Environmental Impact Assessment

June 2013

PAK: Jamshoro Power Generation Project

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APPENDICES

Currency Equivalents
(As of July 2013)
Currency Unit – Pakistani Rupee (PKR)
100 PKR = $1

ABBREVIATIONS

ADB	Asian Development Bank
AFBC	Atmospheric Fluidized Bed Combustion
BFBC	Bubbling Fluidized Bed Combustion
BID	Background Information Document
BMCR	Boiler Maximum Continuous Rating
CDM	Clean Development Mechanism
CEM	Continuous Emission Monitoring
CER	Certified Emission Reduction
CFB	Circulating Fluidized Bed Boiler
CFBC	Circulating Fluidized Bed Combustion
CITES	Convention on International Trade in Endangered Species
CMEC	China Machinery Engineering Corporation
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CPPA	Central Power Purchasing Agency
DA	Degraded Airshed
DCO	District Coordinating Officer
DCS	Distributed Control System
EA	Executing Agency
EHS	Environment Health and Safety
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
EMP	Environmental Management Plan
ESP	Electrostatic Precipitator
FBC	Fluidized Bed Combustion
FGD	Flue Gas Desulfurization
FL	Flood Level
GDP	Gross Domestic Product
GFP	Grievance Focal Points
GHCL	Genco Holding Company Limited
GoP	Government of Pakistan
GRC	Grievance Redress Committee
HBP	Hagler Bailly Pakistan (Pvt.) Limited
HHV	Higher Heating Value
HHV	Higher Heating Value
HP	High-Pressure
HSFO	High Sulfur Fuel Oil
HWL	High Water Level
HWSF	Hazardous Waste Storage Facility
IA	Implementing Agency
ID	Induced Draft
IEE	Initial Environmental Examinations
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature

JPCL	Jamshoro Power Company Limited
JTPS	Jamshoro Thermal Power Station
KP	Karachi Port
LNG	Liquefied Natural Gas
LP	Low Pressure
LUHMS	Liaquat University and Health and Medical Sciences
LWL	Low Water Level
MCR	Maximum Continuous Rating
MFF	Multi-tranche Financing Facility
NDA	Non-Degraded Airshed
NEPRA	National Electric Power Regulatory Authority
NEQS	National Environmental Quality Standards
NGO	Non-Governmental Organization
NOx	Oxides of Nitrogen
NSDW	National Standards for Drinking Water
NTDC	National Transmission and Despatch Company
PA	Primary Air
PC	Pulverized Coal
PCB	Polychlorinated Biphenyl
PCU	Public Complaints Unit
PEPA	Pakistan Environmental Protection Act (1997)
PF	Pulverized Fuel
PFBC	Pressurized Fluidized Bed Combustion
PKR	Pakistani Rupees
PM	Particulate matter
PM_{10}	Particulate matter of less than 10 micron in size
$PM_{2.5}$	Particulate matter of less than 2.5 micron in size
PPE	Personal Protective Equipment
PQ	Port Qasim
PSO	Pakistan State Oil
PVC	Polyvinyl Chloride
RBOD	Right Bank Outfall Drain
RE	Renewable energy
ROHR	Run-of-the-River Hydropower
SCR	Selective Catalytic Reduction
SDPI	Sustainable Development Policy Institute
SEPA	Sindh Environmental Protection Agency
SMART	Self-Monitoring and Reporting
SO_2	Sulfur Dioxide
SPM	Suspended Particulate Matter
SPS	[ADB's] Safeguard Policy Statement (2009)
SSGCL	Sui Southern Gas Limited
WHO	World Health Organization
WWF	World Wide Fund for Nature
XLPE	Cross-Linked Polyethylene

UNITS

MWth	Megawatt thermal input (MWth)
mg/Nm^3	mg per normal meter cube
MW	Megawatt
mmcft	million cubic feet
t/d	tons per day
cumec	cubic meters per second
cusec	cubic feet per second
mg/l	milligrams per liter
kg	kilogram
t/h	tons per hour
m^3/h	cubic meters per hour
m/s	meters per second
mg/kg	milligram per kilogram
mg/Nm^3	milligram per normal cubic meter
km	kilometer
m	meter
ºC	Degree Celsius
MPa	Megapascal
$\mu g/m^3$	Microgram per cubic meter

1. Executive Summary

1. The Government of Pakistan (GoP) is planning to set up a super-critical coal-fired power plant at Jamshoro (the 'Jamshoro Power Generation Project' or the 'Project') to be financed by the Asian Development Bank (ADB). The power plant will be setup within the premises of the existing Jamshoro Thermal Power Station (JTPS). The proposed Project will have a net generation capacity of 600 megawatt (MW) (the 'First Stage') with a provision of expansion to 1,200 MW in the near future (the 'Second Stage'). The gross generation capacity of the Project will be 660 MW in the First Stage and 1,320 MW after expansion.[1] The plant will be owned and operated by the Jamshoro Power Company Limited (JPCL), the implementing agency (IA) of the Project. GENCO Holding Company Limited (GHCL), the parent company of JPCL will be the executing agency (EA).

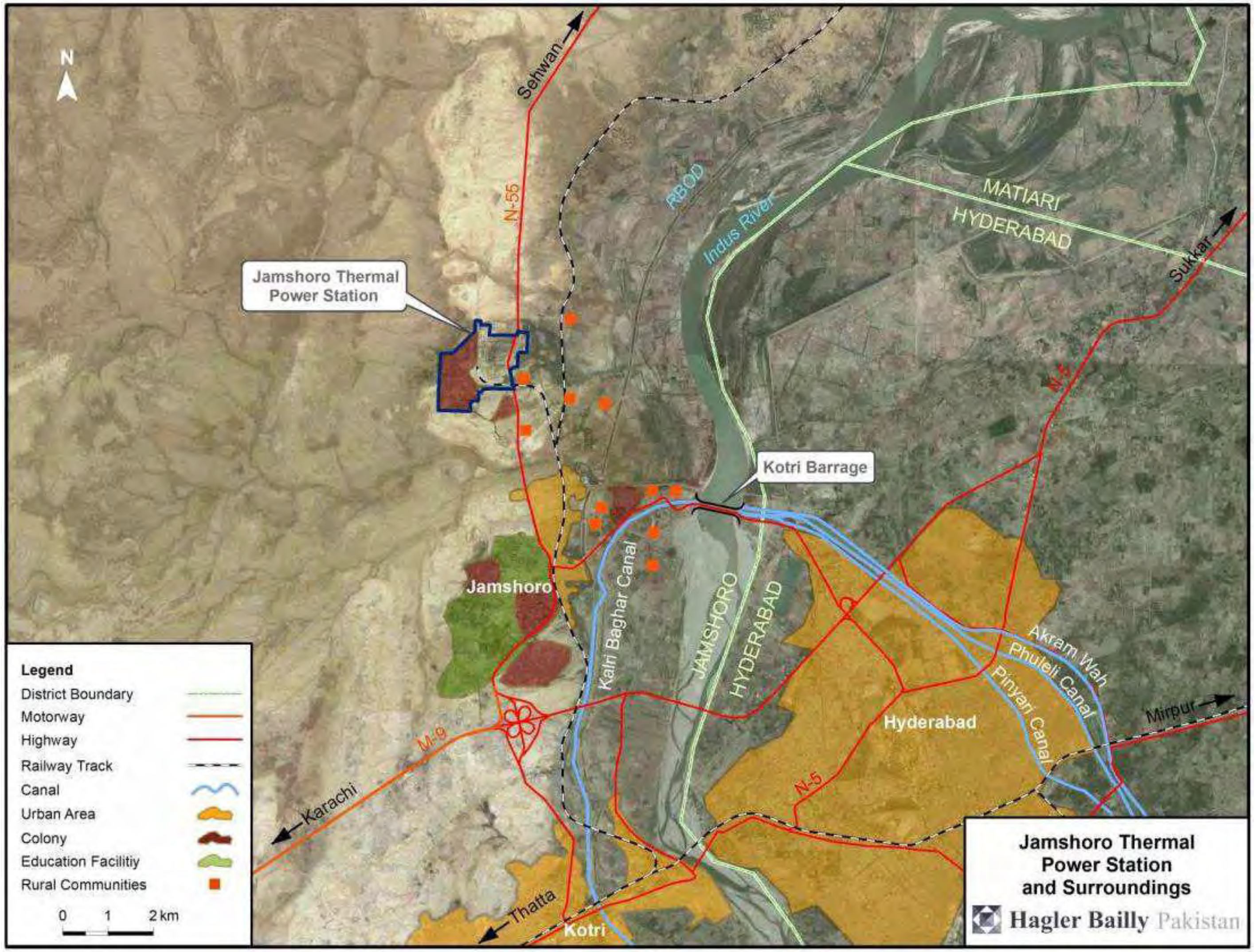
2. This Environmental Impact Assessment (EIA) of the proposed Project is prepared to meet the regulatory requirements of Pakistan and Sindh province as well as the ADB's Safeguard Policy Statement (SPS) 2009. As SPS 2009 requires adherence to International Finance Corporation (IFC)'s Environment, Health and Safety (EHS) Guidelines for pollution prevention and control technologies and practices, this EIA also refers to these guidelines particularly for emission and effluent limits and ambient conditions. The EIA covers the assessment of both the First and Second stages of the Project, separately.

1.1 Project Setting

3. JTPS is located north of Jamshoro town in the Jamshoro district of Sindh province, Pakistan (**Figure** 1-1). The power plant is about 10 kilometer (km) northwest of Hyderabad and about 150 km northeast of Karachi. It is located on N-55, also known as Indus Highway. N-55 is one of the two main highways of the country which connect Karachi, the main port and industrial hub of the country, with the rest of the country. The north and northwest of the power plant is barren flat land. Some smaller sedimentary hills are located in the west and southwest, which rise to an elevation of 100 meters (m) above mean sea level. To the south, at a distance of about 5 km, is the urban area of Jamshoro. Scattered villages and farmlands are located to the east and northeast of the JTPS, in the flood plains along the banks of Indus River. The river also supports fish which is a source of income for local fishermen. In places, small pools of stagnant water are formed within the agricultural fields, some of which are caused by the effluent from the operations of the existing facilities at JTPS. The Indus River flows in the north-to-south direction at a distance of about 4 km to the east of the JTPS. The elevation of the land in surroundings of the JTPS ranges between 20 and 45 m and slopes towards the Indus River. Jamshoro area has a desert climate, characterized by a hot and dry summer, mild winter and low rainfall. The vegetation of this region is typical of arid regions, adapted to extreme seasonal temperatures and moisture fluctuation, and is thin in cover

[1] The total generation capacity of the power plant is the gross capacity. However, a part of the electricity generated is used within the power plant. The balance electricity which is available for supply to the transmission network is the net capacity. After the Second Stage the proposed Project will have 660 X 2 = 1,320 MW gross capacity. Of this 120 MW will be used internally and 1,320 – 120 = 1,200 MW will be the net capacity.

