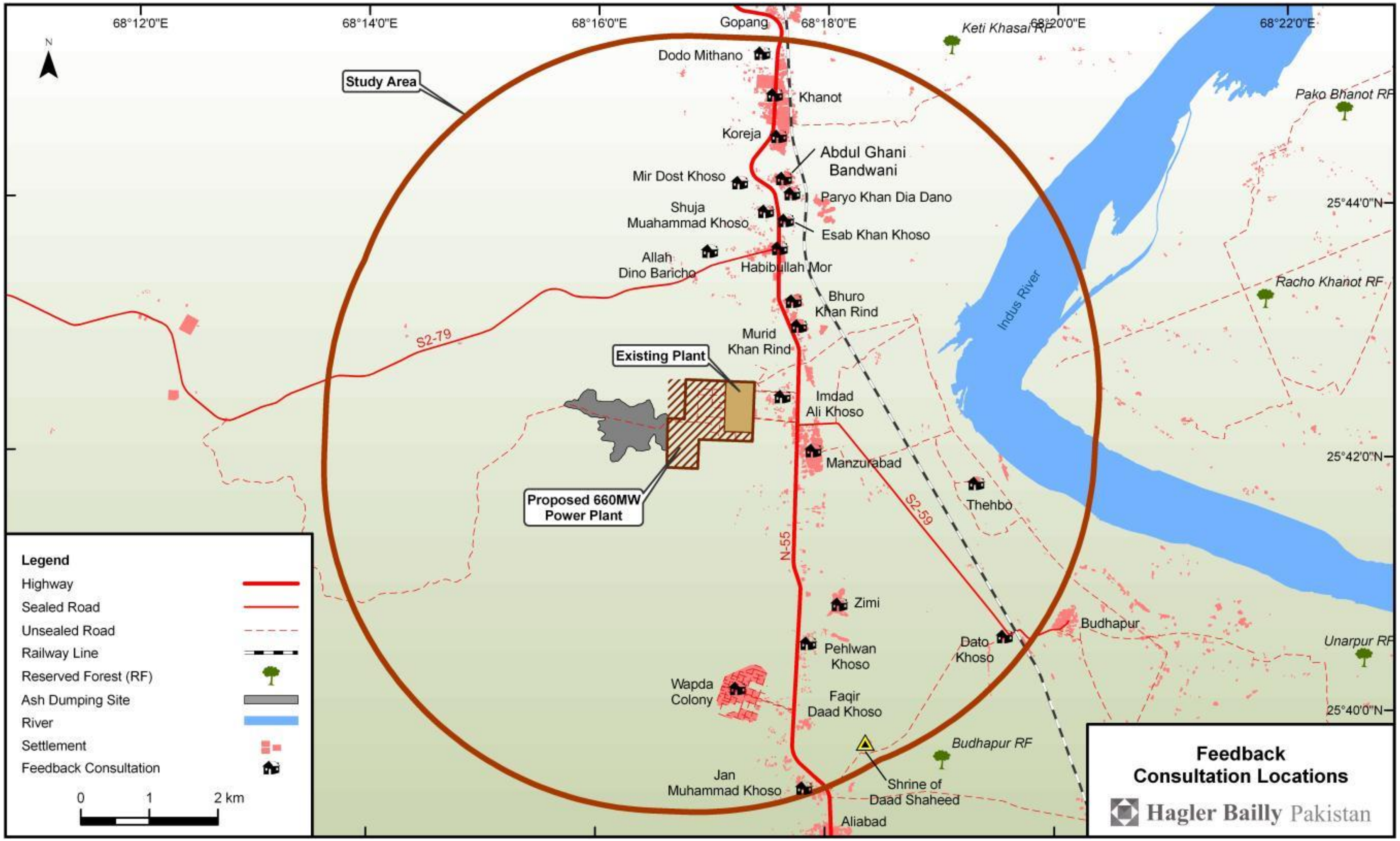


Figure 6-6: Feedback Consultation Locations

Consultation with Imdad Ali Khoso Community

Consultation with Zimi Community

Consultation with Manzurabad Community

Consultation with Esab Khan Khoso Community

Consultation with Allah Dino Baricho Community

Consultation with Murid Khan Rind Community

Consultation with Thehbo Community

Consultation with Dato Khoso Community

Consultation with Pehlwan Khoso Community

Consultation with Bhuro Khan Rind Community

Consultation with Shuja Muhammad Khoso

Consultation with Koreja Community

Consultation with Khanote Community

Consultation with Abdul Ghani Bandwani

Consultation with Mir Dost Khoso Community

Consultation with Dodo Mithano Colony

Consultation with Wapda Colony

Consultation with Traders (Habibullah Mor)

Figure 6-7: Photographs of the Feedback Consultations of Communities

6.5 Opinions Expressed During Consultations

6.5.1 Scoping Consultation

As a positive response from the stakeholders, the project was valued in terms of its contribution for the electricity shortage in the country. The local communities hoped that duration of load shedding will be reduced. The women were generally content with the establishment of the power plant and were hopeful that the plant will bring economic and social development to their area.

The key concerns emerged from consultations were summarized in **Table 6-5** and explained how each concern was addressed in the EIA. Some complaints regarding the existing plant were noted by locals however, people assured that the proposed plant will have mitigation measures in place to minimize any such negative impacts.

The detailed log of scoping consultations is provided in **Appendix 12** and the photographs of the consultations are given in **Figure 6-2**

Table 6-5: Summary of Concerns Expressed in Scoping Consultation and How They Have Been Addressed in the EIA

<table>
<tr><th></th><th>Issues raised by Stakeholders</th><th>Addressed in the EIA</th></tr>
<tr><td>Ecosystem</td><td>Any change in the environment may result in a loss of biodiversity of the area. Measures should be taken to avoid any loss of flora and fauna in the area.</td><td>• Mitigation measures and management measures are addressed to the potential environmental impacts of each component. The construction management plan are also developed to minimize the impacts of construction activities. (Chapter 9)</td></tr>
<tr><td>Water Intake</td><td>Large amount of water intake from the Indus River will affect water availability in the Indus River especially be critical in the low flow season (in the month of December) .</td><td>• Amount of water intake has been planned to secure the water flow during the dry season. (The amount of water taken from the river is approximately 0.5 m^3/s. The lowest water flow amount is 177 m^3/sec in December. The intake amount corresponds to approx. 0.3 % of total flow amount.).</td></tr>
<tr><td rowspan="4">Water Discharge</td><td>The wastewater discharge and thermal discharge from power plant will cause environmental changes in the Indus River and be critical for aquatic life. Wastewater discharge will also damage agriultural field near the power plant.</td><td rowspan="4">• All effluent from the power plant (cooling tower blow down, storm water, etc.) is treated by effluent treatment facility in order to meet the NEQS.

• Domestic water from the colony is initially treated at septic tank and then treated by the effluent treatment facility.

• Oil-contaminated water is treated by oil-separate tank. Separated water is treated by the effluent treatment facility. Separated oil is collected and kept for recycle or proper treatment by licensed company.

• Sludge is regularly collected and disposed of by licensed company.(Chapter 9)

• The construction management plan includes mitigation measures for water discharge from the construction site such as installation of temporary drainage to avoid water and soil contamination.

• The environmental monitoring plan is also proposed for operation stage. (Chapter 9)</td></tr>
<tr><td>Wastewater discharge will harm the quality of the Indus River and create problems for aquatic life and may adversly affect the livelihood of fishermen.</td></tr>
<tr><td>Water discharge furing construction stage should also be carefully treated. Community is dependent on Indus River water for water uses.</td></tr>
<tr><td>The discharge water from the <u>existing LFPS</u> is not treated and polluting water quality.</td></tr>
</table>

	Issues raised by Stakeholders	*Addressed in the EIA*
	Any water discharge from coal yard and ash pond shall be treated properly.	• The ash pond will be lined with a layer of High Density Polyethylene (HDPE) membrane or clay liner in order to avoid water seepages to the ground. • Storm water from coal yard and ash pond will be treated at effluent treatment facility and recycled for greening or sprinkling on coal and ash. • Groundwater samples will be collected from the monitoring wells at ash pond and at the communities within one kilometer from the ash pond to monitor the water quality. (**Chapter 9**)
Stack Emissions	Air emissions from the plant coud adversly affect the communities, agricultural fields in the surrounding areas and, water quality of the Ind us River. The inhabitants of the village suffer from numerous diseases such as respiratory illnesses and eyes problems due to the air emissions from existing LFPS.	• Appropriate equipment's (ESP for total PM emissions/FGD using lime slurry for SO_2 and dry low NOx burners for NO_2) are installed to comply with the NEQS and EHS Guidelines on Thermal Power Plants, 2008, of the World Bank Group. • A stack height of 210 m will be part of design. The equipment type and details may be changed as long as the objectives are met. Any such change will require approval of JICA/investor(s). • The emissions with CEMS (Continuous Emission Monitoring System) and the ambient air quality at vicinity of the project will be monitored. In case the quality exceeds the national standards, countermeasures such as control of power generation shall be conducted.
Ash Disposal	The ash disposal from existing LFPS contaminates the soil and water quality.	• In this Project, the ash pond will be applied appropriate measures as state above [Water Discharge]. • The ash will be temporarily stored in ash silos. However, later it will be either transported to cement companies or will be disposed in the ash ponds.

	Issues raised by Stakeholders	*Addressed in the EIA*
Coal Transportation	Coal transportation by trucks increase traffic and cause various environmental issues.	• Transportation of the imported coal by trucks has been replaced by transportation by rail. The imported coal will be unloaded at Port Qasim and transported to the plant station by rail in order to avoid congestion of traffic on roads. A new spur line from Budhapur to Plant Site will be developed which is the subject of a separate EIA.
Other Concerns	The project should provide job opportunities to local people and internship opportunities to the university students.	• The Project will create additional job opportunities and employ the local resident as many as possible. • About 3,000 people are expected to be employed during construction period and, 347 staff positions will be created at the power plant during operation period. • The Project will prioritize to choose the local services and products wherever possible such as laundry, catering, venders, daily goods etc.
	The project proponent should provide the facility of drinkable water for the community.	The concerns are addressed in Social Augumentation Program.(**Chapter 9, Section 9.9**)
	Unemployment, lack of education and medical facilities and water shortage were identified as the main issues in the community and project proponent should provide sources.	The concerns are addressed in Social Augumentation Program. (**Chapter 9, Section 9.9**)

6.5.2 Feedback Consultation

The local communities hoped that during the construction of new power plant, employment opportunities for locals will be created. They also hoped that before the construction of new power plant, the existing power plant will be rehabilitated. The communities encourage the construction of new power plant and hope that it would improve the socioeconomic conditions in the region and the local communities.

The residents of Koreja settlement are not in a favor of coal power plant at any cost as they are already facing health problems due to the air emissions and ash from existing power plant.

As described in **Section 8.4.8**, *Ambient Air Quality*, it is necessary to install some equipment for mitigating air pollution from the existing plant. In addition, measures will also be required for mitigation of other the adverse impacts from the operation of the existing plant, e.g. contamination and loss in fertility of agricultural land caused by ash dumped in the vicinity of residential areas.

The key concerns emerged from the feedback consultations were summarized in **Table 6-5,** whereas the detailed log of feedback consultations is provided in **Appendix 13** and the photographs of the consultations are given in **Figure 6-5** and **Figure 6-7.**

Table 6-6: Summary of Feedback Consultation

	Response of Stakeholders	*Post-Feedback Consultation Changes to EIA*
Ecosystem	• The community of Koreja settlement will not support the new power plant project at any cost as the pollutants discharge of existing power plant in Indus River is impacting an adverse effect on fish breeding and decreasing fish population.	This issue is related to the existing plant. As discussed in **Chapter 7** the impact of the proposed Project on aquatic fauna will be insignificant. The issue has been brought to the attention of GHCL and LPGCL for addressing the concern of the community.
Water Intake	• Sindh Wildlife Department, Hyderabad and communities demanded that the intake amount of water from Indus River should be minimum as local communities use water of Indus River for their domestic use.	As discussed in **Section 8.12.1**, the proposed power plant requires 0.50 m^3/s water from the River Indus when operating at full capacity. Water extracted by the power plant will be 0.28% of the minimum monthly average flow of the river. Water use for the project has been optimized in the design keeping in view the value of water for existing uses and the need for power generation.
Water Discharge	• The communities and Liaquat University of Medical Sciences (LUMHS), Jamshoro suggested that the treated wastewater should be provided to the communities for their agricultural fields.	Only 0.01 m^3/s of treated effluent will be returned to the river where it will be diluted. This effluent will not be suitable for irrigation use in view of its quality.
	• Sindh Wildlife Department, Hyderabad suggested that there should be audit and monitoring of the proposed mitigation measures for discharged wastewater on yearly basis.	Monitoring of environmental components (including fish) and mitigation measures during implementation and operation stages is a key component of the EMP to safeguard the protection of environment (**Chapter 9**).
	• The community of Koreja settlement will not support the new power plant project as the pollutants discharge of existing power plant in Indus River is having an adverse effect on fish breeding and is decreasing fish population.	The problems mentioned are associated with the existing power plant. The need for rehabilitation of the existing Power Plant has been highlighted in the EIA. The issue has been brought to the attention of GHCL and LPGCL for addressing the concern of the community. The effluent from the Plant is treated at effluent treatment facility to meet NEQS.

	Response of Stakeholders	*Post-Feedback Consultation Changes to EIA*
Stack Emissions	• Sindh Wildlife Department, Hyderabad suggested that there should be audit and monitoring of the proposed mitigation measures for air emissions on yearly basis on yearly basis.	Monitoring of environmental components and mitigation measures during implementation and operation stages is a key component of the EMP to safeguard the protection of environment (**Chapter 9**).
	• The community of Koreja settlement is not in a favor of coal power plant as they are already facing health problems due to the air emissions and ash from existing power plant. Flora and fauna are affected by the release of the pollutant air emissions from the existing power plant.	The need for rehabilitation of the existing power plant has been highlighted in the EIA in order to reduce the pollutants such as PM_{10} and $PM_{2.5}$ to improve the air quality in the vicinity of the plant (**Section 8.4.8**).
	• The communities as well as LUMHS said that they would appreciate it if appropriate equipment's (ESP for total PM emissions/FGD using lime slurry for SO_2/ SCR and dry low NOx burners for NO_2) are installed in the existing power plant before the construction of new power plant.	The need for rehabilitation of the existing power plant has been highlighted in the EIA in order to reduce the pollutants such as PM_{10} and $PM_{2.5}$ to improve the air quality in the vicinity of the plant (**Section 8.4.8**).

	Response of Stakeholders	*Post-Feedback Consultation Changes to EIA*
Ash Disposal	• The ash from the existing power plant is dumped near the settlements. In the rainy days, the ash is washed into the nearby agricultural fields. Resultantly, agricultural fields gradually lose fertility.	The problem mentioned is associated with the existing power plant. In the proposed Project, all the bottom and fly ash will be temporarily stored in ash silos. However, later it will be either transported to cement companies or will be disposed using ash ponds. Trucks will be used to transport the ash from the source to the silos as well as from silos to the cement companies (Chapter 8). The issue has been brought to the attention of GHCL and LPGCL for addressing the concern of the community.
Other Concerns	• The communities appreciated the proposed augmentation plan and hope that with the construction of new power plant, local people will get employment and improved health care facilities in Khanot and Manzurabad. • The community of Allah Dino Baricho demanded the renovation of existing school building and improving their education by providing an educated teacher. • Education is lacking, especially in case of women. Schools should be built in the community. • The communities of Dato Khoso and Pehlwan Khoso raised issue of quality education, unavailability of schools, especially in case of women.	The Social Augmentation Program proposes construction/rehabilitation of drinking water supply scheme, rehabilitation of primary health care clinic in Manzurabad and BHU in Khanot, and provision of training and capacity building activities (**Chapter 9**).

6.6 Future Consultations

6.6.1 Consultation during the EIA Process

Further consultations to be undertaken as part of the Project EIA process include the Project public hearing. The SEPA will require that one or more public hearings are held to assess public opinion on the environmental impacts of the Project. Within 10 days of receipt of the EIA report for the Project and subject to acceptance of the EIA for review, the SEPA will notify the Project proponents that one or more public hearings must be held. The SEPA will advertise the public hearings in a newspaper. The legal requirement is advertisement in at least one English or Urdu national newspaper, but in practice, advertisements are usually placed in two national newspapers and also in local newspapers. The public hearings will be held at least 30 days after the public notice. Copies of the EIA report and a non-technical summary have to be made accessible to the public during the notification period.

6.6.2 Consultation beyond the EIA Process

The Project management will continue community engagement activities throughout the life of the plant. Visits will be undertaken in all the communities twice or more time in a year, depending on the number of concerns raised under each consultation. Ongoing community engagement activities relevant to the EIA include:

- Ongoing reporting on progress on the implementation of environmental and social management measures identified during the EIA process and recording of comments on the effectiveness of these measures;
- Updating communities about new project developments and recording comments on these; and,
- Ongoing operation of the grievance mechanism (**Chapter 10**).

CHAPTER 7. ANALYSIS OF ALTERNATIVES

7.1 No Project Option

The no project alternative will have the following economic and environmental consequences:

- As described in **Section 2.4**, Pakistan is going through an acute power shortage. The gap between supply and demand has crossed 6,000 MW. The proposed Project represents nearly 10% of the current gap. Thus in the absence of this project, the gap in power supply and demand will continue to grow.

- As no large-size coal-based power plant exists in Pakistan, the Project can address many issues related to coal-based power generation in the country. This is likely to reduce the risk for future investment and will attract more investors to invest in coal based technology in future. In the absence of this project, this process is likely to be delayed.

- This Project will expect to contribute towards improving the environmental conditions, particularly the air quality in and around Lakhra. It has been agreed that GENCO will rehabilitate the emission control equipment of the existing power plant before the commission of the proposed 660 MW Power Plant..

- This Project will also contribute to the job creation such as non-skilled workers and guards for the surrounding communities during construction and operation and other jobs for people of Sindh in particular and people of Pakistan in general in skilled, technical and administrative categories. These opportunities would contribute towards improving the economic conditions of the communities. In the absence of this Project, no opportunity to get new jobs from local industry is expected in Lakhra area.

- This Project adopts state of the art technology of coal fired thermal power plant (ultra-supercritical pressure), which will contribute to lower GHG emissions in comparison with sub-critical technology. This would provide an opportunity for eco-friendly development of Pakistan power industry.

Therefore, unless economically, socioeconomically and environmentally more viable options can be found, the ‘no project’ option will have a negative impact on the economy as well as on the socioeconomic and environment conditions around the existing LFPS.

7.2 Alternatives to the Proposed Project

7.2.1 Generation Cost

Table 7-1 shows the generation unit cost for each generation method in 2012. Average generation unit cost was Rs. 12/kWh in 2012. If the cost for transmission line extension corresponding to Rs. 2.7/kWh and losses due to fee collection and stolen power corresponding to Rs. 0.9/kWh are added to above generation unit cost, the generation unit cost at the demand point becomes Rs. 15.6/kWh. In 2012, average selling power unit price was Rs. 9.01/kWh and moreover in 2013 the average power price would be raised up by 30% on average. So Pakistan critically needs cheaper power generation systems.

Gas price for existing gas turbine power stations is cheaper than the other fuel due to local production. But most of the gas has been allotted to household and industrial use, and vehicles. As the demand for gas excesses the supply, there is chronic shortage of gas.

Large-sized hydro power needs about ten year and furthermore the power generation in dry season drops to 30% of its rated capacity. So hydropower cannot be stable power generation throughout the year.

Therefore, the coal fired thermal power plant seems to be the most appropriate power generation system which solves the critical power shortage.

Table 7-1: Power Generation Cost of each Generation Method

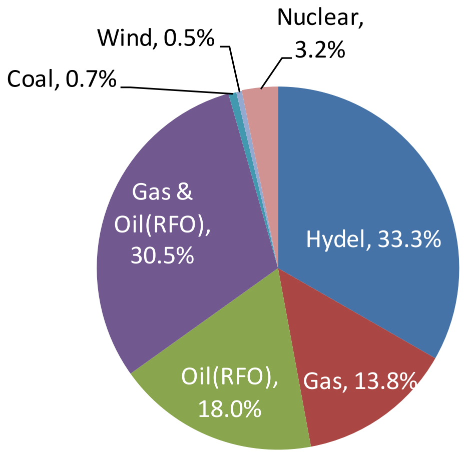
Generation Method	*Cost*	*Source*
Coal fired thermal P/S (with imported coals)	Rs. 7.6	Up-front tariff 600MW class
Coal fired thermal P/S (with Thar coals)	Originally more than Rs. 7.6 but less in a few years	The Thar Coal price is likely higher than the imported coal at the beginning the development of Thar Coalfield. As the investment costs are collected and the amount of Thar coal production is increased, then the Thar Coal price is expected to be lower than the imported ones.
Gas turbine P/S (with domestic gas)	Rs. 7.9 - 8.3	NTDC Power System Statistics 2011 - 2012 Rs. 7.9 GTPS Kotri (2012) Rs. 8.3 GTPS Faisalabad (2011)
Gas turbine P/S (with imported gas)	More than Rs. 10.0	Fuel cost will take Rs. 10/kWh with an estimation of gas price as 11 USD/MMBTU.
Gas & Oil (RFO) mixed thermal P/S	Rs. 12.0	National Power Policy 2013
Oil (RFO) thermal P/S	Rs. 17.0	National Power Policy 2013
Diesel (HSD) engine P/S	Rs. 23.0	National Power Policy 2013
Wind power	Rs. 15.5	Up-front tariff
Hydro power	Rs. 6.5	National Power System Expansion Plan 2011-2030 Main Report
(Reference) Photovoltaic power	Rs. 33.4	Government of Japan calculated in December 2011 (Japanese Yen 33.4).

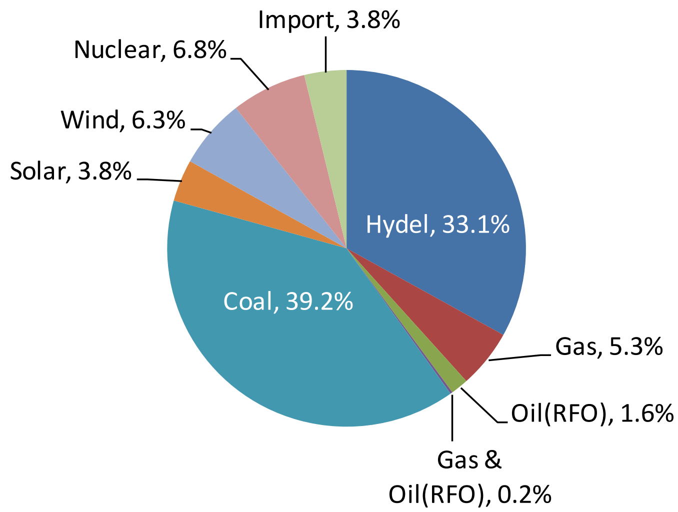
Source: JICA Survey Team

7.2.2 Renewable Energy

Figure 7-1 shows power source composition status as of November 2013 and the power source composition plan from 2013-14 to 2019-20 in Pakistan. This plan indicates that hydropower plant will be kept around 33%, whereas gas-fired, oil-fired and gas & oil-fired power plant will be reduced. Regarding coal-fired power plant, the number will be largely increased.

In terms of renewable energy (RE), the number of solar power (photovoltaic) and wind power station will be increased in the future. There is no plan for biomass energy including waste and solar thermal power plant in Pakistan.





Power Source Composition Status
as of November 2013
(Total Installed Capacity: 20,839 MW)

Power Source Composition Plan
(2013-14 to 2019-20)
(Newly Installed Capacity: 26,296 MW)

Source: NTDC

Figure 7-1: Power Source Composition Plan in Pakistan (NTDC)

Contrary to fossil fuels, greenhouse gas emission from RE is recognized as zero. So the RE is suitable for the world trend of fossil fuel reduction. However, problems are still remained and to be solved to apply RE. Wind power and hydropower depend on location and season. Solar power depends on sunshine duration. Besides, those power plants need larger area for construction than coal-fired power plant.

Current situation of renewable energy (i.e., hydropower, solar energy (photovoltaic) and wind power) and comparison with coal-fired power plant are described below.

(1) Hydropower

The total hydropower potential in Pakistan has been estimated to be 45,000 to 50,000 MW or even more. Most of the hydropower potential sites with 500 mm annual rainfall are located in the northern part of the country, which means that southern parts of the country (Sindh and Balochistan provinces) are not suitable for hydropower. In Pakistan, hydropower projects with their installed capacity less than 50 MW is defined as small hydropower. Alternative Energy Development Board (AEDB) has so far identified 3,010 MW hydropower potential at 680 locations in Khyber Pakhtunkhwa, Punjab, Gilgit-Baltistan, Sindh and Azad Jammu and Kashmir in Pakistan.

As the construction for hydropower plant needs around 10 years, it is not a viable solution for addressing immediate power shortage. Besides, hydropower project requires huge area to be acquired, which sometimes brings about social problems and prolongs the construction period.

(2) Solar Power (Photovoltaic)

According to the National Renewable Energy Laboratory (US), Pakistan has suitable environment for both Photovoltaic (PV) and thermal concentrated solar power applications.

Especially, many parts of Balochistan province are most suitable. Southern parts of Punjab province and northern parts of Sind province are also suitable.

Compared with coal-fired power plant, the stability of generation is less due to the sunshine duration. Besides, the construction area for PV of 600 MW (net) needs eighty times as large as that of coal-fired power plant.

(3) Wind Power

AEDB with the help of international experts and agencies such as National Renewable Energy Laboratory (US), GIT (Germany) and Risoe (Denmark) has identified the RE potential as 340,000 MW. Gharo-Keti Bandar wind corridor, which is located in the southeast of the Karachi City, is estimated to have a potential of 50,000 MW, which has attracted investors from some countries such as Turkey, Germany and China.

Though the generation cost of wind power is less than that of coal-fired power plant, the stability is less due to the location dependence and fluctuation in season.

7.3 Alternative Sites for the Power Plant

Three candidate sites, Thar coalfield mine mouth, Indus River (two sites) and Karachi Port, were selected for the project.

Table 7-2: List of Candidate Site

<table>
<tr><th></th><th>Candidate Site</th><th>Location</th><th colspan="2">Size</th></tr>
<tr><td>1</td><td>Thar coalfield mine mouth</td><td>Tharparkar district, Sindh province</td><td colspan="2">Energy park in Block II (approx. 0.9 km x 1.5 km being developed by Sindh Engro Coal Mining Company (SECMC).</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Indus River</td><td rowspan="2">Hyderabad, Thatta Badin district, Sindh province</td><td>a</td><td>Lakhra Power Station (approx. 0.77 km^2)</td></tr>
<tr><td>b</td><td>North of Jamshoro Power Station (approx. 1.0 km x 1.0 km)</td></tr>
<tr><td>3</td><td>Karachi Port (Port Qasim)</td><td>Karachi, Sindh province</td><td colspan="2">Qasim Industrial Zone owned by Port Qasim Authority (approx. 1.0 km x 1.0 km)</td></tr>
</table>

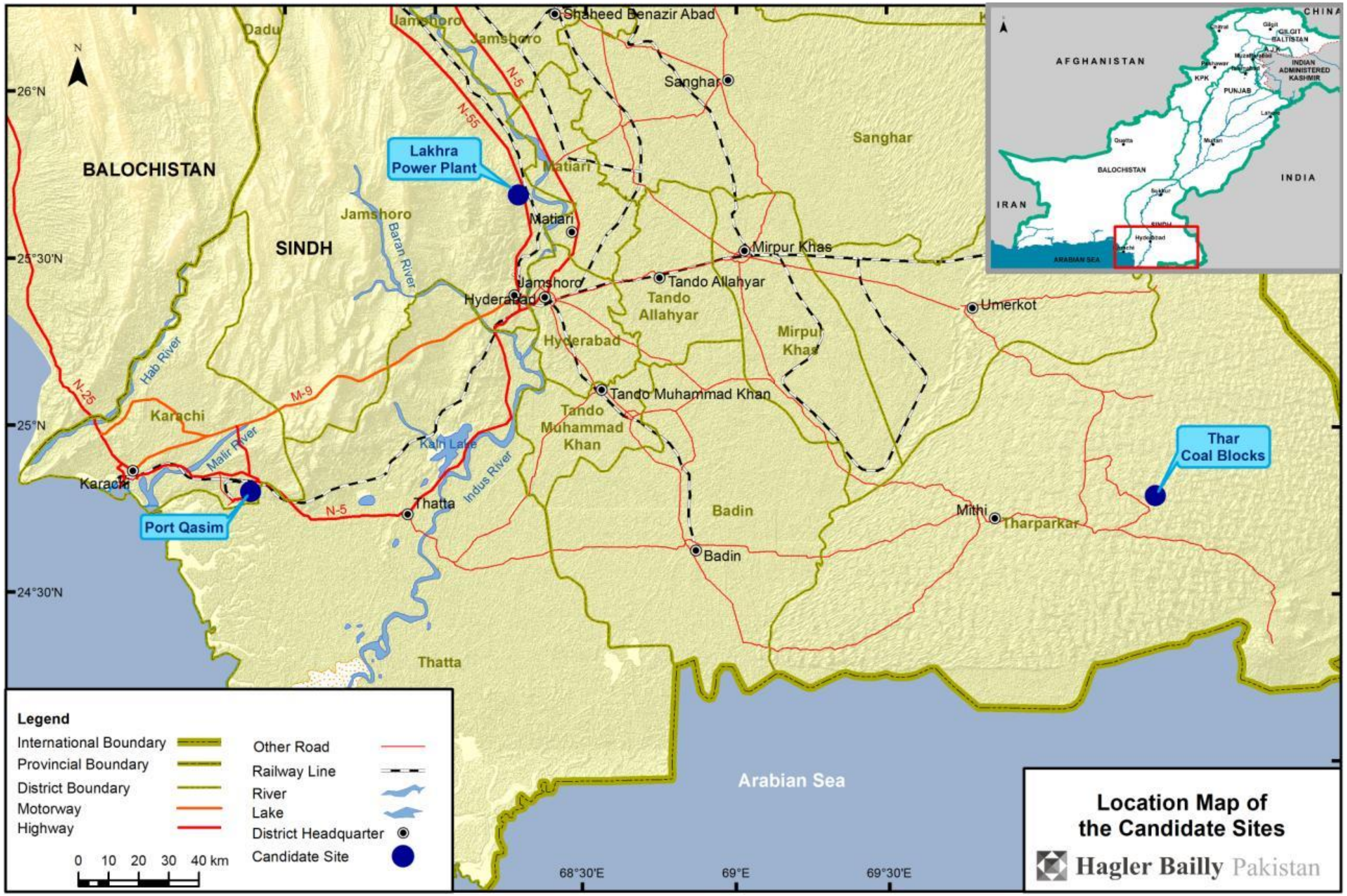


Figure 7-2: Location Map of three Candidate Sites

A comparison of the four sites, based on water availability, infrastructure, existence of transmission lines (T/L), environmental and social factors, and land ownership, is shown in **Table** 7-3.

Table 7-3: Conditions at Each Candidate Site

No	*Candidate Site*	*Water Availability*	*Infrastructure Conditions*	*Transmission Line*	*Environment and Social Conditions*	*Land Owner*
1	Thar Coalfield Mine Mouth	LBOD* is 85 km from site. Water channel and water treatment plant has been constructed from LBOD to Thar by Sindh Coal Authority.	[Thar coal] Domestic roads are used. [Imported coal] Railway shall be constructed between Qasim and Thar.	NTDC has planned to install T/Ls from Thar to Matiari (250 km).	Agricultural land. No residential land use.	Private land being acquired by SECMC
2-a	Lakhra Power Station	Indus River is 4.2 km from site.	[Thar coal] Roads are in good conditions. [Imported coal] Railway exists in good conditions in 2.0 km.	T/L is 1.7 km from site.	The site exists in existing power station. Poor vegetation. No residential land use.	GENCO
2-b	North of Jamshoro Power Station	Indus River is 4.0 km from site.	[Thar coal] Same condition as 2-a. [Imported coal] Railway exists in good conditions in 1.3 km.	T/L is 0.7 km from site.	Barren land with poor vegetation. No residential land use.	Unknown, possibly private land
3	Karachi Port (Port Qasim)	Arabian Sea is 2.5 km from site.	[Thar coal] Roads (Thar -Qasim) are in good conditions. [Imported coal] Roads in Port Qasim are in good conditions.	T/L is 35 km from site.	The site exists in Industrial park. Poor vegetation and no residential land use.	Private Companies

*: LBOD: Left Bank Outfall Drain

Of these four sites, the Lakhra site was preferred for economic as well as environmental reasons. The explanation is as follows:

- Port Qasim will require either installation of desalination plant or construction of large intake channel for once-through cooling water system. For Thar Site, implementation of plan to desalinate and transport water to the site from Left Bank Outfall Drain (LBOD)[1] is underway. In comparison, fresh water in sufficient quantity is readily available at this site (as well as at Jamshoro) which will allow installation of cooling towers.

- Port Qasim site is about 5 km from national highway and railway network. Road network to Thar is being improved from the existing single lane road to two-lane highway. Plans have also been drawn to connect Thar with the railway system. In comparison, both Lakhra and Jamshoro sites are on a major national highway and are also connected to the railway network.

- Transmission line to Thar has been planned and is being implemented. Port Qasim site is within 35 km of the 500 kV transmission line. Both Jamshoro and Thar site are within 2 km of the transmission line.

- It is estimated that no relocation of population is involved in any of the proposed sites. Subsistence rain-fed farming used to take place on part of the Thar site before it was acquired by the SECMC. All other sites are barren with very poor vegetation.

- Area of land proposed for the power plant in the Thar site and the Lakhra site are owned by the Government agencies or government owned entities. The Jamshoro and Karachi sites are most probably privately owned.

7.4 Selection of Imported Coal for the Project

Pakistan is currently embarking on diversifying its fuel mix for power generation. One of the proposed strategies is to import coal for newly designed boilers. GENCO placed a preference on Indonesian coals due to the relatively cheaper cost, shorter transportation distance and large options of low sulfur varieties. This section will discuss the coal supply from Indonesia and covering the available sources and supplies. Other similar coal is available in South Africa and Australia. **Table 7-4** presented the properties of sub-bituminous coal from Australia, Indonesia, and South Africa. Properties of Thar coal are also provided for reference.

[1] As part of the National Drainage Plan, government has developed a system of drains in which subsurface water in the canal-irrigated areas is discharged. The LBOD is the main drain of the system that collects saline water from Sindh and Punjab and carries it to the Arabian Sea.

Table 7-4: Comparisons of Coal Properties

Coal Properties	Sub-bituminous Coal		Lignite Coal	
	Australia*	Indonesia	South Africa	Thar
Total Moisture (wt. %)	21-28	24-38	8.5	45-50
Coal Ash Content (wt. %)	4-9	1.5-7.5	15-62	14-15
Volatile Matter (wt. %)	24-29	28-37	22-25	21-29
Sulfur Content (wt. %)	0.3-0.9	0.07-0.90	0.6-0.9	0.2-2.7
Coal Gross Calorific Value (kcal/kg)	4,500-5,000	4,100-5,200	5,900-6,200	2,500-3,700

* Premier Coal: http://www.premiercoal.com.au/Operations/Coal_Specifications

Indonesian coal has been selected for its large quantity of coal reserves spread out over the majority of its country. An estimate made in 2010 shows that Indonesia has over 100 billion tons of coal inferred reserves, with over 20 billion tons proven reserves.

Indonesian coal is, by large, sub-bituminous, with low ash, low sulfur, high volatilities and average Gross Calorific Value. Coal pricing is a factor of quality. The price index governing Indonesian Coal is known as Harga Acuan Batubara (HAB). The price is derived based on a marker coal price with the quality presented in **Table 7-5**.

Table 7-5: Quality of Coal for Marker Coal Price

Gross Calorific Value (GCV arb)	6,322 kcal/kg
Total Moisture (% arb)	8%
Total Sulfur (% arb)	0.8%
Ash (% arb)	15%

Most large coal mines have an established logistics network between the mines and the sea port. One of the deciding factors for Indonesian coal import is the distance from the source to the ports in Pakistan, which will reduce the transport cost significantly.

7.5 Port Option

Coal consumption in the country in 2011-2012 was 6.89 million tonnes of which 3.71 million tonnes was imported. The imported coal is primarily used in cement brick and textile industries. Coal can be received at Karachi at either the Karachi Port (KP) operated by the Karachi Port Trust, or the Port Qasim (PQ), operated by the Port Qasim Authority. Both the ports have bulk terminals to handle coal, and are connected to the road and rail network for transportation of goods to the northern markets in the country **Figure 7-3**.

KP has 30 dry cargo berths and 3 liquid cargo berths for petroleum and non-petroleum products, and is presently handling about 12 million tons/year of dry cargo, in addition to 14 million tons of petroleum products. KP has two container terminals. Port Qasim was commissioned in 1973 as the capacity at KP was not sufficient to handle the growing cargo volumes, and the options for expansion were limited as the port is encircled by densely populated areas. PQ is located about 35 km east of Karachi, and presently handles about 26 million tons of cargo annually, and is accessible through a 45 km long channel suitable for 11 meter draught vessel. PQ is connected to the national rail network by a 14 km track. The iron ore and coal Berth at PQ is a specialized berth originally designed for handling of raw material imports of Pakistan Steel Mills. The design capacity of the berth stands as 3.03 million tons per annum.

Handling of coal for the project is anticipated at the PQ in view of the existing cargo as well as traffic volumes on the railway network connecting the KP to the national rail network. The Port Qasim Authority through Pakistan Bulk International Terminal Ltd. has planned expansion of capacity to handle up to 8 million tons, initially, of coal and other bulk products with an investment of US $ 185 million[1].

1 www.pibt.com.pk downloaded on September 23 2103.

Figure 7-3: Route for Transportation of Coal to Lakhra Fluidized Bed Combustion Station

7.6 Environmental Control Technology

7.6.1 Particulate Matter Treatment Options

Particulate matter treatment technologies are electrostatic precipitators (ESP), fabric filters, cyclones and wet scrubbers. **Table 7-6** presents a comparison among the technologies in terms of efficiencies, advantages and disadvantages.

For the proposed PC boiler (SH/RH temperature 593 ºC respectively), ESP is the preferred alternative to control particulate matter emission in the flue gas. The exhaust hot flue gas from the boiler will carry the fine particle pass flows through the heat recovery area and then the fine particle will be captured by the ESP and transported to dry fly ash silos. The clean flue gas shall induce by induced draft fan and exhaust through stack. The ESP has been selected to control PM emission since ESP can be applied to wide range of system sizes and should have no effect on combustion system performance. Besides that, ESP will enable the Proposed Project to meet the Pakistan emission standard. The outlet particulate concentration at the ESP is estimated to be less than 50 mg/Nm^3.

Table 7-6: Particulate Matter Control Technologies

Control Technology	*Description*	*Control Efficiency*	*Advantages*	*Disadvantages*
Electrostatic precipitator (ESP)	ESP is applicable to a variety of coal combustion sources and the negatively charged dry precipitator is most commonly used. The high-voltage fields to apply large electrical charges to particles moving through the field. The charged particles move toward an oppositely charged collection surface, where they accumulate. The accumulated particles are than removed by rapper and collected at ESP hopper.	99-99.9%	High collection efficiency of 99% or greater at relatively low energy consumption. Low pressure drop. Continuous operation with minimum maintenance. Relatively low operation costs. Operation capability at high temperature (up to 700 °C) and high pressure (up to 10 atm) Capability to handle relatively large gas flow rates. (up to 50,000 m^3/min)	High capital cost High sensitivity to fluctuations in gas stream (flow rates, temperature, particulate and gas composition, and particulate loadings) Difficulties with the collection of particles with extremely high or low resistivity. - High space requirement for installation - Highly trained maintenance personnel required.
Fabric filters or bag houses	Fabric filters or bag houses are widely applied to combustion sources since 1970s. It consist of a number of filtering elements (bags) along the bag cleaning system contained in a main shell structure incorporating dust hopper. The particle-laden gas stream pass through the tightly woven fabric and the particulates are collected on one side of fabric. Filtered gas passes through the bags and is exhausted from the unit. When cleaning is necessary, dampers are used to isolate a compartment of bags from the inlet gas flow. Then, some of the filtered gas passes in the reverse direction in order to remove some of the dust cake. The gas used for reverse air cleaning is re-filtered and released.	99.9%	Very high collection efficiency (99.9%). Relative insensitivity to gas stream fluctuations and large changes in inlet dust loadings (for continuously cleaned filters). Recirculation of filter outlet air. Dry recovery of collected material for subsequent processing and disposal. No corrosion problems. Simple maintenance, flammable dust collection in the absence of high voltage Various configurations and dimensions of filter collectors	Requirement of costly refractory mineral or metallic fabric at temperatures in excess of 290 °C. Need for fabric treatment to remove collected dust and reduce seepage of certain dusts. Relatively high maintenance requirements Shortened fabric life at elevated temperatures and in the presence of acid or alkaline particulate. Respiratory protection requirement for fabric replacement. Medium pressure drop.

Control Technology	*Description*	*Control Efficiency*	*Advantages*	*Disadvantages*
			Relatively simple operation	
Wet scrubber	Wet scrubbers including venture and flooded disc scrubbers, tray or tower units, turbulent contact absorbers or high pressure impingement scrubbers are applicable particulate matter and SOx control on coal-fired combustion sources. The system requires substantial amounts of water and chemicals for neutralizing. Water is injected into the flue gas stream at the venture throat to form droplets. Fly ash particles impact with the droplets forming a wet by-product which then generally requires disposal.	95-99%	Relatively small space requirement. Ability to collect gases, as well as “sticky” particulates. Ability to handle high temperature, High humidity gas streams Low capital cost (if Wastewater treatment system is not required) High collection efficiency of fine particulates (95-99%).	Potential water disposal/effluent treatment problem. Corrosion problems (more severe than with dry systems). Potentially objectionable steam plume opacity or droplet entrainment Potentially high pressure drop. Potential problem of solid buildup at the wet-dry interface Relatively high maintenance costs.
Cyclone or multicyclone	A cyclone is a cylindrical vessel which can be installed singly, in series or groups as in a multicyclone collector. The flue gas enters the vessel tangentially and sets up a rotary motion whirling in a circular or conical path. The particles are hits against the walls by centrifugal force of the flue gas motion where they are impinge and eventually settle into hoppers. Cyclones is referred as mechanical collectors and are often used as a pre-collector upstream of an ESP, fabric filter or wet scrubber so that these devices can specified for lower particle loadings to reduce capital and operating costs.	90-95%	Low capital cost. Relative simplicity and few maintenance problems. Relatively low operating pressure drop. Temperature and pressure limitations imposed only by the materials of construction used Dry collection and disposal. Relatively small space requirements	Relatively low overall particulate collection efficiencies especially for particulate sizes below 10 micron (PM10). Inability to handle sticky materials.

7.6.2 SO_2 Emission Control Methodology

Several techniques are used to reduce SO_2 emissions from coal combustion. Flue gas desulfurization (FGD) systems are in current operation on several lignite-fired utility boilers. Post combustion FGD techniques can remove SO_2 formed during combustion by using an alkaline reagent to absorb SO_2 in the flue gas. Flue gases can be treated using wet, dry, or semi-dry desulfurization processes of either the throwaway type (in which all waste streams are discarded) or the recovery/regenerable type (in which the SO_2 absorbent is regenerated and reused).

Table 7-7 presents the post combustion SOx control for coal combustion sources. The typical control efficiencies percentage is more referred to pulverized technology with higher combustion temperature.

Table 7-7: Post combustion SOx Control for Coal Combustion Sources

Control Technology	*Description*	*Control Efficiency*	*Remarks*
Wet scrubber	Lime/limestone	80 – ≥95	Applicable to high sulfur fuels, wet sludge products.
	Sodium carbonate	80 – 98%	430 MMRTU/hr typical application range, high reagent costs.
	Magnesium oxide/hydroxide	80 – ≥95	Can be regenerated.
	Dual alkali	90 – 96%	Used lime to regenerate sodium-based scrubbing liquor.
Spray drying	Calcium hydroxide slurry, vaporizes in spray vessel	70 – 90%	Applicable to low and medium sulfur fuels, produces products
Furnace injection	Dry calcium carbonate/ hydrate injection in upper furnace cavity	25 – 50%	Commercialize in Europe, several U.S demonstration projects are completed.
Duct injection	Dry sorbent injection into duct, sometimes combined with water spray	25 – ≥50	Several research, development and demonstration projects underway, not yet commercially available.

Source: JICA Survey Team

Based on the proposed design coal, SO_2 emission without FGD installed will be above the World Bank's Environmental, Health and Safety Guidelines of 2008 for Thermal Power Plant, with capacity >50<600MW boilers: 400mg/Nm^3 for degraded airshed. The Wet Type FGD, with limestone is selected as SOx emission treatment option, due to the high rate of removal, plus the system will yield a marketable byproduct Gypsum.

1. Wet FGD is the most commonly applied techniques for SO_x emission reduction. Wet systems generally use alkali slurries as the SO_2 absorbent medium and can be designed to remove greater than 90% of the incoming SO_2. The effectiveness of these devices depends not only on control device design but also on operating variables. Lime or

limestone scrubbers, sodium scrubbers, and dual alkali scrubbers are among the commercially proven wet FGD systems. These are favored because their availability and relatively low cost. Although wet scrubbers can also be utilized in particulate removal, they are most effective when coupled with ESP or filters. Wet scrubbers consist of a spray tower or absorber where flue gas is sprayed with calcium-based water slurry.

Dry FGD/ Spray Drying: Dry scrubbers are an alternative application for SO2 removal. Dry FGD require the use of efficient particulate control device such as ESP or fabric filter. Instead of saturating the flue gas, dry FGD uses little or no moisture and thus eliminates the need for dewatering. Lime is mixed in slurry with about 20% solids; the slurry is atomized and injected into the boiler flue gas. The SO2 reacts with the alkali solution or slurry to form liquid-phase salts. The slurry is dried by the latent heat of the flue gas to about 1% free moisture. The dried alkali continues to react with SO2 in the flue gas to form sulfite and sulfate salts. The spray dryer solids are entrained in the flue gas and carried out of the dryer to a particulate control device such as an ESP or baghouse. The absorber construction material is usually carbon steel making lower capital cost. However, the necessary use of lime in the process will increase the operational costs. Besides than, dry FGD's efficiency is slightly lower than wet FGD (70-90% wt.). Dry FGD have been proven with low-sulfur coal in the United States and elsewhere, but their applicability for use with high-sulfur coals has not been widely demonstrated.

Furnace Injection: A dry sorbent is injected into the upper part of the furnace to react with the SO_2 in the flue gas. The finely grinded sorbent is distributed quickly and evenly over the entire cross section in the upper part of the furnace. In PF system, the combustion temperature at furnace is range between 750-1,250ºC. Commercially available limestone or hydrated lime is used as sorbent. Removal efficiency can be obtained up to 50%. Limestone may also be injected into the furnace, typically in an FBC, to react with SO_2 and form calcium sulfate.

Duct Injection: In duct injection, the sorbent is evenly distributed in the flue gas duct after the pre-heater where the temperature is about 150ºC. At the same time, the flue gas is humidified with water if necessary. Reaction with the SO_2 in the flue gas occurs in the ductwork and the by product is captured in a downstream filter. Removal efficiency is greater than with furnace injection systems. An 80% SO_2 removal efficiency has been reported in actual commercial installations.

7.7 Ash Disposal Options

As described in Chapter 4, the residuals of coal combustion in power plants that are captured by pollution control technology include fly ash, bottom ash, and flue gas desulfurization gypsum. Given the industry practice, alternatives that can be considered for disposal of ash and gypsum that will be generated by the Project are recycling, or storage in an ash pond. Given the fact that a lined ash facility involves investment, land, and continuing management to contain the material stored, recycling is the preferred alternative from both environmental and economic viewpoint.

7.7.1 Ash Recycling Options

Fly ash is a product of burning finely ground coal in a boiler to produce electricity. It is removed from the plant exhaust gases primarily by electrostatic precipitators or baghouses and secondarily by scrubber systems. Physically, fly ash is a very fine, powdery material, composed mostly of silica. Fly ash is a pozzolan, a siliceous material which in the presence of water will react with calcium hydroxide at ordinary temperatures to produce cementitious compounds. Because of its spherical shape and pozzolanic properties, fly ash is useful in cement and concrete applications. The spherical shape and particle size distribution of fly ash also make it good mineral filler in hot mix asphalt applications and improve the fluidity of flowable fill and grout when it is used for those applications. Fly ash applications include its use as a:

- Raw material in concrete products and grout
- Feed stock in the production of cement
- Fill material for structural applications and embankments
- Ingredient in waste stabilization and/or solidification
- Ingredient in soil modification and/or stabilization
- Component of flowable fill
- Component in road bases, sub-bases, and pavement
- Mineral filler in asphalt

A review of the utilization of fly ash produced in the coal powered plants in India[1] shows that on an average the utilization of fly ash produced by the coal fired power plants is over 50%, with a number of plants achieving 100% utilization. Pakistan Standards and Quality Control Authority (PSQCA), on the initiative of cement manufacturers have modified the Portland cement standards in 2008[2] to allow for up to 5% blending of fly ash in the manufacturing of cement. There are a number of potential users of ash produced by the project in the vicinity of LFPS. These include cement plants are located at a distance of 130-180 km from the plant mainly on the main highway M-9 linking Hyderabad to Karachi (**Figure 7-4**), which is also the route through which coal will be transported to LPP. One of the manufacturers, the Power Cement Limited (Formerly Al-Abbas Cement Limited) located about 90km from the LFPS has indicated that their plant can utilize about 100,000 tons/year of ash as finished product extender, and about 150,000 t/year as kiln feed. Production of cement concrete blocks where bottom ash can be used as an aggregate is also common and widespread in the Karachi-Hyderabad area.

FGD Gypsum is a product of a process typically used for reducing SO_2 emissions from the exhaust gas system of a coal-fired boiler. The physical nature of these materials varies from a wet sludge to a dry powdered material depending on the process. The wet sludge from a lime-based reagent wet scrubbing process is predominantly calcium sulfite. The wet product from limestone based reagent wet scrubbing processes is predominantly calcium sulfate. The

1 Report on Fly Ash Generation at Coal/Lignite Based Thermal Power Stations and its Utilization in the Country for the Year 2010-11, Central Electricity Authority, New Delhi, December 2011

2 PS 232-2008 (R), Pakistan Standard: Ordinary Portland Cement (OPC) (33, 43 & 53 Grades), Pakistan Standards and Quality Control Authority

largest single market for FGD material is in wallboard manufacturing. Other FGD Gypsum applications include its use as a:

- Fill material for structural applications and embankments
- Feed stock in the production of cement
- Raw material in concrete products and grout

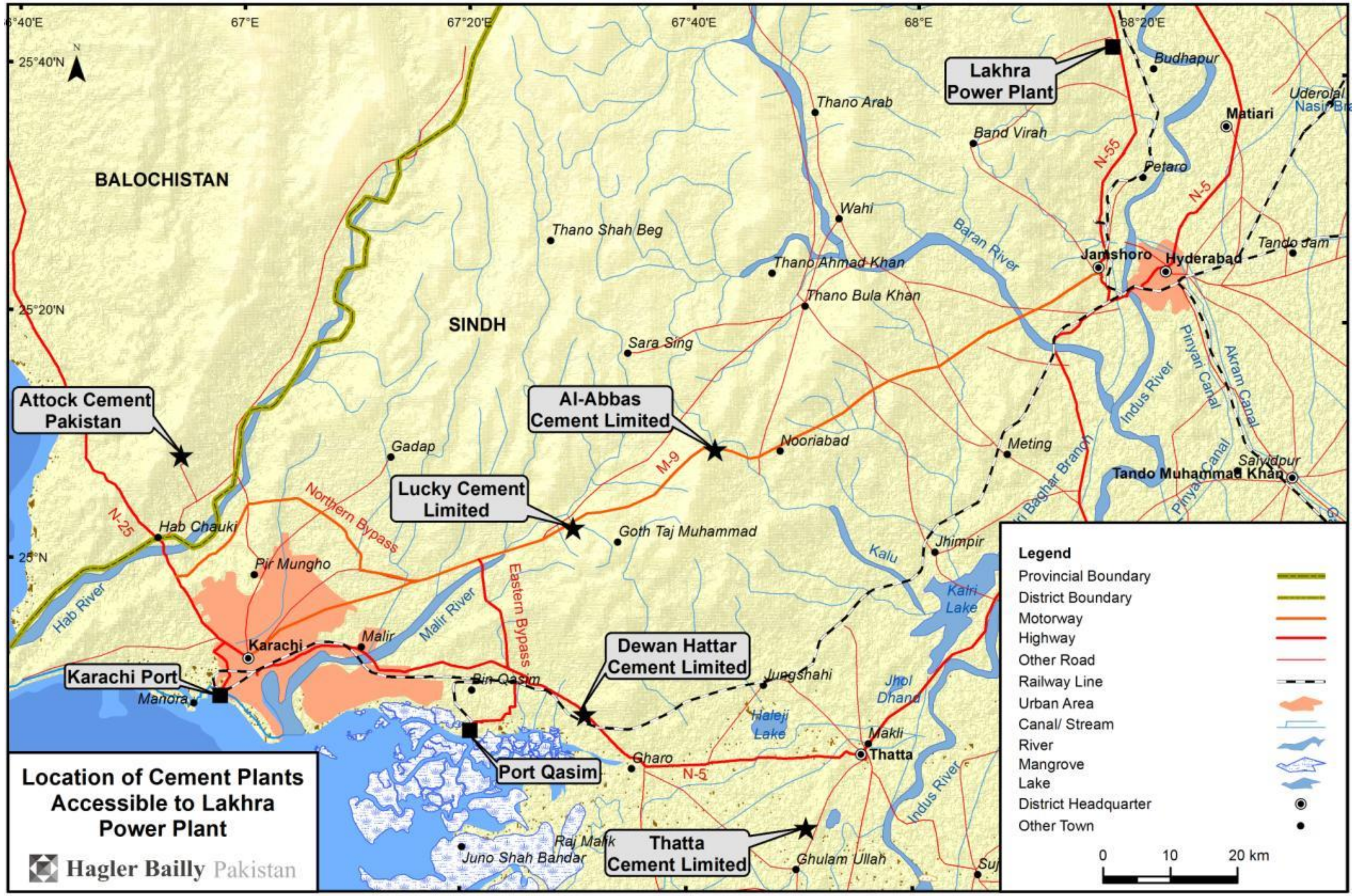


Figure 7-4: Location of Cement Plants Accessible to LPP

7.7.2 Preferred Ash Disposal Approach for the Project

Recycling of ash will be the preferred option for ash disposal. LPP can generate revenue by a proper planning of ash disposal. As the cement industry has already shown interest in utilization of ash produced at the Project, LPP management will consult and enter into agreements with cement factories and other construction industries for utilization of the ash. Meanwhile, lined ash disposal areas will be developed in stages to store surplus ash that cannot be recycled, with the initial stage sized to accommodate five years of the total facility ash output as described in Chapter 4.

7.8 Location Alternatives of the Ash Pond Facility

As described in Chapter 4, ash will be transferred to the ash pond by trucks. Land requirement for the ash pond is estimated at 28.3 hectares or 70 acres. The applicable land within the existing power plant area, however, is not enough for the ash pond. So land acquisition is required for the half portion of the ash pond.

Alternative locations for the almost half of the ash pond are indicated in **Figure 7-5**. The following factors were considered in selection of the location for the ash pond.

1. The site should be close the power plant for economic as well as management reasons. Piping of the ash slurry to a distance of more than 2 km is not recommended.
2. The economic value of the land should be low in terms of both the current and potential uses.
3. The location should not be subject to flooding.
4. The impact of ash dispersion on local people should be minimized.

According to the above criteria, two locations are selected as candidate sites. Feature of location A and B is shown in **Table 7-8**.

Location A is situated in the northwest of the LFPS. This location is used as ash disposal site for existing LFPS. The land is flat and there is no residence, where coal ash generated from LFPS has already been disposed of from its commissioning. The area is adjacent to the proposed ash pond located within the plant estate.

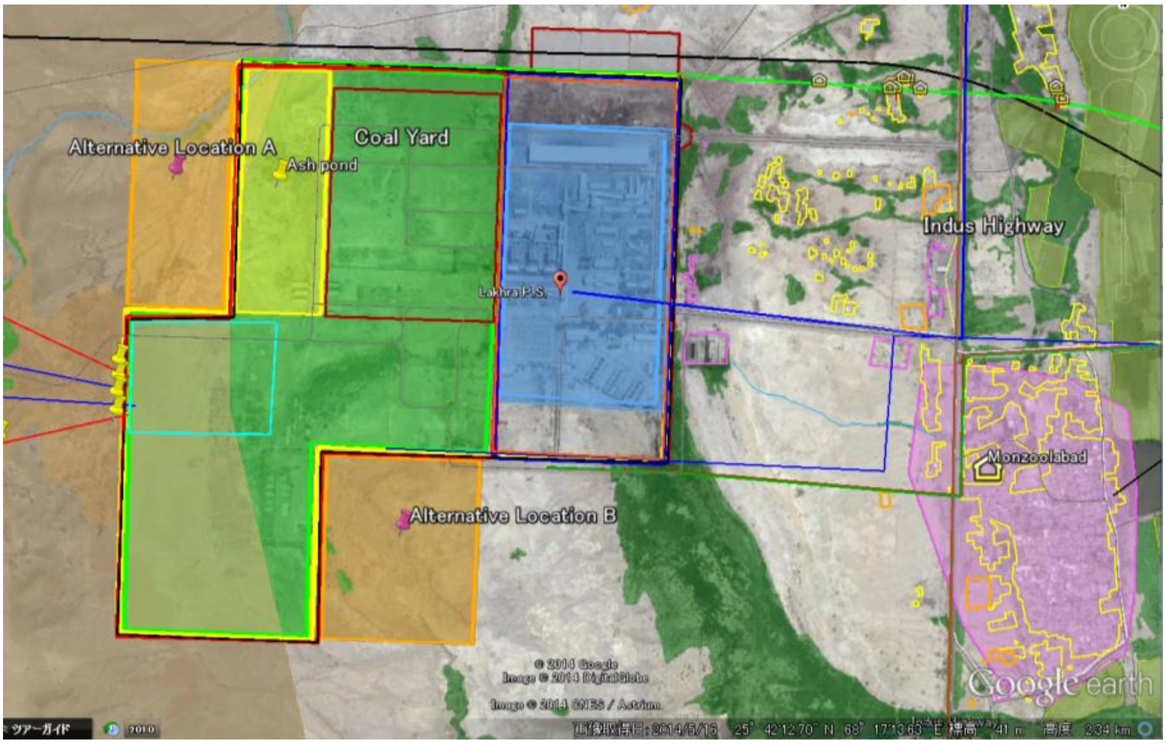
Location B is situated in the southern site of the LFPS. This location is also not used for any purpose at present. This site is closer to resettlements than Location A.

Table 7-8: Comparison of Alternative Sites

	Location A	*Location B*
Distance to inside ash pond	0 km	0.4 km
Land use	Ash disposal site of LFPS	Not used
Residence	Not found	Not found
Topological condition	Undulating landscape	Relatively gentle landscape
Geological condition	Land is covered with sand and gravel up to approx. 5m from the surface	Land is covered with sand and gravel up to approx. 5m from the surface
Distance to resettlement	3.7 km (Lakhra Colony) 1.6 km (Manzurabad)	2.9 km (Lakhra Colony) 1.0 km (Manzurabad)

Source: JICA Survey Team

Location B is closer to resettlement than Location A. Location A is adjacent to the ash pond in the power plant estate. From social and workable point of view, the Location A is preferred for the construction of ash pond.



Source: Google earth

Figure 7-5: Alternative Locations for LPP Ash Disposal Site

CHAPTER 8. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES FOR THE PROPOSED PROJECT

8.1 Identification of Significant Environmental Aspects

This section covers the assessment of potential environmental impact of the proposed activities. Each potential impact is then categorized based on Table 8-1 to identify the potentially significant issues according to anticipated risk to environment due to the Project activity. Risk is defined qualitatively in terms of consequence and probability. Consequence is defined in terms of magnitude, duration, and spatial scale. Thus, the three categories are defined as follows:

- A+/-: Significant positive/negative impact is expected
- B+/-: Positive/negative impact is expected to some extent
- C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
- D: No impact is expected

The significant issues are then further discussed in the following sections.

Table 8-1: Potential Environmental and Socioeconomic Impacts of the Proposed Activities

No.	Item	Assessment: Pre/Construction Phase	Assessment: Operation Phase	Assessment Reason
Pollution Control				
1	Air Quality	B-	A-	**[Construction Phase]** Soil dust might emit from civil works of land clearance. Soil dust and emissions of particulate matter (PM) and sulfur dioxides (SO_2) might emit from trucks transporting equipment and heavy machines. **[Operation Phase]** The operation of power plant might emit SO_2, PM and nitrogen oxides (NO_X). Coal dust might be generated during transporting coal. Coal ash might emit from coal piles. Spontaneous ignition is predicted.
2	Water Quality	B-	B-	**[Construction Phase]** Effluent of concrete and water with oil might percolate into underground water. Domestic effluent from base camps might percolate into underground water. **[Operation Phase]** Cooling tower discharge would be drained into the Indus River. Effluents from associated equipment (regular and irregular effluents), domestic water from administration office and water with oil can percolate into underground water. Storm water from ash pond might include arsenic and heavy metals, which might pollute the underground water. Leachate from ash pond may contaminate underground water.
3	Soil Quality	B-	B-	**[Construction Phase]** The leakage of lubricant oil and fuel oil from construction vehicles and machines might pollute soil. **[Operation Phase]** The leakage of lubricant oil and fuel oil used in the power plant might pollute soil. Leachate form ash pond may contaminate the soil around the facility.
4	Wastes	B-	B-	**[Construction Phase]** Solid wastes and hazardous wastes might be generated from base camps and construction sites. **[Operation Phase]** Solid wastes and hazardous wastes might be generated from administration building, accommodation and canteen. Coal ash and by-product gypsum from flue gas desulfurization will be generated from the power plant.

No.	*Item*	*Assessment*		*Assessment Reason*
		Pre/Construction Phase	*Operation Phase*	
5	Noise and Vibration	B-	A-	**[Construction Phase]** Noise and vibration might be generated from large-sized vehicle traffic on access roads and construction sites. Noise and vibration might be generated from heavy machines during excavation works and equipment setting. **[Operation Phase]** Noise and vibration might be generated from each unit such as boiler and power generator, etc.
6	Subsidence	D	D	**[Construction & Operation Phase]** No subsidence will occur due to no use of underground water.
7	Odor	B-	B-	**[Construction Phase]** Odor might be generated from kitchen wastes at base camps and septic tanks. **[Operation Phase]** Odor might be generated from kitchen waste at administration building and canteen and manure treatment systems. Irritating smell might be generated from the spontaneous ignition of coal and ash.
8	Sediment Quality (bottom of Indus River)	B-	B-	**[Construction Phase]** Sediment in the Indus River might be damaged due to civil works of intake and outlet facilities. **[Operation Phase]** Some impacts on sediment are predicted due to disposal of cooling tower discharge into the Indus River.
Natural Environment				
9	Protected Areas	C-	C-	**[Construction & Operation Phase]** Keti Khasai Reserved Forest in 6km northeast and Budhapur Reserved Forest in 6km southwest from the project site exist. Site investigation will be done in the third site works.
10	Ecosystem	C-	C-	**[Construction & Operation Phase]** Two species of mammals, two species of birds, six species of reptile and seven species of fish listed in the IUCN Red List 2013 have been reported. Further site investigations will be done especially for aquatic organisms such as Indus River blind dolphin.
11	Hydrology	B-	B-	**[Construction Phase]** Temporary impacts on the hydrology are predicted due to construction of intake water and effluent discharge facility in the Indus River. **[Operation Phase]** Impact by intake water and effluent discharge may adversely impact on the Indus River.

No.	Item	Assessment		Assessment Reason
		Pre/Construction Phase	Operation Phase	
12	Topography and Geology	B-	D	**[Construction Phase]** Excavation and land clearance for ash pond being acquired may have adverse impact on topography. **[Operation Phase]** No impact would be predicted.
Social Environment				
13	Resettlement	B-	B-	**[Pre Construction Phase]** Land acquisition is required for ash pond, access road, water pump station and temporary for water pipelines and some of the land are private owned land. **[Operation Phase]** Land would be permanently acquired and impacts on that economical activities in some extent.
14	People below the Poverty Line	C-/C+	C-/C+	**[Pre Construction Phase]** A further study is required to reveal if people below poverty line are included in the affected people **[Construction and Operation Phase]** Job creation and provision of job training would impact positively. **[Operation Phase]** Loss of income may cause adverse impact on people's living.
15	Ethnic, Minorities and Indigenous People	C-	C-	**[Pre/ Construction & Operation Phase]** People other than Muslim (such as Hindi, Christian and other minor groups) may be more vulnerable to project impacts compared with the major religious group.
16	Living and Livelihood	C-/C+	C-/C+	**[Pre Construction Phase]** A further study is required to find out the state of fishery activities in the Indus River and whether intake/discharge of riverine water result in any adverse impacts on fishery products, fishing area and, fisherman's income. **[Construction Phase]** Temporary increase in traffic may disturb existing traffic and may lead to adverse impact on regional economic activities. **[Construction and Operation Phase]** Job creation and provision of job training would impact positively. **[Operation Phase]** Intake/discharge of water from/to the Indus River may cause adverse impact on income

No.	*Item*	*Assessment*		*Assessment Reason*
		Pre/Construction Phase	*Operation Phase*	
				source of fishermen without appropriate mitigation measures.
17	Use of Land and Resources	C-	C-	**[Construction and Operation]** Intake/discharge of water from/to the Indus River may cause adverse impact on use of aquatic resources (such as water, water area, fishery products) without appropriate mitigation measures.
18	Water Use	C-	C-	**[Construction]** Some quantity of water intake and, discharge of rain water contaminating particulate matter, oil and sediment from construction site may negatively impact on water use (for the purpose of drinking, rice production and fishing). **[Operation]** Large quantity of water may be required for cooling systems and domestic use, and some quantity of effluent may be discharged into surface water (e.g. Indus River, drainage).
19	Infrastructure and Social Services	B-	D	**[Construction Phase]** Temporary increase in traffic may disturb existing traffic and may lead to adverse impact on regional economic activities.
20	Social Capita, Institutions and Conflicts	C-	D	**[Pre Construction Phase]** Differences in acceptance of the project and income gap among stakeholders may change social relation, deepen hierarchies and, create conflicts.
21	Unevenness of Project Benefits and Impact	C-	C-	Unevenness of the project benefit and impacts may deepen economic inequality amongst communities.
22	Heritage	C-	D	**[Construction Phase]** Possibility of sound and vibration impacts on the Syed Daad Shaheed Graveyard and Shrine, that are located 6 km south-east from the candidate site, is expected.
23	Landscape	D	D	No large scale earth works are involved None
24	Gender	C-	C-	**[Construction Phase]** Difference in benefits of temporary job opportunities between men and women will be arisen. **[Construction and Operation Phase]** Women's work load may be caused by degradation of income source

No.	*Item*	*Assessment*		*Assessment Reason*
		Pre/Construction Phase	*Operation Phase*	
				and livelihood standard.
25	Child Right	C-	C-	**[Construction Phase]** Temporal job opportunities in construction work may result in an increase in number of child labors. **[Construction and Operation Phase]** Degradation of income source and livelihood standard may worsen the situation of child labor and school attendance.
26	Infectious Diseases	B-	D	**[Construction Phase]** Influx of workers may increase risks in respiratory and infectious disease.
27	Working Condition and Accident	B-	B-	**[Construction Phase]** Risks of accident, spread of infectious diseases may be increased. **[Operation Phase]** Accident could be occurred in work environment. Possibility of spontaneous combustion at the coal yard is expected.
28	Transboundary Waste Treatment and Climate Change	B-	A-	**[Construction & Operation Phase]** No transboundary waste treatment would be predicted. **[Construction Phase]** Temporary carbon dioxides (CO_2) emissions from vehicle and heavy machinery are predicted. **[Operation Phase]** Certain amount of CO_2 will be generated.

Source: JICA Survey Team

8.2 Terms of Reference for Environmental and Social Considerations

According to Table 8-1, the items which should be investigated further are selected. TOR for environmental and social considerations is shown in Table 8-2.

Table 8-2: Terms of Reference

Environmental Item	*Survey Item*	*Survey Method*
Air Quality	(1) Confirmation of environmental standards (SEQS, IFC, etc.) (2) Current condition of air quality (3) Confirmation of location of residence, school, and hospital, etc. around the project site. (4) Impact during construction	(1) Collection of air quality standards and exhaust standards (2) Collection of meteorological data such as temperature, humidity and wind speed, etc. Measurement of air pollution substances such as SOx, NOx and PM. (3) Site investigation (4) Confirmation of construction method
Water Quality	(1) Confirmation of environmental standards (SEQS, IFC, etc.) (2) Confirmation of surface (e.g., Indus River, pond) and groundwater quality	(1) Collection of standards for drinking and effluent water quality (2) Measurement of surface and groundwater quality
Soil Quality	(1) Oil leakage prevention measures during construction and operation	(1) Measurement of groundwater quality (turbidity, BOD, heavy metals, etc.)
Wastes	(1) Environmental standards (2) Type and treatment method of construction wastes (3) Domestic waste during construction (4) Wastes during operation (ash, waste oil, etc.)	(1) Collection of waste-related law, guidelines (2) Hearing with the project proponent (3) Hearing with the project proponent (4) Confirmation of construction method
Noise and Vibration	(1) Confirmation of environmental standards (NEQS, IFC, etc.) (2) Distance between the site and residential area, school and hospital, etc. (3) Impact during construction (4) Current conditions of noise and vibration	(1) Collection of standards for noise and vibration (2) Confirmation of the location of residential areas, school, hospital, etc. at each site (3) Confirmation of construction method (4) Measurement of noise (baseline)
Odor	(1) Odor generation source	(1) Hearing with project proponent
Sediment Quality (bottom of Indus River)	(1) Location and structure of water intake and effluent outlet equipment (2) Impact scale	(1) Site investigation (2) Confirmation of construction method and equipment's specification

Environmental Item	*Survey Item*	*Survey Method*
Protected Areas	(1) Confirmation of Reserved Forest adjacent to the site	(1) Site investigation (2) Associated report collection
Ecosystem	(1) Current conditions of mammals, birds (migratory birds etc.) and reptiles including precious species	(1) Confirmation of related data, and ecological survey
Involuntary Resettlement (Land Acquisition)	(1) Land and assets to be relocated (2) Affected people (economically or physically) (3) Renters, business, workers, employees, people without allocation (squatters and encroachers) (4) Replacement cost for land and assets (farm land, urban land, houses and other structures) (5) Supplementary measure for loss of assets	Analysis of legal frameworks Collection of reference material Analysis on satellite image Population census survey Collection of land record and assets inventory Socioeconomic survey (interviews, public meeting, group discussion, site investigation)
People below poverty line	(1) Presence of fishery activities in the Indus River (2) Presence of people below poverty line in the affected fishermen	Collection of reference material Socioeconomic survey Income and livelihood survey Interview to local fishery association and local governments
Ethnic Minorities & Indigenous People	(1) Baseline information on ethnic, minorities and indigenous people, the social relations and vulnerability.	Collection of reference material Socioeconomic survey Interview to local community
Living and Livelihood / Regional Economy	(1) Baseline information on livelihoods and standards of living of which affected people	Collection of reference material Socioeconomic survey Income and livelihood survey Site investigation and interview to affected people, labor's association, local government and NGO etc.
Land and Resources	(1) Baseline information on land use (2) Baseline information on Aquatic resources	Collection of reference material Analysis on satellite image Analysis of land use map Site investigation and interview
Water Use	(1) Baseline information on use of river and underground water (for different purposes i.e. drinking and irrigation	Collection of reference material Analysis of water management record Interviews to local government Site investigation

Environmental Item	*Survey Item*	*Survey Method*
Infrastructure and Social Services	(1) Transporting route of construction materials and equipment (2) Transporting route of coal (3) Location of social infrastructures (school, hospital and other services)	Analysis on satellite image Analysis of land use map Site investigation to understand geographic relations of roads and infrastructures and Interviews to local government
Gender and Child	(1) Baseline information of women's role and work state (especially in family of fishermen) (2) Baseline information of child labor and school attendance (especially in family of fishermen)	Socioeconomic survey Income and livelihood survey Site investigation and interview to affected people, fishermen, labor's association, local government and NGO etc.
Infectious (HIV/AIDS) diseases	(1) Infection rate of diseases such as respiratory diseases and HIV/AIDS in the local community (2) Local NGOs conduct activities regarding infectious disease	Collection of reference materials Interviews to local government, medical facilities, NGOs etc.
Working Conditions and Accident	(1) Time, route and area of public movement (2) Potential hazards to workers at construction and operation stage (3) Potential health risk to workers (4) Baseline information of forces labor	Collection of reference material (similar projects' EIA) Analysis of satellite image Analysis of land use map Requirements and guideline of occupational health and safety in Pakistan Environmental, Health and Safety Guidelines (EHS Guidelines) are Interview with local government, NGOs, labors association etc.
Stakeholder consultation	(1) Stakeholder's states and the relations (2) Concerns and comments on project (3) Baseline information	Stakeholder meetings Public consultations Focus group interviews Individual interviews

Source: JICA Survey Team

8.3 Construction Impact

Some of the environmental and social impacts of construction activities relate to activities at the construction site whereas others relate to the setting up and operation of the construction crew camp. Typical issues include:

- Site clearance leading to dust emission

- Removal of vegetation leading to loss of vegetation cover
- Erosion and sedimentation due to large scale earthwork
- Air quality impact from operation of construction machinery and earthwork
- Noise and vibration from machinery and construction work
- Generation of waste and its disposal
- Off-site impacts such as those related to borrow pits
- Disposal of effluent from construction camp
- Impact of stormwater on the surrounding areas
- Cultural impact related to presence of non-local workers

Many of the construction impacts are temporary and end with the completion of the construction activity. However, poor management can result in long-term residual impacts. To avoid adverse impact of the construction activities on the environment, following measures are proposed:

- The camp of the construction contractor(s) will be developed within the premises of LFPS.
- The construction contractor will develop a specific construction management plan (CMP) based on the CMP included in the EMP. The CMP will be submitted to the LFPS and Project Implementation Consultant (PIC) for approval.
- The CMP will clearly identify all areas that will be utilized during construction for various purposes. For example, on a plot plan of the construction site the following will be shown:
    - Areas used for camp
    - Storage areas for raw material and equipment
    - Waste yard
    - Location of any potentially hazardous material such as oil
    - Parking area
    - Loading and unloading of material
    - Septic tanks
    - Stormwater run-off direction and control measures

8.4 Disposal of Waste from Construction Works

8.4.1 Solid Waste

The plant construction and installation of equipment will generate considerable amount of solid waste. It will include metals (mainly iron and copper), concrete, wood, cotton, plastic, packing materials, electronic, and insulation material. Different types of hazards are associated with some of the waste material. For example:

- Sharp edges in metals
- Tripping hazards if material is left in the pathways
- Soil contamination from leaking oil from equipment
- Slipping hazard from oil on floors
- Potentially toxic content
- Dust and soot
- Respiratory disorders

A comprehensive Waste Management Plan will be instituted by the Project and re-use opportunities for waste generated during construction will be investigated. Hazardous waste identified, if any, will be stored in an on-site Hazardous Waste Storage Facility.