Figure 1-1: Jamshoro Thermal Power Station and Surroundings



4. The population clusters in the surroundings of the JTPS can be broadly classified as rural, urban and institutional housing colonies. The rural area population is found in small scattered villages having agriculture as the main source of livelihood. The urban areas comprise of a contiguous population belt of the Jamshoro town and housing colonies. The housing colonies are purpose-built residential areas associated with institutions such as the JTPS, the University of Sindh and the Liaquat University of Health and Medical Sciences (LUHMS). The housing colonies and the urban areas together constitute the more developed and better-off segments of the area in the surroundings of the JTPS.

1.2 Project Rationale

5. Pakistan is going through an acute power shortage. According to the National Electric Power Regulatory Authority's (NEPRA) 'State of the Industry Report 2012' the gap between supply and demand in 2011-2012 was well above 5,000 MW mark and remained between 4,000 MW and 5,000 MW for most part of the year. The country has therefore an urgent requirement to generate additional power to feed into the national power grid. The gap between supply and demand is likely to persist over next few years. The gap represents about one-third of the total demand in National Transmission and Despatch Company (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.[2]

6. Chronic power shortages in Pakistan are the most serious constraints to the country's 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.

7. In addition to the economic impact, the shortage has environmental and social impacts as well. Other than complaints of general discomfort, students 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 power 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. Due to the power shortages, use of back-up power generators has increased significantly, both in commercial and residential sectors.[3] As there is no regulatory control over the emission from these generators, their widespread use in the urban areas has resulted 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.

8. In addition to increasing the generation capacity, it is essential to lower the generation cost. One possible option is the hydropower. It despite being the ideal solution has long implementation period and is not useful to address immediate issues.

[2] Load shedding, also known as rolling black out, is method of electric power management where the supply falls short of the demand. In this, the power supply to different sections of the network is stopped on a pre-defined schedule for a pre-defined period of time.

[3] It is estimated that currently the total power generation by small to medium sized generator is in 10,600 Gigawatt-hour (GWh).

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 22% in 10 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

9. Two 600 MW net power unit will be installed at the JTPS site. The basic design parameters for these are:

- Capacity: 2 x 600 MW net
  2 x 660 MW gross (nominal)
- Power technology: Pulverized coal firing in super-critical boilers
- Steam conditions: Main steam 24.1 Megapascal (MPa) at 593 ºC
  Single reheat steam 4.5 MPa at 593 ºC
- Fuel: Blended coal—subbituminous coal 80% (minimum), lignite (balance)
- Plant efficiency LHV: Gross 43.4% for subbituminous coal
  42.8% for subbituminous-lignite blend in 80:20 ratio.
- Cooling system: Natural draft cooling tower
- Emission controls: ESP efficiency > 99.9%
  FGD efficiency > 95%
  SCR efficiency > 80%

10. The major systems of the proposed Project are the following:

A. Coal handling and processing system

B. Super-critical boiler

C. Steam turbine and condenser

D. Electrical power generator and power export system

E. Flue gas treatment system

F. Cooling water system

G. Ash handling system

H. Utilities and waste management system

11. The new coal-fired power plant will be erected within the existing JTPS site, in an empty plot south of the existing units. It will consist of two 600 MW net capacity, super-critical, coal-fired units. The arrangement of the 600 MW units, in order from west to east, will be the electrical transformers, turbine hall, boilers, ESPs, FGDs and stack. The coal receiving and storage yard will be to the south of the new generating units. The new cooling towers will be located east of the power blocks and to the north of the coal yard. Raw water will be taken from the Indus River in a newly constructed intake structure and pump house. Wastewater will be collected in a basin treated and reused to the greatest extent for coal dust suppression, ash handling and other purpose. For

ash disposal additional land will be acquired adjacent to existing JTPS site. A residential colony will be constructed within the existing JTPS site.

12. The main fuel for the power plant will be imported subbituminous coal. Lignite, either from Thar coalfields or imported, in the ratio of 10-20% will be blended with the subbituminous coal. The design specification of the fuel is shown in **Table 1-1**.

Table 1-1: Coal Quality of Design Coal

Parameter	Sub-bituminous (e.g., INDO5(P))		Lignite (e.g., Thar)	
	Range	Selected Value	Range	Selected Value
C	50-65	50.0	28.0-37.4	28.0
H	1-3	1.0	1.6-301	1.6
O	30–50	30.0	6.6-10.5	6.6
S	<1	1.0	0.2-2.7	2.7
N	<2	2.0	0.2-0.4	0.4
Moisture	<26	26.0	44.9-50.4	50.4
Ash	<9	9.0	4.0-15.1	15.1
High Heating Value (HHV), kcal/kg	> 4,780	4,780	2,231-3,250	2,231

13. For the purpose of design, three different blending percentage of lignite has been considered, namely 10%, 15%, and 20%. The fuel properties under these blending scenarios, identified as Coal E, Coal F, and Coal G, respectively, are shown in **Table 1-2**.

Table 1-2: Blended Fuel Properties

	Coal E Sub-bituminous 90% Lignite 10%	Coal F Sub-bituminous 85% Lignite 15%	Coal G Sub-bituminous 80% Lignite 20%
C	40.65%	39.96%	39.26%
H	0.90%	0.93%	0.96%
O	23.52%	22.67%	21.80%
S	1.00%	1.07%	1.15%
N	1.56%	1.51%	1.45%
Moisture	24.19%	25.38%	26.58%
Ash	8.17%	8.48%	8.80%
High Heating Value (HHV), kcal/kg	4,525	4,398	4,270

14. The total coal consumption will depend on the ratio of blending of subbituminous and Thar coals. The coal consumption for the 1,200 MW plant for three possible scenarios is shown in **Table 1-3**. In the First stage of 600 MW, the consumption will be half of that of the values shown in **Table 1-3**.

Table 1-3: Coal Consumption for 1,200 MW

Coal	Sub-bituminous	Lignite	Total
Daily Consumption (tons)			
Coal E 90:10	12,698	1,411	14,109
Coal F 85:15	12,355	2,180	14,535
Coal G 80:20	12,054	3,013	15,067
Annual Consumption at 85% Plant Factor (million tons)			
Coal E 90:10	3.94	0.44	4.38
Coal F 85:15	3.83	0.68	4.51
Coal G 80:20	3.74	0.93	4.67

15. Imported coal for the Project will be transported to JTPS by rail. Extension of railway system to Thar will be essential to meet future demands of the new plant at Jamshoro.

1.4 Corrective Actions for Existing Facilities at JTPS

16. ADB requires that when the proposed project involves an existing facility, the existing facility shall be audited to identify past or present concerns related to impacts on the environment. If the audit identifies non-conformance, plans for appropriate remedial measure are to be developed to address outstanding issues. The remedial measures proposed for improvement of environmental performance of the existing facilities are the following:

- Flue Gas Desulfurization (FGD): An FGD will be installed on the two existing stacks to ensure that the emission from these meet the national standards and guidelines for sulfur dioxide (SO_2). This will also ensure that there is enough room in the ambient air to accommodate new plant.
- Spilled oil collection and drainage system: JPCL is in the process of acquiring spilled oil collection and drainage system. It will be ensured that this system for the decanting station is commissioned not later than June 2014. Until the spilled oil collection and drainage system is installed, drip pans will be provided at the decanting station to prevent further spills on soil. The contaminated soil from the decanting area will be collected and stored in a secured place for future disposal.
- Rehabilitation of effluent pipeline: The plant wastewater system will be revamped to ensure that the cooling tower effluent is segregated from other plant wastewater. A pipeline for transport of effluent from the plant to the river will be installed, as in the original design of the plant, which was operated for about first five years after the plant was commissioned, and then abandoned.

As the effluent meets the national Environmental Quality Standards (NEQS) and is suitable for agricultural use, the option of regulated discharge for agricultural use will be considered

- Rehabilitation of evaporation pond: The evaporation pond has filled with silt and reed and is no longer usable. The evaporation pond will be reconstructed. It will be a 'zero-discharge' system which means that it will be sized to ensure that it can receive all potentially hazardous wastewater from the existing plant without the need to discharge to the surrounding areas or the Indus River. The pond will be lined to prevent seepage from the pond and potential contamination of the surrounding land and groundwater. All low volume waste non-complaint with the NEQS will be isolated and discharged to the evaporation pond.
- Municipal wastewater from the housing colony: The municipal wastewater from the JTPS housing colony is presently pumped out of the colony without any treatment. The water is then used for irrigation purposes. A small wastewater treatment plant will be installed in the housing colony.
- Development of a hazardous waste storage facility: A hazardous waste storage facility will be developed at the plant near the switchyard to safe disposal of potentially hazardous waste. Hazardous waste includes soot from boiler and asbestos waste from old equipment.
- Development of a landfill site for colony waste: A properly designed landfill to cater for the plant needs will be developed. Presently, waste dumps can be seen in different location of the plant and the colony. Solid waste is presently being disposed in dug pits which are later covered by soil.
- Bio-remediation facility for oily waste: A bioremediation facility for oily waste will be developed that will treat all contaminated soil present on the plant site in about five years.
- Occupational health and safety management system: A complete occupational health and safety management system will be developed at the plant. Use of Personal protective equipment (PPE), safety criteria for heated surface, working at heights and entering confined spaces entry are standard procedures that will be adopted as a part of the management system.