As a standard practice all metal (mainly iron and copper) parts generated as waste will be recycled. Similarly, wood will also be recycled. Part of the recycling may be done internally, within the Plant or other companies owned by GHCL.

8.4.2 Wastewater

The wastewater generated during construction work, the associated hazards and the method in which it will be handled are as follows:

1. Camp sanitary waste—Biological hazard leading to potential spread of disease. Septic tanks will be constructed to contain the waste. Wastewater from the septic tank will be emptied out before closure of camp or periodically and discharged to a municipal treatment plant. Alternatively, a packaged wastewater treatment unit will be installed

2. Camp washing waste—Corrosion, contamination of land and soil. Wastewater will be screened, neutralized and will be used for plantation.

3. Wash water from workshop—Oil and grease. Wastewater will be screened; oil and grease separated using API separator; neutralized and will be used for plantation

4. Stormwater run-off—Oil and grease and other contamination. Drainage from area containing potentially hazardous material will be separated from the rest. Run-off from these areas will be directed to a settling basin. It may be further treated if required

before discharge. The run-off discharged point will be selected so that the contaminated water does not go to agricultural fields.

8.5 Air Quality Impacts during Operation

8.5.1 Modeling Approach

Three simulations were carried out to assess the impacts of the proposed power plant. The details of the simulations and the rationale for selecting them are as follows:

1. *LFPS Current Emission Simulation:* The simulation is for the existing conditions of LFPS where one unit operates at 30 MW on Lakhra coal and there are practically no controls on emission. Results from this simulation were used to determine the background concentration (due to sources other than the existing and proposed power plants) of pollutants (**Section 8.5.2**).
2. *660 MW Plant Simulation* - This is the predicted impact on ambient quality due to the proposed Project, that is, the incremental concentration of pollutants in the ambient air as a result of emissions from the Proposed Project.
3. *Combined Sources Simulation:* This simulates the future ambient air quality. It includes a) the existing LFPS after rehabilitation of environmental controls and at a full capacity of 150 MW (3 x 50 MW); b), the proposed 660 MW power plant; and c) the background concentration of the pollutants.

The existing plant is equipped with fluidized bed technology to control SOx emissions and filter bags/bag house to control the emissions of particulate matter. However, due to various reasons, currently only one unit is operating at the reduced capacity of 30 MW. Further most of the control measures are not operational. The rehabilitation of the emission control systems will allow the existing plant to operate at its full 150 MW capacity while meeting the SEQS for ambient air quality.

8.5.2 Background Air Quality

Background air quality at the Project location is defined as the air quality that would exist without the LFPS. It includes contributions from road traffic, household combustion of fossil fuel and biomass, and natural sources. The background concentration of common pollutants as determined from the analysis and used in the impact assessment is shown in Table 8-3. This value was used for the entire air shed, although the concentrations are likely to be lower at locations away from the road and settlements.

Table 8-3: Average Background Concentration Used

Pollutant	*Background Concentration (µg/m³)*
SO_2	10.8
NO_2	21.13
PM_{10}	69.1
$PM_{2.5}$	43.1

The details of the calculations of these background concentrations are given below.

SO_2 and NO_2

The background concentrations of SO_2 and NO_2 were calculated by subtracting the increment of pollutants caused by the existing plant from the estimated annual baseline concentrations. The estimated annual baseline concentrations were calculated from the measured value (**Section 5.2.6**). As the measurement was done for 30 days only, a 30% margin was added to cater for the possibility that during the 30-day measurement period the concentrations were on the lower side due to the prevalent atmospheric conditions. Table 8-4 shows the modeling parameters used for the simulation done for determining the contribution of existing plant in the baseline concentration**,** whereas Table 8-4 provides a summary of the calculations undertaken for determining the background concentration of NO_2 and SO_2.

Table 8-4: Air Quality Modeling Parameters Used for the Existing Plant

Parameter	Value
Capacity, MW	30
Stack Height, m	100
Inner Dia, m	4.5
Flue Gas Temperature, K	430
Exit Velocity, m/s	3.5
SO_2, g/s	661
PM_{10}, g/s	445.5
$PM_{2.5}$ g/s	222.2
NO_2, g/s	41.2

Table 8-5: Summary of Estimation of Background Concentration

Sample ID	Pollutant	Measured Monthly Baseline Concentration (µg/m³)	Estimated Annual Baseline Concentration (µg/m³)	Contribution of Existing Plant in the Baseline Concentration (µg/m³)	Estimated Background Concentration (µg/m³)
APSTA02	SO_2	22.6	29.5	7.4	22.1
	NO_2	9.7	12.6	0.5	12.2
APSTA03	SO_2	7.9	10.3	6.2	4.1
	NO_2	12.9	16.8	0.4	16.4
APSTA04	SO_2	13.9	18.1	11.8	6.3
	NO_2	19.8	25.7	0.7	25.0
APSTA05	SO_2	_	_	_	_
	NO_2	24.0	31.2	0.2	31.0
			Average Background Concentration	SO_2	10.8
				NO_2	21.13

PM_{10} and $PM_{2.5}$

The baseline concentration of PM_{10} and $PM_{2.5}$ were determined using the during another EIA study in a similar area were used. The estimated annual average background PM_{10} and $PM_{2.5}$ concentrations in Jamshoro area located about 25 km south of the existing plant and with very similar background conditions is shown in Table 8-6 [1].

Table 8-6: Estimation of Annual Average Background PM_{10} and $PM_{2.5}$ Levels in Jamshoro Area

	Estimated Values for Jamshoro Area	**Duration of Season (months)**
$PM_{2.5}$		
Spring	37.6	2
Summer	47.3	3.5
Monsoon	49.0	2
Post-Monsoon	47.3	1
Winter	37.6	3.5
Weighted Annual Average	**43.1**	**12**
PM_{10}		
Spring	45.0	2

1 EIA of Jamshoro Power Generation Project, Hagler Bailly Pakistan, 2013, Islamabad.

	Estimated Values for Jamshoro Area	Duration of Season (months)
Summer	104.0	3.5
Monsoon	75.3	2
Post-Monsoon	104.0	1
Winter	34.4	3.5
Weighted Annual Average	**69.1**	**12**

8.5.3 Emissions Sources and Modeling Parameters

Table 8-7 shows the modeling parameters used for each source.

Table 8-7: Air Quality Modeling Parameters Used

Parameter	Existing Power Plant (150MW)	Proposed Power Plant (660 MW)
Fuel	Lakhra Coal	Imported coal 80 %, Thar Coal 20 %
Load Factor	80%	80%
Gross Capacity, MW	150	660
Stack Height, m	100	210
Inner Dia, m	4.5	6.4
Flue Gas Temperature, K	430	430
Exit Velocity, m/s	14.1	20
SO_2, g/s	282.7	61
PM_{10}, g/s	17.8	26
$PM_{2.5}$ g/s	8.9	13
NO_2, g/s	164.7	106

8.5.4 Fugitive Emissions

The fugitive dust emissions will be generated from coal storage yards, coal conveyor belt area, ash dumping areas, transportation of fuel, and solid waste. The dust emissions, if any, from the above areas will be fugitive in nature and maximum when the wind velocities are high. The dust emissions are likely to be confined to the place of generation only. Generally large dust particles (greater than about 30 μm), that make up the greatest proportion of dust emitted from construction activities and stockpiles will largely deposit within 100 m of sources. Dust particles in the size range 10 – 30 μm are typically likely to travel 200 m to 500 m. Smaller particles than these are not produced in significant amounts from construction activities. The potential for significant dust nuisance is therefore greatest within 500 m of the source and will be limited to within the plant. The quantification of these fugitive emissions from the area sources is difficult as it depends on a number of factors such as dust particle size, specific gravity of dust particles, wind velocity, moisture content of the material and ambient temperatures etc. Also, there is a high level of variability in these factors. Hence, these are not amenable for mathematical dispersion modeling.

For mitigation of coal ducts from coal stockpile and conveyor belt, much water is needed. Also, a balance between environmental impact due to water use and environmental impact due to coal dust has to be maintained. As mentioned above, since the size of dust particles is not small, they will drop in the nearby coal yard, and not in the residential area. So measures against coal dust diffusion are not critical for maintaining air quality around the plant.

8.5.5 Emission Controls

Emission Controls for the Proposed Plant

Following emission controls will be installed to reduce the emission from the proposed plant:

- High efficiency (> 99.7%) electrostatic precipitators (ESP) will be installed to limit the total PM emissions to 30 mg/Nm^3.
- Flue Gas Desulphurization (FGD) units (efficiency > 80%) using lime slurry will be installed to limit SO_2 emissions on the existing as well as the proposed plant.
- Low NOx burners with overfire air ports will be designed and procured to limit the NOx generation to 261 mg/Nm^3.
- A stack height of 210 m is proposed for wider dispersion of emission and thereby dilution. A higher stack will also effectively disperse the thermal pollution from the stack, which represents about 8 to 10% of the total input of the furnace.

Emission Controls for the Existing Plant with 150 MW Capacity

The expected emission control after the rehabilitation of the control systems of the existing power plant will be:

- 99% control on emission of particulate matter (Typical control efficiency of filter bag house)[1]
- 90% control on emission of SO_2 (Typical control efficiency of dry FGD system)

8.5.6 Model Description

USEPA regulatory model AERMOD, a standard model recommended by USEPA[2], was used to simulate criteria pollutants from major sources in the project area and predict air quality for SO_2, NO_2 and PM_{10} and $PM_{2.5}$.

---

[1] International Finance Corporation. "Environmental, Health, and Safety Guidelines for Air Emissions and Ambient Air " World Bank Group, 2007.

[2] US Environmental Protection Agency, “Support Center for Regulatory Atmospheric Modeling, Recommended Models,” last modified on April 8, 2015, http://www.epa.gov/scram001/dispersion_prefrec.htm.

Model Area

A 10 km by 10 km area with the proposed power plant's stack in the center was selected as the modeling area.

Meteorological Data

A pre-processed hourly meteorological data for the study area for 2009, 2010, and 2011 were purchased and used in the model. A monthly summary of the meteorological data is given in Table 8-5.

Table 8-8: Summary of 2009, 2010 and 2011 Meteorological Data Input to AERMOD

Month	Wind		Temperature (ºC)		Relative Humidity (%)	
	Max. Speed (m/s)	Predominant Direction	Min	Max	Min	Max
Jan	11.0	N	10.0	28.8	15	95
Feb	11.3	N	12.2	34.2	13	91
Mar	15.1	SW	15.9	40.0	7	97
Apr	15.8	SW	20.9	43.6	5	88
May	17.8	SW	25.6	45.0	10	90
Jun	17.2	SW	23.8	45.9	10	93
Jul	18.2	SW	26.3	42.7	25	96
Aug	15.1	SW	24.6	38.4	38	98
Sept	14.4	SW	23.8	36.8	31	99
Oct	12.7	N	19.6	39.6	11	97
Nov	12.0	N	16.0	36.3	17	95
Dec	11.3	N	9.7	29.8	14	89

Sensitive Receptors

Sensitive receptors such as schools and hospitals were incorporated in the model area to assess the impact of air quality on those areas. The list of sensitive receptors, their locations and details are given in Table 8-6. These are also shown in **Figure 8-1** to **Figure 8-3**.

Table 8-9: Details of Sensitive Receptors

Facilities Type and Name	*Settlement in which Facility is located*	*Easting*	*Northing*
Educational Facilities			
Government Primary School	Allah Dino Baricho	68° 17' 26.916" E	25° 43' 37.704" N
Government Primary School	Bhuro Khan Rind	68° 17' 39.084" E	25° 43' 8.508" N
Government Primary School	Dodo Mithano	68° 17' 30.300" E	25° 45' 6.696" N
Government Primary School	Imdad Ali Khoso	68° 17' 36.204" E	25° 42' 16.812" N

Facilities Type and Name	*Settlement in which Facility is located*	*Easting*	*Northing*
Government Primary School Boys	Khanot	68° 17' 33.000" E	25° 44' 49.812" N
Government Primary School Girls	Khanot	68° 17' 37.392" E	25° 44' 42.504" N
Indus Resource Center Elementary School	Khanot	68° 17' 39.588" E	25° 44' 43.512" N
Government High School	Koreja	68° 17' 29.508" E	25° 44' 36.096" N
Government Primary School Boys	Koreja	68° 17' 39.012" E	25° 44' 29.796" N
Government Primary School Girls	Koreja	68° 17' 29.616" E	25° 44' 25.512" N
Government High School	Manzurabad	68° 17' 53.412" E	25° 42' 9.288" N
Government Primary School	Manzurabad	68° 17' 34.584" E	25° 42' 16.992" N
Government Primary School Girls	Manzurabad	68° 17' 50.388" E	25° 41' 54.816" N
Indus Resource Center Elementary School	Manzurabad	68° 17' 52.188" E	25° 42' 3.384" N
Government Primary School	Paryo Khan Dia Dano	68° 17' 47.004" E	25° 44' 1.608" N
Sindh Education Foundation Primary School	Paryo Khan Dia Dano	68° 17' 39.408" E	25° 44' 2.904" N
Government Primary School	Shuja Muhammad Khoso	68° 17' 30.408" E	25° 43' 46.092" N
Elementary School City School	WAPDA Colony	68° 17' 23.892" E	25° 40' 0.084" N
Sindh Education Foundation High School	WAPDA Colony	68° 17' 23.100" E	25° 39' 56.808" N
Government Primary School	Zimi	68° 18' 7.200" E	25° 40' 50.700" N
Government Primary School Boys	Murid Khan Rind	68° 17' 46.392" E	25° 42' 53.388" N
Government Primary School Girls	Murid Khan Rind	68° 17' 44.988" E	25° 42' 56.016" N
Government Primary School Boys	Thehbo	68° 19' 14.700" E	25° 41' 47.004" N
Government Primary School Boys	Faqir Daad Khoso	68° 17' 49.740" E	25° 39' 52.236" N
Health Facilities			
Hospital	Allah Dino Baricho	68° 17' 27.816" E	25° 43' 36.516" N
Basic Health Unit	Khanot	68° 17' 27.384" E	25° 44' 39.696" N
Dispensary	WAPDA Colony	68° 17' 19.284" E	25° 40' 6.312" N
Dispensary	Manzurabad	68° 17' 53.304" E	25° 42' 11.304" N
Dispensary	Zimi	68° 18' 9.216" E	25° 40' 47.604" N

Facilities Type and Name	*Settlement in which Facility is located*	*Easting*	*Northing*
Hospital	Habibullah Mor	68° 17' 35.700" E	25° 43' 34.284" N
Clinic	Habibullah Mor	68° 17' 32.208" E	25° 43' 35.616" N
Religious Places			
Mosque	Manzurabad	68° 17' 54.996" E	25° 42' 2.700" N
Mosque	Manzurabad	68° 17' 55.392" E	25° 41' 57.408" N
Mosque	Zimi	68° 18' 6.588" E	25° 40' 49.512" N
Mosque	Imdad Ali Khoso	68° 17' 35.016" E	25° 42' 17.604" N
Mosque	Imdad Ali Khoso	68° 17' 40.704" E	25° 42' 24.012" N
Mosque	Imdad Ali Khoso	68° 17' 43.116" E	25° 42' 18.000" N
Mosque	Shuja Muhammad Khoso	68° 17' 31.884" E	25° 43' 53.796" N
Mosque	Bhuro Khan Rind	68° 17' 39.192" E	25° 43' 9.804" N
Mosque	Jan Muhammad Khoso	68° 17' 46.392" E	25° 39' 27.288" N
Mosque	Khanot	68° 17' 30.300" E	25° 44' 44.592" N
Mosque	Khanot	68° 17' 30.912" E	25° 44' 50.892" N
Mosque	Dodo Mithano	68° 17' 34.008" E	25° 45' 4.896" N
Mosque	Khanote	68° 17' 35.304" E	25° 44' 40.704" N
Mosque	Paryo Khan Dia Dano	68° 17' 46.896" E	25° 44' 0.312" N
Mosque	Koreja	68° 17' 38.616" E	25° 44' 30.516" N
Mosque	Allah Dino Baricho	68° 17' 25.908" E	25° 43' 35.796" N
Mosque	Murid Khan Rind	68° 17' 46.284" E	25° 42' 46.296" N
Mosque	Mir Dost Khoso	68° 17' 29.004" E	25° 44' 9.096" N
Mosque	Abdul Ghani Bandwani	68° 17' 16.692" E	25° 40' 2.784" N
Eid Gah	Shuja Muhammad Khoso	68° 17' 31.200" E	25° 43' 45.516" N
Eid Gah	Murid Khan Rind	68° 17' 45.492" E	25° 42' 54.504" N
Hindu Temple	Thehbo	68° 19' 17.112" E	25° 41' 46.716" N
Shrine (Budhal Shah)		68° 17' 59.784" E	25° 43' 51.384" N
Shrine (Daad Shaheed)		68° 18' 20.988" E	25° 39' 43.524" N
Eid Gah	Manzurabad	68° 17' 38.616" E	25° 42' 2.880" N

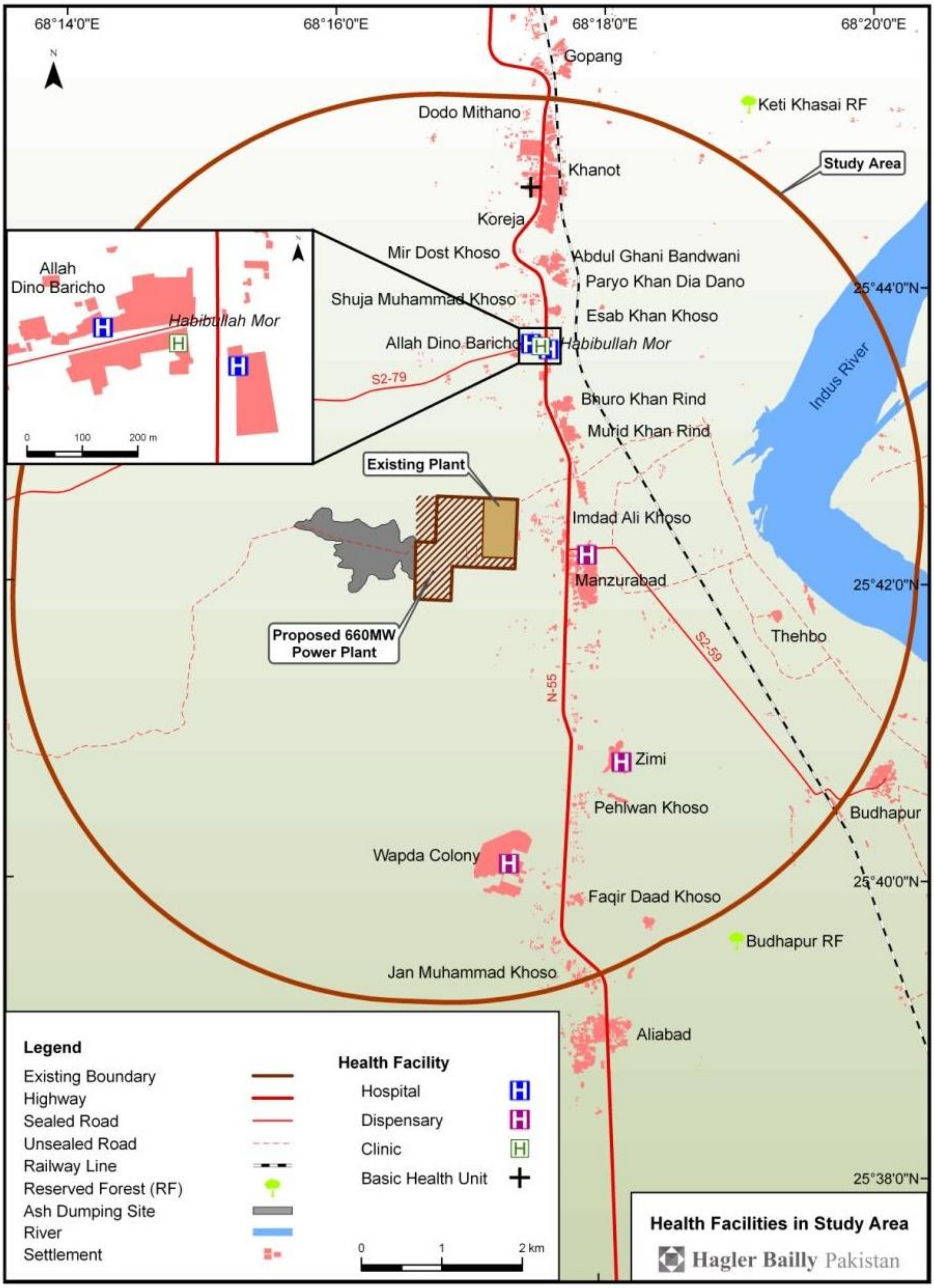


Figure 8-1: Location of Sensitive Receptors – Health Facilities

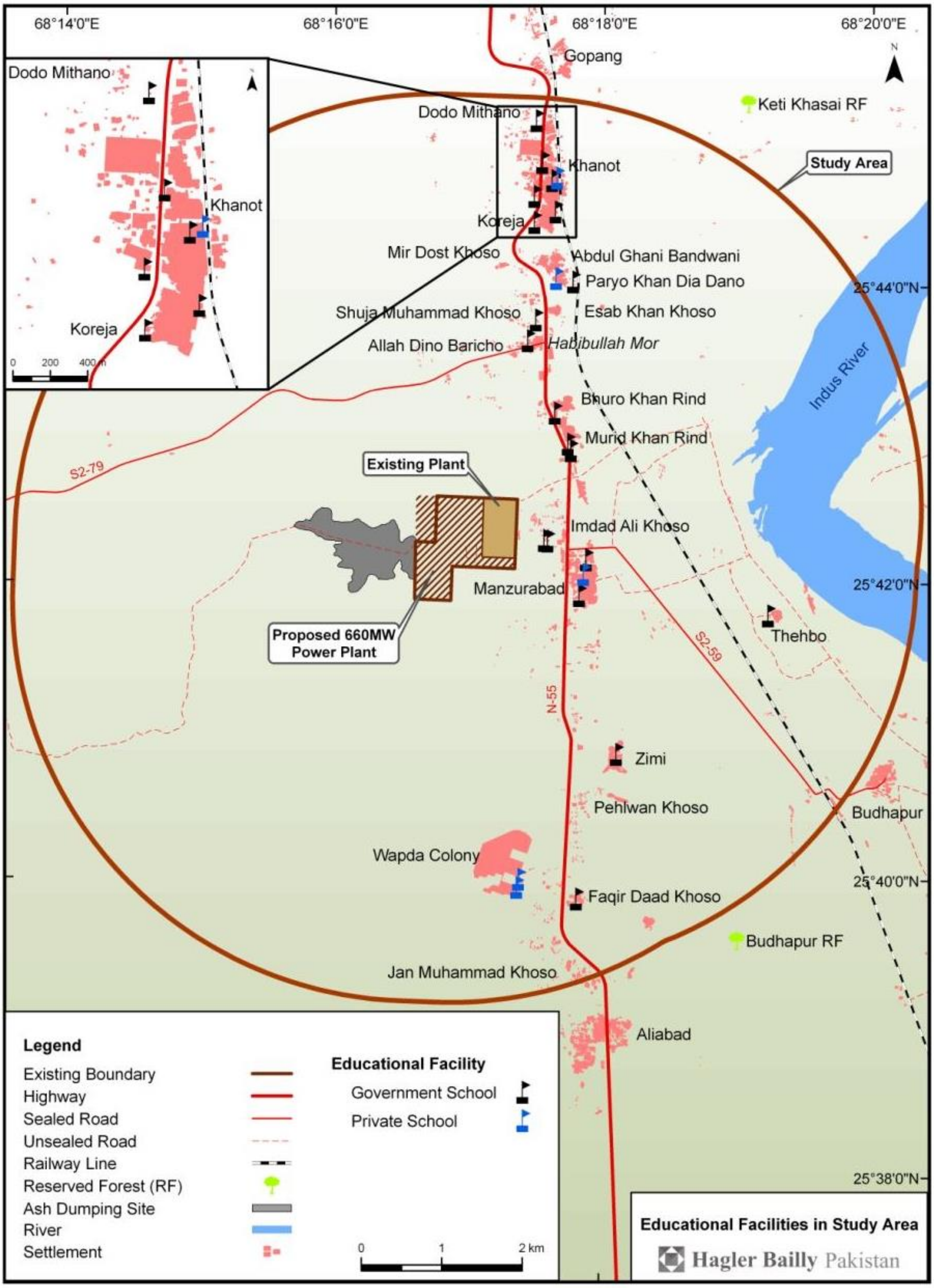


Figure 8-2: Location of Sensitive Receptors – Educational Facilities

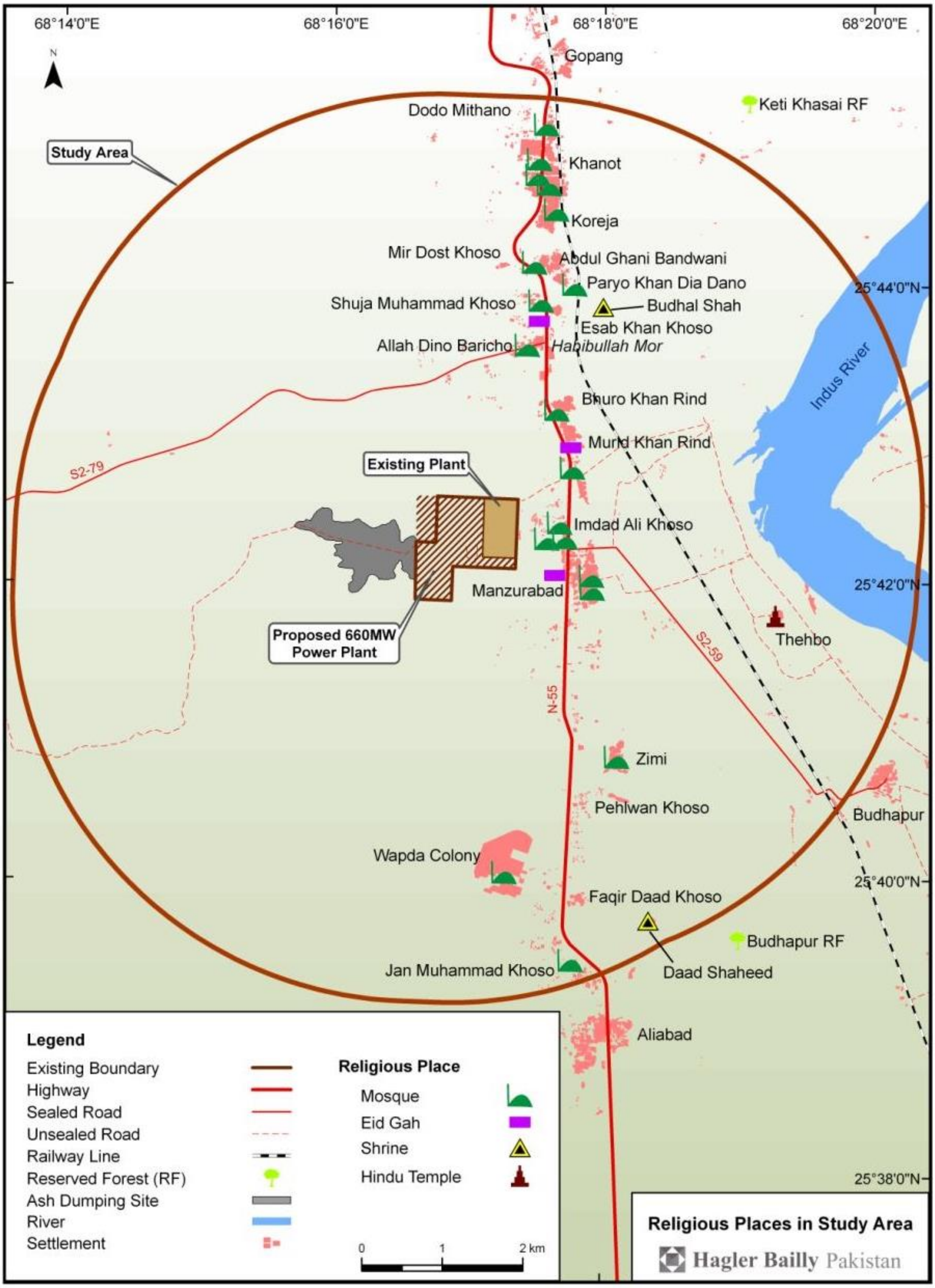


Figure 8-3: Location of Sensitive Receptors – Religious Facilities

8.5.7 Air Quality Modeling Results

Model was run for two scenarios. **Scenario 1** assumes that the power plant will be fired using 80 %Imported coal and 20 % Thar coal. **Scenario 2** assumes that the power plant will use 100% Imported coal.

1. **Table 8-7**: summarizes the air quality modeling results for the simulations. Concentration levels in ambient air were predicted for SO_2, NO_2, PM_{10}, and $PM_{2.5}$ for the simulations, whereas;

Figure 8-4 through **Figure 8-11** show the contour maps for the increment in pollutants concentration caused by the proposed Project for **Scenario 1**. Whereas **Figure 8-12** through **Figure 8-19** show the contour maps for the predicted ambient air quality after the proposed plant is commissioned and LFPS is rehabilitated for **Scenario 1**.

For SO_2, NO_2, PM_{10}, and $PM_{2.5}$ the maximum concentration levels were modeled for 24-hour averaging period and annual averaging period to correspond with the SEQS requirements. The maximum value is the highest concentration reached for a particular averaging period based on 3 years meteorological data. The 98th percentile value shows the highest concentration 98% of the time in a year, which is found by eliminating 2% of the highest values as per the standards.

The contour maps for **Scenario 2** are provided in **Appendix 14**

Table 8-7: Air Quality Modeling Results (μg/m³)

Pollutant	Period	SEQS	IFC Guidelines	Estimated Background	Predicted Increment due to Proposed Plant (660 MW)		Predicted Ambient Air Quality After Proposed Plant Commissioning and LFPS Rehabilitation	
					Scenario 1 80%Imported Coal; 20% Thar Coal	Scenario 2 100%Imported Coal	Scenario 1 80%Imported Coal; 20% Thar Coal	Scenario 2 100%Imported Coal
SO_2	Maximum 24–hr	–	125	10.8	7.7	7.1	120.9	120.5
	24–hr (98th %le)	120	–		7.3	6.7	88.1	87.8
	Annual	80	–		1.9	1.8	38.4	38.2
NO_2	Maximum 24–hr	–	200	21.1	6.2	6.1	86.6	86.5
	24–hr (98th %le)	80	–		5.8	5.8	67.3	67.2
	Annual	40	40		1.5	1.5	37.6	37.4
PM_{10}	Maximum 24–hr	–	150	69.1	1.5	1.5	75.9	75.9
	24–hr (98th %le)	150	–		1.5	1.4	73.8	73.8
	Annual	120	70		0.4	0.4	69.1	69.1
PM2.5	Maximum 24–hr		75	43.1	0.7	0.7	46.5	46.5
	24–hr (98th %le)	75	–		0.7	0.7	45.5	45.5
	Annual	40 or back-ground plus 9	35		0.2	0.2	43.9	43.9

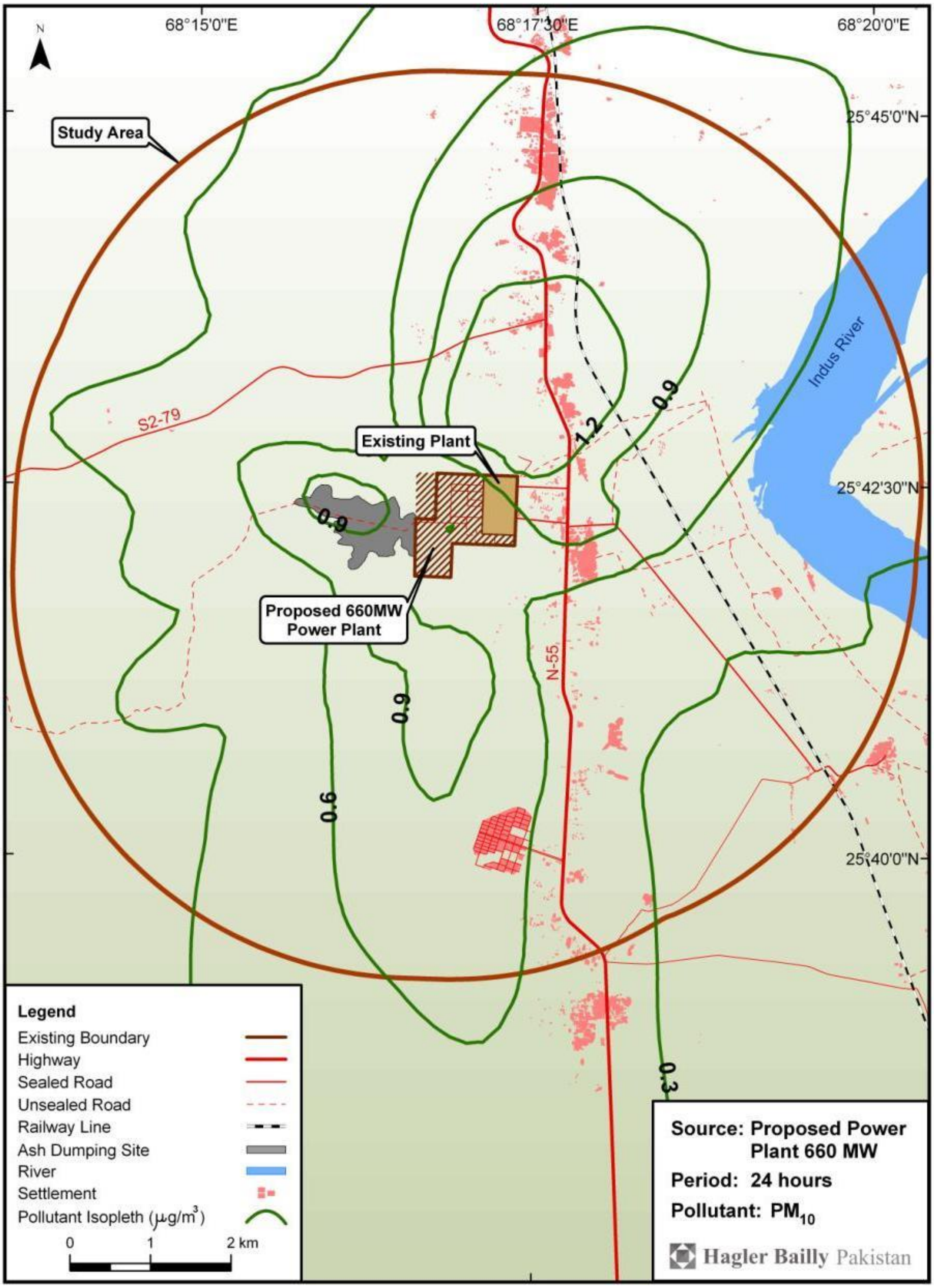


Figure 8-4: Predicted Increment to the 24–hour PM_{10} Levels Caused by the Proposed Plant (Scenario 1)

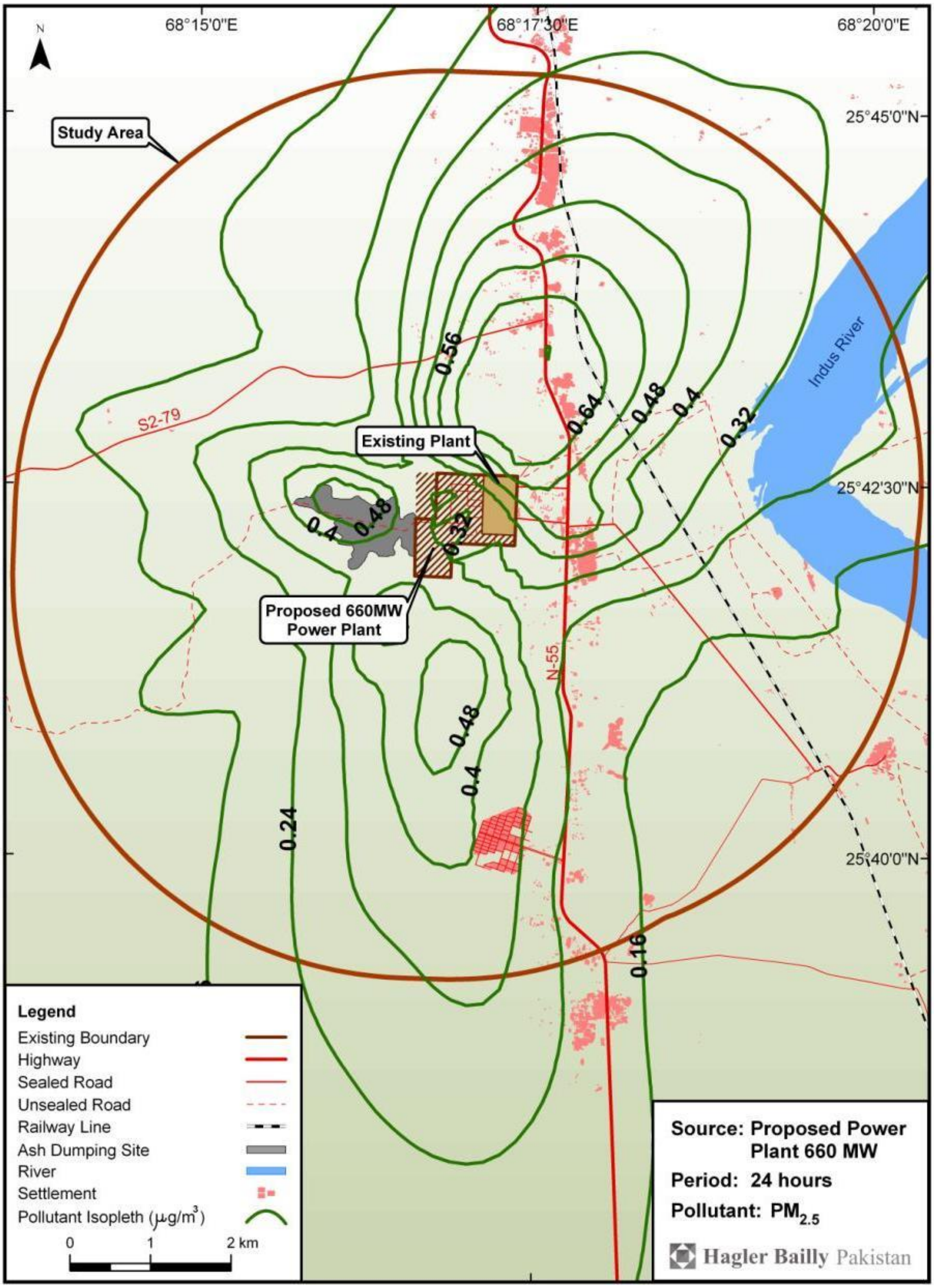


Figure 8-5: Predicted Increment to the 24–hour $PM_{2.5}$ Levels Caused by the Proposed Plant (Scenario 1)

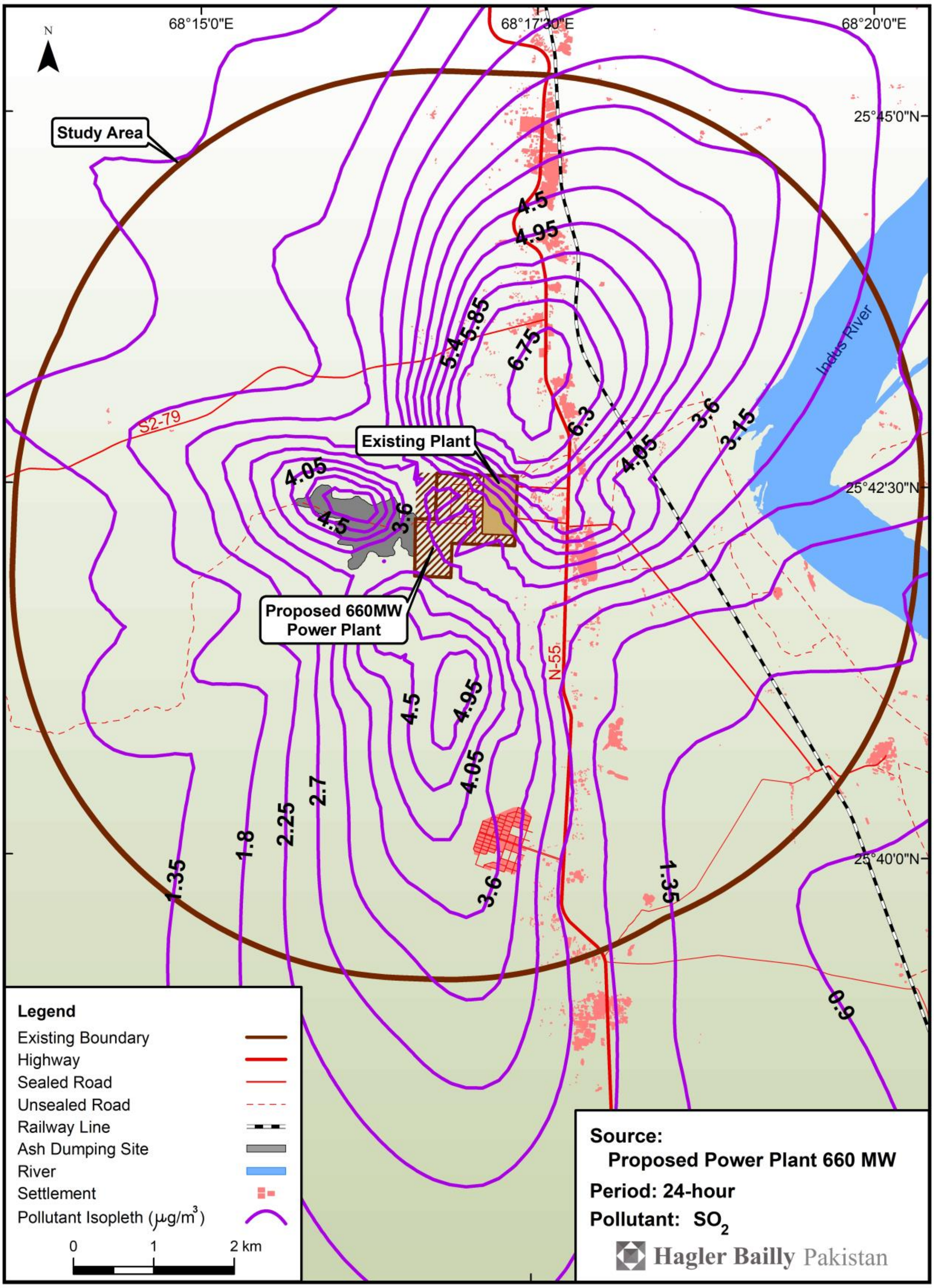


Figure 8-6: Predicted Increment to the 24–hour SO_2 Levels Caused by the Proposed Plant (Scenario 1)

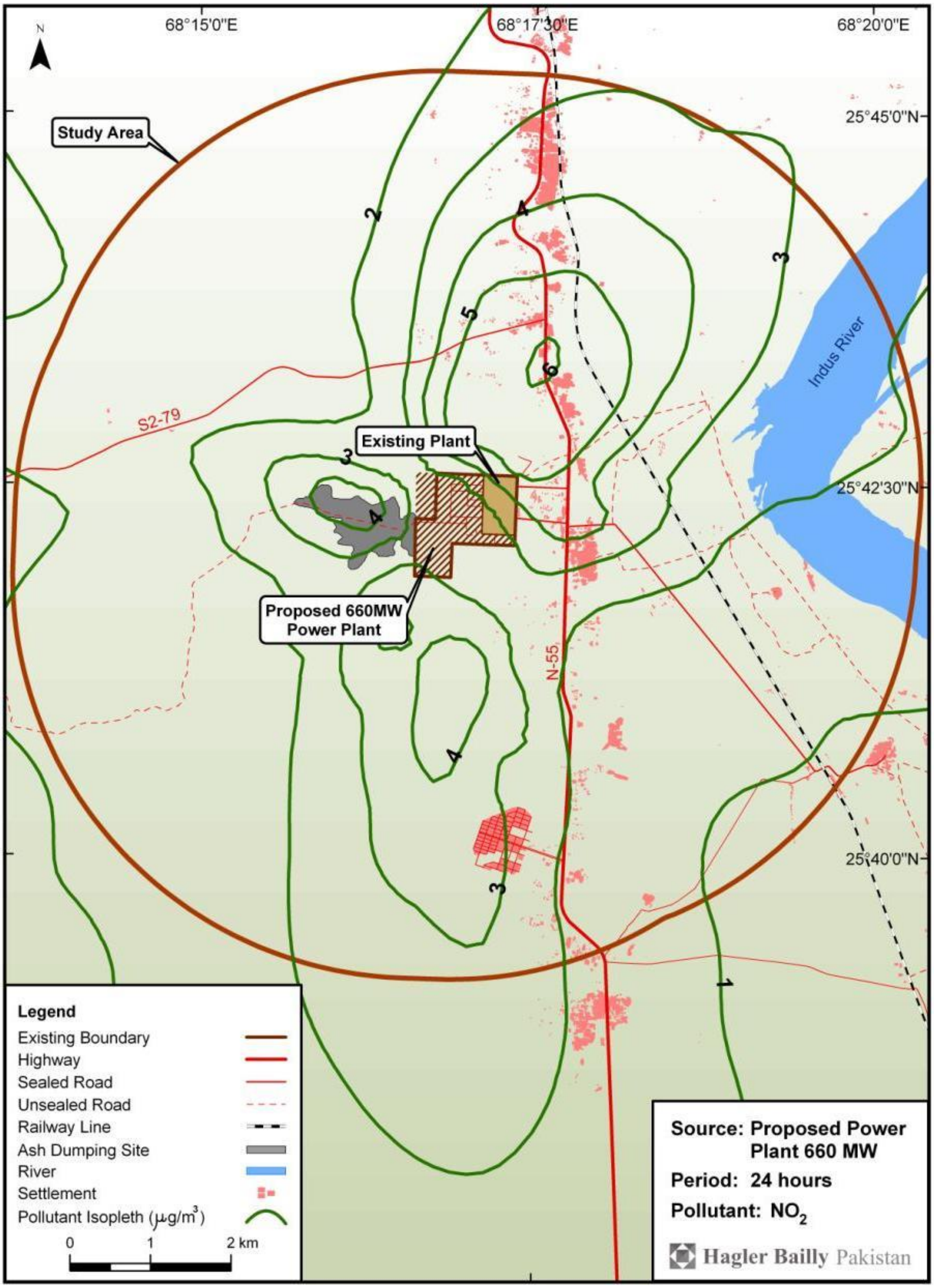


Figure 8-7: Predicted Increment to the 24–hour NO_2 Levels Caused by the Proposed Plant (Scenario 1)

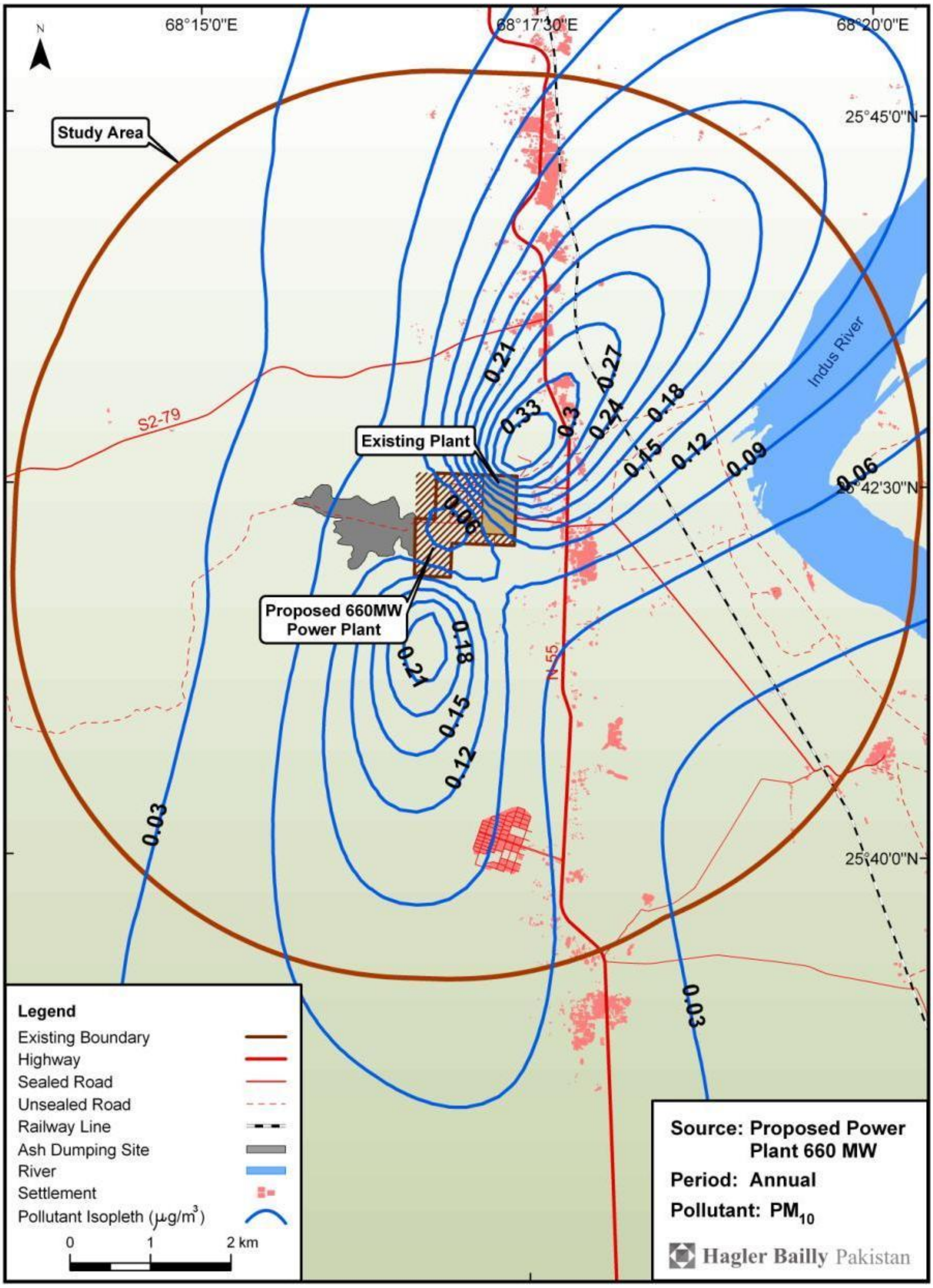


Figure 8-8: Predicted Increment to the Annual PM_{10} Levels Caused by the Proposed Plant (Scenario 1)

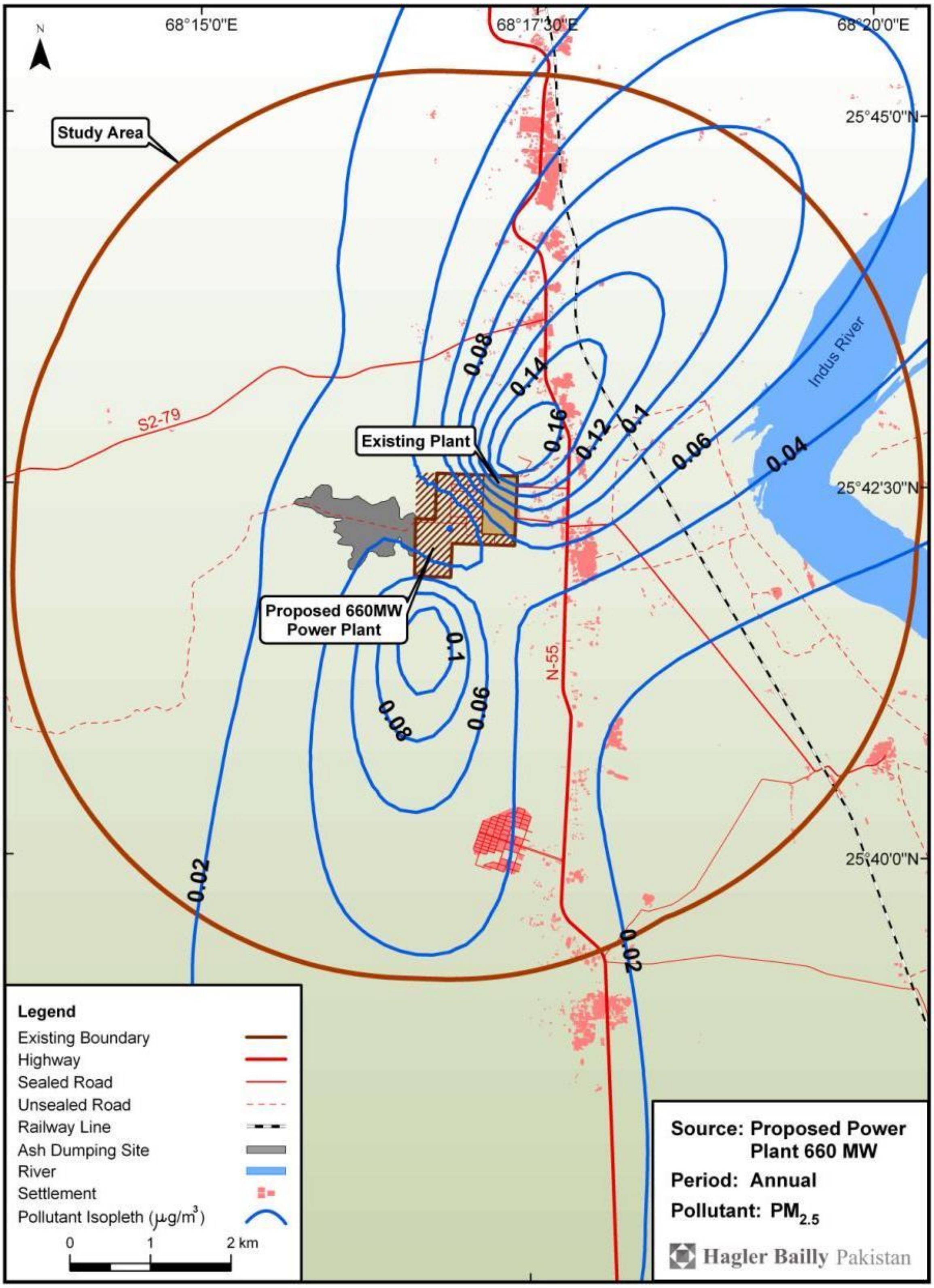


Figure 8-9: Predicted Increment to the Annual $PM_{2.5}$ Levels Caused by the Proposed Plant (Scenario 1)

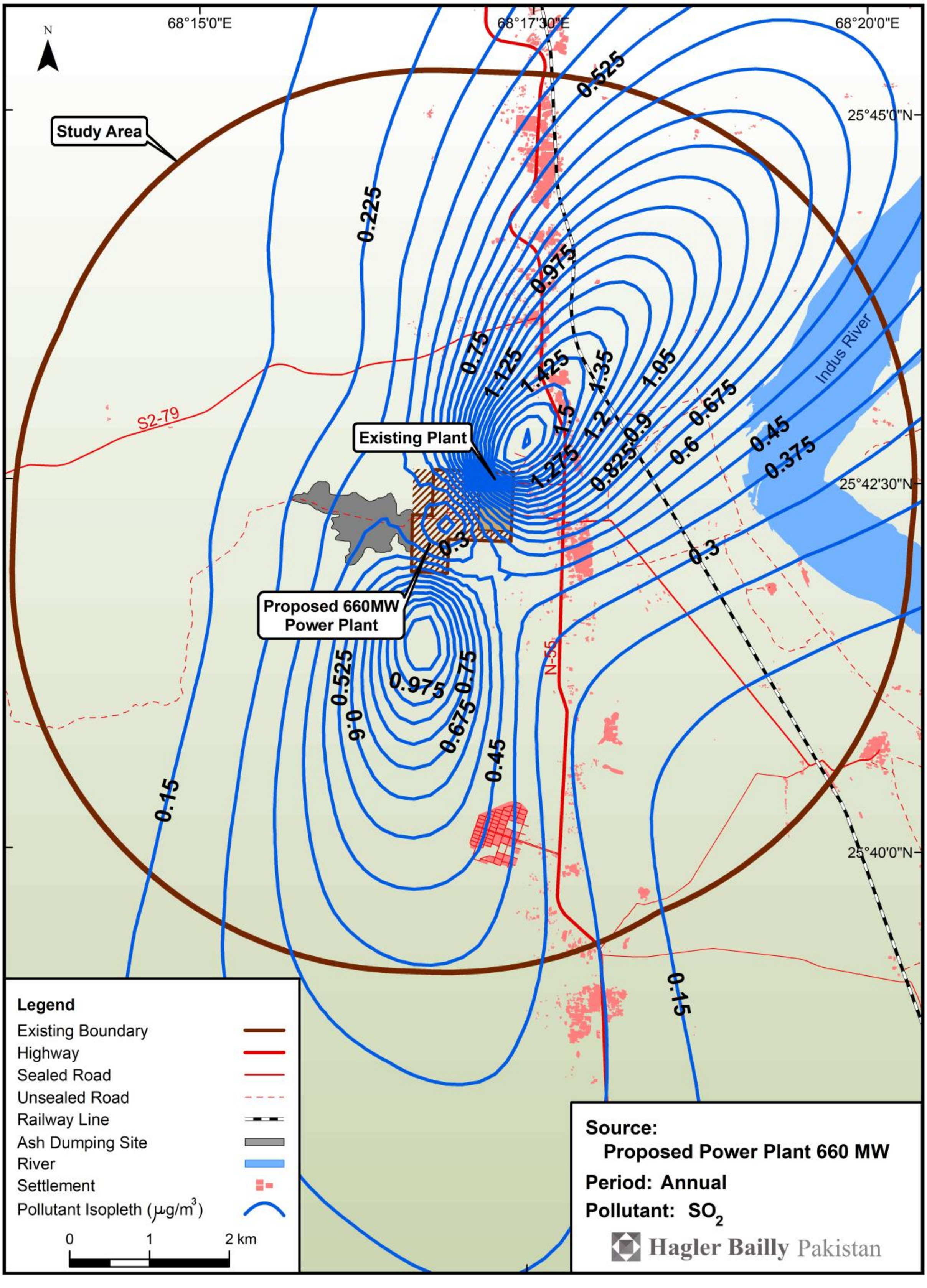


Figure 8-10: Predicted Increment to the Annual SO_2 Levels Caused by the Proposed Plant (Scenario 1)

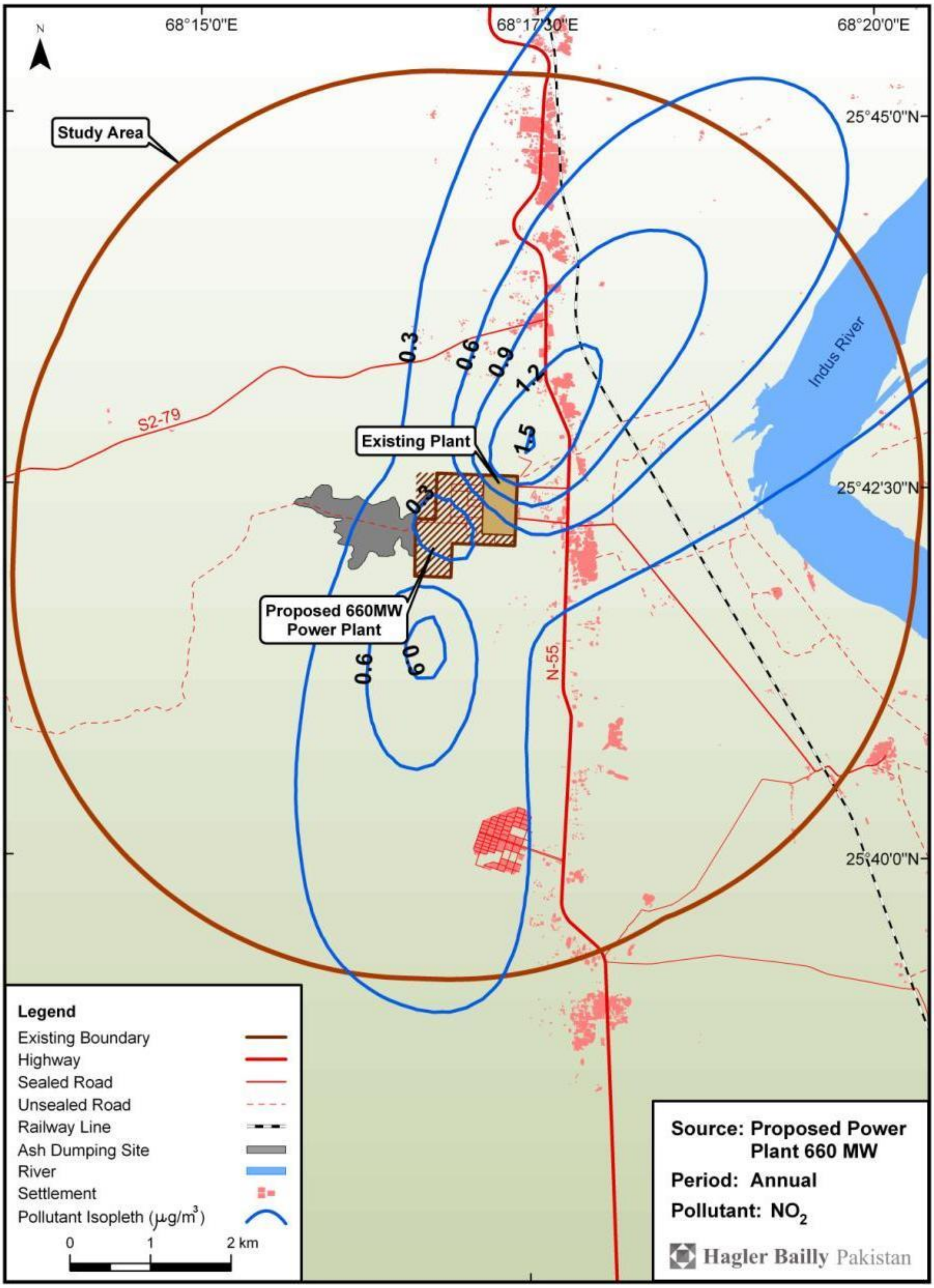


Figure 8-11: Predicted Increment to the Annual NO_2 Levels Caused by the Proposed Plant (Scenario 1)

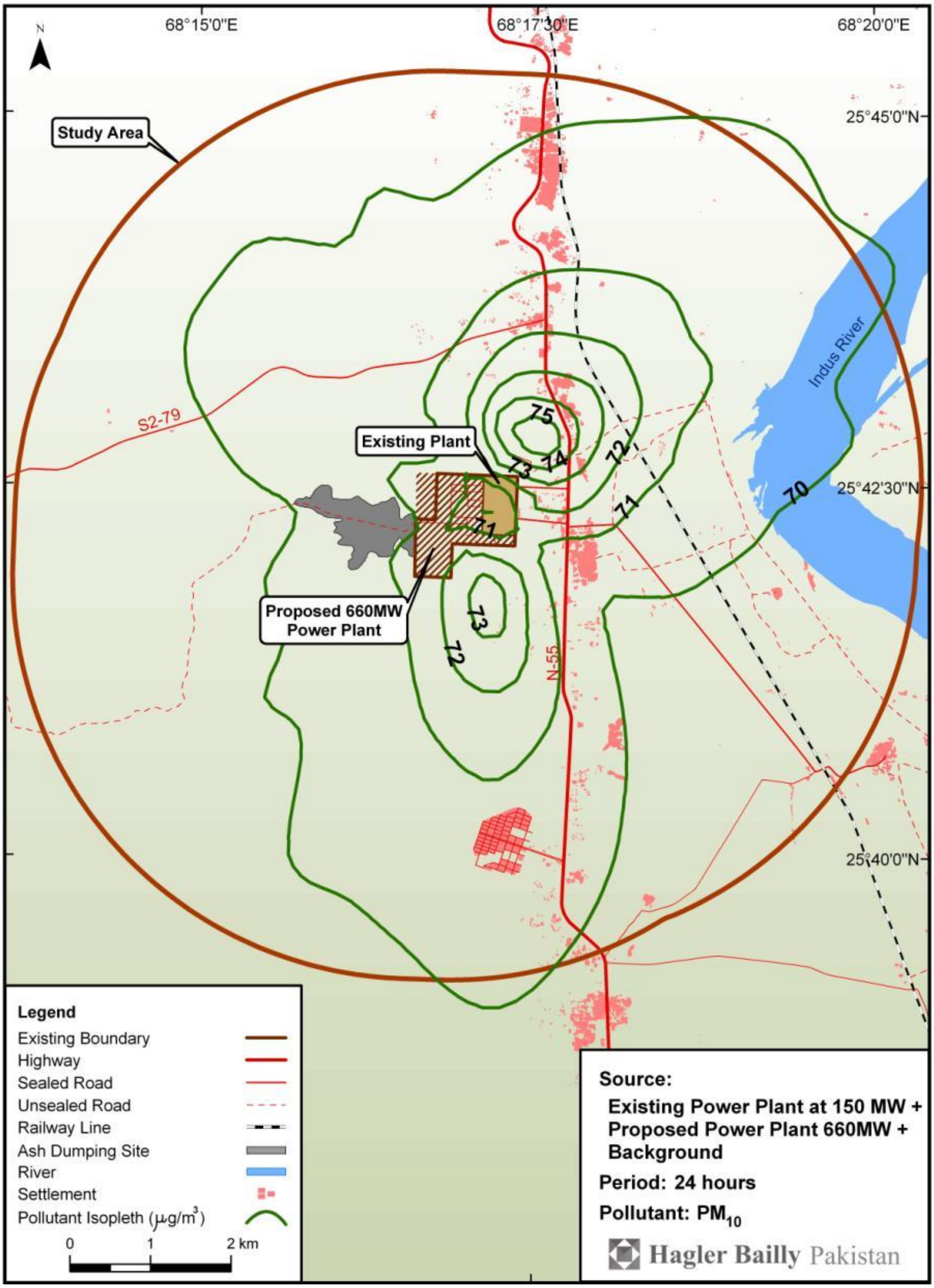


Figure 8-12: Combined 24–hour PM_{10} Levels (Scenario 1)

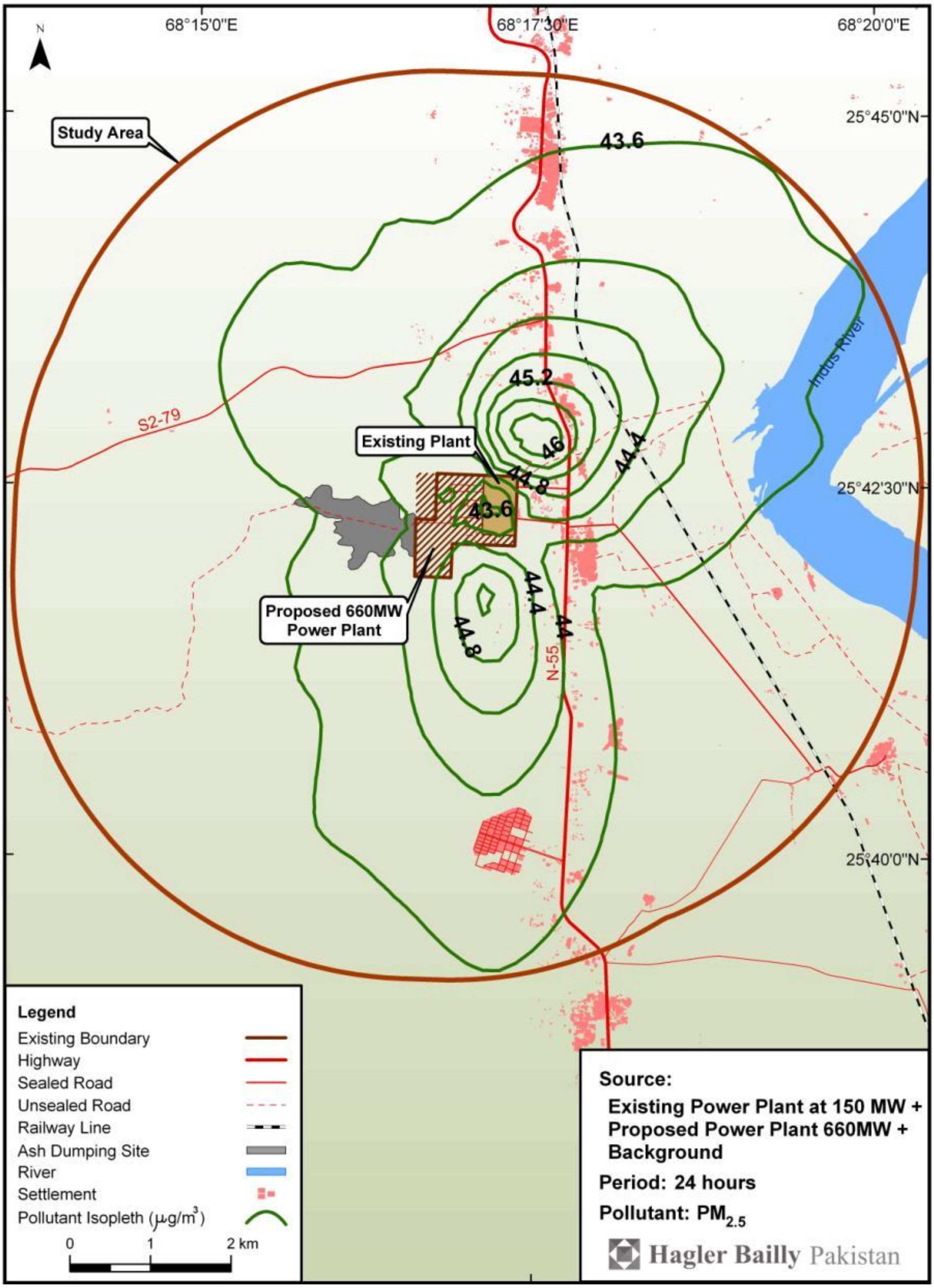


Figure 8-13: Combined 24–hour $PM_{2.5}$ Levels (Scenario 1)