1.5 Environmental Impact of New Plant

1.5.1 Air Quality Impacts

17. 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. Important air pollutants from the stack are respirable particulate matter (PM_{10} and $PM_{2.5}$),[4] 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. Following emission controls will be installed to reduce the emission from the plant:

[4] 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.

- An Electrostatic precipitator (ESP) with an efficiency of 99.9% to limit the total PM emissions to 30 mg/Nm^3.
- An FGD using lime slurry and with an efficiency of 95% to limit SO_2 emissions to within the World Bank Group guidelines.
- A Selective Catalytic Reduction (SCR) with an efficiency of 80% and low NOx burners with overfire air ports will be designed and procured to minimize the NOx generation to meet the World Bank Group guideline.
- 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.

18. The emission of gaseous pollutants from the 1,200 MW power plant was modeled for blended Coal G (subbituminous 80%, Thar 20%) with an LHV efficiency of 42.8%; the ESP, FGD, and SCR installed and plant factor 85%. The compliance of the emission to the emission standards and guidelines is shown in **Table 1-4**.

Table 1-4: Compliance of Plant Emission with NEQS and IFC Guidelines

Parameter	Emission from Each Stack	Standards	IFC Guidelines
Particulate matter	30 mg/Nm^3	500 mg/Nm^3	For NDA: 50 mg/Nm^3 For DA: 30 mg/Nm^3
Sulfur oxides	254 mg/Nm^3 (20% blending of Thar with maximum 2.7% S) 200 mg/Nm^3 (20% blending of Thar with maximum 1.4% S)		For NDA: 200-850 mg/Nm^3 For DA: 200 mg/Nm^3
	17.3 TPD (Both Units)	100-500 Tons per day	
Oxides of nitrogen	75.2 mg/Nm^3		For NDA: 510 mg/Nm^3 For DA: 200 mg/Nm^3
	19.0 ng/J of heat input	260 ng/J of heat input	

DA: Degraded Airshed; NDA: Non-Degraded Airshed

19. Air quality impacts due to the proposed power plant were estimated for five scenarios. The scenarios and the rationale for selecting them is as follows:

(i) *Without JTPS scenario*—the conditions that would exist if there was no JTPS (neither the existing units nor the proposed power plant)

(ii) *Baseline scenario*—the existing conditions where all the units with existing efficiency operate on HSFO, and there are no controls on emission. This is the worst-case present day condition. It is important to establish the baseline condition and determine whether the present airshed shall be considered degraded or non-degraded.

(iii) *Baseline scenario with Offset*—All the units with existing efficiency operate on HSFO, and FGDs are installed on stacks. Installation of FGD will reduce the emission of SO_2 to a fraction (5% or less) of its present value. It will also, therefore, reduce the concentration of SO_2 in ambient air. To a lesser degree it will also reduce the particulate matter in the ambient air. This will be the virtual baseline for the proposed project as discussed later.

(iv) *Post 600 MW Scenario*—This is the predicted ambient quality once First Stage 1 of the project is commissioned. It includes incremental impact due to the project but also takes into account the offset on the existing units.

(v) *Post 1,200 MW Scenario*—This is the predicted ambient quality after both units of the Project are operational. It includes incremental impact due to the project but also takes into account the offset on the existing units.

20. USEPA regulatory model AERMOD 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}. Potential SO_2 emissions from existing 4 units after the project will decrease. The concentration of SO_2 in the ambient air will also be less than the current levels after the new project. The compliance status of the 1,200 MW power plant against the applicable standards and guidelines is summarized in **Table 1-5**.

21. The 1,200 MW plant meets all the limits under the NEQS and IFC Guidelines except for:

- PM_{10} with respect to IFC Guidelines, where the estimated Annual Average concentration of 79.2 µg/m³ exceeds the limit of 70 µg/m³.
- $PM_{2.5}$ with respect to IFC Guidelines, where the estimated Annual Average concentration of 47.6 µg/m³ exceeds the limit of 35 µg/m³.
- $PM_{2.5}$ with respect to NEQS, where the estimated Annual Average concentration of 47.6 µg/m³ exceeds the limit of 15 µg/m³.
- $PM_{2.5}$ with respect to NEQS, where the estimated concentration of 67.1 µg/m³ exceeds the 24–hour (98th percentile) limit of 35 µg/m³.

Table 1-5: Predicted Ground Level Concentration of Criteria Pollutants

Pollutant and Averaging Time	Criteria		Ambient Air Quality Under Various Scenarios Concentration (µg/m³)				
	NEQS (µg/m³)	IFC Guidelines (µg/m³)	No JTPS	Current Baseline	Current Baseline with Offset	600 MW	Post 1200 MW
SO_2							
Maximum 24–hr	–	125	10.3	223.0	22.3	34.8	47.2
24–hr (98^{th} %le)	120		9.2	184.5	21.0	32.6	44.1
Annual	80		3	55.5	5.7	8.5	11.2
NO_2							
Maximum 24–hr	–	200	9	56.1	56.1	59.2	62.3
24–hr (98^{th} %le)	80		7.2	37.6	37.6	47.4	57.2
Annual	40	40	1.2	12.0	12.0	17.2	22.3
PM_{10}							
Maximum 24–hr	–	150	108.4	126.1	126.1	129.2	132.2
24–hr (98^{th} %le)	150		100.8	117.2	117.2	118.9	120.5
Annual	120	70	69.1	73.2	73.2	76.2	79.2
$PM_{2.5}$							
Maximum 24–hr		75	60.8	68.8	68.8	70.2	71.5
24–hr (98^{th} %le)	35		57.7	66.3	65.5	66.3	67.1
Annual	15	35	43.1	44.9	44.9	46.3	47.6
CO							
1–hr	10,000			8,846	8,846	9,352	9,858
Maximum 8–hr	–			4,083	4,083	4,347	4,611
8–hr (98th %le)	5,000			1,541	1,541	1,610	1,678

22. The estimated annual average concentration of PM_{10} at 79.2 µg/m³ exceeds the IFC Guideline for PM_{10} by 9.2 µg/m³, and the current baseline level by 6.0 µg/m³. The background concentration of PM_{10} is estimated at 69 (No JTPS case in **Table 1-5**), while the baseline is estimated at 73.2 µg/m³ (Current Baseline in **Table 1-5**). An increase of 13% over the background concentration of PM_{10} can be considered as acceptable under the ADB Guidelines[5], as the background concentration associated with natural sources in the area is already close to the limit in the IFC Guideline. Similarly, the background concentration of $PM_{2.5}$ associated mainly with natural sources at 58 µg/m³ for 24–hour (98^{th} percentile) and 43 µg/m³ for Annual Average basis which are already above the limits set in NEQS and IFC Guidelines. The increase in $PM_{2.5}$ concentrations due to

5 According to ADB Safeguards Policy Statement 2009 Appendix 1 para 34, 'The borrower/client will avoid, or where avoidance is impossible, will minimize or control the intensity or load of pollutant emission and discharge.' The Project includes best available technology for removal of particulate matter in the form of ESP units with efficiency of 99.9%.

Project will be of the order of 3 µg/m³. Under these conditions, an increase of about 6% over the current baseline concentration of $PM_{2.5}$ can also be considered as acceptable under the ADB Guidelines.

23. NEQS has three different limits for $PM_{2.5}$—Annual, 24-hour and 1-hour. A review of the NEQS for $PM_{2.5}$ and the regional practice indicates that the NEQS 1-hour limit is inconsistent with the annual limit. The limit for 1-hour (15 µg/m³) is the same as the annual limit. This is contrary to the practice world-wide where the limits for longer time frame are always lower than that of a shorter time frame to allow for variations over time.[6] Similarly, the NEQS 1-hr limit of 15 µg/m³ for $PM_{2.5}$ is inconsistent with the 24 hour limit of 35 µg/m³. The ambient air quality standards of other countries in the region are reflective of the high $PM_{2.5}$ levels in the ambient air. The annual limits for $PM_{2.5}$ in India and Sri Lanka are 40 µg/m³ and 25 µg/m³ respectively. Similarly, the 24-hr limits for $PM_{2.5}$ in these countries are 60 and 50 µg/m³ respectively. Given the high natural background particulate levels in Pakistan where environmental conditions are somewhat similar to those in India and the current level of controls on industrial and vehicular emissions, it is unlikely that compliance with the NEQS annual limit of 15 µg/m³ for the $PM_{2.5}$ can be achieved in any part of Sindh in the near future.

24. The project proponent has approached the Sindh Environmental Protection Agency of the Government of Sindh for review of the $PM_{2.5}$ standards. The Agency has indicated its willingness to review the standards. 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 for at least two years before commissioning of the Project.

1.5.2 GHG Emissions

25. Estimated greenhouse gas emissions from the power plant are provided in **Table 1-6**. These estimates have been developed using two different methodologies: The IPCC Tier 1 methodology that assumes a 96,100 kg of CO_2 emission per terajoule of heat input from subbituminous and 101,000 kg of CO_2 emission per terajoule of heat input from lignite and calculation using the carbon content of design coals. The GHG emission based on the IPCC Tier 1 method for Coal G is being used as the benchmark.

26. The ADB Guidelines for GHG emission require the project proponents to consider available options for offset of the GHG emissions. In the case of this Project, options for offset that can be considered include tree plantations, carbon capture, 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. ADB is considering provision of $ 1 million from its Carbon Capture and Storage (CCS) to conduct a study on determining potential for CCS in Pakistan. Subject to determination of financial viability, ADB will consider a CCS demonstration project to offset carbon in Pakistan.

[6] Higher pollutant concentrations are permitted for shorter intervals only and prolonged stress to receptors over a longer period of time is avoided by prescribing a lower limit for an extended period of time. The average for a longer period cannot also mathematically be higher than the maximum figures for the shorter intervals.

Table 1-6: Carbon Dioxide Emission Estimates

	Sub-bituminous (Million Tons per Year)	Lignite (Million Tons per Year)	Total (Million Tons per Year)
IPCC Tier 1			
Coal E	7.577	0.413	7.990
Coal F	7.372	0.638	8.010
Coal G	7.192	0.882	8.074
From Carbon Content			
Coal E	6.069	0.429	6.498
Coal F	5.905	0.663	6.568
Coal G	5.761	0.916	6.677

Note: All figures for both units and assume 85% plant factor.