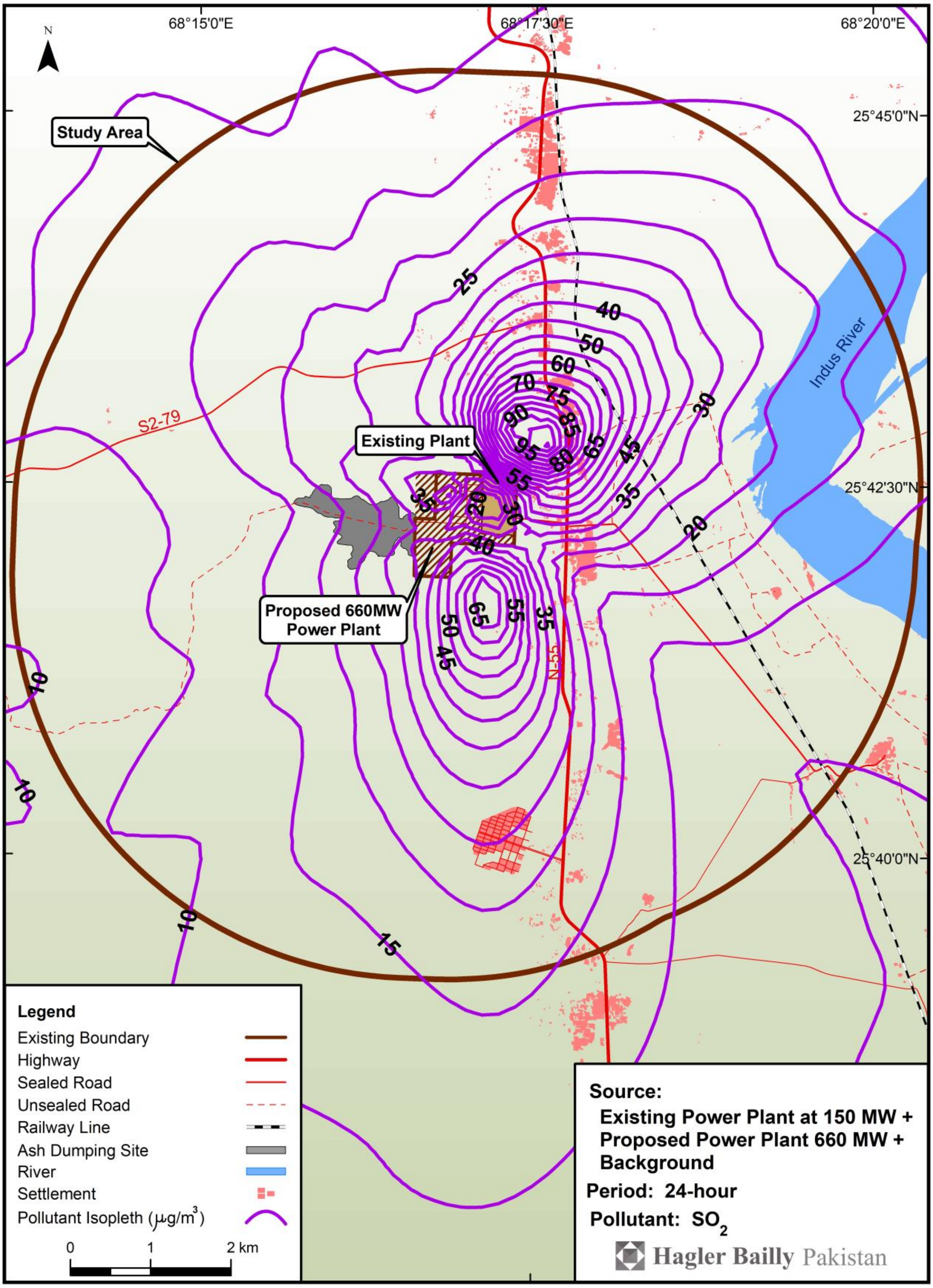


Figure 8-14: Combined 24–hour SO_2 Levels (Scenario 1)

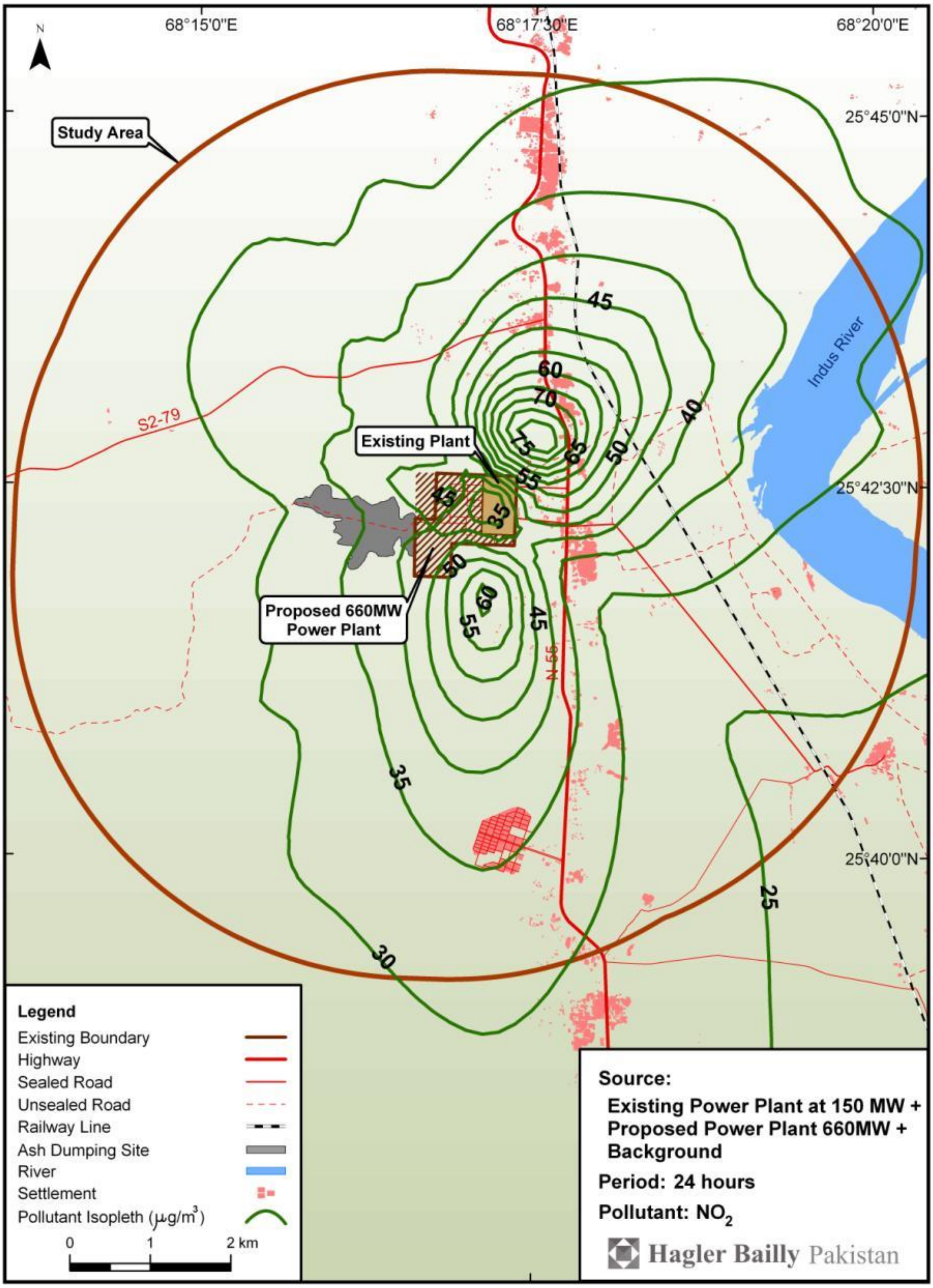


Figure 8-15: Combined 24–hour NO_2 Levels (Scenario 1)

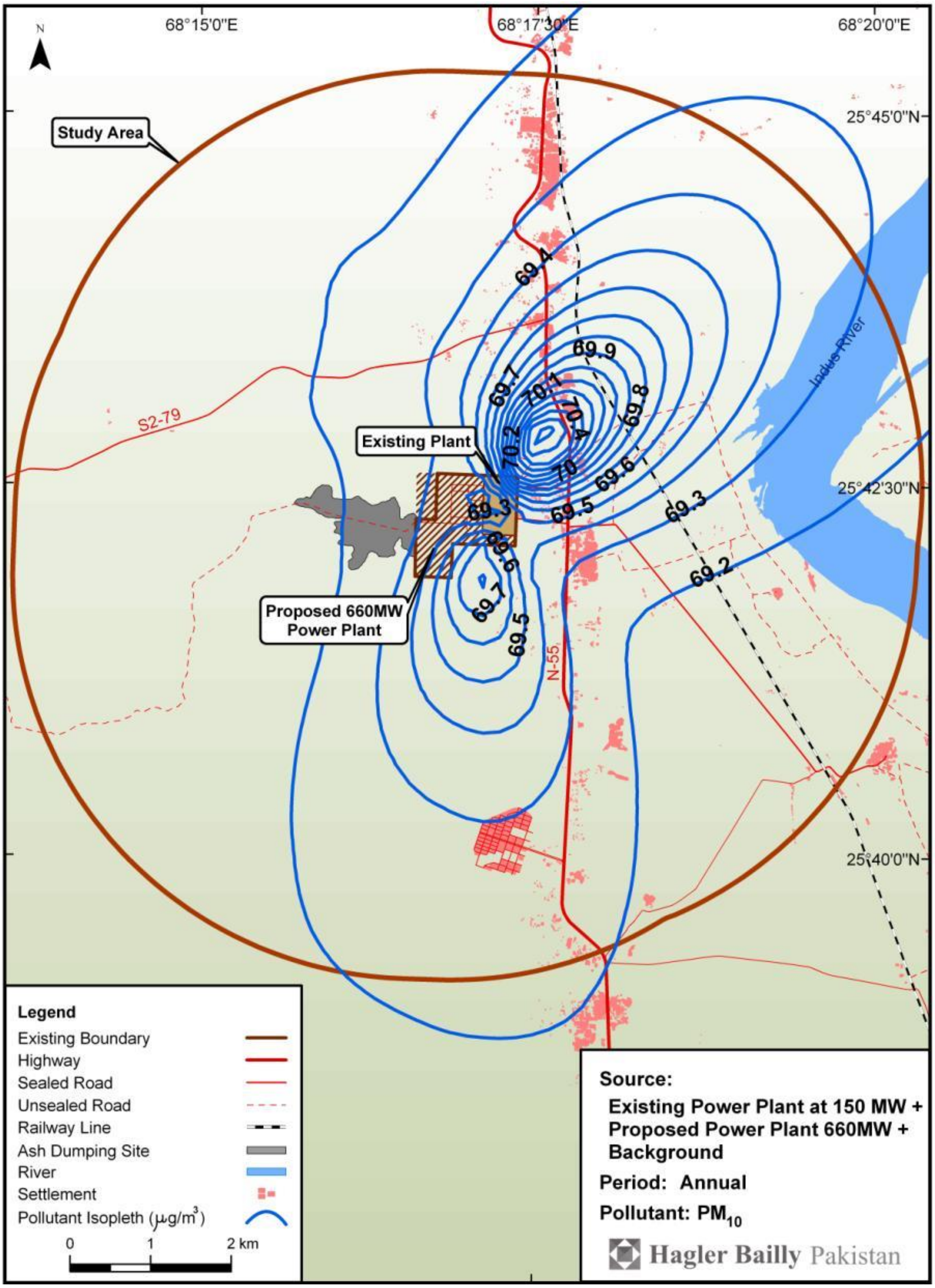


Figure 8-16: Combined Annual PM_{10} Levels (Scenario 1)

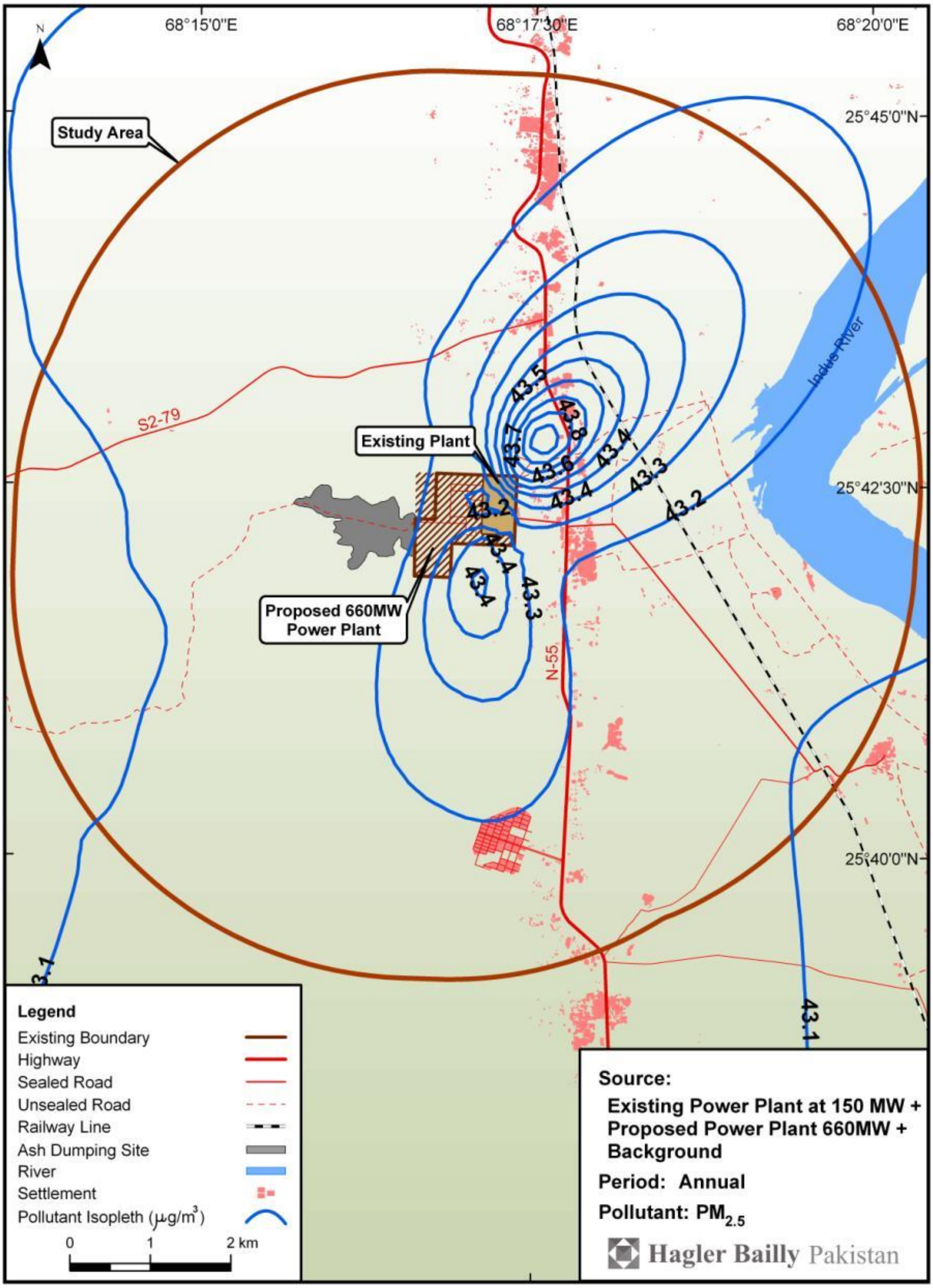


Figure 8-17: Combined Annual $PM_{2.5}$ Levels (Scenario 1)

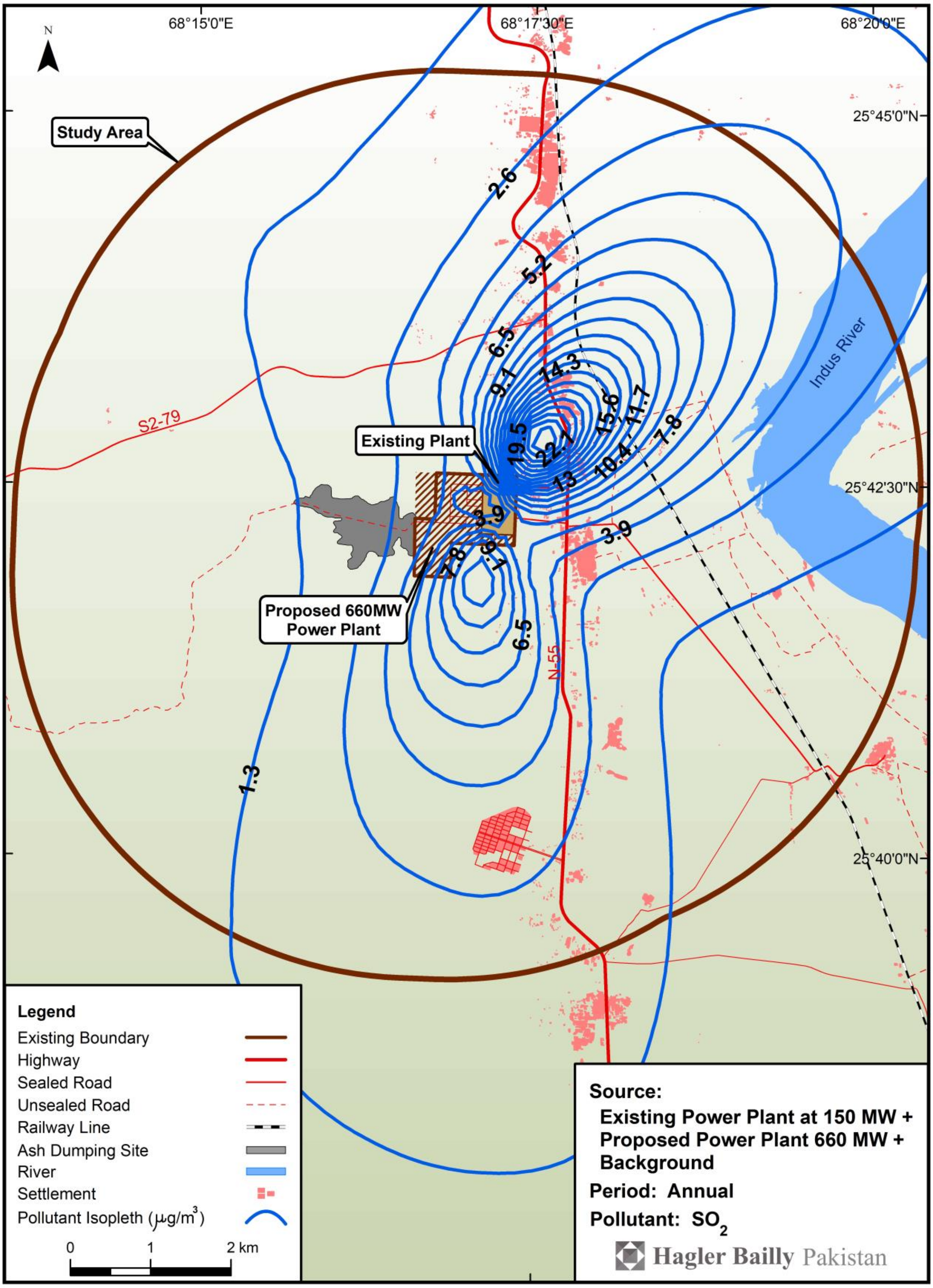


Figure 8-18: Combined Annual SO_2 Levels (Scenario 1)

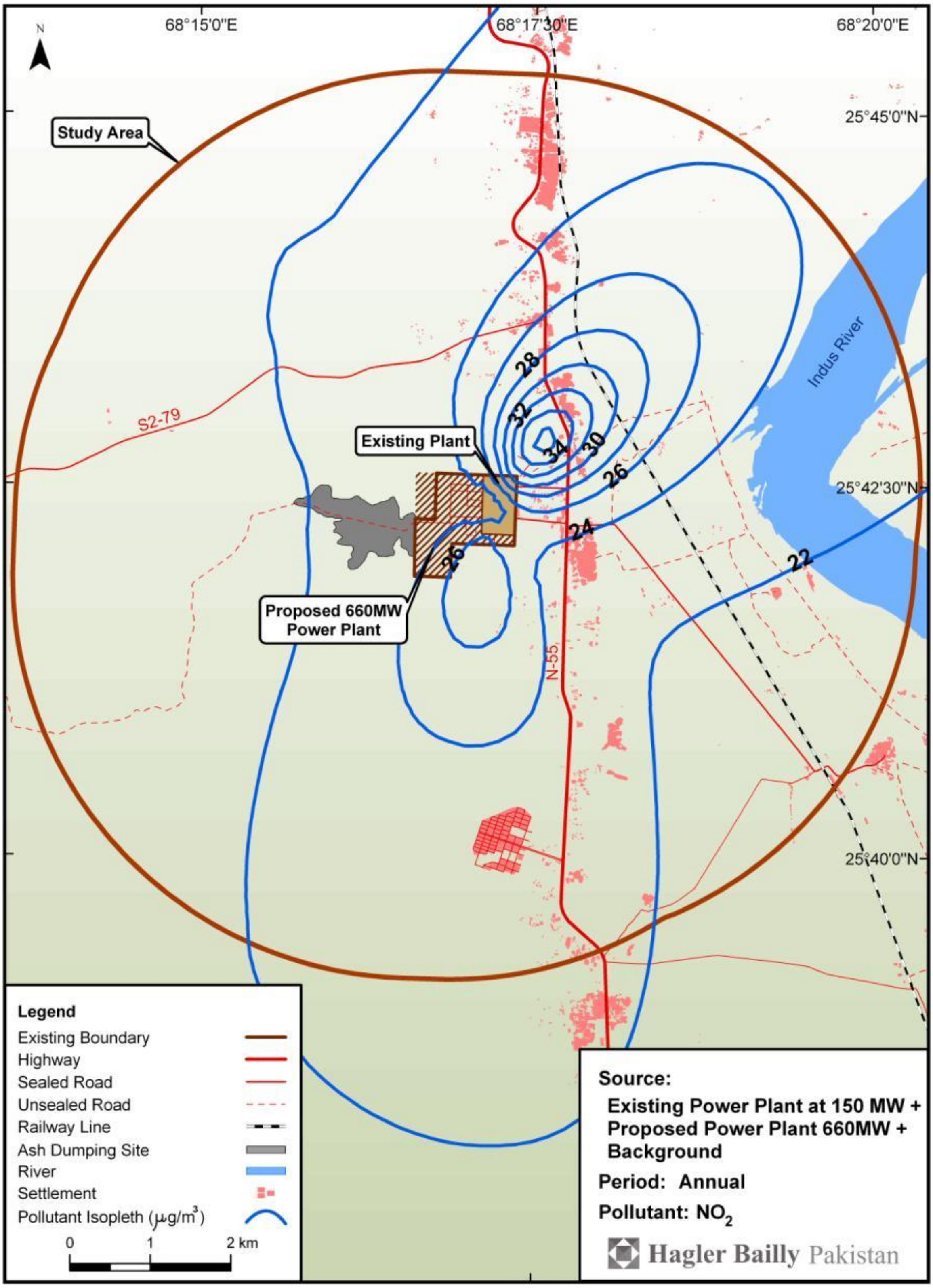


Figure 8-19: Combined Annual NO_2 Levels (Scenario 1)

8.5.8 Compliance with Guidelines and Standards

Ambient Air Quality

The compliance status of the 660 MW power plant against the applicable standards and guidelines is summarized in **Table 8-7**:**.** The results show that the predicted increment caused by the proposed Project is very small in comparison to the background and baseline levels. However, the existing plant with inadequate control measures is causing substantial amount of pollutants to the ambient air causing the pollutant concentration levels to exceed both the SEQS as well as the IFC guideline limits. If the existing plant is allowed to run in its present condition, the concentration SO_2, PM_{10} and $PM_{2.5}$ in the ambient air may exceed the limits prescribed by SEQS as well as IFC guidelines. For the existing plant to comply with the SEQS, it will be necessary to rehabilitate the existing pollutant control system.

With rehabilitated control measures on the existing plant, the proposed 660 MW plant meets all the limits prescribed by SEQS as well as IFC guidelines. The annual average limit for $PM_{2.5}$ is 40 $\mu g/m^3$ or 'background plus 9 $\mu g/m^3$'. The increment from the 660 MW plant, however, is very small, 0.2 $\mu g/m^3$ in comparison to the background concentration of 43.1 $\mu g/m^3$ on annual average basis.

Degraded vs Non-degraded Airshed

In general, IFC emission guidelines are different for degraded and non-degraded air sheds. The degraded air shed is defined by IFC as: *Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly*.[1]

As Pakistan has established national ambient air quality standards which, although not identical to those of the WHO, are comparable and even more stringent in certain cases, the decision of degraded or non-degraded airshed shall be based solely on the national criteria. For this purpose, a baseline monitoring was undertaken which is discussed in **Section 5.2.6**. As this was a limited monitoring, it is not considered sufficient to establish the year-round average concentration to categorize the airshed. However, based on the results shown in **Table 8-7**:, it is argued that the airshed after the rehabilitation of the existing plant shall be considered as non-degraded as all ambient air quality standards (with the possible exception of $PM_{2.5}$) will be met.

IFC recommends that facilities in degraded airsheds should minimize incremental impacts by meeting IFC guidelines. Further, it suggest that "facilities or projects located within poor quality airsheds should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards …"

---

1 This definition is provided in several places in the IFC's EHS Guidelines. For example, Tables 6(A), 6(B), 6(C) of the Thermal Power Plant Guidelines.

The airshed of the LFPS will be classified as degraded under the present conditions as it does not meet national ambient air quality standards with respect to SO_2. The rehabilitation of emission controls on the existing stacks will result in reducing the emission of SO_2, PM_{10}, and $PM_{2.5}$. This will result in cleaning the air to the extent that the concentration of SO_2 and PM_{10} will be well within the ambient air quality standards, and that of $PM_{2.5}$ will be substantially reduced. This would result in re-classifying the airshed as non-degraded.

8.6 Greenhouse Gas Emissions

The estimated greenhouse gas emission from the power plant is provided in Table 8-11. Carbon dioxide (CO_2) emission (PE_y) during power plant operation was calculated by the following formula.

$$PE_y = FC_{i,y} \times ,yF_i \times ,y_{fuel,i}$$

PE_y : Annual emissions during operation (t-CO_2/year)

$FC_{i,y}$: Annual consumption amount of fossil fuel i (t/year)

NCV_i : Calorific value of fossil fuel i (GJ/t)

$EF_{fuel,i}$: Emission factor of fossil fuel i (t-CO_2/GJ)

Calculation results of CO_2 emissions in case of single burning with imported coal and mix burning with 80% imported coal and 20% Thar coal is shown in Table 8-11. Those results show that CO_2 emissions from mix burning would be increased by 3.1% compared with single burning.

Table 8-11: Carbon Dioxide Emission Estimates

	Parameter	FCi,y 1)	$NCVi$ 2)	$EFfuel,i$ 2)	PEy
Burning Type	Type of coal	ton/year	GJ/ton	t-CO_2/GJ	t-CO_2/year
Single Burning	Imported coal (Sub-bituminous)	1,494,360	18.9	0.0961	**2,714,191**
Mix Burning	Thar coal (Lignite)	296,877	11.9	0.1010	356,816
	Imported coal (Sub-bituminous)	1,344,924	18.9	0.0961	2,442,772
	Total	1,641,801			**2,799,588**

1) Equivelant quantity with 600MW (net)

2) 2006 IPCC Guidelines for National Greenhouse Gas Inventries

The IFC Performance Standard[1] for GHG emission requires the project proponents to consider available options for reduction of the GHG emissions. In the case of this Project, options for offset that can be considered include tree plantations, carbon capture system (CCS), and recycling of fly ash. Experience of application of carbon capture technologies is lacking in Pakistan, and application of available technologies for carbon capture in the present environment are likely to adversely affect the project economics in view of cost of application.

[1] IFC Performance Standard 3, Resource Efficiency and Pollution Prevention (July 1, 2012)

Recycling of fly ash which is presently being practiced in India and elsewhere in the world was investigated further as an offset option. As discussed in Chapter 9, fly ash can be used as a cement replacement. There are cement manufacturers that indicate interests in pursuing this option in Sindh province. Recycling of fly ash results in reduction of GHG emissions associated with production of a corresponding quantity of cement. USEPA estimates the emissions reduction factor in terms of tons of carbon equivalent per ton of fly ash recycled (TCE/Ton of ash) at 0.24.[1] On this basis, potential for offset of GHG emissions assuming recycling of 75% of fly ash produced by the Project is estimated at 29,552 TCE.[2]

Offset potential of tree plantations will be limited in view of limited availability of land and water in the LFPS area. However, the project will consider this option. A comprehensive study to assess the potential of tree plantation to offset the GHG emission will be undertaken.

8.7 Traffic Impact

Aspects resulting from transportation of construction equipment and plant machinery to the Project site are:

- Incremental increase in the existing traffic on the road will affect the daily commuters
- Traffic interference, may cause nuisance and safety hazards
- Emission and noise level will affect the air quality and cause nuisance to communities living alongside the route selected for transportation
- Degradation of the existing roads

Currently Lakhra coal is transported from Lakhra coalfield to LFPS using N-55. As the route where trucks transports Lakhra coal and one where trucks would transport Thar coal are not duplicated, when it comes to traffic baseline, the number of trucks transporting Lakhra coal is not considered.

In Table 8-8, the existing traffic and the projected traffic on N-55 is presented.

Table 8-12: Daily Road Traffic

Current Traffic (2013)	
Light vehicles	7594
Heavy vehicles	1804
Total	**9,398**
Projected traffic (2015)[3]	

1 ‘Background Document for Life-Cycle Greenhouse Gas Emission Factors for Fly Ash Used as a Cement Replacement in Concrete’, Reference Document EPA530-R-03-016, November 7, 2003. http://www.epa.gov/climatechange/wycd/waste/downloads/FlyAsh_11_07.pdf

2 Corresponding to fly ash production of 200,843 t/year. (10% of coal is assumed to be fly ash.)

3 Pakistan Economic Survey, 2008-2009, a 7.7% annual growth applied based on last 10 years average growth of Pakistan countrywide traffic from 1992-2009

Light vehicles	8,809
Heavy vehicles	2,093
Total	10,901

Thar coal will be transported by trucks. GHCL will work with the Sindh Coal Authority (SCA) to undertake appropriate actions such as rehabilitation, bypass constructions, etc. to enable the heavy trucks to move smoothly taking into account environmental and social aspects. Traffic impact on N-55 associated with transportation of local lignite/Thar coal will be minor as the blending quantity will be limited to 20% and the incremental traffic volume will be one fifth of the levels indicated in Table 8-9.

During construction, additional road traffic carrying equipment will be generated. These shall not be more than 10 trucks daily during peak construction period.

8.8 Ash Disposal and Handling

The annual ash produced from the Project will be in excess of approximately 223,000 tons. Options for disposal of fly ash and prospects for sale to the cement industry are discussed in **Chapter 4.** In case no fly ash is recycled in the cement and construction industry, the land requirement for the ash disposal for five years is about 72.77 acres. The bund will be constructed around the ash pond to avoid ash dust diffusion by the wind. The following practices will be followed for the construction and operation of the ash pond.

- The area will be demarcated
- The area will be properly lined
- Quantity and quality of ash will be monitored regularly
- Off-site disposal i.e., selling to cement and construction industry will be considered
- The dry and wet ash will be handled separately
- Bottom-liner will be laid and monitoring wells will be installed to assess any contamination to the groundwater
- Fugitive emissions will be controlled by sprinkling

8.9 Coal Handling

The predominant discharge from the proposed coal yard will be particulate matter. Small quantities of engine exhaust emissions will be generated from the mobile equipment used on the site. The emissions from the engines are considered to be relatively minor and are expected to be well dispersed prior to reaching sensitive receptors. The dust that will be discharged from the coal stockpile in the coal yard will be comprised of a wide variety of size fractions. The larger deposited dust is material generally greater than 50μm in diameter. It poses a nuisance potential due to soiling of surfaces and can cause irritation to eyes and nose. Because it is relatively large in size, deposited particulate usually falls out of the air within a short distance of the source and usually within 100m. There are no sensitive receptors within a 100 m radius of the Plant Site.

The finer materials commonly referred to as Total Suspended Particulate or TSP, and generally less than 20 μm, can travel large distances downwind. While these pose the greatest potential health effect, the major source of the finer particulates in the atmosphere is combustion processes which have been discussed in the air quality section. The particulate generated from processes such as those involved in a coal yard are likely to be predominantly made up of larger size fractions (greater than 10μm).

The major factors that influence dust emissions from surfaces are:[1]

- Wind speed across the surface – the critical wind speed for pickup of dust from surfaces is 5 m/s; above 10 m/s pickup increases rapidly.
- The percentage of fine particles in the material on the surface.
- Moisture content of the material on the surface.
- The area of exposed surface.
- Disturbances such as traffic, excavation, loading and unloading of materials.
- The height of the source above the surrounding ground level.

Dust emissions from material handling and storage can be significant if not controlled. However, if standard dust control techniques are used the emissions can be reduced significantly. The smaller the particle size of the material on the surface of a road or an exposed surface, the more easily the particles are able to be picked up and entrained in the wind. Moisture binds particles together preventing them from being disturbed by wind or vehicle movements. Each coal type and grade has a unique moisture content above which dust emissions are substantially reduced. It will be ensured that the moisture content of the coal is maintained as required throughout the coal handling process from the point it arrives at the ports, to its injection into the boilers, to minimize dust emissions.

Coal–handling operations are recommended to consider dust–suppression systems such as spraying water on the coal at the ports and/or prior to unloading at plant–site and being exposed to the sun and wind in order to cater for some evaporation and seepage.

Sources of Particulates and Proposed Mitigation Methods

The activities that will take place at project's coal storage yard, that may generate discharge to air are:

- Construction

---

[1] Beca Pty Ltd (Beca). (2010). L&M Coal Ltd Assessment of Environmental Effects of Discharges to Air from Proposed Coal Stockpiles. Greymouth, New Zealand: West Coast Regional Council.

- Vehicle movements on unpaved surfaces
- Wind generated dust from dry exposed surfaces such as stockpiles and yard areas.
- Loading and unloading of materials
- Stockpiling.

The methods proposed to mitigate the potential sources of particulate emissions are summarized below:

Construction

During the excavation of the site designated for the coal yard, stripping of soil from the surface and the formation of bunds and roads have the potential to generate significant quantities of dust if the processes are not carefully controlled. To control dust from these activities during the preparation of the coal yard following mitigation methods will be used:

- Keep exposed surface areas to a minimum and vegetate exposed areas as soon as practical.
- Restrict potentially dusty activities such as the stripping and spreading of topsoil on days when conditions are dry and winds are strong and blowing towards sensitive receptors.
- However, since the climate and weather conditions in the Project site will be dry and windy on most days, dust from the construction of the coal yard has the potential to generate a lot of dust, therefore, availability of large quantities of water will be ensured. This water will be used as a dust suppressant to keep unvegetated surfaces and roads damp.

Yard Areas and Roads

Vehicle traffic on access roads and vehicle traffic around the stockpile all have the potential to be significant sources of dust. Dust from yard areas and roads will be controlled primarily by limiting the amount of fine particles exposed to the wind and, keeping surfaces damp.

On areas of the yard and roads that are crossed by vehicles any coal deposited onto the surface can be ground into small particles which are particularly susceptible to pick up by the wind. This dust will be controlled by removing the buildup of fine material on a regular basis and replacing the surface of the area with coarser grade material.

Yard areas disturbed, and roads used frequently will be watered regularly. It is also recommended that control shall be applied on vehicle speeds in the vicinity of the coal stockpile. Limiting the speed of vehicles reduces the turbulent wake behind moving vehicles and reduces the amount of material picked up and entrained by the wind.

The coal stockpile area will be designed to minimize haul distances between the stockpile and the boiler loading area and the number of vehicle movements. Bunds will be built strategically to shelter the yard area from the wind, providing a significant barrier to dust being carried beyond the boundary wall of the Project site.

In summary the following dust mitigation methods will be adopted:

- Coal stockpile to be inside bund area,
- Vehicle speeds to be controlled in the vicinity of the stockpile,
- Road and yard surfaces to be cleaned or kept damp when required,
- Internal haul roads and yard areas to be maintained by removal of fine material and the laying of fresh gravel.
- Travel distances be minimized to load coal onto the stockpiles and by locating the stockpile in close proximity to the boilers.

Loading and Unloading of Materials

Coal falling onto a stockpile and at conveyor transfer points is a potential source of dust as the wind picks up fine dry particles of coal from the surface of the conveyors. Coal falling off conveyors due to blockages and dropping from return belts can result in a buildup of coal under conveyors. This material can become a source of dust if not removed.

Transfer points to the yard conveyor will be covered, however, some parts, such as the transfer point between the yard conveyor and the stacker may not be able to be covered due to the design of the equipment. Dust suppression systems will be installed in those parts.

Elevated stacker conveyors will be provided with covers or windshields to shelter the coal from the wind and reduce dust potential. The coal will be damp when it is loaded onto the stockpile and water will be available to dampen the coal plume falling onto the stockpile to reduce dust formation. This will be required especially when thermal coal is being stockpiled given the high percentage of fine material in the coal. However, ensuring relatively high moisture content of the coal in the yard will reduce this risk.

Conveyor belts will be fitted with belt scrapers to remove coal build up on the return belts. Coal dropping onto the ground as a result of spillages will be regularly removed. Coal being reclaimed from the stockpile for use in the boilers will also lead to possible spillage. Such loading areas will be cleared of any spilled coal regularly and bunds surrounding the stockpile area will shelter the load out activities from the wind and water used to dampen surfaces. These mitigation methods will reduce the potential for dust generated from these activities leaving the site.

To control dust from the loading and unloading of coal the following methods will be adopted:

- Water will be used to dampen any dust produced from the coal falling onto the stockpiles,
- Transfer points will be covered,
- Wind shields or covers will be provided on elevated areas of activity,
- Coal deposits under the truck unloading area will be regularly removed,

- Bunds will be strategically located around points of frequent handling of coal at the stockpile to shelter the loading and unloading activities from the wind.