27. Fly ash can be used as a cement replacement and consultations with cement manufacturers located in the vicinity of JPCL 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.[7] Offset potential of tree plantations will be limited in view of limited availability of land and water in the JTPS area. However, the project will consider this option. The proposed 1,200 MW power plant will replace power production from small to medium sized backup generators used by electricity consumers during load shedding. The capacity of these backup generators installed by the residential, commercial, and industrial consumers is estimated at 2,500 MW. The 1,200 MW power available from the new coal fired power plant is estimated to result in 31% reduction in load shedding. Assuming the IPCC emission factors for the fuels, reduced operation of backup generators will result in an offset of an estimated 1.06 million tons of GHG annually.

1.5.3 Other Aspects

28. Other environmental issues related to the proposed plant are:

- Construction activities have different types of construction impacts. Some of these relate to activities at the construction site where as others relate to the setting up and operation of the construction crew camp. Typical issues include dust, vegetation loss, noise, vibration, waste management, and camp effluent. To avoid adverse impact of the construction activities on the environment, a construction management plan (CMP) will be developed.
- The annual ash produced from the Project will be in excess of 400,000 tons. Options for disposal of fly ash and prospects for sale to the cement industry are under consideration**.** Taking into account the potential for recycling of fly ash in

[7] Corresponding to fly ash production of 349,600 t/year.

the cement and construction industry, the land requirement for the ash disposal for ten years is about 100 acres. The depth of the ash pond will be around 3.5 m to avoid ash dust formation from the wind.

- 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:
- Additional employment opportunities, resulting in increased prosperity and wellbeing due to higher and stable incomes of employed people,
- Potential negative socioeconomic impact includes land acquisition resulting in physical or economic displacement of people. A land acquisition and resettlement framework has been developed. This will be followed by a land acquisition and resettlement plan.

1.6 Environmental Management Plan

29. A comprehensive environmental management and monitoring plan has been developed. It includes the following:

- Identification of institutional responsibilities
- Institutional strengthening and capacity building of TPS Jamshoro
- Reporting and feedback mechanism
- Performance indicators
- Environmental Mitigation Plan
- EMP for Waste Management
- Contaminated Soil Bioremediation Plan
- Environmental Monitoring Plan
- Construction Management plan
- Coal dust management plan
- Ash management plan
- Asbestos Management Plan
- Social augmentation plan
- Grievance redress mechanism
- Air quality monitoring program

30. The estimated cost of environmental monitoring and management, in US $3.85 million.

1.7 Conclusions

31. The proposed power plant, 600 MW in the First Stage and 1,200 MW after the completion of the Second Stage will be installed within the premises of the JTPS. However, it will be an independent power plant, with its own fuel source, storage, utilities and operations.

32. As the existing plant is not fully compliant with the national environmental regulations and is also below the international best environmental practices as signified by ADB's SPS 2009 and IFC's HSE Guidelines, a corrective action plan has been developed. The plan is an essential part of the project as the improvement it will bring to the environmental practices of JPCL and to the physical environment in the vicinity of the JTPS, will enable the installation of the 1,200 MW power plant. The key areas in which the project is likely to bring a positive environmental changes are:

- Installation of FGD on the existing stacks and thereby reducing the emission of sulfur dioxide;
- Rehabilitation of effluent pipeline and therefore preventing of spread of plant waste in the vicinity of the plant;
- Development of a waste storage facility for hazardous waste;
- Development of a landfill site for colony waste;
- Installation of a treatment plant for colony wastewater;
- Rehabilitation of existing evaporation pond and this prevention of release of untreated wastewater to the river; and
- Clean-up and remediation (or containment) of oily waste.

33. 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.

34. The Project will contribute to improved health of the local community by improving air quality through installation of FGDs on the existing boilers to lower SO_2 concentrations in ambient air associated with utilization of HSFO.

35. The project will contribute to improvement in environmental management practices and capacities in the JPCL through institution of a range of environmental management systems and provision of training to the staff of the plant.

36. The new 1,200 MW power project will comply with all the Pakistan regulatory requirements and that of the ADB safeguard policies, with the exception of ambient air quality standards of PM_{10} and $PM_{2.5}$. It has been shown in this document that the background concentration levels of PM_{10} and $PM_{2.5}$ (without JTPS) reflecting the emissions from natural sources either already exceed or are close to the limits specified by the IFC Guidelines. This is a phenomenon that is prevalent all across Pakistan where due dry conditions the dust levels are very high. The annual average background concentration of PM_{10} is about the same as the limit specified under the IFC Guidelines, while that of $PM_{2.5}$ exceeds both the limits in both the NEQS and IFC Guidelines. The Project includes installation of electrostatic precipitators with 99.9% efficiency on the boilers for the 1,200 MW capacity. The ESP will limit the PM_{10} and $PM_{2.5}$ emission to level that is recommended for degraded airshed. The incremental contribution of the 1,200 MW plant in the ambient air will be about 13% in PM_{10} concentration and 6% in $PM_{2.5}$. The Project will utilize technology to achieve the maximum control possible, will have small incremental impact, and the background concentrations are mainly due to

natural sources which cannot be reduced. The Project is therefore considered acceptable under ADB guidelines which require avoidance, or where avoidance is impossible, minimization or control of the intensity or load of pollutant emission and discharge. The proposed 1,200 MW power plant will replace power production from small to medium sized backup generators used by electricity consumers during load shedding. The proposed project will result in a country-wide reduction of $PM_{2.5}$ emission by 5,600 tons. The power consumption in Hyderabad area is about 5.5% of the country-wide demand. Thus, the reduction of $PM_{2.5}$ emission in the Hyderabad Area will be about 300 tons annually due to the 1,200 MW power plant. A detailed ambient air monitoring program including that of the $PM_{2.5}$ will be instituted. The program will be initiated before the commissioning of the Project with the objective of developing a good understanding of the $PM_{2.5}$ issue in Jamshoro area and possibly designing future mitigation programs.

37. It has been recognized that national standards for ambient air quality will require revision. This issue has been discussed with the Sindh Environmental Protection Agency and they have expressed willingness to review the standards.

2. Introduction

38. The Government of Pakistan (GoP) is planning to set up a super-critical coal-fired power plant at Jamshoro (the 'Jamshoro Power Generation Project' or the 'Project') to be financed by the Asian Development Bank (ADB). The power plant will be setup within the premises of the existing Jamshoro Thermal Power Station (JTPS), owned and operated by the Jamshoro Power Company Limited (JPCL). The proposed Project will have a net generation capacity of 600 megawatt (MW) (the 'First Stage') with a provision of expansion to 1,200 MW in the near future (the 'Second Stage'). The gross generation capacity of the Project will be 660 MW in the First Stage and 1,320 MW after expansion.[1]

39. Hagler Bailly Pakistan (HBP) has been retained by Asian Development Bank (ADB) to undertake an Environmental Impact Assessment (EIA) of the proposed Project as required under the Pakistan's environmental law as well as the ADB's Safeguard Policy Statement (SPS) 2009. The EIA covers the assessment of both the First and Second stages of the Project, separately.

2.1 Introduction to the EIA

2.1.1 Objectives

40. Both the Pakistan's environmental law and ADB's SPS 2009 require that environmental assessment of the projects involving existing facilities shall a) cover the potential environmental impact of proposed new activity and b) address any environmental issues of the existing facilities. To realize this, an environmental audit of the existing facilities is undertaken as part of the EIA. The objectives of the EIA, therefore, are as follows:

- Review the operations of existing JTPS and identify all environmental aspects including natural resource consumption, gaseous emission, liquid effluent, and solid waste;
- Based on available information determine whether the current operations are in compliance with the national regulatory requirements and that of the SPS 2009;
- Using evidence—documentary, observational or circumstantial—identify and quantify to the extent possible any issues related to non-compliance with the law or the SPS 2009 in the past that may have resulted in environmental liability for the plant or have the potential to become a liability in future;
- Undertake consultation with the stakeholders to scope out the study and again to provide them the feedback on the outcome of the study;

1 The total generation capacity of the power plant is the gross capacity. However, a part of the electricity generated is used within the power plant. The balance electricity which is available for supply to the transmission network is the net capacity. After the Second Stage the proposed Project will have 660 X 2 = 1,320 MW gross capacity. Of this 120 MW will be used internally and 1,320 – 120 = 1,200 MW will be the net capacity.

- Prepare a physical, ecological and social baseline of the area of influence (the 'Study Area') of the existing and proposed activities in order to evaluate the environmental impacts of the existing plant; assess the environmental impacts of the proposed activities, and serve as reference for future;
- Propose a corrective action plan for the existing plant, where needed, to ensure that the operations are in compliance with the legal requirements and ADB's SPS 2009;
- 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 ADB's SPS 2009 for submission to the ADB and the Sindh Environmental Protection Agency (SEPA).

41. This report is prepared to meet the above objectives.

2.1.2 Scope of the EIA

42. The scope of the EIA includes the operation of the existing JTPS and the construction and operation of the proposed Project. It also includes the transportation of equipment from ports of Karachi to the JTPS and the transportation of coal.

43. The scope does not include the construction and operation of the transmission line. The power from the proposed Project will be evacuated through the proposed *MFF Power Transmission Enhancement Investment Program - Proposed Tranche 3: Third Circuit 500 kV Transmission Line Jamshoro to Rahimyar Khan and Moro Grid Stations*. The environmental assessment for the transmission line was completed in 2011[2] and has been disclosed on the ADB website. Conversion of boilers is not in the scope of this project.[3]

2.1.3 Background of the EIA Study

44. JPCL was originally planning to a) convert two of the existing boilers in the JTPS from High Sulfur Fuel Oil (HSFO)-firing to coal-firing and b) install one new 600 MW coal-fired power generation unit. Both the components were envisaged to use imported coal. An EIA for this project was initiated in May 2012 for which an environmental audit of the JTPS was conducted, scoping consultation was undertaken, and environmental and social baseline data was collected.

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[2] *Environmental Assessment and Review Framework: PAK: MFF Power Transmission Enhancement Investment Program – Proposed Tranche 3*, Asian Development Bank, November 2011 (www.adb.org/sites/default/files/projdocs/2011/37192-043-pak-earf.pdf), accessed June 2013. and *Initial Environmental Examination: PAK: MFF Power Transmission Enhancement Investment Program – Proposed Tranche 3*, Asian Development Bank, November 2011 (www.adb.org/sites/default/files/projdocs/2011/37192-043-pak-iee-02.pdf), accessed June 2013.

[3] This study assumes that the boilers will continue to run on HSFO. If the GoP undertakes conversion of the boilers, the responsibility of the EIA will be that of the proponents.

45. In 2012 GoP initiated a new policy that required that all conversion of boilers in the existing public sector power plant shall be based on indigenous coal. Consequently, the scope of this project has been redefined to include installation two 600 MW units. Conversion of boilers is not in the scope of this project.[4] Further, the boilers will now be designed on a blend of imported coal and indigenous coal instead of only imported coal.

46. This EIA is a continuation of the previous study however wherever necessary new baseline data collection, stakeholder consultation, and assessment has been done, especially with regards to the new technology and scope of operation.

2.2 Institutional Arrangements

47. 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 JPCL personnel; monitor, coordinate and provide support to implementing agencies in construction work of the proposed Project; monitor implementation of the environmental management plan (EMP) and the corrective action plan and ensure that implementing agencies comply with all the legal requirements and the ADB safeguard requirements)

- Jamshoro Power Company limited (JPCL)

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

- ADB

  Main project financier

48. In addition to the above, additional institutional arrangements will be made for implementation of the project. These are described in **Chapter 10** of the EIA.

2.3 Project Setting

49. JTPS is located north of Jamshoro town in the Jamshoro district of Sindh province, Pakistan (**Figure 2-1**). The power plant is about 10 km northwest of Hyderabad and about 150 kilometer (km) northeast of Karachi. It is located on N-55, also known as Indus Highway. N-55 is one of the two main highways of the country which connect Karachi, the main port and industrial hub of the country, with the rest of the country. The north and northwest of the power plant is barren flat land. Some smaller sedimentary hills are located in the west and southwest, which rise to an elevation of 100 meters (m) above mean sea level.

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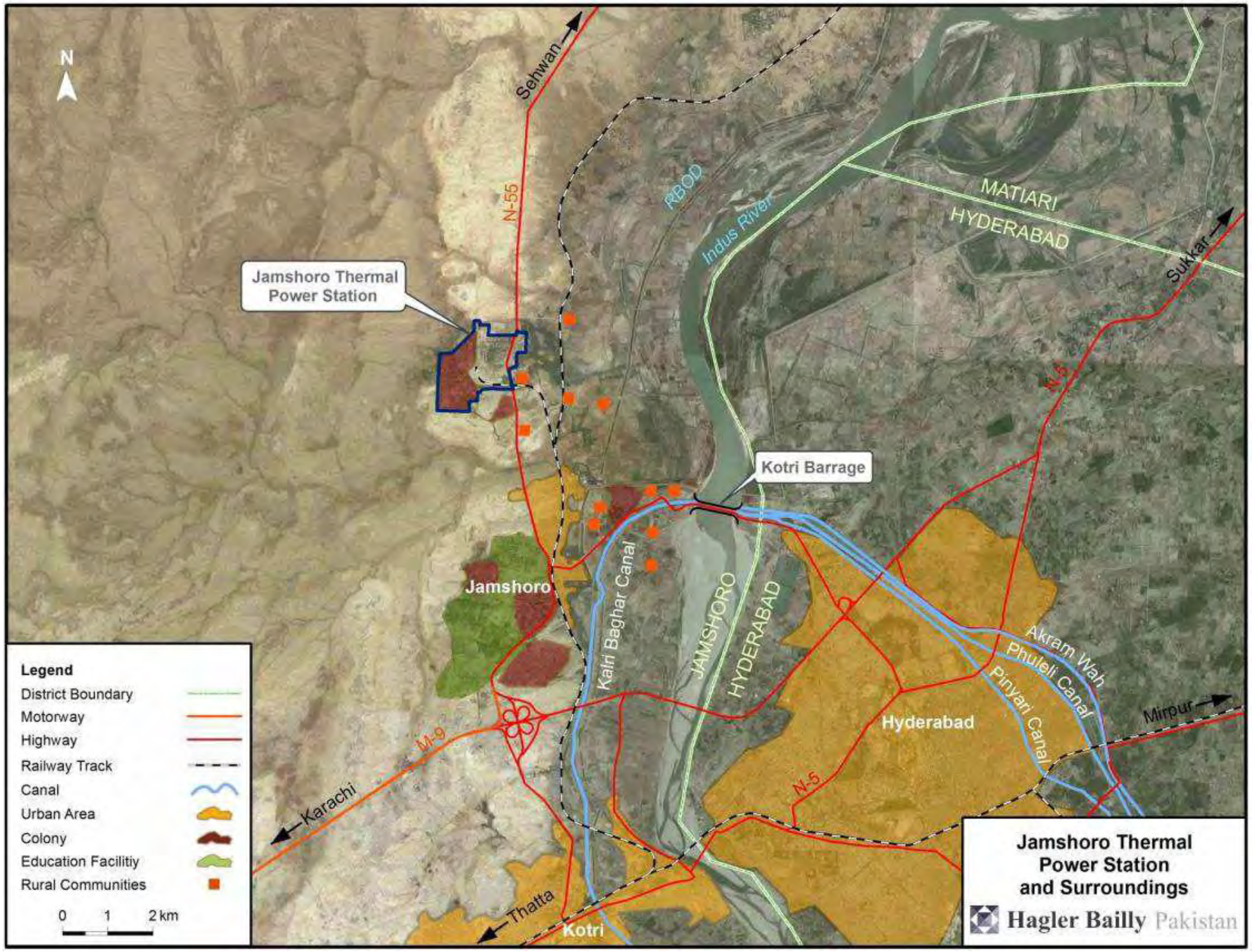
[4] Any boiler conversion will be considered separately. This study assumes that the boilers will continue to run on HSFO.

Figure 2-1: Jamshoro Thermal Power Station and Surroundings



50. To the south of the Plant, at a distance of about 5 km, is the urban area of Jamshoro. Scattered villages and farmlands are located to the east and northeast of the JTPS, in the flood plains along the banks of Indus River. The river also supports fish which is a source of income for local fishermen. In places, small pools of stagnant water are formed within the agricultural fields, some of which are caused by the effluent from the operations of the existing facilities at JTPS. The Indus River flows in the north-to-south direction at a distance of about 4 km to the east of the existing facility. The elevation of the land in surroundings of the plant ranges between 20 and 45 m. It slopes towards the Indus River.

51. Jamshoro 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.

52. The population clusters in the surroundings of the JTPS can be broadly classified as rural, urban and institutional housing colonies. The rural area population is found in small scattered villages. Agriculture is the main source of livelihood for the rural areas. The urban areas comprise of a contiguous population belt that forms the Jamshoro town. The urban areas have better access to facilities, such as, roads, schools and hospitals. The housing colonies are purpose-built residential areas associated with JTPS and educational institutions such as the the University of Sindh and the Liaquat University and Health and Medical Sciences (LUHMS). The housing colonies and the urban areas together constitute the more developed and better-off segments of the area in the surroundings of the plant. Photographs of the project surrounding area are included in **Figure 2-2**.

This area intentionally left blank

Figure 2-2: Photographs of JTPS Surrounding Area

Barren lands towards the north and northwest

Hills towards the west and southwest

Typical vegetation cover observed in the surroundings

An agricultural field

Pools of stagnant water created by plant effluent

Indus River, flowing at the east of the plant

Urban area of Jamshoro

Village near power plant

2.4 Project Rationale

53. Pakistan is going through an acute power shortage. **Figure 2-3** provides a brief description of the power market players. According to the National Electric Power Regulatory Authority's (NEPRA) 'State of the Industry Report 2012' the gap between supply and demand in 2011-2012 was well above 5,000 MW mark and remained between 4,000 MW and 5,000 MW for most part of the year. The country has therefore an urgent requirement to generate additional power to feed into the national grid. **Table 2-1** shows the projections of power supply and demand in the NTDC's and KESC's systems indicating that the gap between supply and demand is likely to persist over next few years. The gap represents about one-third of the total demand in National Transmission and Despatch Company (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. Any slippage in the addition of new generation capacity or fuel availability will further widen the gap between supply and demand.

54. Chronic power shortages in Pakistan are the most serious constraints to the country's 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.

Figure 2-3: Pakistan Power Market Players

The power sector in Pakistan primarily consists of two systems: newly corporatized generation, transmission and distribution companies that have been formed out of the former vertically integrated power utility, the Water and Power Development Authority (WAPDA), and the Karachi Electric Supply Corporation (KESC).

In 1998, WAPDA's Power Wing was restructured into 13 independently functioning corporate entities with an aim to gradually move the power market towards competition, inject private capital in mainstream development, and improve the sector's operational efficiency. Under the restructuring process, the functions of generation, transmission and distribution were separated through the creation of 13 distinct entities – 4 thermal generation companies (GENCOs), one central National Transmission and Dispatch Company (NTDC), and 8 distribution companies (DISCOs) – through an extensive corporatization process in which the assets and liabilities of these companies were identified and separated, and independent boards of directors appointed to manage the affairs of each new company. The four GENCOs are now under the control of GENCO Holding Company (GHC), a government–owned entity. Later two new DISCOs have been formed by bifurcating two existing DISCOs, thus raising the total number of DISCOs to 10.

Since corporatization, these companies have been functioning under the aegis and financial control of the Ministry of Water and Power (MoWP). The ultimate plan was to privatize the generation and distribution companies so as to achieve high operating efficiencies through prudent private management in the power sector. This is yet to be achieved.

In addition to the generation capacity installed by WAPDA and the KESC, there are a number of power plants in the private sector that are known collectively as independent power producers (IPPs). KESC is a vertically integrated utility serving only the city of Karachi and has already been privatized.

The MoWP and National Electric Power Regulatory Authority (NEPRA) are the two institutions responsible for governance of the power sector.