Dust Control System for the Project

Dust control is achieved by dust suppression and extraction system. Dust suppression is achieved by two methods; Plain Water Dust Suppression System and Dry Fog Type Dust Suppression System. Design and construction features of Dust control system shall be generally in conformity with the recommendation of “American Conference of Governmental Industrial Hygienists” or applicable international standards.

Type of dust suppression system to be provided at various locations shall be as given below:

- Around the Coal unloading station – Plain water dust suppression.
- Crusher receipt and discharge points – dry fog type dust suppression
- For all transfer points – Dry fog type dust suppression system
- For stock pile – Plain water type dust suppression system with swiveling nozzles.
- Boom belt discharge of stacker / reclaimer – Dry fog type dust suppression system
- Dry fog type dust suppression system:–
- Spray head minimum pressure at inlet (dry fog) shall be provided by the Contractor for water and air.
- Dust extraction System shall be provided at following locations:
    - For bunker floor
    - For crusher house

At the outlet of the dust extraction system, the dust concentration shall be well below as per International standard applicable for working areas

Coal Stockpiles

Wind blowing across the stockpile and vehicle movements disturbing the surface of the stockpile has the potential to generate dust. The amount of dust generated from surfaces such as stockpiles is dependent on the wind speed across the surface and the proportion of fine material on the surface of the pile exposed to the wind. Inactive stockpiles develop a crusty surface that effectively minimizes dust emissions.

The principal means of controlling dust from stockpiles is the use of water as a dust suppressant and minimizing the disturbance of the surface with vehicles. The coal will have inherently high moisture content when it is loaded onto the stockpile. Moisture loss from evaporation will reduce the surface moisture content quickly and increase the dust potential if it is not replaced.

Considering the dry and windy conditions for the bulk of the year at the Project site, dust–suppression watering system will be installed to maintain the moisture content of the stockpile surfaces all year around.

8.10 Disposal of FGD Gypsum

Options for disposal of FGD gypsum and prospects for sale to the cement industry are discussed in Chapter 7. Surplus gypsum accumulated while the market in cement industry is developed will be stored in the ash pond in an area separately demarcated for this purpose.

8.11 Noise

Noise is defined as a loud, undesired sound that interferes with normal human activities. If it affects the well-being of the surrounding community (environmental noise), it is considered a nuisance. Exposure to very high noise levels (exceeding 85 dBA), particularly for prolonged period can cause hearing loss. Construction and operation of a coal fired power plant will encounter certain unavoidable noise.

The noise during the construction phase greatly depends on the stage of construction work and equipment used at the site. The construction activities can be divided into the following phases:

- site clearing and preparation,
- excavation and pile driving,
- foundations and concrete placement,
- erection of metal structures,
- delivery of equipment and materials to the site,
- installation of mechanical and electrical equipment, and
- steam blowing and commissioning.

The source of noise during operation and maintenance phase includes:

- coal delivery, unloading and handling,
- operation of equipment within the turbine generator building and outside,
- steam blowing and purging,
- electric power transmission to the switchyard, and
- shutting down of components and switching to other equipment,

A settlement, Manzoorabad, exists in the vicinity of the power plant. The noise measured at two points, NPSTN01 (350 m east of the plant, residential huts, primary school) and NPSTN02 (950 m east of the plant, Manzoorabad settlement) in night exceed the NEQS by almost 10 dB. This may be attributed due to the location near the highway (N-55) and the existing plant.

IFC Guidelines[1] requires that noise impacts should not exceed daytime (0700 – 2200 hours) levels (55 dBA) and night-time (2200 -0700 hours) levels (45 dBA), or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site. This Project will be designed not to increase the noise level more than 3 dB at the nearest receptor (see Table 9-1 for details).

Noise will be measured and monitored around the periphery of the site to assure that permissible limits have not been exceeded. Alarms system will be employed to alert the main control room when any of the detectors indicate excessive noise levels. The detectors will be installed at critical receptor areas, such as hospital, school and residential areas. These detectors will be checked and calibrated periodically by plant personnel.

8.12 Port Impacts

Port Qasim currently has a capacity to handle 4 million tons of coal annually. The Project will require about 2 million tons of imported coal annually. During the past 5 years, the port has handled less than one million tons of coal annually. Given the low current handling and the fact that a plan to expand the capacity to 8 million tons annually is also underway, it is envisaged that the port has capacity to handle the coal requirement for the proposed Project.

8.13 Waste Management

The main environmental and social concerns relate to waste disposal. Other issues mainly relate to occupational health and safety. In Table 8-10, the mitigation measures related to different activities are described.

Table 8-13: Mitigation Measures Related to Corrective Action

Activity	Mitigation Measure(s)
Onsite handling and storage of new equipment	The new equipment will be stored in properly demarcated and identified areas. Separate storage of each item will be adopted and each area should be marked either on floor or cordoned off by tapes Lifting equipment (cranes) used for the equipment will follow the prescribed safety specification. Material Safety Data Sheet (MSDS) for chemicals, if any, will accompany the consignment. A copy of the MSDS will be available near the storage area at all times.

[1] IFC General EHS Guidelines: Environmental Noise Management

Construction activities – General	Appropriate Personal Protected Equipment (PPE) will be provided to the workers and it will be ensured that the PPE are used. The staff will be provided with training in use of PPE. Proper scaffolding platforms will be provided for all work areas located more than 1 m above floor level. First Aid facilities and fire protection devices should be placed in areas where activates will be performed. Ear protection devise will be used if the noise level is above 85 dB(A)
Construction – Working in confined Spaces	All confined spaces[1] will be identified. The temperature of the confined space will be in the human tolerance range. Artificial and intrinsically safe lighting will be provided in the confined spaces. If there is a risk of gases or fumes in the confined space the provisions for ventilation will be made.

8.14 Water Resource Impacts

8.14.1 Extraction of Water from the River

Water will be extracted from the Indus River and used for cooling in the proposed Project. The proposed power plant requires 0.50 m^3/s water from the River Indus when operating at full capacity. Of this, an estimated quantity of 0.01 m^3/s will be returned to the river. The net extraction of water by the proposed power plant is therefore estimated at 0.49 m^3/s at full capacity. As detailed in Chapter 5, river flow upstream of Kotri barrage[2] varies from a monthly average level of 4,592 m^3/s in August, to a monthly average level of 177 m^3/s in December. Water extracted by the power plant will therefore be 0.28% of the minimum monthly average flow of the river. Minimum daily flows in the drought periods can drop to as low as 14% of the minimum monthly average flows. In these conditions, the water extracted by the plant as a percent of the river flow will increase to about 2.0%. This level of change of flow will not cause any significant change in the geomorphology and the hydraulic parameters of relevance to the river ecology such as the depth of water, the width of the river, and the area wetted by it.

8.14.2 Quality of the Effluent Discharged into the River

As discussed in Chapter 5, a sample from effluent water was assessed for compliance with NEQS and all the analyzed parameters were found within the permissible levels of the standards. As described in **Chapter 4**, the proposed 660 MW power plant will discharge cooling tower effluent/ blowdown and the other waste water generated into the river after treated. Effluent flow with the proposed 660 MW power plant will increase by only 0.1 m^3/s. The additional effluent from the Project will be controlled to meet the SEQS (**Chapter 3**, **Table 3-5**, concentrations for circulating water).

[1] Confined space" means a space that:
(1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and
(2) Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
(3) Is not designed for continuous employee occupancy.

[2] Data provided by Irrigation & Power Department, Government of Sindh for the period 2005-2014

8.15 Ecological Impacts

As described in **Chapter 4**, 0.5 m^3/s of fresh water will be required for the 660 MW power plant, over and above an average of 0.06 m^3/s being consumed by the existing unit at present. The Project will therefore increase the water intake from the river to about 0.6 m^3/s. As discussed in **Section 8.13.1** above, there will be minor impact on the hydraulic parameters and consequentially the aquatic fauna due to change in the quantity of water extracted. The level of key pollutants in the effluent returned to the river from the plant will remain well below the SEQS limits. The river ecology will therefore not be at risk on account of higher point concentrations of pollutants discharged by the existing power plant into the river. There are no reserve forests in the Study Area and the forests outside the Study Area are not likely to be impacted by Project activities. Birds and mammals are not expected to be attracted to the ash pond due to existing levels of disturbance and restricted ground access. Transport of additional coal and supplies for construction of the Project will increase traffic volumes and can result in land disturbance and habitat fragmentation of animals. However, since existing road networks will be used to accommodate the additional traffic volumes, this impact is not likely to be significant considering that the area is already heavily disturbed.

8.16 Socioeconomic Impacts

The Project activities will result in both positive and negative impact on the existing socioeconomic environment of the Socioeconomic Study Area as well as the broader region. The positive impacts include:

- Reduction in power outages,
- Increase job opportunities and
- Increase in income source as a result of new job opportunities.

The potential adverse impacts include:

- Loss of land ,
- Changes in values and norms of the local culture as a result of social interaction between the local communities and incoming labors.

Each of these is discussed below.

Reduction in Power Outages

Pakistan is suffering from an acute energy crisis as describe in **Chapter 2.** The unreliable power supply is affecting the productive end-uses of power due to which the direct and multiplier benefits of productive activities are foregone and the economy incurs a loss. Due to the Project, 600 MW (net) will be added to the system. The power generated by the Project would be supplied to various sectors that are currently impacted by the power shortages and bridge part of the energy shortfall facing the country. This, in turn, will have a positive impact on the country's economy through increase in gross domestic product (GDP). The impact will last through the life of the Project and thus, be of a long duration.

Changes in Employment and Local Economy

The Project will create new job opportunities both during construction. During construction period, about 3,000 people will be hired and local people will be given priority. Job experience during construction periods and/or the skill training and capacity building activities provided in this Project as a part of the social augmentation will open up new job fields and opportunities for the local residents. The project will prohibit labor contracts with children.

During the operation period, about 347 staff positions will be created, however this will involve a limited number of people from local communities as this Project is designated with high technology which requires special expertise and capabilities. The project will coordinate efforts to recruit unskilled labor from the adjacent communities if any are required under the Project. To avoid conflicts between the contracted staff and local people, the Project proposes to use services from local vendors who will provide regular business and everyday goods at camp site during construction as well as at the power plant during operation.

Loss of Land

In this project, 46.25 acres of additional land will be required for the access roads, water pumping stations and path to pumping station, water pipeline and ash pond (see Table 8-14).

Table 8-14: Land Acquisition Requirements by Components

No	*Project Component*	*Required Land (Acres)*	*AHs*	*APs*
1	Northern Access Road	3.95	-	-
2	Southern Access Road	1.99	-	-
3	Water Pumping Station	0.11	1	9
4	Path to Pumping Station	0.76	3	18
5	Water Pipeline (Temporary acquisition)	3.29	-	-
6	Ash Pond	36.15	-	-
Total		46.25	3	18*

Source: Resettlement Field Survey June–July 2014

*Some of the AHs and APs are being affected by more than one component therefore total does not match with the sum of the columns.

As a result of efforts on site selection and consideration of alternatives, none of the project sites is used for residential and agricultural purposes therefore physical and economical displacement will not be involved. As shown in **Table 8-15**, The project implementation will only affect 0.87 acres of uncultivated land of three households with a population of 18. The project will have no other impacts on their assets and livelihood. The Project will also affect 42.09 acres of un-surveyed barren land, consisting 0.5 acres of on-road barren land and 41.59 acres are off-road barren land. During construction period, 3.29 acres of land will be temporary occupied.

Table 8-15: Type of Land affected by the Project

Type of Land	*Unit*	*Quantity*	*AHs*	*APs*
Cultivated land	Acres	0	-	-
Un cultivated Land	Acres	0.87	3	18
On Road Barren Land	Acres	0.5	-	-
Off Road Barren Land	Acres	41.59	-	-
Temporary acquisition	Acres	3.29	-	-
Total		46.25	3	18

Source: Resettlement Field Survey June–July 2014

The land will be acquired through the principles and standards laid out under Pakistan Land Acquisition Act 1894 and the JICA Guideline (2010), World Bank Safeguard Policy OP 4.12 Annex A. Both require that the affected people be compensated adequately for their loss due to project implementation. A framework of the land acquisition implementation under the Project is given in Land Acquisition and Resettlement Action Plan (LARAP). As a mitigation measure, the LPGCL/GHCL will compensate the owner of the land and other assets on replacement value basis.

Other Changes in Social Environment

Social Conflicts: With the influx of labor force and other staff related to the construction activities, conflicts with the local people on the cultural issues may arise and the local custom and norm may be affected. In order to minimize the impacts, the contractor will maintain close liaison with the local communities to ensure that any potential conflicts related to the use of common resource and if any, resolve quickly.

Disturbance to Society: During the construction phase, the general mobility of the locals and their livestock around the project area will be affected. The movement of the heavy equipment may increase traffic conjunction and accident, and affects mobility of the locals. As mitigations, specific timings for construction work will be planned so to avoid disturbance to the local communities and their mobility during business hours. If necessary, traffic signs, driving safety education, speed restriction, check/maintain vehicle equipment (brake, klaxon) will be installed. Also, mobility of the contractor's staff through the nearby residential areas should be prohibited to avoid any inconvenience or risk.

Gender: Influx of migratory labor during construction works may increase impact on female daily activities, privacy of the female and/or increase possibility of abuse to the local female. The contracted labors will be educated and the local communities will be consulted and monitored

Infectious Diseases: Influx of migratory labor during construction works may increase risk of infection. To minimize the effects, the project will implement periodic medical check and conduct education programs on health of workers.

Working condition and accident: Projects are exposed to the risks of accident and spread of infectious diseases especially during construction period. To control these risks, following mitigation measures are proposed.

- Safety and sanitation management plan will be developed
- Regular health check of the labors will be implemented.
- Long-time exposure of workers to noise will be restricted.
- The workers will be directed to wear personal protective gears.
- Construction of temporary first aid station at the working site with nurse.
- Establishment of cooperative relationship with the local medical facilities.

8.17 Occupational Health and Safety

Other than environmental impact, the proposed Project can also increase the risk of exposing the workers and employees of the power plant and its contractors to occupational and safety hazards. Generally the probability of such risks occurring is low. However, an occupation health and safety management system could control and manage the risks. There is no explicit occupational health and safety law in Pakistan. To some extent it is covered in the Factory Act 1934 (see **Chapter 3**). The proposed Project will develop a safety policy and a management system in accordance with the international standards and best practices.

Public risk associated with on-site activities will be restricted by the security controls in place and the awareness training provided to visitors to the sites.

8.18 Cumulative Impacts

The followings are the special aspects of the location of 660 MW power plant that are of relevance to the cumulative impacts of the project:

- LFPS has been operated with air pollution control of sulfur removal through injection of limestone in the fluidized bed and particulate emissions are controlled by bag filters. However rehabilitation of this equipment is required.
- The proposed Project will be connected to the national transmission system at a key point where the power supplied by it can feed both the southern as well northern markets in the country.
- The plant will have access to river water for operation of cooling towers and general plant use.
- The plant will be connected to the national rail network by constructing spur line from the Budhapur station.
- With proximity to Jamshoro town and city of Hyderabad, the plant has access to a pool of skilled and unskilled labor.

If this project is implemented, the existing rail and road transportation networks connecting the plant to the supply points at ports and mines can come under further stress. These are discussed in the following sections. Given the potential for industrial development and installation of power generation capacity in the area, LPGCL will remain in touch with the relevant local and national authorities to ensure that the development plans take the baselines, impacts, and mitigations presented in the Project EIA into account.

Capacity expansion at Lakhra can trigger further industrial and housing development in the vicinity of the plant. Air quality in the residential areas (existing Lakhra Colony situated in 3 km south of the plant) could be a potential concern.

8.18.1 Port Facility

As discussed earlier the port capacity and existing usage has sufficient capacity to handle the proposed Project coal supply. Against the existing capacity of 8 million tons for both Port Qasim and Karachi Port, the potential future coal handling requirements are:

- Pakistan Steel Mills: 3 million tons
- New plant at Jamshoro: 3.7 million tons
- Coal Conversion KESC Bin Qasim: 3 million tons
- Coal conversion at FFBQ, Port Qasim: 0.5 million tons

It is evident that without the planned expansion plan Port Qasim will not be able to handle the coal traffic demand in future. A new bulk coal terminal is under construction at Port Qasim with a capacity of 8 million tonnes (www.pibt.com.pk). There are plans to enhance the capacity of this terminal to 12 million tons in future.

8.19 Impact Assessment

The result of the environmental and social impact assessment due to the proposed Project is presented in Table 8-15.

Table 8-16: Result of Environmental and Social Impact Assessment

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
	Pollution Control					
1	Air Quality	B-	A-	B-	B-	**[Construction Phase]** Soil dust is generated by civil works of land clearance. Exhaust gas from vehicles is generated. However, as most of the activity is conducted within the existing Lakhra Plant, the risk is low. **[Operation Phase]** Emission of SO2, NOx, PM10 and PM2.5 will be controlled to meet ambient air quality in SEQS and IFC Guidelines. Coal ash diffusion from ash pond is mitigated by water sprinkling and dikes with 5m height around it. Spontaneous ignition will be avoided by appropriate management (periodic inspection, limiting the coal stock height, compaction of coal stock, and water sprinkling).
2	Water Quality	B-	B-	B-	B-	**[Construction Phase]** Oil-contaminated water, fuel used for heavy machines, domestic water at construction site and base camps can be leaked into underground water. Civil works of intake and outlet facilities will bring about some impacts on river water quality. **[Operation Phase]** All of the effluents including rainfall runoff from ash pond and coal piles will be routed to the wastewater treatment facility for treatment and discharged to the river. Leachate from ash pond may contaminate underground water.
3	Soil Quality	B-	B-	B-	B-	**[Construction Phase]** The leakage of lubricant oil and fuel oil from construction vehicles and machines can pollute soil. **[Operation Phase]** Oils are stored in the particular building or on the asphalt-covered area. Leachate from ash pond may contaminate the soil around the facility.

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
4	Wastes	B-	B-	B-	B-	**[Construction Phase]** Municipal solid waste, industrial and hazardous waste will be generated, which will be stored by each type of wastes, collected and treated appropriately by local licensed firms.
						[Operation Phase] Municipal solid waste, industrial and hazardous wastes will be generated. Coal ash and by-product gypsum will be generated.
5	Noise and Vibration	B-	A-	B-	B-	**[Construction Phase]** Noise and vibration are generated from large-sized vehicle traffic on access roads and construction sites, and from heavy machines during excavation works and equipment setting.
						[Operation Phase] Insulation measures such as building, sound absorber, green belt, insulation wall, etc. are applied.
6	Subsidence	D	D	N/A	N/A	No use of underground water
7	Odor	B-	B-	B-	B-	**[Construction Phase]** Odor may be generated from solid and liquid waste, and septic tanks of base camp.
						[Operation Phase] Spontaneous ignition of coal and ash might occur.
8	Sediment Quality (bottom of Indus River)	B-	B-	B-	D	**[Construction Phase]** Civil works of intake and outlet facilities may impact on sediment quality.
						[Operation Phase] No significant impact on sediment quality is predicted due to small quantity of effluent water.
Natural Environment						
9	Protected Areas	C-	C-	N/A	N/A	**[Construction & Operation Phase]** Project site is not included in any protected area.

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
10	Ecosystem	C-	C-	B-	B-	**[Construction Phase]** Construction of intake and effluent discharge facilities may impact on the aquatic organisms.
						[Operation Phase] No significant impact is predicted. However, fish monitoring will be implemented taking into account the impact on fishery.
11	Hydrology	B-	B-	B-	D	**[Construction Phase]** Some impact is predicted due to the construction of intake water facility, which installs steel piles in the river.
						[Operation Phase] No significant impact is predicted.
12	Topography and Geology	B-	D	D	D	**[Construction & Operation Phase]** No large-sized topographical and geological changes occur.
Social Environment						
13	Involuntary Resettlement (Land Acquisition)	B-	B-	B-	B-	**[Pre-construction/Construction/Operation Phase]** 46.25 acres of land will be acquired for two access roads, water pumping station and path to pumping station, water pipelines (temporary acquisition) and ash pond. Project will affect 0.87 acres of uncultivated private land of three households (18 people). There will be no other impacts on assets and livelihood. Compensation for the loss of land on replacement value basis and other support will be provided to restore/improve livelihood of affected people.
14	People below the Poverty Line	C-/C+	C-/C+	D	D	**[Pre-construction/Construction/Operation Phase]** Project affected people do not include people below national poverty line[1].

[1] The Pakistan national poverty line is US$ 1.25 per person per day (that is PKR 3,703 at exchanging rate US$ 1 = PKR 98.75 on 4th August 2014).

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
15	Ethnic, Minorities and Indigenous People	C-	C-	D	D	**[Pre-construction, Construction and Operation Phase]** There is no significant impact since group of people such as Hindi, Christian and other minor groups are harmonized with the major religious group, Muslim people.
16	Living and Livelihood	C-/C+	C-/C+	B+	B+	**[Pre-construction and Construction Phase]** Project would employ about 3,000 people and give priority to local people, provide job skill training and capacity building activities as part of social augmentation. Project will also use services from local vendors for regular business and every goods at labor camp site. **[Operation Phase]** Project would expedite new job and business opportunities by recruiting unskilled labors from the adjacent communities and using services from local vendors for regular business and every goods.
17	Use of Land and Resources	C-	C-	B-	D	**[Construction Phase]** Movement of local people, their livestock and traffic will be disturbed from land acquisition, construction activities and influx of workers. **[Operation Phase]** No impact on the existing traffic and movement of local people as coal will be transported by rail.
18	Water Use	C-	C-	B-	D	**[Construction Phase]** Storm water runoff from construction site may temporally impact on quality of irrigation water from Indus River that is used in some settlements located less than one kilometer from Indus River; underground water that is used through wells, dug wells and hand pumps in some settlements in Study Area. Construction works of intake and discharge facilities may temporally affect water quality of Indus River. **[Operation Phase]** There is no significant impact on water use as water flow of the river is secured and waste water will be treated appropriately before discharged.
19	Infrastructure	B-	B-	B-	D	[**Construction Phase]**

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
	and Social Services					Construction activities and influx of labors may affect availability and capacity of existing social infrastructures and social services such as transportation, schools and health facilities. **[Operation Phase]** Coal will be transported by trucks, so that there would be no increase in the volume of traffic.
20	Social Capita, Institutions and Conflicts	C-	D	B-	D	**[Pre Construction / Construction Phase]** Differences in acceptance of the project among local communities and changes of cultural value and norms between the local communities and incoming labors may cause social conflicts.
21	Unevenness of Project Benefits and Impact	C-	C-	B-	B-	**[Construction / Operation Phase]** Inappropriate compensation and supports may cause unevenness among project beneficiaries. Income gaps between the project employed workers and the other locals may cause unevenness of the project benefit.
22	Heritage	C-	D	D	D	**[Pre Construction / Construction / Operation Phase]** There is no heritage site within the Study Area.
23	Landscape	D	D	D	D	**[Pre Construction / Construction / Operation Phase]** No large scale earth works are involved.
24	Gender	C-	C-	B-	B+	**[Construction Phase]** Influx of migratory labor during construction works may increase impact on female daily activities, privacy, and possibility of abuse of local female. As measures, the labors will be educated, the local community will be consulted and monitored. **[Operation Phase]** Women's work load may be eased if community water utilities were provided by the executing agency as part of the social augmentation program.
25	Child Right	C-	C-	D	B+	**[Construction Phase]** It will be made sure that children will not be employed in the project. **[Operation Phase]**

No.	Item	Assessment of Scoping		Assessment of Survey Result		Results
		Pre/Construction Phase	Operation Phase	Pre/Construction Phase	Operation Phase	
						Improvement in local economy, social infrastructures such as water utilities, schools and health facilities as part of social augmentation may positively impact on social environment for children.
26	Infectious Diseases	B-	D	B-	D	**[Construction Phase]** Influx of workers may increase risks in respiratory and infectious diseases. The project will implement periodic medical check and health education for the workers.
27	Working Condition and Accident	B-	B-	B-	B-	**[Construction / Operation Phase]** Projects are exposed to the risks of accident and occupational health and safety hazards. Mitigation measures are proposed to control these risks.
Other						
28	Transboundary Waste Treatment and Climate Change	C-	C-	D	B-	**[Construction Phase]** Transboudary of waste is not predicted. **[Operation Phase]** The power plant generates 2.7 – 2.8 million ton-CO_2/year.

A+/-: Significant positive/negative impact is expected

B+/-: Positive/negative impact is expected to some extent

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D: No impact is expected

Source: JICA Survey Team

CHAPTER 9. ENVIRONMENTAL MANAGEMENT PLAN

The main objective of the Environmental Management Plan (EMP) is to identify mechanisms to implement the environmental mitigation measures discussed in **Chapter 8**. It is the fundamental tool that:

- consolidates all mitigation measures;
- identifies and specifies implementation responsibilities; and
- resources required to implement the measures are provided.

The EMP also includes monitoring measures, as a feedback mechanism, on implementation and effectiveness of the mitigation measures.

The EMP is prepared for all the identified environmental impacts during design, construction, and O&M stages (**Chapter 8**) associated with the Project. The methodology followed for preparing the EMP consisted of the following steps:

- deriving mitigation/protection measures for identified impacts;
- recommending mitigation, compensation and enhancement measures for each identified impact and risk;
- developing a mechanism for monitoring the proposed mitigation measures;
- estimating budget requirements for implementation mitigation and monitoring measures; and
- identifying responsibilities of various agencies involved in the Project for implementation and monitoring of mitigation measures.

In addition to the environment mitigation plan (**Section 9.1**) and environmental monitoring plan (**Section 9.2**), specific management plans have been developed for areas of concern, including the following:

- Waste Management Plan (**Section 9.8.1**)
- Construction Management Plan (**Section 9.8.2**)
- Coal Dust Management Plan (**Section 9.8.3**)
- Ash Management Plan (**Section 9.8.4**)
- Spill Management Plan (**Section 9.8.5**)
- Fire Emergency Response Plan (**Section 9.8.6**)
- Transportation Management Plan (**Section 9.8.7**)

Social Augmentation Plan (**Section 9.9**) and Ambient Air Quality Monitoring Program (**Section 9.10**) have also been developed.

The EMP will be included in all the bid documents of the Project and will become part of the civil works contract. The strict implementation of the EMP and Project management's strict enforcement of the adequate construction practices and standards will greatly reduce the negative impacts of the Project.

9.1 Environmental Mitigation Plan

The mitigation plan prepared in accordance with the above framework is given in **Table 9-1**. The key components of the plan are discussed in the following sections. The environmental and social mitigation plan includes the following:

- the measures that are required to be implemented during the design, construction and implementation phases of the Project are identified
- for each mitigation measure the person responsible to implement and monitor the implementation is identified
- the timing to implement and the location to implement

Table 9-1: Environmental Mitigation and Management Plan

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
A. Design Phase					
Project disclosure	Stakeholder concerns	Submit EIA to Sindh EPA and obtain approval.	Before start of construction	LPGCL	GHCL
Land Acquisition	Effects of resettlement on livelihood	The Land Acquisition And Resettlement Plan (LARAP) will be implemented. In case of any change in the area of the land, the LARAP will be updated before any acquisition of land. Coordination of activities with relevant regulatory government departments such as the DC and the Revenue Department.	Before start of construction	LPGCL	PIC/GHCL
Stack Emissions	SO_2, NO_x and PM emissions from the stack	Ensure that the following equipment are included in the project design in order to ensure compliance with the World Bank Group EHS Guidelines on Thermal Power Plants, 2008, national standards and international best practices: • ESP (High efficiency 99.7%) to limit the total PM emissions to 30 mg/Nm^3 • FGD (High efficiency 80%) using lime slurry to limit SO_2 emissions • Low NO_x burners to minimize the NO_x generation • A stack height of 210 m. The equipment type and details may be changed as long as the objectives are met. Any such change will require approval of JICA/investor(s).	During detailed designing	PIC	GHCL/LPGCL
Ash pond	Dust and leachate are	About 73 acres of land are allocated for the ash disposal	During	Design	GHCL/LPGCL

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Prepared/ Implemented by	Reviewed/ Approved/ Supervised by
	potential sources of contamination	with the capacity of about 5 years of ash and gypsum waste for the 660 MW project. The fly ash will be collected from silos and recycled as much as possible or disposed of at the ash pond. Bottom ash will be collected and disposed of at the ash pond. Water will be sprinkled on the ash pond for avoiding ash dispersion. The ash pond will be provided with trenches to collect the storm water during rainy days. Greenbelt will be provided enveloping the ash pond to arrest the fugitive dust emissions. Ash pond will also be provided with clay or HDPE liner. The design will allow phased expansion of the ash pond to store ash. The storm water coming from the ash pond will be treated at the effluent treatment facility and will be discharged into Indus River.	detailed designing	consultant	
Plant Wastewater	Discharge of untreated waste water will pollute the surface water and expose river ecology to thermal stress	Ensure that the following measures are included in the project design in order to ensure compliance with the World Bank Group EHS Guidelines, 2008, national standards and international best practices: • Cooling tower blow down will be extracted from the outlet of the cooling tower instead of the present practice of drawing it from the inlet sump of the cooling tower/condenser outlet • Replacement of the pipeline originally designed to carry the effluent from the plant to the river and restoration of the system for collection of effluent water and its routing to the effluent pipeline	During detailed designing	PIC	GHCL/LPGCL

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Prepared/ Implemented by	Reviewed/ Approved/ Supervised by
Fire prevention	Fire hazards and impact on community	A hazard and operability study (HAZOP) will be undertaken. In the study, the power plant process will be systematically assessed to identify risks to personnel, equipment, or community. The fire fighting system and the emergency response plan will be developed on the basis of the HAZOP study.	During detail designing	EPC Contractor	PIC/LPGCL/ GHCL
B. Construction and Implementation Phase					
Construction management	Construction activities although temporary can potentially have adverse impact on the environment.	Ensure that a detailed Construction Management Plan (CMP) based on the skeleton plan included in **Table 9-6** is developed.	Before construction	EPC Contractor	PIC
		Ensure that the CMP is implemented	During Construction	EPC Contractor	PIC
Environment					
Air quality	Ambient air quality (soil dust, exhaust gas from vehicles)	・Water sprinkling is implemented at construction area ・To ensure that appropriate maintenance is conducted for vehicles	During construction	EPC Contractor	PIC
Water quality	Leakage into underground water	・Before disposing of the waste water, coagulation or oil separation process is applied. ・Chemicals are kept in the specific storage with roof and wall. ・Trainings for cleaning method of chemicals are implemented for labors in case of chemical leakage accidents.	During construction	EPC Contractor	PIC
	River water pollution during civil works	・The waste water from sanitary facilities (temporary lavatories) is collected by licensed company. ・To adopt the construction method with less impact on the river water.	During construction	EPC Contractor	PIC
Soil quality	Soil contamination by oil	・Lubricant/fuel oil is dealt appropriately. ・Training for oil management is conducted for labors by	During construction	EPC Contractor	PIC

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
		EPC Contractor in advance.			
Disposal of replaced construction related spare parts and fluids (oil filters, engine oil, tires, *etc*.)	Generates wastes such as iron, copper, electronics and oil	Ensure that the waste is disposed as per the waste management plan.	During construction	EPC Contractor	LPGCL
Baseline particulate levels in ambient air in the Project Area	Measurement of changes in particulate levels in ambient air due to future stack emissions from Project	Regular monitoring of PM_{10} and $PM_{2.5}$ is recommended and presented in the environmental monitoring plan (**Section 9.2**).	Two years before operations and three years during operations	EPC Contractor	PIC, GHCL
Noise and vibration	Noise	・To disclose the construction plan and duration to residents ・Vehicles do not enter the construction sites during night time (22:00 - 6:00) ・O&M and fix are regularly conducted to construction machines and vehicles ・Civil works with big noise and vibration are implemented during daytime (6:00 - 22:00) ・Excavation and piling works are implemented during daytime (6:00 - 22:00) ・Where big noise is emitted, insulation wall is constructed or silencer is installed on construction machine	During construction	EPC Contractor	PIC
Odor	Odor from kitchen waste and septic tanks	・Kitchen waste is segregated at waste storage facility. ・Septic tanks are inspected regularly and kept in good condition by adding chlorine appropriately.	During construction	EPC Contractor	PIC

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
Sediment quality	Impact on sediment quality during civil works	▪ To adopt the construction method for water intake and effluent discharge facility, which has less impact on the sediment quality ▪ To adopt the outlet method for effluent discharge facility, which has less impact on the sediment quality	During construction	EPC Contractor	PIC
Ecosystem	Water pollution during construction phase	To adopt the construction method for water intake and effluent discharge facility, which brings about less impact on the sediment quality	During construction	EPC Contractor	PIC
Socio-economics					
Involuntary resettlement and land acquisition	Changes in income source patterns	▪ LARAP will be implemented. ▪ Progress of effectiveness of LARAP implementation will be monitored.	During construction	PIU/LPGCL	PIC/GHCL
Living and livelihood	Changes in income sources and local economic structure	▪ LARAP will be implemented. ▪ Progress and effectiveness of LARAP implementation will be monitored. ▪ Establishment of grievance system. ▪ Job creation as construction workers and give priority to locals including PAPs. ▪ Provision of job skill training and capacity building activities. ▪ Using local services and local venders.	During construction	PIU/LPGCL	PIC/GHCL
Use of land resources	Loss of land based economic production/	Same EMP as [Living and Livelihood]	During construction	PIU/LPGCL	PIC/GHCL
	Disturbance of movement of local people and their livestock	▪ Specific timings for construction work will be planned to avoid disturbance to the local communities and their mobility during business hours. ▪ Mobility of the contractor's staff through the nearby residential areas will be controlled and prohibited, where possible	During construction	EPC Contractor	PIC

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Prepared/ Implemented by	Reviewed/ Approved/ Supervised by
Water use	Disturbance of water use for everyday use, agriculture and fishing due to temporary degradation of water quality.	· Same EMP as [Water Quality] · Consultations/explanation to the locals · Monitoring of the local community. Implementation of grievance system.	During construction	EPC Contractor	PIC/GHCL
Infrastructure and social services	Availability and capacity of existing infrastructure and services	· Upgrade, repair and/or develop social infrastructures and services, if necessary. · Develop camp site that facilitates required infrastructures, if necessary · Traffic of construction vehicles during business hours shall be avoided. · Installation of traffic signs, driving safety education, speed restriction, check/maintain vehicle equipment (brake, klaxon) if necessary.	During construction	EPC Contractor	PIC
Social capita, institutions and conflicts	Social conflicts	· Consultations/explanation to the locals · Education of employees about local cultural value, norms and common resources. · Maintain liaison between incoming workers and local communities. Mobility of the contractor's staff through the nearby residential areas will be controlled and prohibited, where possible. · Monitoring of the local community. · Establishment of grievance system.	During construction	EPC Contractor	PIC/GHCL
Unevenness of project benefits and impact	Income gaps between project beneficiaries	· Implement fair compensation · Proposal of social augmentation · Consultations/explanation to the locals. · Monitoring of the local community. · Establishment of grievance system.	During construction	EPC Contractor	PIC/GHCL
Gender	Influx of workers may increase impact on female	· Education of employees · Establishment of grievance system.	During construction	EPC Contractor	PIC/GHCL

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
	daily activities, privacy and possibility of abuse.	･ Local community will be consulted and monitored			
Infectious diseases	Influx of workers may increase risks in respiratory and infectious disease.	･ Implementation of periodic health check and education for workers ･ Monitoring of the local community.	During construction	EPC Contractor	PIC/GHCL
Working condition and accident	Risks of accident, occupational health and safety hazards, spread of infectious diseases	･ Development of occupational health and safety management plan ･ Implementation of periodic health check and education for workers ･ Restriction of long-time exposure to noise for workers. ･ Application of personal protective gears ･ Construction of temporary first aid station at the working site with nurse. ･ Establishment of cooperative relationship with the local medical facilities.	During construction	PIU/LPGCL/ EPC Contractor	PIC/GHCL
Changes in Social Environment	Impacts of the influx of labor force and staff and social conflicts	Maintain liaison with the local community to ensure that conflicts related to the use of common resources, if any, are identified as early as possible, and are resolved in a timely and appropriate manner. Ensure grievance mechanisms and implement regular monitoring (**Section 9.2**).	During construction	EPC Contractor	LCPGL
	Impacts of the influx of labor force and staff on females	Ensure grievance mechanisms are developed and implemented. Carry out regular review of the efficacy of mechanisms (**Section 9.2, 9.4 and 9.6**).	During construction	EPC Contractor	LCPGL
	Impacts of the influx of labor farce and staff on infectious diseases.	Regular health checks of labor and conduct education programs on health of workers.	During construction	EPC Contractor	PIC
	Effects of movement of	Specific timings for construction work will be planned to	During	EPC Contractor	PIC