Table 2-1: Projected Supply and Demand in NTDC and KESC Systems

Financial Year ending 30th June	Planned Generation Capability as per NTDC (MW)	NTDC Projected Demand Growth Rate	NTDC Projected Demand during peak hours (MW)	Surplus/ (Deficit) (MW)
NTDC				
2012 (actual)	13,733	-	20,058	−6,325
2013	21,299	7.4%	24,126	−2,827
2014	21,668	7.4%	25,918	−4,250
2015	30,510	7.7%	28,029	2,481
2016	20,352	5.5%	24,018	−3,666
2017	24,075	5.5%	25,352	−1,277
KESC				
2012 (actual)	2.371	5%	2,564	−193
2013	2,371	5%	2,692	−321
2014	2,419	5%	2,827	−408
2015	2,437	5%	2,968	−531
2016	2,737	5%	3,116	−379

Source: NEPRA's State of Industry Report, 2012

55. In addition to the economic impact, the shortage has environmental and social impacts as well. Other than complaints of general discomfort, students have complained of effects of the load shedding on their studies. It has also resulted in deterioration of health care services.

56. 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.

57. The power shortage cannot be attributed to any single cause. Failures in a number of areas have led to the present conditions. Some of the factors which significantly contributed in increasing the shortages to such staggering levels are as follows:

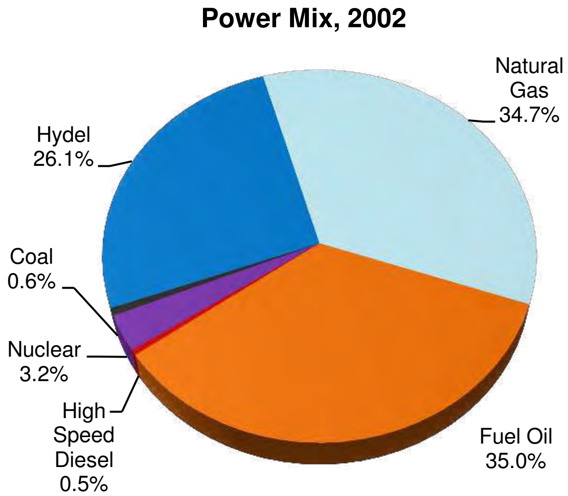
- Addition in power generation capacity was not planned or achieved to match the demand, consequently rapid growth in demand outstripped the corresponding additions in generation capacity over the past few years.

- Shortage of natural gas has resulted in increased power generation on HSFO. As shown in **Figure 2-4**, for the last ten years about one-third of the power generation has been on HSFO. Average generation cost of power on HSFO at JTPS is presently about Pakistani Rupees (PKR) 21.00 per kilowatt-hour (kWh). A continuing high level of generation on HSFO combined with rising oil prices in the international market have contributed significantly to increase in electricity tariff which has increased from PKR 5.50/kWh in 2008 to PKR 11.81/kWh in 2012. As the Government of Pakistan (GoP) subsidizes the electricity by about PKR 3.17/kWh, the increasing dependence on HSFO has resulted in widening the budget deficit. It is also making it difficult for the GoP to eliminate power subsidy due to political considerations. This, in turn, has affected the availability of cash to public sector power generation companies, and distribution companies.
- Shortage of funds has resulted in poor maintenance. Owing to this, the GENCOs have lost nearly 35% of their total installed capacity due to plant degradation and are operating at lower availability of around 75% with frequent break downs of generation units when compared to Independent Power Producers' (IPPs) which are liable to maintain availability of 88% and 85% in their respective contracts under the power policies of 2002 and 1994. By compounding the two factors, the net availability of GENCOs merely stands around 49%, nearly half that of IPPs; and
- Excessive and prolonged shut-downs of the IPPs plants resulting from contractual disputes and withholding of payments by the Central Power Purchasing Agency (CPPA) constraining their ability to procure fuel or operate the plants.

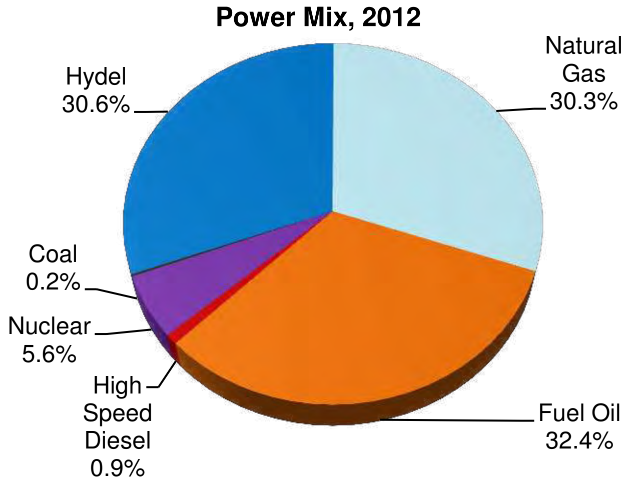
58. In addition to increasing the generation capacity, it is essential to lower the generation cost. One possible option is the hydropower. The government is pursuing both large and small hydropower projects to utilize domestic resources. However, hydropower despite being the ideal solution has long implementation period and is not useful to address immediate issues. Liquefied Natural Gas (LNG) and imported pipeline gas are the other alternatives. Import on natural gas through pipelines, if it happens, is going to take a long time to materialize. The LNG is relatively a short-term alternative but given the current market price of LNG it is unlikely to help in lowering the cost of power produced. Further discussion on alternatives for power generation is included in **Section 8.2**.

59. 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 22% in 10 years (**Figure 2-4**). This will require converting existing 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.

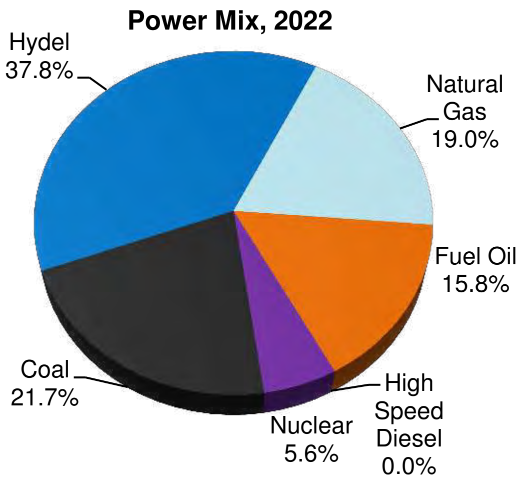
Figure 2-4: Pakistan Energy Mix (2011-12)



Source: Pakistan Energy Yearbook, 2002



Source: Pakistan Energy Yearbook, 2012



Source: Based on NTDC Electricity Demand Forecast and Generation Expansion Plan

2.5 Organization of the Report

60. The EIA contains 12 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 ADB SPS 2009. A description of the existing JTPS and the proposed Jamshoro 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**).

61. The environmental legacy of the existing JTPS are identified and discussed in **Issues Related to Existing Plant and Corrective Action** (**Chapter 6**) along with the proposed corrective action.

62. Following two chapters are **Information Disclosure, Consultation, and Participation** (**Chapter 7**) and **Analysis of Alternatives** (**Chapter 8**). These cover two key aspects of the EIA process.

63. The core of the EIA is the **Environmental Impacts and Mitigation Measures** (**Chapter 9**) 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 10**) 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 11**) proposes the mechanism to affectively address any grievances of the community and other stakeholders against the project.

64. Finally, **Conclusions** (**Chapter 12**) concludes the report. The background information and detailed data is provided in the appendices.

3. Legal and Institutional Framework

3.1 Historical and Constitutional Context

65. 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, 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 1930 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 IEE and EIA Regulations (IEE-EIA Regulations) 2000* which provided the necessary details on the preparation, submission, and review of initial environmental examinations (IEE) and environmental impact assessments (EIA). In addition to the PEPA 1997, Pakistan's statute books contain a number of other laws that have clauses concerning the regulation and protection of the environment.

66. 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 are as follows:

- The Ministry of Environment at the federal level has been abolished. Its functions related to the national environmental management haves been transferred to the provinces. The international obligations in the context of environment will be managed by a new ministry, the Ministry of Climate Change of the federal government.
- The PEPA 1997 is technically no longer applicable to the provinces. The provinces are required to enact their own legislation for environmental protection. It is understood that to ensure legal continuity PEPA 1997 continues to be the legal instrument in Sindh for environmental protection till enactment of new law.

67. It is anticipated that the provincial acts will be based on the PEPA 1997 and will provide the same level of protection. The discussion on regulatory requirements is, therefore, based on the provisions of PEPA 1997.

3.2 Environmental Law

68. The PEPA 1997 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 articles of PEPA 1997 that have a direct bearing on the proposed Project are listed below. The details are discussed in the following sections.

- Article 11 that deals with the national environmental quality standards and its application
- Article 12 that establishes the requirement for environmental impact assessment
- Article 14 that deals with hazardous substances
- Article 15 that relates to vehicular pollution

69. To implement the provisions of PEPA 1997, several *rules* and *regulations* have been promulgated.[1] 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
- Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations, 2000

70. Guidelines are issued by the Pakistan Environmental Protection Agency for preparation of environmental assessment. The relevant guidelines are discussed in **Section 2.3**.

71. The articles of PEPA 1997 that have a direct bearing on the proposed Project and their implications are as follows:

3.3 Requirements for Environmental Impact Assessment

72. The articles of PEPA 1997 that have a direct bearing on the environmental assessment of the proposed Project are:

- Article 12(1): 'No proponent of a project shall commence construction or operation unless he has filed with the Federal Agency[2] an Initial Environmental Examination or, where the project is likely to cause adverse

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[1] 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 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.

[2] The term 'Federal Agency' refers to the government agency which has the power or to which the powers have been delegated to implement the provisions of this act. In case of this project, the concerned agency is the Sindh EPA.

environmental effects an environmental impact assessment, and has obtained from the Federal Agency approval in respect thereof.'

- Article 12(3): 'Every review of an environmental impact assessment shall be carried out with public participation…'

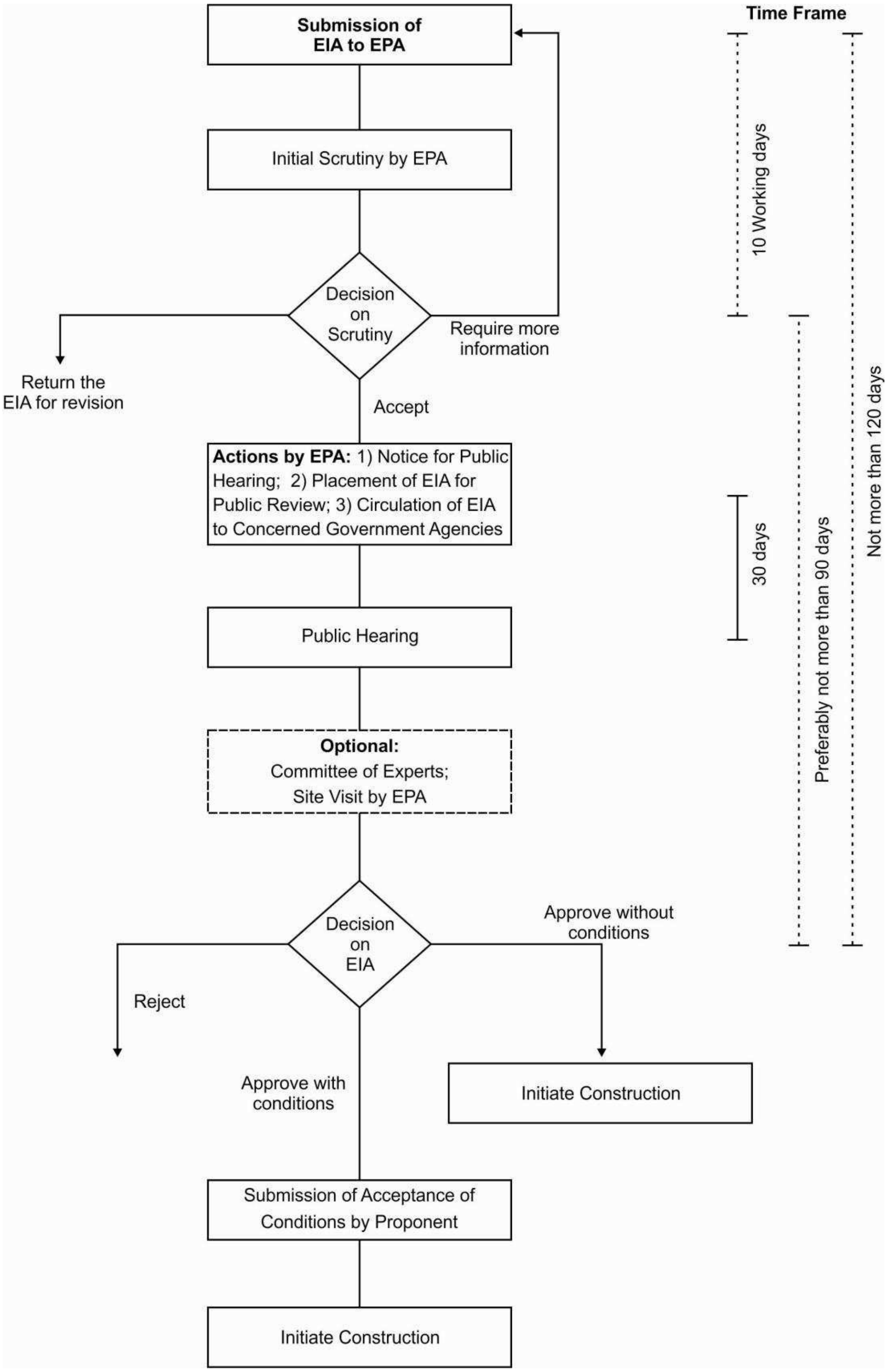
73. The IEE-EIA Regulations 2000 provide the necessary details on the preparation, submission, and review of the IEE and the EIA. Categorization of projects for IEE and EIA is one of the main components of the IEE-EIA Regulations 2000. Projects have been classified on the basis of expected degree of adverse environmental impact. Project types listed in Schedule II of the regulations are designated as potentially seriously damaging to the environment and require EIA, and those listed in Schedule I as having potentially less adverse effects and require an IEE. Thermal power generation of capacity less than 200 MW is included in Schedule I (List of Projects requiring an IEE) whereas thermal power generation of capacity more than 200 MW is included in Schedule II (List of Projects requiring an EIA). 'Project' is defined in PEPA 1997 as 'any activity, plan, scheme, proposal or undertaking involving any change in the environment and includes (f) alteration, expansion, repair, decommissioning or abandonment of existing buildings or other works, roads or other transport systems, factories or other installations.' As the project involves expansion of an existing thermal power plant of capacity larger than 200 MW, it falls within the category of Schedule II and an EIA has been prepared for it.

74. Regulation 8 of the IEE-EIA Regulations 2000 require 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 IV; and (b) copy of receipt showing payment of the review fee.'

75. The prescribed procedure for review of EIA by the EPA is described in Regulations 9–14 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 12(4) of PEPA 1997 binds the EPA to 'communicate its approval or otherwise within a period of four months from the date the initial environmental examination or environmental impact assessment is filed complete in all respects in accordance with the prescribed procedure, failing which the initial environmental examination or, as the case may be, 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 made thereunder.' Regulation 11 of the IEE-EIA Regulations 2000, states that the EPA 'shall make every effort to carry out its review of the EIA within ninety days, of issue of confirmation of completeness'.

Figure 3-1: EIA Review and Approval Procedure



76. Regulation 6 of the IEE-EIA Regulations 2000 pertains to the guidelines. It states that: '(1) The Federal Agency may issue guidelines for preparation of an IEE or EIA 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, as the case may be, EIA and departure therefrom.' The relevant guidelines are the follows:

77. *Policy and Procedures for the filling, review, and approval of environmental assessments,* which 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.

78. 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;
- Reporting;
- Review and decision making;
- Monitoring and auditing;
- Project management.

79. 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)

80. *Guidelines for sensitive areas* which identifies the sensitive areas.

81. *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 Pollution Control Regulations and Standards

82. Two articles of the PEPA 1997 that are relevant to pollution control are:

- Article 11(1): 'Subject to the provisions of this Act and the rules and regulations made thereunder no person shall discharge or emit or allow the discharge or emission of any effluent or waste or air pollutant or noise in an amount, concentration or level which is in excess of the National Environmental Quality Standards…'
- Article 14: 'No person shall generate, collect, consign, transport, treat, dispose of, store, handle or import any hazardous substance except—(a) under a license issued by the Federal Agency and in such manner as may be prescribed; 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 Pakistan is a party."

83. As per Article 14(1), the requirements of Article 14 are applicable 'in such manner as may be prescribed'. PEPA 1997 defines that 'prescribed' to mean as prescribed under the rules made under the Act. Hazardous Substances Rules were drafted by Pakistan EPA in 2003 but were never notified. Therefore this article of the PEPA 1997 is not enforceable and will not affect the proposed project. However, best industry practice and internationally acceptable guidelines for hazardous substances would be used for the proposed project.

84. The complete set of NEQS is included as **Appendix 1**. It covers the following:

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

85. All industrial standards (ambient air quality, gaseous emission, ambient noise, and industrial effluent) are applicable to the proposed Plant.

86. 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 I 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 Sindh EPA in accordance with the rules.

3.5 Other Relevant Laws

3.5.1 The Forest Act, 1927

87. 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.

3.5.2 Factories Act, 1934

88. 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 Environmental Guidelines

3.6.1 ADB's Safeguard Policy Statement 2009

89. As per Asian Development Bank's SPS 2009, depending on the significance of project impacts and risks, the assessment may comprise a full-scale environmental impact assessment (EIA) for category A projects, an initial environmental examination or equivalent process for category B projects, or a desk review. ADB uses a classification system to reflect the significance of a project's potential environmental impacts. A project's category is determined by the category of its most environmentally sensitive component, including direct, indirect, cumulative, and induced impacts in the project's area of influence. Projects are assigned to one of the four categories shown in **Table 3-1.**

90. When the project involves existing activities or facilities, relevant external experts will perform environmental audits to determine the existence of any areas where the

project may cause or is causing environmental risks or impacts. *If the project does not foresee any new major expansion, the audit constitutes the environmental assessment for the project.* The policy principles under the SPS 2009 for environmental assessment are:

- Apply pollution prevention and control technologies and practices consistent with international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety (EHS) Guidelines.
- Adopt cleaner production processes, and good practices of energy efficiency.
- Avoid or, when avoidance is not feasible, minimize or control the intensity or load of pollutants emissions and discharges, including direct and indirect greenhouse gases emissions, waste generation, and release of hazardous material from their production, transportation, handling and storage.

Table 3-1: ADB Project Categories

Category	Project Description and Requirements
Category A	A proposed project is classified as category A if it is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. An environmental impact assessment is required.
Category B	A proposed project is classified as category B if its potential adverse environmental impacts are less adverse than those of category A projects. These impacts are site-specific, few if any of them are irreversible, and in most cases mitigation measures can be designed more readily than for category A projects. An initial environmental examination is required.
Category C	A proposed project is classified as category C if it is likely to have minimal or no adverse environmental impacts. No environmental assessment is required although environmental implications need to be reviewed.
Category FI	A proposed project is classified as category FI if it involves investment of ADB funds to or through a FI

- Avoid the use of hazardous materials subject to international bans or phase-outs.
- Use, purchase and manage pesticides based on integrated pest management approaches and reduce reliance on synthetic chemical pesticides

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

91. 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.

92. 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**.

3.7 Institutional Framework

93. The success of environmental assessment as a means of ensuring that development projects are environmentally sound and sustainable depends in large measure on the capability of regulatory institutions for environmental management. The institutional framework for decision-making and policy formulation in environmental and conservation issues is briefly described below.

3.7.1 Sindh Government Institutions

94. Environment and Alternate Energy Department is functioning as a department of the Government of Sindh (GoS) since 2002. Sindh EPA operates under this department. It is a monitoring and regulating agency with the following main functions:

- Enforcement of PEPA 1997
- Enforcement of NEQS
- Implementation of Self-Monitoring and Reporting Tool (SMART)
- Review of EIAs and IEEs
- Providing advice to the government on issues related to environment
- Coordination of pollution prevention and abatement measures between government and non-governmental organizations
- Assistance to provincial and local governments in implementation of schemes for proper disposal of wastes to ensure compliance with NEQS
- Undertake measures to enhance awareness on environment among general public
- Conduct research and studies on different environmental issues
- Attend to public complaints on environmental issues.
- Carry out any other task related to environment assigned by the government.