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
	construction equipment on traffic congestion and movement of people	avoid disturbance to the local communities and their mobility during business hours. If necessary, traffic signs, driving safety education, speed restrictions will be implemented. Regular maintenance of vehicles and associated equipment will be carried out. See, also, **Table 9-6**. Mobility of the contractor's staff through the nearby residential areas will be controlled and prohibited, where possible, to avoid any inconvenience or risk.	construction		
	Exposure to the risks of accident	The following mitigation measures will be employed: • Waste management plan will be developed and implemented (**Section 9.8.1**). • Training for Health, Safety and Environment unit and labor (**Section 9.3 and 9.4**). • Use of appropriate of personal protective equipment (PPE) and appropriate training (Section 9.4 and **Table 9-6**) • Construction of temporary first aid station at the working site with nurse. • Establishment of cooperative relationship with the local medical facilities (**Section 9.9**).	During construction	EPC Contractor	PIC
C. Operation and Maintenance Phase					
Environment					
Air Quality					
Fugitive emissions from Coal Storage Areas	Dust emissions	Dust extraction/suppression system will be provided at transfer points of conveyor system and ventilation system to supply fresh air; Roof extraction fans will be provided in essential areas like crusher house and boiler bunker floors.	During operation	LPGCL	GHCL

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
		Conveyor belt will be enclosed to prevent dust generation; Provision of water sprinkling system at material handling and storage yard; Asphalting of the roads within the plant area; and Developing of Greenbelt around the plant to arrest the fugitive emissions.			
	Fire hazards from auto generated combustion	Self–generated combustion of coal stock prevented by limiting the coal stock height to design limit of 15 meters, and compaction of coal stock to avoid the air passage.	During operation	LPGCL	GHCL
Fugitive emissions from fuel		Provision and periodic inspections of mechanical seals in pumps; Preventive maintenance of valves, flanges, joints, roof vents of storage tanks; and Submerged filling of liquid fuel storage tanks.	During operation	LPGCL	GHCL
Stack emission	Changes in ambient air quality due to stack emissions	▪ Regular monitoring of ambient air quality is recommended and presented in the Environmental Monitoring Plan. ▪ Installation of continuous emission monitoring system (CEMS) equipment on the new stack for coal-fired boilers.	During operation	LPGCL	GHCL
Water and Effluent Waste					
Wastewater from plant	Pollution of receiving water bodies	Complete treatment of wastewater including the cooling tower blowdown. Use of infiltration and runoff control measures such as compacted soils, protective liners, and sedimentation controls for runoff from coal piles; treatment of low–volume wastewater streams that are typically collected in the boiler and turbine room sumps in conventional oil–water separators before discharge;	During operation	LPGCL	GHCL

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Prepared/ Implemented by	Reviewed/ Approved/ Supervised by
		treatment of acidic low–volume wastewater streams, such as those associated with the regeneration of makeup demineralizer and deep–bed condensate polishing systems, by chemical neutralization in–situ before discharge; pretreatment of cooling tower makeup water, installation of automated bleed/feed controllers, and use of inert construction materials to reduce chemical treatment requirements for cooling towers; and elimination of metals such as chromium and zinc from chemical additives used to control scaling and corrosion in cooling towers.			
Storm Water	Typically storm water runoff contains suspended sediments, metals, petroleum hydrocarbons, coliform, etc.	Rainfall runoff from the coal pile will contain mainly suspended solids. This runoff will be routed to the wastewater treatment facility for treatment and re-use for sprinkling, if possible, or discharged. Storm water will be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge. Surface runoff from process areas or potential sources of contamination will be prevented. Oil water separators and grease traps will be installed and maintained as appropriate at refueling facilities, workshops, parking areas, fuel storage and containment areas. Adequate storm drains will be constructed along the boundary of the plant area and within the plant area to drain off the storm water during monsoon period. Limestone and gypsum storage areas will be covered so that there will be no contaminated runoff.	During operation	LPGCL	GHCL
Ground water	Contamination of	HDPE membrane is applied to the bottom of ash pond	During	LPGCL	GHCL

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
	groundwater due to leachate from ash pond		operation		
Treated waste water from Housing Colony	Land degradation due to open drainage of water	Regulation of the use of effluent water for agriculture and provision of outlets to farmers under agreements for water use with permission from the Irrigation Department;	During operation	LPGCL	GHCL
Waste					
Wastes	Health hazard by inappropriate disposal of municipal, industrial and hazardous waste	· Municipal and industrial wastes are segregated by labours before the collection. · Training for handling the hazardous waste is implemented to all labors in advance. · Licensed company is selected by bid every year.	During operation	LPGCL	GHCL
Fly ash	Dust	Fly ash will be collected from silos and recycled by cement industry as much as possible.	During operation	LPGCL	GHCL
Sludge from FGD	Water pollution	The sludge from the FGD will be treated to separate the gypsum which can be potentially sold in the market and water. The water will be treated by first separating the solid material and then through the plant treatment system. The gypsum, if it cannot not be marketed, will be disposed in the ash pond.	During operation	LPGCL	GHCL
Noise pollution					
Noise	Noise from the equipment	The occupational noise exposure to the workers in the form of 8 – hourly time weighted average will be maintained well within the 60 dB (A)). Acoustic enclosures will be provided wherever required to control the noise level below 60 dB (A). Anywhere not possible technically to meet the required noise levels, personal	During operation	LPGCL	GHCL

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
		protection equipment will be provided to the workers. The operation noise of the plant will comply with IFC +3 noise level standards which restricts the noise to 3 decibel increase in the existing background noise level prevailing in the nearby communities. For this purpose, noise mufflers will be employed around the noisy machinery to reduce their impact on the ambient noise level.			
Odor					
Odor	Kitchen waste, septic tanks	▪ Kitchen waste is segregated at waste storage facility. ▪ Septic tanks are inspected regularly and kept in good condition by assing chlorine.	During operation	LPGCL	GHCL
	Spontaneous ignition of coal, ash	▪ Water is sprinkled on coal and ash in order to avoid spontaneous ignition.	During operation	LPGCL	GHCL
Ecosystem					
Ecosystem	Suction of aquatic organism	▪ To install the intake screen to avoid suction of fishes.	During operation	LPGCL	GHCL
Socio-economics					
Health and Safety					
Boilers	Higher exposure to electric and magnetic fields	Identification of potential exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities; Training of workers in the identification of occupational EMF levels and hazards; Establishment and identification of safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public	During operation	LPGCL	GHCL

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Prepared/ Implemented by	Reviewed/ Approved/ Supervised by
		exposure, limiting access to properly trained workers; Implementation of action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non–Ionizing Radiation Protection (ICNIRP), the Institute of Electrical and Electronics Engineers (IEEE). Personal exposure monitoring equipment will be set to warn of exposure levels that are below occupational exposure reference levels (e.g., 50 percent). Action plans to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.			
	Heat Exposure	Regular inspection and maintenance of pressure vessels and piping; Provision of adequate ventilation in work areas to reduce heat and humidity; Reducing the time required for work in elevated temperature environments and ensuring access to drinking water; Shielding surfaces where workers come in close contact with hot equipment, including generating equipment, pipes etc.; Use of warning signs near high temperature surfaces and personal protective equipment (PPE) as appropriate, including insulated gloves and shoes.	During operation	LPGCL	GHCL
Living and livelihood	Positive impact on local economic structure	· Project would expedite new job and business opportunities by recruiting unskilled labors from the adjacent communities	During operation	PIU/LPGCL	PIC/GHCL

Aspect or Concern	*Potential Environmental Impact*	*Environmental Mitigation and Management Measures*	*When*	*Institutional Responsibilities*	
				Prepared/ Implemented by	*Reviewed/ Approved/ Supervised by*
		Using services from local vendors for regular business and every goods.			
Working condition and accident		･ Development of occupational health and safety management plan ･ Implementation of periodic health check and education for workers ･ Restriction of long-time exposure to noise for workers. ･ Application of personal protective gear ･ Installation of first aid station/kits at the working site ･ Installation of traffic signs, driving safety education, speed restriction, check/maintain vehicle equipment (brake, klaxon). ･ Development of gas-leakage prevention management plan. ･ Installation of gas-leakage alarm system, stationary fire prevention system, fire hydrant, fire extinguisher, fire escape exit, fire alarm, fireproof compartment, emergency exit, etc. ･ Installation of automatic control system. ･ Same EMP as [Use of Land Resource]	During operation	EPC Contractor	PIC
Other					
Transboundary waste treatment and climate change	Carbon dioxides emissions	･ High efficient power generation technology, USC, is adopted, which generates less CO_2 than subcritical and supercritical pressure type of boiler.	During operation	GHCL	-

Source: Hagler Bailly Pakistan

9.2 Environmental Monitoring Plan

Monitoring of environmental components and mitigation measures during implementation and operation stages is a key component of the EMP to safeguard the protection of environment. The objectives of the monitoring are to (i) monitor changes in the environment during various stages of the project life cycle with respect to baseline conditions; and (ii) manage environmental issues arising from construction works through closely monitoring the environmental compliances. A monitoring mechanism is developed for each identified impact and it includes the:

- location of the monitoring (near the Project activity, sensitive receptors or within the Project influence area);
- means of monitoring, i.e. parameters of monitoring and methods of monitoring (visual inspection, consultations, interviews, surveys, field measurements, or sampling and analysis); and
- frequency of monitoring (daily, weekly, monthly, seasonally, annually or during implementation of a particular activity)

The monitoring program will also include regular monitoring of construction and commissioning activities for their compliance with the environmental requirements as per relevant standards, specifications and EMP. The purpose of such monitoring is to assess the performance of the undertaken mitigation measures and to immediately formulate additional mitigation measures and/or modify the existing ones aimed at meeting the environmental compliance as appropriate during construction.

During construction, environmental monitoring will ensure the protection of air and noise pollution, community relations, and safety provisions. Given the sensitivity with respect to air quality and the need for additional information to assess the air quality and to assist the Government of Sindh in rationalization of standards, monitoring of PM_{10} and $PM_{2.5}$ in air quality is proposed starting at least two years before commissioning of the Project. Post monitoring evaluation will be carried to evaluate the impacts of the Project during first 3 years of operation of the Project. During operation, emissions, air, noise, and wastewater quality monitoring and greenbelt development around the plant will be important parameter of the monitoring program.

The environmental monitoring program is presented in **Table 9-2**.

Table 9-2: Environmental Monitoring during Construction and Operation

Parameter	*Location*	*Means of Monitoring*	*Frequency*	*Responsible Agency*	
				Implementing	*Supervising*
During Construction					
Handling and storage of parts and equipment at plant	Work Sites	Visual inspection	Daily	EPC Contractor	PIC/LPGCL/ GHCL
Top soil	Construction areas	Top soil of 0.5 m depth will be excavated and stored properly	Beginning of earth filling works	EPC Contractor	PIC/LPGCL/ GHCL
Erosion	Construction areas and material storage sites	Visual inspection of erosion prevention measures and occurrence of erosion	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Hydrocarbon and chemical storage	Construction camps	Visual Inspection of storage facilities	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Local roads	Approach Roads	Visual inspection to ensure local roads are not damaged	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Traffic safety	Access Roads	Visual inspection to see whether proper traffic signs are placed and flagmen for traffic management are engaged	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Air quality (dust, smoke)	Construction sites	Visual inspection to ensure good standard equipment is in use and dust suppression measures (spraying of waters) are in place.	Daily	EPC Contractor	PIC/LPGCL/ GHCL
	Material storage sites	Visual inspection to ensure dust suppression work plan is being implemented	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Air quality (PM, NO_2, SO_2, CO)	Suggested locations are: a) locations where the	Fixed air quality monitoring station (two) and mobile air quality monitoring station (one). Also see	Suggested frequency is continuously at two locations (fixed	EPC Contractor through External contractor or	PIC/LPGCL/ GHCL

Parameter	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implementing	Supervising
	impact of power plants, road traffic, and other sources are minimal; b) locations near the N-55; c) locations near maximum ground level concentration (GLC); and d) sensitive receptors (e.g. plant housing colony).	Section 9.10 Ambient Air Quality Monitoring Program	station) and once in a month at other locations for one day.	arrangements with educational or government agencies	
Noise	Construction sites	Visual inspection to ensure good standard equipment are in use	Weekly	EPC Contractor through a nationally recognized laboratory	PIC/LPGCL/ GHCL
		Hourly, day and night time noise levels (dB) monitoring using noise meters	Quarterly	EPC Contractor through a nationally recognized laboratory	PIC/LPGCL/ GHCL
Waste management	Construction camps and construction sites	Visual inspection that solid waste is disposed at designated site	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Drinking water and sanitation	In construction sites and construction camps	Ensure the construction workers are provided with safe water and sanitation facilities in the site	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
River water pollution by effluent	Construction sites along the Indus River	Ensure the construction workers are provided with sanitation facilities (temporary lavatories) in the site	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Odor (kitchen waste)	Waste storage facility	Visual inspection that those wastes are disposed of at designated sites	Monthly	EPC Contractor	PIC/LPGCL/

Parameter	*Location*	*Means of Monitoring*	*Frequency*	*Responsible Agency*	
				Implementing	*Supervising*
					GHCL
Odor (septic tank)	Lavatory	Visual inspection that the lavatories are properly managed.	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Cultural and archeological sites	At all work sties	Visual observation for chance finding	Daily	EPC Contractor	PIC/LPGCL/ GHCL
Reinstatement of work sites	All work sites	Visual Inspection	After completion of all works	EPC Contractor	PIC/LPGCL/ GHCL
Gender	Project site	Status of the Grievance Redress Mechanisms (GRM) establishment, The number of grievance	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
Infectious Diseases	Construction site	The number of reported infections	Regular health checks	EPC Contractor	PIC/LPGCL/ GHCL
Accidents and Safety	Construction site	The numbers, contents, and processing results of diseases, accident if occurred	Every day	EPC Contractor	PIC/LPGCL/ GHCL
Safety of workers	At work sites	Usage of Personal Protective equipment	Monthly	EPC Contractor	PIC/LPGCL/ GHCL
During Operation and Maintenance					
Wastewater drained into the river	At the point where effluent leaves within the plant boundary	SMART parameters (flow, temperature, pH, TSS, and oil & grease) and TDS for a 24 hour composite sample	Monthly	LPGCL	GHCL
		Heavy metals (Zn, Pb, Ni, Fe, Hg, Cu, Co, Cr, As, CD) for a 24 hour composite sample – in order to meet the regulatory requirement and IFC guidelines	Quarterly	LPGCL	GHCL

Parameter	Location	Means of Monitoring	Frequency	Responsible Agency	
				Implementing	Supervising
Municipal waste, industrial waste, hazardous waste	Waste storage facility at power plant	▪ Visual inspection that each waste is disposed of at designated site ▪ Evidenced documents (invoice, payment receipt, manifesto, etc.)	Monthly	LPGCL	GHCL
Ash	Department/person in charge of ash management	▪ Evidenced documents (delivery record, etc.) ▪ Agreement between cement company	Monthly	LPGCL	GHCL
Fish Fauna	At three locations: upstream of Project, point of effluent discharge and downstream of Project	Sampling surveys to determine abundance (catch per unit effort) and diversity of fish at selected locations	Annually in November	LPGCL	GHCL
Stack emissions	Prior to pre–treatment in ESP and FGD and at the exit of the stack	For the new stack for coal-fired boilers, continuous monitoring using on–line equipment during operation phase (SO_2, NO_x, CO, PM_{10} and $PM_{2.5}$) and exit gas temperature and velocity. Monthly monitoring as per the SMART rules through third-party contractor.	Continuous monitoring	LPGCL	GHCL
Ambient air quality	Near sensitive sites and settlements	24 hours air quality monitoring of PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO	Suggested frequency is: Continuously at two location (fixed station) and once every month at other locations for one day	LPGCL through nationally recognized laboratory/ with mobile lab to be owned by LPGCL for air quality monitoring	GHCL
Groundwater	At the baseline monitoring sites and	Sampling and laboratory analysis for heavy metals (Zn, Pb, Ni, Fe, Hg,	Bi–annually	LPGCL through nationally	GHCL

Parameter	*Location*	*Means of Monitoring*	*Frequency*	*Responsible Agency*	
				Implementing	*Supervising*
	from piezometers around the ash pond	Cu, Co)		recognized laboratory	
Noise	At the work areas, control rooms and nearest residential areas	Hourly, day and night time noise levels (dB) monitoring using noise meters	Quarterly	LPGCL through nationally recognized laboratory	GHCL
Odor (solid and liquid waste)	Waste storage facility	Visual inspection that those wastes are disposed of at designated sites	Monthly	LPGCL	GHCL
Odor (septic tank)	Lavatory	Visual inspection that the lavatories are properly managed.	Monthly	LPGCL	GHCL
Odor (spontaneous ignition of coal)	Coal yard	Visual inspection	Continuous	LPGCL	GHCL
Odor (spontaneous ignition of ash)	Ash pond	Visual inspection	Continuous	LPGCL	GHCL
Coal and fly ash specifications		Heavy metals (Mainly As, Be, Cd, Cr, Pb, Hg, and Ni)	Every lot of coal (and ash produced) received from abroad and quarterly on local coal.	LPGCL through recognized laboratory (as part of operations)	GHCL
Grievances on Land Acquisition, Resettlement, Living and Livelihood, Use of Land, Water and Social Infrastructure, Social conflicts, Unevenness of Project	NA	The numbers, contents, and processing results of grievances	Everyday	Public Complaints Unit (PCU), Grievance Redress Committee (GRC), Grievance Focal Points (GFPs)	GHCL

Parameter	*Location*	*Means of Monitoring*	*Frequency*	*Responsible Agency*	
				Implementing	*Supervising*
Benefits					
Gender	Project site	Status of the Grievance Redress Mechanisms establishment, the number of grievance	Monthly	Public Complaints Unit (PCU), Grievance Redress Committee (GRC), Grievance Focal Points (GFPs)	GHCL

Source: JICA Survey Team

9.3 Institutional Framework

Figure 9-1 and **Figure 9-2** present the structure of the project organization for construction and operation phase. Institutions responsible for executing and monitoring the environmental aspects of this Project are:

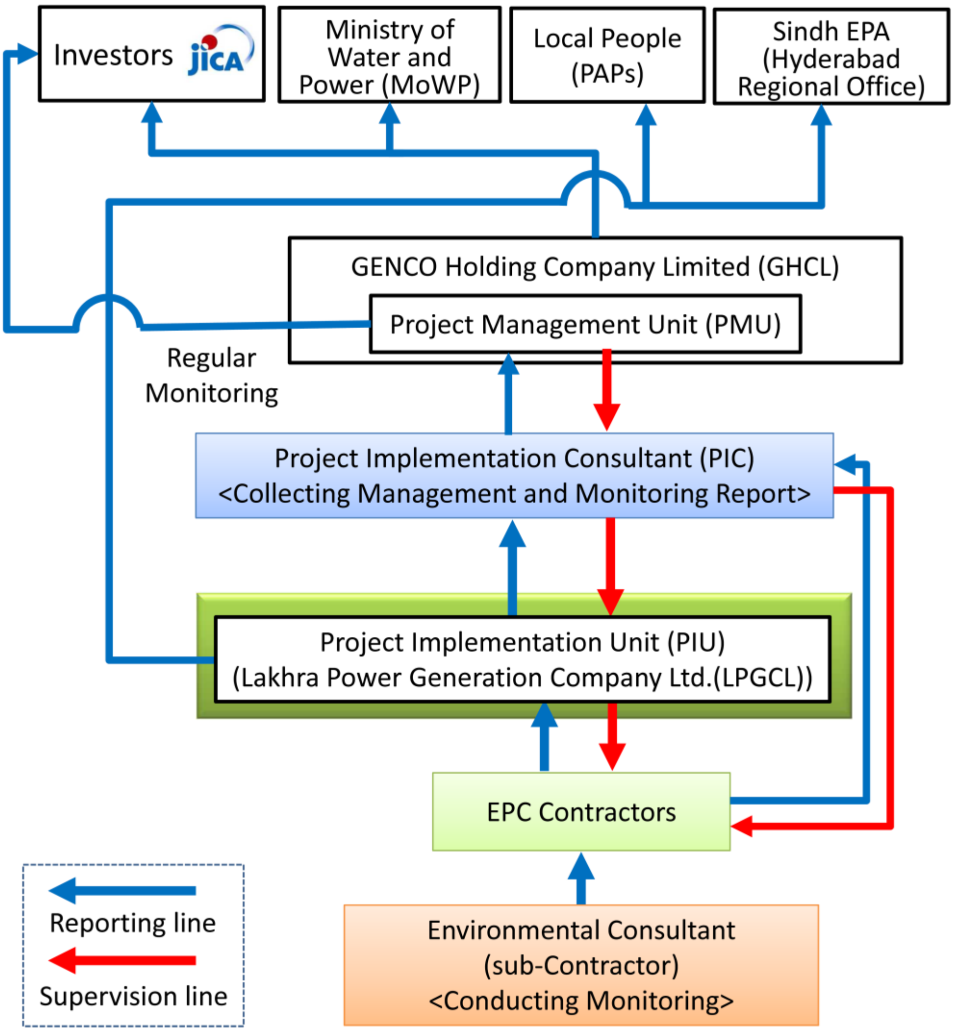
- Project Management Unit (PMU) at the GHCL Headquarters, and,
- Project Implementation Unit (PIU) at LPGCL.

PMU and PIU will ensure that the mitigation and management measures proposed in the EIA are properly implemented. The top management of LPGCL and GHCL will ultimately head the PIU and PMU. For this purpose, LPGCL and GHCL will develop internal institutional capacity for environmental management (**Section 9.4**).

The Project Implementation Consultant (PIC) will be primarily responsible for the implementation of the EMP, and will report to the PMU. The PIC will be engaged at the start of the Project and will remain engaged through the construction and commissioning of the Project. The PIU will supervise, while PMU will monitor the implementation of the EMP. The PIC will ensure that all activities of the EPC contractor(s) carried out under the Project comply with the JICA guidelines and international standards and will provide necessary guidance and supervision to PIU for this purpose. As the EPC contractors will be working simultaneously for timely and speedy implementation of the project, it is important that PIC ensures that the environmental activities are being implemented in the field. The PIC will also be responsible to update or make necessary changes to the EMP if required based on the revised designs and locations.

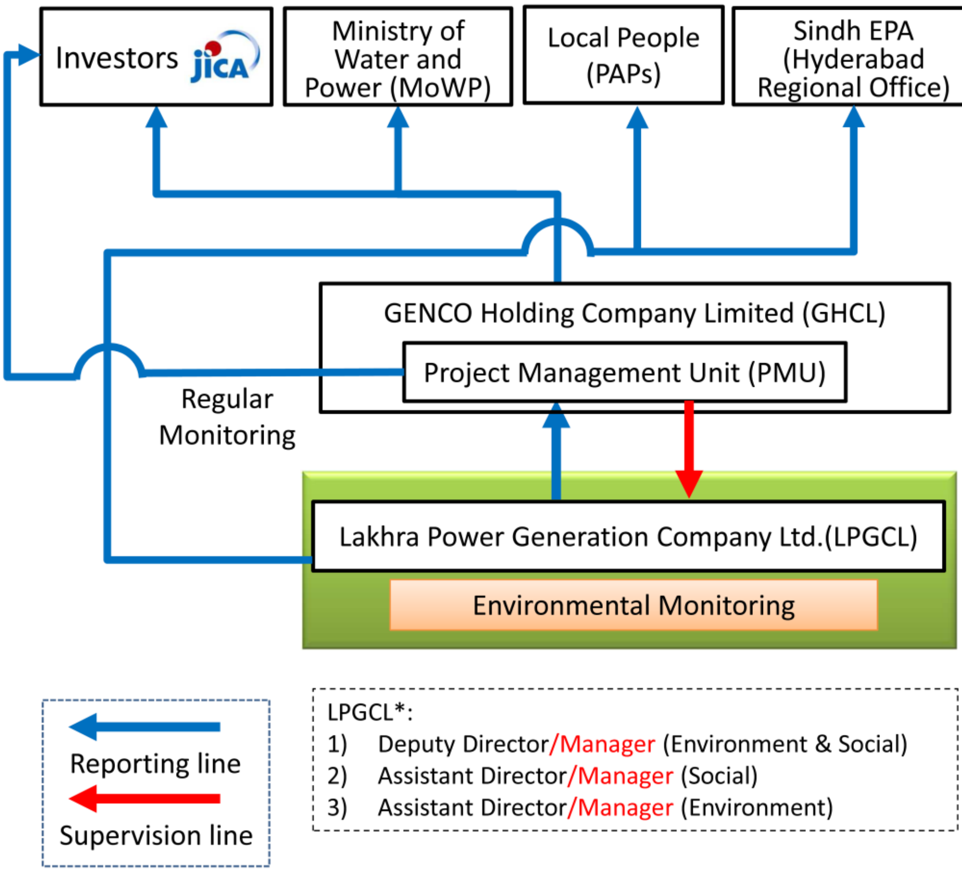
Each EPC contractor engaged for this project will be responsible for implementation of the EMP to the extent that it applies to the contractor's area of work. Each contractor will be recommended to have an environmental management system compliant with ISO 14001:2004 Environmental Management System (EMS) certification. The major contractors will be required to have one Environmental Specialist and one Occupational Health and Safety Specialist, who will be working in close coordination with the environmental staff of PIC and LPGCL. .

A Recycling Marketing Expert will work under the PIC in order to market the ash, liaise between LPGCL and cement manufacturers and facilitate the signing of ash purchase agreement between LPGCL and cement manufacturers.



Source: GHCL

Figure 9-1: Project Organization (Construction Phase)



Source: GHCL

Figure 9-2: Project Organization (Operation Phase)

9.4 Institutional Strengthening

The plant laboratory, part of the LPGCL, will be responsible for monitoring of environmental conditions at the plant. A Health, Safety and Environment (HSE) Department will be established under LPGCL as part of the Project. Initially, the HSE Department will be tasked to oversee all environmental, health and safety related issues arising during the implementation of the corrective action plan. Eventually, this department will be responsible for environmental management of the entire plant during operation and maintenance.

The department will be headed by an EHS Manager. The person will have qualification in environmental sciences or environmental engineering, and have 7 year experience in environmental management in industrial units preferably in thermal power sector . The person will have at least 5 years of experience in environmental management in industrial units.

A Resettlement Specialist will be hired for the duration land acquisition and resettlement period.

9.5 Reporting and Feedback Mechanism

The Contractor will prepare a ‘Construction Environmental Action Plan’ (CEAP) demonstrating the manner in which they will comply with the requirements of mitigation measures proposed in the EMP of the EIA Report. The CEAP will form the part of the contract documents and will be used as monitoring tool for compliance. Violation of the compliance requirements will be treated as non–compliance leading to the corrections or otherwise imposing penalty on the contractors.

Contractor, through the environmental specialist on the team, will prepare monthly status reports on the EMP implementation. Such reports must carry information on the main types of activities carried out within the reporting period, status of any clearances/permits/licenses which are required for carrying out such activities, mitigation measures applied, and any environmental issues emerged in relations with suppliers, local authorities, affected communities, etc. Contractor’s monthly status reports shall be submitted to the PIC and LPGCL.PIC will prepare monthly reports on the status of EMP implementation and environmental performance of the contractor, which shall be submitted to LPGCL/GHCL for onward submission to financing agencies/EPA. These reports will be based on the contractor’s reports and their supervision. PIC will assess the accuracy of factual information provided in the contractor’s reports, fill any gaps identified in them, and evaluate adequacy of mitigation measures applied by contractor. PIC will highlight any cases of incompliance with EMPs, inform on any acute issues brought up by contractor or revealed by supervisor himself, and propose corrective actions.

The LPGCL will prepare annual environmental reports during construction and operation. The construction period environmental report will contain information on status of EMP implementation and environmental performance of the contractor; any damage to the environment, and corrective measures taken. The report will also provide monitoring data and analysis. The environmental report, after plant commissioning, will be based on the operation phase EMP, which will be submitted to SEPA prior to plant operation. It may contain information on status of EMP implementation, environmental performance of LPGCL, and monitoring data and its analysis. The annual environmental reports will be shared with SEPA, institutional stakeholders (e.g., educational institutions), government departments (such as the Irrigation Department and Fisheries Department) and will also be available to the community. Copies of summary of the report in Sindhi will be made available to community elders and representatives.

The GHCL will report to the JICA on the status of environmental compliance once in a quarter during construction period and once in a half year in the first two years during operation period. The monitoring form is presented in Appendix 15. Such reporting will contain information on all violations identified and the actions taken for fixing of such cases. GHCL will inform JICA on any major environmental issues at any time, independently from the schedule of regular reporting.

After project completion, LPGCL will be in charge of the operation and maintenance of the Project. HSE Department of LPGCL will be responsible for compliance with the monitoring plan during O&M.

Feedback and adjustment will be carried out in two tiers. Upon request for EMP modification by the Contractor and LPGCL will review the proposals in detail and consider their acceptance or rejection. Only those modifications will be considered, which do not contradict to the Conditions of the Environmental Permit. LPGCL will consider comments and suggestions from PIC and JICA. Appropriate responses and revisions in the EMP will be implemented, if necessary. The contractor and LPGCL will then implement the modifications.

LPGCL will be responsible for enforcing compliance of contractor with the terms of the contract, including adherence to the EMP. For minor infringements, an incident which causes temporary but reversible damage, the contractor will be given 48 hours to remedy the problem and to restore the environment. If restoration is done satisfactorily during this period, no further actions will be taken. If it is not done during this period, GHCL will arrange for another contractor to do the restoration, and deduct the cost from the offending contractor's next payment. For major infringements, causing a long-term or irreversible damage, there will be a financial penalty up to 1% of the contract value in addition to the cost for restoration activities.

9.6 Performance Indicators

The environmental parameters that may be qualitatively and quantitatively measured and compared are selected as 'performance indicators' and recommended for monitoring during project implementation and O&M stages. These monitoring indicators will be continuously monitored to ensure compliance with the national or other applicable standards and comparison with the baseline conditions established during design stage. The list of indicators and their applicable standards to ensure compliance are given below. The monitoring data will be reviewed on a regular basis (as and when collected and annually) to determine trends and issues. The performance indicators are given in **Table 9-3**.

Table 9-3: Performance Indicators

Aspect	*Indicator*
Stack emissions (SO_2, NO_2, PM_{10})	As per specifications of emissions control equipment manufacturers and/or supplier.
Ambient air quality (PM_{10}, $PM_{2.5}$, SO_2, and NO_2)	Requirement of IFC EHS Guidelines and the NEQS for Ambient Air (Table 1-6 of APPENDIX 1)
Noise levels	Requirement of IFC EHS Guidelines and the NEQS for Ambient Noise (Table 1-7 of APPENDIX 1
Wastewater Quality	Requirement of IFC EHS Guidelines and the NEQS for Wastewater Quality (Table 1-1 of APPENDIX 1)
Groundwater Quality	Baseline values to be established. Monitoring wells will be installed for the ash pond. Groundwater samples will be collected from the monitoring wells.

9.7 Training Program

The planned training program is shown in **Table 9-4**.

Table 9-4: Training Program

	Type of Training	*Training By*	*Personnel to be Trained*	*Training Description*	*Period*	*Duration*
1	Occupational Health and Safety	External Sources	EHS Manager, Plant managers and supervisors	Training will be provided to aware staff to conform to safety codes. The plant manager will ensure the mandatory use of PPE by the senior administration during all plant visits. That will attract other junior and maintenance staffs to abide by the rules. Precautions to be taken for working in confined areas.	Before starting of project activities	Full day (8 hour session)
2	Occupational Health and Safety	EHS Manager	Workers Staff	Health, safety and hygiene Proper usage of personnel protective gear Precautions to be taken for working in confined areas.	Before starting of project activities During project activities	Full day (8 hour session)
3	Health, Safety and Environmental Auditing	External Source	Staff responsible for inspection/audits	Procedures to carry out Health, Safety and Environmental Audits Reporting requirements	Before starting of project activities	Full day (8 hour session)
4	Waste Disposal and Handling	External Sources	Relevant Workers Relevant Staff	Segregation, identification of hazardous waste, use of PPEs, waste handling	Before starting of project activities	Full day (8 hour session)
5	Social & environmental laws & regulations, norms, procedures and guidelines of government and JICA	External sources	EHS staff Plant managers and supervisors	Environmental standards and their compliance JICA and Govt. regulations	Before starting the project activities	Full day (8 hour session)

	Type of Training	*Training By*	*Personnel to be Trained*	*Training Description*	*Period*	*Duration*
6	Pollution monitoring, Pollutant analysis & Pollution control facilities	External sources	EHS staff Plant managers and supervisors	The understanding for the basic theory and pollution abatement	Before starting the project activities	Full day (8 hour session)
7	Implementation of environmental management and monitoring plant	External Sources	EHS staff Responsible supervisory staff Management	Concepts of environmental management and monitoring plan	Once in 3 months during the entire construction period	Full day (8 hour session)

9.8 Specific Management Plans

9.8.1 Waste Management Plan

The waste inventory and disposal plan is presented in **Table 9-5**.

Table 9-5: EMP for Waste Management

	Material Waste	*Final Disposal Method*	*Associated Risks*	*Recommended Procedure*
1	Iron	• Material returned to Store as unserviceable • Scrap Store • Recycling	• Equipment and parts may be contaminated with oil or other liquids. This may pose hazards during recycling and/or melting.	• Separate contaminated parts and ensure disposal contractor cleans and removes contaminations before recycling equipment.
2	Copper	• Recycling • Scrap Store	• Copper wires and tubes may be covered with insulation and may pose hazard if melted.	• Separate insulated copper from rest and ensure disposal contractor removes it before recycling.
3	Other Materials	• Material returned to Store as unserviceable • Scrape Store • Recycling • Landfill	• Some waste materials may contain hazardous materials (such as mercury and lead) which may pose health risks if not handled or disposed of properly.	• All hazardous substances such as lead and mercury will be identified and separated. • Ensure waste contractor disposes hazardous materials in accordance with accepted methods.
4	Wood, Cotton, Plastic, Waste and Packing Materials	• Recycling • Landfill	• Burning of wood, paper, plastic and other materials may cause air pollution • Littering due to improper disposal	• Ensure waste contractor disposes all non–recyclable plastic wastes and other non–recyclable materials at land disposal.
5	Electronics	• Material returned to Store as unserviceable	• Some electronic equipment may contain toxic materials and pose a health risk if opened or dismantled.	• Ensure contractor disposes equipment properly and equipment is opened only under guidance of qualified professional.
6	Insulation	• Material Re–used • Landfill	• Burning may cause air pollution. • Littering due to improper disposal	• Ensure properly certified recycling contractors are used.

	Material Waste	*Final Disposal Method*	*Associated Risks*	*Recommended Procedure*
7	Oil	• Recycling Contractors	• May cause contamination of soil or waterways	• Ensure properly certified recycling contractors are used.
8	Concrete	• Landfill or reuse as for filling	• None	• Ensure safe storage till disposal

9.8.2 Construction Management Plan

The construction contractor will develop a specific construction management plan (CMP) based on the CMP included in the **Table 9-6**. The CMP will be submitted to the LPGCL and JICA for approval.

The CMP will clearly identify all areas that will be utilized during construction for various purposes. For example, on a plot plan of the construction site the following will be shown:

- Areas used for camp
- Storage areas for raw material and equipment
- Waste yard
- Location of any potentially hazardous material such as oil
- Parking area
- Loading and unloading of material
- Septic tanks
- Stormwater run-off direction and control measures

Table 9-6: Construction Management Plan

Aspect	*Objective*	*Mitigation and Management Measure*
Vegetation clearance	Minimize vegetation clearance and felling of trees	Not applicable to the Project (N/A)
Poaching	Avoid illegal poaching	N/A
Discharge from construction sites	Minimize surface and ground water contamination Reduce contaminant and sediment load discharged into water bodies affecting humans and aquatic life	• Install temporary drainage works (channels and bunds) in areas required for sediment and erosion control and around storage areas for construction materials • Prevent all solid and liquid wastes entering waterways by collecting waste where possible and transport to approved waste disposal site or recycling depot • Ensure that tires of construction vehicles are cleaned in the washing bay (constructed at the entrance of the construction site) to remove the mud from the wheels. This will be done in every

Aspect	Objective	Mitigation and Management Measure
		exit of each construction vehicle to ensure the local roads are kept clean.
Soil Erosion and siltation	Avoid sediment and contaminant loading of surface water bodies and agricultural lands.	• Minimize the length of time an area is left disturbed or exposed. • Reduce length of slope of runoff • Construct temporary cutoff drains across excavated area • Setup check dams along catch drains in order to slow flow and capture sediment • Water the material stockpiles, access roads and bare soils to minimize dust. • Increase the watering frequency during periods of high risk (e.g. high winds) • All the work sites (except permanently occupied by the plant and supporting facilities) will be restored to its initial conditions (relief, topsoil, vegetation cover).
Excavation, earth works, and construction yards	Proper drainage of rainwater and wastewater to avoid water and soil contamination.	• Prepare a program for prevent/avoid standing waters, which PIC will verify in advance and confirm during implementation • Establish local drainage line with appropriate silt collector and silt screen for rainwater or wastewater connecting to the existing established drainage lines already there
Ponding of water	Prevent mosquito breeding	• Establish local drainage to avoid ponding of water
Storage of hazardous and toxic chemicals	Prevent spillage of hazardous and toxic chemicals	• Implement waste management plans • Construct appropriate spill containment facilities for all fuel storage areas
Land clearing	Preserve fertile top soils enriched with nutrients required for plant growth or agricultural development.	• Strip the top soil to a depth of 15 cm and store in stock piles of height not exceeding 2 m and with a slope of 1:2 • Spread the topsoil to maintain the physio–chemical and biological activity of the soil. • The stored top soil will be utilized for covering all disturbed area and along the proposed plantation sites
	Avoid change in local topography and disturb the natural rainwater/ flood water drainage	• Ensure the topography of the final surface of all raised lands are conducive to enhance natural draining of rainwater/flood water; • Reinstate the natural landscape of the ancillary construction sites after completion of works
Construction vehicular traffic	Control vehicle exhaust emissions and combustion of fuels.	• Use vehicles with appropriate exhaust systems and emission control devices. • Establish and enforce vehicle speed limits to minimize dust generation • Cover haul vehicles carrying dusty materials (cement, borrow and quarry) moving outside the

Aspect	*Objective*	*Mitigation and Management Measure*
		construction site • Level loads of haul trucks travelling to and from the site to avoid spillage • Use of defined haulage routes and reduce vehicle speed where required. • Transport materials to site in off peak hours. • Regular maintenance of all vehicles • All vehicle exit points from the construction site shall have a wash-down area where mud and earth can be removed from a vehicle before it enters the public road system.
	Minimize nuisance due to noise	• Maintain all vehicles in good working order • Make sure all drivers comply with the traffic codes concerning maximum speed limit, driving hours, etc.
	Avoid impact on existing traffic conditions	• Prepare and submit a traffic management plan • Restrict the transport of oversize loads. • Operate transport vehicles, if possible, in non–peak periods to minimize traffic disruptions.
	Prevent accidents and spillage of fuels and chemicals	• Restrict the transport of oversize loads. • Operate transport vehicles, if possible, in non–peak periods to minimize traffic disruptions. • Design and implement safety measures and an emergency response plan to contain damages from accidental spills. • Designate special routes for hazardous materials transport.
Construction machinery	Prevent impact on air quality from emissions	• Use machinery with appropriate exhaust systems and emission control devices. • Regular maintenance of all construction machinery • Provide filtering systems, duct collectors or humidification or other techniques (as applicable) to the concrete batching and mixing plant to control the particle emissions in all stages
	Reduce impact of noise and vibration on the surrounding	• Appropriately site all noise generating activities to avoid noise pollution to local residents. • Ensure all equipment is in good repair and operated in correct manner. • Install high efficiency mufflers to construction equipment. • Operators of noisy equipment or any other workers in the vicinity of excessively noisy equipment are to be provided with ear protection equipment • The project shall include reasonable actions to ensure that construction works do not result in vibration that could damage property adjacent to the works.

Aspect	*Objective*	*Mitigation and Management Measure*
Construction activities	Minimize dust generation	• N/A
	Reduce impact of noise and vibration on the surrounding Avoid driving hazard where construction interferes with pre–existing roads.	• Notify adjacent landholders or residents prior to noise events during night hours • Install temporary noise control barriers where appropriate • Avoid working during 21:00 to 06:00 within 500 m from residences.
	Minimizing impact on water quality	• Stockpiles of potential water pollutants (i.e. bitumen, oils, construction materials, fuel, etc.) shall be located so as to minimize the potential of contaminants to enter local watercourses or storm-water drainage.
		• Storm-water runoff from all fuel and oil storage areas, workshop, and vehicle parking areas is to be directed into an oil and water separator before being discharged to any watercourse. • An Emergency Spills Contingency Plan specifically for construction shall be prepared (see also **Section 9.8.5**).
Siting and location of construction camps	Minimize impact from construction footprint	• Arrange accommodation in local towns for small workforce • Locate the construction camps at areas which are acceptable from environmental, cultural or social point of view.
Construction Camp Facilities	Minimize pressure on local services	• Adequate housing for all workers • Safe and reliable water supply. • Hygienic sanitary facilities and sewerage system. • Treatment facilities for sewerage of toilet and domestic wastes • Storm water drainage facilities. • In–house community entertainment facilities.
Disposal of Waste	Minimize impacts on the environment	• Ensure proper collection and disposal of solid wastes in the approved disposal sites • Store inorganic wastes in a safe place within the household and clear organic wastes on daily basis to waste collector. • Establish waste collection, transportation and disposal systems • Ensure that materials with the potential to cause land and water contamination or odor problems are not disposed of on the site. • Ensure that all on-site wastes are suitably contained and prevented from escaping into neighboring fields, properties, and waterways, and the waste contained does not contaminate soil, surface or groundwater or create unpleasant odors

Aspect	*Objective*	*Mitigation and Management Measure*
		for neighbors and workers.
Fuel supplies for cooking purposes	Discourage illegal fuel wood consumption	• Provide fuel to the construction camps for domestic purpose • Conduct awareness campaigns to educate workers on preserving the protecting the biodiversity and wildlife of the project area, and relevant government regulations and punishments on wildlife protection.
Site Restoration	Restoration of the construction camps to original condition	• Restore the site to its condition prior to commencement of the works
Construction activities near religious and cultural sites	Avoid disturbance to cultural and religious sites	• Stop work immediately and notify the site manager if, during construction, an archaeological or burial site is discovered. • It is an offence to recommence work in the vicinity of the site until approval to continue is given by the plant management. • Maintain appropriate behavior with all construction workers especially women and elderly people • Resolve cultural issues in consultation with local leaders and supervision consultants
Best practices	Minimize health and safety risks	• Implement suitable safety standards for all workers and site visitors which will not be less than those laid down on the international standards (e.g. International Labor Office guideline on 'Safety and Health in Construction; World Bank Group's 'Environmental Health and Safety Guidelines') and contractor's own national standards or statutory regulations, • Provide the workers with a safe and healthy work environment, taking into account inherent risks in its particular construction activity and specific classes of hazards in the work areas, • Provide personal protection equipment (PPE) for workers, such as safety boots, helmets, masks, gloves, protective clothing, goggles, full–face eye shields, and ear protection. • Maintain the PPE properly by cleaning dirty ones and replacing them with the damaged ones.
Water and sanitation facilities at the construction sites	Improve workers' personal hygiene	• Provide portable toilets at the construction sites and drinking water facilities. • Portable toilets will be cleaned once a day. • All the sewerage will be pumped from the collection tank once a day into the common septic tank for further treatment.

9.8.3 Coal Dust Management Plan

Coal dusts from the stockpile and conveyor belt area are the major source of fugitive emissions. Two methods of dust control will be implemented: dust extraction and dust suppression.

Dust suppression using a sprinkler system will be employed to control coal dust from the conveyor belt and stockpile area. The dust suppression will comprise wetting air–borne dust particles with a fine spray of water, causing the dust particles to agglomerate and move by gravity to the coal stream flow. Once properly wetted, the dust particles will remain wet for some period and will not tend to become airborne again. The dust suppression system in the stockpile yard will consist of swiveling and wide–angle full–cone spray nozzles. These nozzles will be provided on both sides of the pile and at ground level, spaced every 50 m.

In the coal dust extraction system, dust will be extracted from screening feeders and belt feeders by suctioning the dust–laden air and trapping coal particles in fine water sprays, thereafter discharging the clean air into the atmosphere. The dust collection equipment will include cyclones, wet scrubbers, fans, collecting hoppers, filters, hoods, ducts, dampers, and drain pipes. In this system, the dust–laden air will enter the collector where it comes in contact with water; the slurry will be collected in the hopper and disposed of in the settling pond. Settle dust will be put back into the stockyard where it will be mixed with crushed coal for use. In addition, roof extraction fans will be provided in essential areas like crusher house and boiler bunker floors. Air conditioning for control room and pressurized ventilation with unitary air filter unit for Electrical and Control buildings of coal handling plant will be provided.

Rainfall runoff from the coal pile and runoff from the application of dust suppression sprays will contain mainly suspended solids. This runoff will be routed to the wastewater treatment facility.

The volatility of the coal of this Project is high, easy to cause spontaneous combustion; therefore, the coal at the yard must be stored in different piles and compacted. Coal will be used as soon as possible, with regular rearrangement of the coal piles. The bucket wheel machine will be equipped with a water tank to spray water over the fly dust points so as to reduce the fly dust. The coal pile will have an automatic temperature monitoring system; when an increase in temperature is detected an alarm will be immediately triggered to alert personell of the presence of hot spots. Based on the temperature and the risks, the coal will be either sent to the boiler for utilization immediately, or that portion of coal will be isolated and allowed to burn off. Coal fires cannot be extinguished by water. The rubber belt of the belt conveyer shall use flame retardant material.

9.8.4 Ash Management

The ash pond area will initially be about 265,000 m^2. During operation, additional ash ponds would be constructed in phases. This will enable the ponds to be filled properly, and in case of future reclamation, the process will be easier. The ash pond will be lined with a layer of HDPE membrane or clay liner in order to avoid water seepages to the ground.

The options of ash utilization including the ash–based products include:

- Brick/Block/Tiles Manufacturing
- Cement Manufacturing
- Roads and Embankment Construction
- Structural Fill for Reclaiming Low Lying Areas
- Mine-Filling
- Agriculture, Forestry and Wasteland Development
- Part Replacement of Cement in Mortar, Concrete and Ready Mix Concrete Hydraulic Structure (Roller Compacted Concrete)
- Ash Dyke Raising
- Building Components – Mortar, Concrete,
- Concrete Hollow Blocks, Aerated Concrete Blocks etc.
- Fill material for structural applications and embankments
- Ingredient in waste stabilization and/or solidification
- Ingredient in soil modification and/or stabilization
- Component of flowable fill
- Component in road bases, sub–bases, and pavement
- Mineral filler in asphalt
- Other Medium and High Value Added Products (Ceramic Tiles, Wood, Paints), Pavement Blocks, Light Weight Aggregate, Extraction of Alumina, Cenospheres, etc.

The following strategies will be adopted to ensure full fly ash utilization in brick and cement block manufacturing: During the first three years a study will be undertaken to ascertain the market for utilization of fly as in cement and other industry. Subsequently, the LPGCL will enter into formal contract with the cement unit(s) to sell the fly ash. The contract will be commissioned before the commissioning of the power plant. In case this agreement could not be reached, purchase of additional land for landfill may be mandated.

Practically there should not be any leachate from ash pond due to provision of impermeable layer at the bottom of ash pond. However, a groundwater monitoring program is recommended to detect any possible groundwater contamination from ash pond. 3 piezometers, one on upstream, 2 on downstream of the ash pond will be installed for collection of water levels and water samples.

9.8.5 Spill Management Plan

Liquid waste spills shall be appropriately managed not to have the potential to harm the environment. By taking certain actions LPGCL can ensure that the likelihood of spills occurring is reduced and that the effect of spills is minimized.

Avoiding Spills

By actively working to prevent spills, LPGCL can save money and time by not letting resources go to waste. In addition, the environment is protected from contaminants that can potentially cause harm.

All liquids will be stored in sealed containers that are free of leakage. All containers will be on sealed ground and in an undercover area. Keep sharp parts and items away from containers containing liquid to avoid damage and leaks.

Bunding: To prevent spills from having an effect on the plant site operations or the environment, bunding will be placed around contaminant storage areas. A bund can be a low wall, tray, speed bump, iron angle, sloping floor, drain or similar and is used to capture spilt liquid for safe and proper disposal.

Spill Management

To enable spills to be avoided and to help the cleanup process of any spills, both management and staff members should be aware of spill procedures. By formalizing these procedures in writing, staff members can refer to them when required thus avoiding undertaking incorrect spill procedures. As part of the overall EMP for the site, spill procedures will be practiced by holding drills. A detailed Spill Management Plan will be prepared that will contain the following:

- Identification of potential sources of spill and the characterization of spill material and associated hazards.
- Risk assessment (likely magnitude and consequences).
- Steps to be undertaken taken when a spill occurs (stop, contain, report, clean up and record).
- A map showing the locations of spill kits or other cleaning equipment.

Spill Kits

Spill kits are purpose designed units that contain several items useful for cleaning up spills that could occur. Typical items are:

- Safety gloves and appropriate protective clothing (depending on the type of chemicals held onsite).
- Absorbent pads, granules and/or pillows.
- Booms for larger spills.

- Mops, brooms and dustpans.

Spill kits are used to contain and clean up spills in an efficient manner. LPGCL will have enough spill kits or big enough spill kits to deal with any potential spills. Spill kits will be kept in designated areas that are easily accessible to all staff.

Staff members will be trained in using the spill kit correctly. The supplier may do this at the time of purchase or the management may organize it itself.

After cleaning up a spill, the materials used to clean up will be disposed of correctly. Depending on the spill material, the used material may be disposed in the hazardous waste facility or the landfill site.

Responding to Spills

Stop the source: If it is safe to do so, the source of the spill will be stopped immediately. This may be a simple action like upturning a fallen container.

Contain and control the flow: To stop the spill from expanding, absorbent materials and liquid barriers will be placed around the spill. Work from the outside to soak up the spill. It is vital that spilt liquid is not allowed to reach storm water drains, sewer drains, natural waterways or soil. For large scale spills that involve hazardous materials, authorities may have to be alerted.

Clean up: Using information from Material Safety Data Sheets (MSDS) about the properties of the liquid spilled and the spill equipment available, spills will be cleaned up promptly.

Record the incident: By keeping a simple log of all spills, precautionary measures can be put in place to avoid similar accidents from occurring in the future.

9.8.6 Fire Emergency Response Plan

A firefighting system will be installed in the LPGCL with a standard operating procedure considering the potential fire from the sparks in coal storage and handling.

9.8.7 Transportation Management Plan

A detailed transportation management plan will be prepared through the PIC. The outline of the plan is as follows:

- *Objective*: To protect the community and environment from potential hazards of coal unloading and bulk transportation and to protect the workers of LPGCL and its contractors from occupational hazards of associated with bulk transportation of material.

- *Scope:* The plan will cover both rail and road transportation of all material including, but not limited to, coal, equipment, ash, limestone, construction material and gypsum.

- *Referring Documents:* The Plan will be prepared in light of the preparatory survey[1] conducted by JICA and this EIA of the Project.

[1] Preparatory survey for Lakhra coal fired thermal power plant construction project, JICA (2014)

- *Timeline:* The Plan for the construction phase of the Project will be completed before the start of construction activity and arrival of the equipment on port. The Plan for the operations phase will be completed at least one year before commissioning of the Project.

- *Executing Arrangement:* The PIC will be responsible to commission the study and implement its recommendations.

9.9 Social Augmentation Program

Social Augmentation Program is defined as corporate social responsibility (CSR) program and is beyond the scope of the EIA and EMP for GHCL. An effective CSR program is essential for the long-term sustainability of a firm and its' projects. The broadest definition of CSR considers CSR in a holistic way where it is a means on the part of a firm to engage and maintain a meaningful relationship with a wide spectrum of stakeholders, individual or group that might affect or be affected by the organization's activities, including employees, suppliers, contractors, customers, clients, shareholders, government, communities and non-governmental organizations. It is also recognized as a way of dealing with indirect or subtle environmental and social impacts of the firm's activities, particularly impacts that may not have been directly captures and mitigated in the EIA. The social augmentation program is proposed in this context. It can also be seen as a means of investing back in the host communities some of the profits earned by the firm.

The specific measure of the proposed social augmentation programs are explained below. These programs are proposed based on the community needs as identified by the community itself.

Water Supply Facility

The people living in the community surrounding the LPGCL site reported that they suffer from severe shortage of water for safe drinking, cooking, washing, bathing. The Lakhra Power Plant Pipeline (LPPP), Water Tankers (WT), Sindh Government Water Scheme (SGWS) are the major water supply system identified in the rural settlements. SGWS supplies tap water from Habibullah Mor to six rural settlements including Manzurabad, Khanot, Koreja, Jan Muhammad Khoso, Mir Dost Khoso and Paryo Khan Dia Dano. Residents reported that the scheme is only functional for certain period of the year. In Paryo Khan Dia Dano, the scheme is non–functional and the pump, motor and other water supply equipment have been stolen, rendering the structure unfit for functioning.

As a result, people purchase water from WT for domestic use. On average, four or more tankers are consumed in one month depending on the financial capability. However, the poorer residents and villagers utilize untreated water from the Indus River, groundwater or hand pump water the poor water quality causes health issues.

This Environmental Management Plan (EMP) proposes financial support to repair the existing un-functional water schemes in order to contribute on provision of drinking water to communities and improvement of the general health of the residents

Health Care

There are four District Head Quarter Hospitals (DHQs) in the entire Jamshoro district, (one located in each taluka), five Rural Health Centers (RHCs), 16 Basic Health Units (BHUs) and six government dispensaries. These facilities are equipped for primary health care services and to some extent comprehensive emergency obstetric care services. In the study area, the following health facilities are observed.

Type of Health Care Facilities	***Location***	***Notes***
Private hospital	Habibullah Mor	Named Zainab Trust - Functional and opens every Friday, Saturday and Sunday
BHU	Khanot	Facilities are insufficient and inefficient
Government dispensaries	Zimi	Not functional
	Manzurabad	Facilities are insufficient and inefficient
	Wapda Colony	Exclusively for colony residents only

Communities indicated that the government health facilities are insufficient and inefficient, mainly because of lack of qualified doctors and quality medicines. People requested for creating an opportunity for their health care.

It is proposed to support improving the buildings, purchasing equipment, repair and purchase furniture's for both BHU in Khanot and one primary health care clinic in Manzurabad.

Training and Capacity Building Activities

People reported that lack of job opportunities in the vicinity of the project area. This EM proposes economical contribution to skills training and capacity building activities for the communities, especially for the women, youth and people below average income. This would enhance their earnings and living standards. Training programs will focus in skill development in construction and power industries.

Tentative Budget for Social Benefits

The proposed Social Augmentation Plan (SAP) will cover social enhancement measures to the project affected communities. It includes all costs including construction of facilities, fixtures and furniture and all other administrative and operation costs such as hiring of implementing NGO(s), and monitoring of the implementation arrangements by the consultants. The total estimated budget for the SAP is US$ 122,320 million, as presented in **Table 9-7**.

Table 9-7: Social Augmentation Plan Implementation Cost Estimates

Activity	Social Augmentation and Monitoring Costs			
	Unit	Quantity	Cost in US Dollars	
			Rate	Amount
Social Augmentation Costs – Civil Works				
Construction/Rehabilitation of Drinking Water Supply Scheme	No.	6	4,000	24,000
Rehabilitation of Primary Health Care Clinic, Manzurabad	No.	1	6,000	6,000
Rehabilitation of Basic Health Unit, Khanot	No.	1	9,000	9,000
Sub–total (a):	**–**	**–**	**–**	**39,000**
Operational Costs of Project Provided Facilities				
NGO Training Services (3 Trainers)	Years	3	2,500	7,500
Primary Health Training Equipment & Material	Sites	2	2,500	5,000
Skills Training for Women and Youth	Sites	2	2,500	5,000
Sub–total (b):	**–**	**–**	**–**	**17,000**
Social Monitoring During Project's Construction				
Domestic Social Development Specialist (periodic input)	Months	0.5 months/trip x 4 trips/year x 3 years	8,000	48,000
Vehicle Rental for Social Development Specialist	Months	0.25 months/trip x 4 trips/year x 3 years	2,400	7,200
Sub–total (c)	**–**	**–**	**–**	**55,200**
Total Itemized Costs (a+b+c)	–	–	–	111,200
Admin. Costs & Contingency (10% of Total Itemized Cost)	–	–	–	11,120
Total Estimated Cost (USD)	**–**	**–**	**–**	**122,320**

9.10 Ambient Air Quality Monitoring Program

An ambient air quality monitoring program will be initiated in the Lakhra Area. The outline of the program is as follows:

- *Objective*: To determine the $PM_{2.5}$ and PM_{10} levels in Lakhra area, understand seasonal variation, and undertake source apportionment of $PM_{2.5}$ and PM_{10} in the area.

- *Spatial Coverage:* existing LFPS, projected LPGCL, and a 5 km potential impact zone around them including settlements (Khanot, Manzurabad, Zimi, Bhian) and Lakhra power plant colony. The area is roughly bounded by the Indus River on the East, the hills on the West.

- *Parameters to be Covered:* Focused on aerosol (SPM, PM_{10} and $PM_{2.5}$) but will also include other key pollutants (NO_2, NO, SO_2 and CO) for complete characterization. In addition to the concentration of aerosol, analysis of aerosol will also be carried out to determine the distribution of elemental carbon and organic carbon to characterize the source

- *Monitoring Locations:* Suggested monitoring locations are a) locations where the impact of power plants, road traffic, and other sources are minimal; b) locations near the N-55; c) locations near maximum ground level concentration (GLC); and d) sensitive receptors (e.g. plant housing colony).

- *Additional Information to be Collected:* For source characterization and apportionment, data on load shedding, household fuel, back-up power source, traffic and any other major source in the area of study area be collected.

- *Timeline:* Data will be collected such that prior to commissioning of the proposed Project at least two years of data is collected and analyzed. The study will then continue for at least three years after the commissioning of the Project.

- *Executing Arrangement:* The PIC will be responsible to design the program, define the implementing arrangement (through Jamshoro academic institutions, appropriate public sector organizations, or private organizations) monitor and supervise the execution of the plan.

9.11 Total Budget Estimates

Cost estimates are prepared for all the mitigation and monitoring measures proposed in the EMP. The details of the cost estimates and the budget during construction stage and first three years of operation stage for the mitigation and monitoring measures are given in **Table 9-8**. The cost estimates for control measures and some of the mitigation measures that were already part of Engineers estimate are not included in the EMP.

The cost estimates also includes the budget for environmental monitoring, consultants for EMP implementation, institutional strengthening and capacity building of power plant staff and environmental enhancement/compensation measures.

The total budget for EMP implementation is estimated to be about US$ 866 thousand.

Table 9-8: Summary of Costs for Environmental Management and Monitoring

	Item	*Unit*	*Unit Cost US$*	*Qty*	*Total Cost US$*
A	**Environmental Monitoring (Design, Construction, and Operation Periods) – 6 years**				
1	Air quality monitoring fixed station	Station	80,000	2	160,000
2	Air quality monitoring mobile station	Station	50,000	1	50,000
3	Air quality monitoring recurring cost (6 years)				428,000
4	Monitoring of SMART parameters in effluent water @ monthly monitoring over 6 years)	Site	50	72	3,600
5	Heavy metals monitoring in effluent water (@ Quarterly over 6 years)	Site	70	24	1,680
6	Groundwater quality monitoring (5 sites@ 3 yearly over 6 years)	Site	500	30	15,000
7	Noise monitoring (5 sites@ 4 yearly over 6 years)	Site	25	120	3,000
8	Equipment for monitoring noise and dust				7,400
	Sub Total (A)				668,680
B	**Social Augmentation Plan Implementation**				**122,320**
C	**Training Cost**				**75,000**
	Grand Total (A+B+C)				866,000

CHAPTER 10. GRIEVANCE REDRESS MECHANISM

Timely and effective redress of stakeholder grievances contribute to bringing sustainability in the operations of a project. In particular, it will help advocate the process of forming and strengthening relationships between project management and the stakeholder community groups and bridge any gaps to create a common understanding, providing the project management the 'social license' to operate in the area. The grievance redress mechanism proposed for the Project will help achieve the objectives of sustainability and cooperation by dealing with the environmental and social issues of the Project.

The proposed grievance redress mechanism will be designed to cater for the issues of the people that can be affected by the Project. The population that can be affected by the Project is identified in **Chapter 5**, and comprises of the people residing within five kilometer of the plant site. The potential impacts of the Project are described in **Chapter 8**.

10.1 Framework for Grievance Redress Mechanism

The grievance redress mechanism proposed for the Project will meet the compliance requirements laid out under the relevant national legislation and will be in accordance with the environmental and social safeguards laid out under JICA Guideline 2010 and World Bank Safeguard Policy, OP 4.12, Annex A (Resettlement Plan).

10.1.1 JICA Guidelines for Environmental and Social Considerations (April 2010)

Developing a grievance redress mechanism is mandated under JICA Guideline 2010. The requirements for the grievance redress mechanism under the JICA Guideline 2010 are laid out below.

> Involuntary Resettlement
>
> Appropriate participation by affected people and their communities must be promoted in the planning, implementation, and monitoring of resettlement action plans and measures to prevent the loss of their means of livelihood. In addition, appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

World Bank Safeguard Policy

JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies, and refers as a benchmark to the standards of international financial organizations; to internationally recognized standards, or international standards, treaties, and declarations, etc.; and to the good practices etc. of developed nations including Japan, when appropriate.

The requirements for the grievance redress mechanism under the World Bank's Social Safeguards are laid out below.

Grievance Redress Mechanisms (GRMs)

A Grievance Redress Mechanism is a process by which queries or clarifications about the project are responded to, problems that arise out of implementation are resolved and grievances are addressed efficiently and effectively. Both Indigenous Peoples and Involuntary Resettlement Policies have mandatory Grievance Redress requirements. Both policies require affordable and accessible procedures for third-party settlement of disputes arising from project implementation. Such grievance mechanisms should take into account the availability of judicial recourse and community and traditional dispute settlement mechanisms.

It is the role of the borrower country governments to ensure that affected peoples do not face barriers to express grievances.

Some suggested methods to remove barriers are:

Establishing grievance uptake locations in areas where poor and marginalized people live;

Engaging local intermediaries (community based or civil society organizations) to facilitate submission of grievances;

Deploying community-specific communication strategies to allay fears about and increase comfort levels for submitting grievances;

Ensuring that there is no formal or informal charge for making grievances; and

Treating grievances confidentially.

Sindh Environmental Protection Act 2014

The IEE-EIA Regulations 2014 (see **Chapter 3** for more details) do not set any specific requirements for developing a grievance redress mechanism for projects. However, under the Guidelines for Public Consultation 1997, the proponents are required to consult stakeholders during the implementation phase of the project. In this regards, it is stated that the representatives of local community partake in the monitoring process to promote a stable relationship between the project management and the community.

10.1.2 Existing Grievance Redress

The existing LFPS operated by the LPGCL has grievance redress mechanism for internal staff only which is called Trouble Report. In this mechanism, any employee can drop a written complaint in the complaint box. The deputy director or the head of the department is responsible to redress the grievance.

Currently, the communities or any person of the communities can submit their grievance in writing to the Resident Engineer. However, there is no proper grievance redress mechanism for the communities or outsiders.

10.2 Proposed Mechanism for Grievance Redress

The proposed Project will be operated by a dedicated management company under GENCO. Under the company (Lakhra Plant Management Company or LPMC), the following will be established or appointed to ensure timely and effective handling of grievances:

Details of the proposed mechanism are given below

	Public Complaints Unit (PCU)	*Grievance Redress Committee (GRC)*	*Grievance Focal Points (GFPs)*
Members	• One senior official • Two assistants (one male and female)	• Head of Environment, Health and Safety Department of LPMC • Senior engineer of LPMC • Two literate representatives from the communities	• Two literate people from each community (one male and female)
Functions	PCU will receive, log, and resolve complaints.	GRC will oversee the functioning of the PCU as well as the final non-judicial authority on resolving grievances that cannot be resolved by PCU.	GFPs be approached by the community members for their grievances against the Project. The GFPs will be provided training by the Project in facilitating grievance redress.

10.2.1 Function and Structure of Public Complaint Unit (PCU)

PCU will be set up as part of the Environment, Health and Safety Department[1] of the Project. It will comprise of:

- A senior official, with experience in community and public liaison who will lead the unit and will be responsible to review all documentation.
- Two assistants, one male and one female with the responsibility of coordinating correspondence, preparing documentation work, assisting the senior official, and maintaining regular contact with the community.

The PCU will be responsible to receive, log, and resolve grievances. The female community members have restricted mobility outside of their villages and homes, the female PCU staff will be required to undertake visits to the local communities. The frequency of visits will depend on the nature and magnitude of activity in an area and the frequency of grievances.

10.2.2 Function and Structure of Grievance Redress Committee (GRC)

The GRC will function as an independent body that will regulate PCU and the grievance redress process. It will comprise of:

- Head of environment, health and safety department, LPMC or another senior officer appointed by the Resident Engineer, LPMC;

---

[1] An Environment, Health and Safety Department is proposed to be set up under the Project (see Chapter 9).

- One senior engineer from LPMC responsible to oversee the contractors work;
- Two literate representatives from the communities residing near the plant site, at least one of them should be from Manzurabad;
- A representative of the local government. In case the local government elections take place, this could be the Naib-Nazim or Nazim (the district governor). If not, this would be the District Coordinating Officer (DCO) or an appointed representative;
- Senior member from the local civil society, which could be a professor from one of the universities of Jamshoro;
- A female member from the local civil society preferably with experience in community relations.

The GRC will meet once every three months to review the performance of the PCU; the frequency can be changed depending on the nature and frequency of grievances received. The performance will be gauged in terms of the effectiveness and the timeliness with which grievances were managed. In case there are any unresolved or pending issues, the GRC will deliberate on mechanisms to resolve those and come up with solutions acceptable to everyone.

10.2.3 Grievance Focal Points

The Grievance Focal Points (GFPs) will be literate people from each community who will facilitate their community members in reporting grievances from the Project. The GFPs will be provided training by the Project in facilitating grievance redress. Each community will have a male and female GFP appointed for this purpose.

10.2.4 Operating Principles for PCU

The PCU will operate on the principles of transparency, approachability and accountability. To achieve these, the PCU will be required to:

- Be equipped to handle grievances in the local languages;
- Be equipped to work through all possible modes of communication, such as, emails, by-post and face-to-face meetings at plant site or requiring visits;
- Maintain a log of all grievances, with record of the date and time of the complaint logged and stakeholder information, such as, name, designation and contact details;
- Provide opportunity to the stakeholder to revert with their comments on the proposed plan of action;
- Keep the stakeholder informed of the progress in grievance resolution;
- Obtain stakeholder consent on the mechanism proposed to redress the grievance and document consent; and,
- Maintain confidentiality of the stakeholder, if requested so.

10.2.5 Procedure of Filing and Resolving Grievances

Grievances will be logged and resolved in the following steps (**Figure 10-1**):

Step 1: Receive and Acknowledge Complaint

Once the PCU receives a complaint, which could be the complainant giving it in person, via letter or email, through phone call, or through a GFP, an acknowledgement of receipt of the complaint has to be sent within two working days to the complainant. The complainant will be issued a unique complaint tracking number for their and PCU's record.

Step 2: Investigation by PCU

PCU will work to understand the cause of the grievance for which the PCU may need to contact the complainant again and obtain details. The PCU will be required to complete preliminary investigations within five working days of receiving the complaint and send a response to the complainant documenting the results of their investigations and what the PCU plans to do ahead.

Step 3: Resolution through PCU

Once the PCU have investigated a grievance, it will share with the complainant the proposed course of action to resolve the complaint, should PCU believe any to be necessary. If the complainant considers the grievance to be satisfactorily resolved, the PCU will log the complaint as resolved in their records.

For minor or less complex grievances, Steps 1, 2 and 3 or Steps 2 and 3 can be merged.

Step 4: Resolution through GRC

Any complaints that could not be resolved within four weeks by the PCU will be referred to GRC and reassessed. However, the complainant or the PCU can convene the GRC at any point in time, depending on the nature and urgency of the issue.

Step 5: Further Resolution

If the GRC cannot resolve the issue, it will be inform GHCL head office accordingly, and the GHCL head office will organize a special mission to address the problem and identify a solution.

If the stakeholders are still not satisfied with the reply, they can go through local judicial proceedings.

10.3 Stakeholder Awareness

The stakeholders will be informed of the establishment of the PCU through a short and intensive awareness campaign. Under the awareness campaign, the proponent will share:

- Objective, function and the responsibilities of the PCU;
- Means of accessing the PCU and the mechanics of registering a grievance at the PCU;

- Operating principles of the PCU; and,
- Contact details.

Additional awareness campaigns may be organized, if necessary.

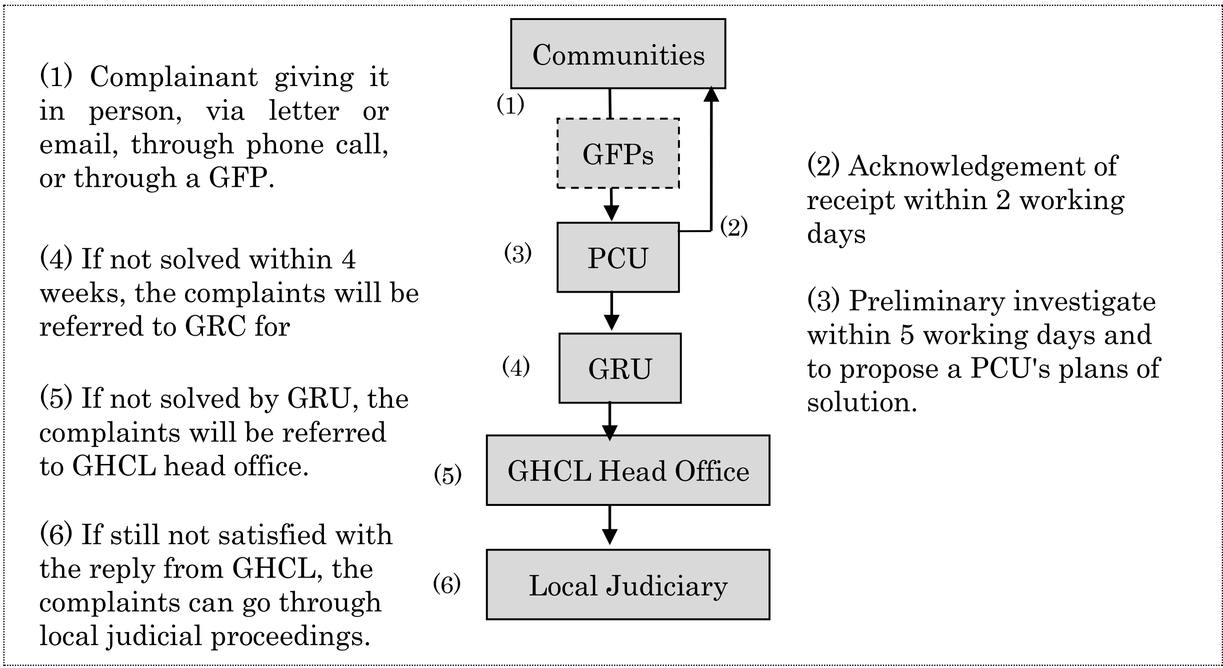


Figure 10-1: Grievance Redress Procedure

CHAPTER 11. CONCLUSIONS

The proposed 660 MW power plant will be installed on the land adjacent to the existing LFPS. However, it will be an independent power plant, with its own management, fuel source, storage, utilities and operations.

The Project will fill critical gaps and provide significant support to the local economy as well as that of the country. The cost of a unit of electricity generated by using imported coal as fuel is less than 50% of that for fuel oil. In addition to reducing power outages which are affecting growth of the economy, the Project will also lower the average cost of power generation in the country by shifting the fuel mix in power generation from fuel oil to imported coal. A diversified fuel mix with a lower dependence on oil products for power generation will also improve the energy security of the country.

The results of air quality modeling show that the predicted increment in pollutant concentrations caused by the proposed Project is very small compared to the background levels. However, the existing plant with inadequate control measures is causing substantial amount of pollutants to the ambient air causing the pollutant concentration levels to exceed both the SEQS as well as the IFC guideline limits. If the existing plant is allowed to run in its present condition, the concentration of SO_2, PM_{10} and $PM_{2.5}$ in the ambient air after commissioning of the proposed Plant may exceed the limits prescribed by SEQS as well as IFC Guidelines. For the proposed Plant to operate, it will therefore be necessary to rehabilitate the environmental controls on the existing plant. The 660 MW plant on its own meets all the air quality limits prescribed by SEQS as well as IFC guidelines. A detailed ambient air monitoring program including that of the $PM_{2.5}$ will be instituted.

Impacts on water quality, noise, and aquatic environment will be within acceptable limits. The proposed Project will bring improvement in ambient air quality as the rehabilitation of the emission controls on the existing plant is a necessary condition for the realization of the new plant. The proposed Project will bring socioeconomic benefits to the community in the form of employment and business opportunities.

A comprehensive environmental management plan has been developed to ensure the implementation of the environmental and social mitigations measures committed in the EIA. It includes the monitoring plan, the required institutional set up for implementing the plan, reporting and feedback mechanism, performance indicators, training program, specific management plans for waste, construction activities, coal dust control, ash, spill control, fire control, and transportation. Grievance mechanism and social augmentation plan are also proposed.