95. Sindh EPA will be responsible for the review and approval of the EIA of Jamshoro power plant.

3.7.2 International and National NGOs

96. 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.

97. 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.

3.8 International Treaties

98. 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 stabilisation 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 and legally binding measures. It sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas emissions.	1997	2005
	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	1989	1994

Topic	*Convention*	*Date of Treaty*	*Entry into force in Pakistan*
	international and national levels.		
	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
Desertifi-cation	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 genetic resources.	1992	1994
	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

Topic	*Convention*	*Date of Treaty*	*Entry into force in Pakistan*
	Agreement for the Establishment of the Near East Plant Protection Organization - to establish the Near East Plant Protection Organisation (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 (amendment 1967)	1958 (amendment 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 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.	1972	1976

3.9 Comparison of NEQS with IFC Guidelines

99. The proposed project is legally required to comply with the NEQS for gaseous emission, ambient air quality, and liquid effluent. In addition, the ADB financing requires that IFC environmental guidelines should also be followed. In **Table 3-3** to **Table 3-5**, a comparison of NEQS and IFC Guidelines for key parameters of emission, ambient air quality, and effluent is provided for reference. The details are found in **Appendix 1** and **Appendix 2**.

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

Parameter	Standards	IFC Guidelines
Particulate matter	500 mg/Nm^3	For NDA: 50 mg/Nm^3 For DA: 30 mg/Nm^3
Sulfur oxides	100-500 Tons per day [1]	For NDA: 200-850 mg/Nm^3 For DA: 200 mg/Nm^3
Carbon monoxide	800 mg/Nm^3	–
Oxides of nitrogen	260 ng/J of heat input	For NDA: 510 mg/Nm^3 For DA: 200 mg/Nm^3

Notes:

1. For additional parameters and explanation, see complete NEQS in **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
3. NDA = Non-degraded airshed; DA = Degraded airshed

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

Pollutants	Time-weighted Average	NEQS	IFC Guidelines
Sulfur Dioxide (SO_2)	Annual Average	80 µg/m^3	
	24 hours	120 µg/m^3	125 µg/m^3
	10 min		500 µg/m^3
Oxide of Nitrogen as (NO)	Annual Average	40 µg/m^3	
	24 hours	40 µg/m^3	
Oxide of Nitrogen as (NO_2)	Annual Average	40 µg/m^3	40 µg/m^3
	24 hours	80 µg/m^3	200 µg/m^3
Ozone (O_3)	1 hour	130 µg/m^3	
	8 hour		160 µg/m^3
Suspended Particulate Matter (SPM)	Annual Average	360 µg/m^3	
	24 hours	500 µg/m^3	
Respirable particulate Matter. PM_{10}	Annual Average	120 µg/m^3	70 µg/m^3
	24 hours	150 µg/m^3	150 µg/m^3
Respirable Particulate Matter. $PM_{2.5}$	Annual Average	15 µg/m^3	35 µg/m^3
	24 hours	35 µg/m^3	75 µg/m^3
	1 hour	15 µg/m^3	
Carbon Monoxide (CO)	8 hours	5 mg/m^3	
	1 hour	10 mg/m^3	

Notes:

1. For additional parameters and explanation, see complete NEQS in **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. The NEQS for $PM_{2.5}$ are not consistent with those for PM_{10} . The issue is under consideration of Sindh EPA.

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

Parameter	NEQS	IFC Guidelines
Temperature increase	=<3°C	–
pH value	6 to 9	6 to 9
Five-day bio-chemical oxygen demand $(BOD)_5$ at 20°C	80	–
Chemical oxygen demand (COD)	150	–
Total suspended solids (TSS)	200	50
Total dissolved solids (TDS)	3,500	–
Grease and oil	10	10
Chlorides (as Cl')	1,000	–
Cadmium (Cd)	0.1	0.1
Chromium (Cr)-Total	1.0	0.5
Copper (Cu)	1.0	0.5
Lead (Pb)	0.5	0.5
Mercury (Hg)	0.01	0.005
Selenium (Se)	0.5	–
Nickel (Ni)	1.0	–
Silver (Ag)	1.0	–
Total toxic metals	2.0	–
Zinc (Zn)	5.0	1.0
Arsenic (As)	1.0	0.5
Barium (Ba)	1.5	–
Iron (Fe)	8.0	1.0
Manganese (Mn)	1.5	–
Boron (B)	6.0	–
Chlorine (Cl), Residuual	1.0	0.2

Notes:

1. For additional parameters and explanation, see complete NEQS in **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. NEQS are those for the discharge to inland waters

4. The Proposed Project

100. The proposed power plant will be installed within the premises of the JTPS. However, it will be an independent power plant, with its own fuel source, storage, utilities and operations.

4.1 Existing Jamshoro Power Plant

4.1.1 Generating Units

101. JTPS is an existing power plant with total installed capacity of 850 MW. Four conventional steam power generating units, installed in two phases, are in operation at the plant. Phase I involved the installation of one unit (Unit 1) with a capacity of 250 MW. Fuji Electric Company (Japan) supplied, erected and commissioned this unit in 1990. Phase II involved the installation of three units (Units 2, 3 and 4) with a capacity of 200 MW each. These units were designed, supplied and commissioned by China Machinery Engineering Corporation (CMEC).

4.1.2 Fuel and Performance

102. The boilers are mainly dual fuel-fired (heavy fuel oil and gas), except for Unit 1, which is designed for high sulfur fuel oil (HSFO). Current efficiencies for Units 1, 2, 3 and 4 are 34.0%, 28.3%, 28.5% and 28.6%, respectively. Presently, all four units are predominantly fired on HSFO because natural gas is no longer readily available. In 2010-11, the plant produced 2,803.87 GWh of electricity, of which only 19% was produced using natural gas.[1] Data for the current year are not available; however, the proportion of gas used as fuel is likely to be significantly lower.

4.1.3 Handling, Transportation and Storage of Fuel

103. JTPS has fuel delivery arrangements for HSFO for both railway tank wagons and road tankers. However, the power station presently receives HSFO only through road tankers from Karachi through Pakistan State Oil (PSO), as delivery by rail was discontinued in 2003. Oil is unloaded by transfer pumps from the trucks into storage tanks. The plant is also connected to the gas transmission network of Sui Southern Gas Company Limited (SSGCL). However, as mentioned above, natural gas is presently not being supplied to the power plant in view of the prevailing shortage of gas in the country.

104. The unloading capacity for furnace oil is 5,000 tons per day (t/d). Road tankers used for the transportation of HSFO have capacity of 40,000 liters (about 38.4 tons) each, based on which the design unloading capacity is about 130 tankers per day. The actual supply depends on the level of power production at the plant and given the derating in capacity is, on average, less than 60 tankers per day.

105. There are four HSFO storage tanks at the premises, each with a capacity 250,000 liters; three service tanks each with a capacity of 250,000 liters; and one service tank with a capacity of 100,000 liters.

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1 Hydrocarbon Development Institute of Pakistan, Pakistan Energy Yearbook 2011.

4.1.4 Water Supply System

106. The source of water for JTPS is the Indus River. An allocation of 1.13 cubic meter per second (m^3/s) or 40 cubic feet per second (ft^3/s) has been assigned by the Irrigation Department of the Government of Sindh (GoS) to the power plant. There are 16 intake water pumps, four for each unit, installed at the river to meet the requirements of the plant and the associated housing colony. Current major uses of water are for the cooling water system, and the operation of the coagulator/clarifier, where coagulated silt is removed and returned back to the river as coagulator blowdown (0.2 m^3/s). Other uses include those for the boilers, offices, other plant and housing colony needs.

4.1.5 Wastewater Generation and Disposal

107. The major discharge of wastewater generated from the facility is the cooling tower blowdown, which goes into the Indus through an open channel. The settled silt is removed from the coagulator (coagulator blowdown) as slurry which is also pumped into the open channel that carries wastewater from the plant to the river. Wastewater generated during regeneration of demineralized water is discharged to an unlined evaporation pond. 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 evaporation pond. Sanitary wastes from the plant are drained into septic tanks and the contents of the septic tanks are also transferred to the evaporation pond. There is heavy overgrowth of vegetation in the evaporation pond, with the result that the wastewater drained into the pond flows into open channels that ultimately join other wastewater discharges from the plant outside the eastern boundary of the plant. Untreated wastewater from the housing colony is drained outside the boundary wall of the colony at several points, and is partly used for agriculture by the local community.

4.1.6 Cooling Water System

108. The cooling towers are forced-draft counter-flow type, designed for a difference in temperature (ΔT) of 10 ºC. Except for the cooling tower of Unit No.1, which has six cells, all the cooling towers for Units 2, 3, and 4 have 12 cells each. The cooling towers are presently operating at a lower efficiency and the temperature reduction achieved across the cooling towers is only about 5 ºC, rather than the design reduction of 10 ºC. Of the six cells installed in the cooling tower for Unit 1, only three are operating.

4.1.7 Solid Waste Storage and Disposal

109. Hazardous waste dumped in the plant disposal areas includes asbestos sheets and soot removed during cleaning of the boilers operating on fuel oil. There is currently no facility for the proper storage of hazardous waste at the plant. Other non-hazardous solid wastes produced at the plant include metallic refuse, fiberglass insulation, and other materials removed during plant maintenance. This waste is stockpiled inside the plant. Municipal waste generated in the housing colony and the plant offices is dumped inside the housing colony.

4.1.8 Waste Fuel Oil Handling and Management

110. Oil spilled doing oil transfer operations is drained into an unlined sump located just north of the oil storage tank area, from where the oil is pumped back to the oil

storage tanks and the separated wastes are pumped and drained outside the plant boundary.

4.1.9 Stacks and Emissions

111. There are two exhaust gas stacks at the power plant. Two units are connected to each stack. Stack parameters are shown in **Table 4-1**. Stack emissions from the plant were monitored for this study for two units that were operating at the time the investigation was conducted, the results of which are presented in **Table 4-2**. The stack emission measurements show SO_2 concentration to be exceeding limits defined by the National Environmental Quality Standards (NEQS) 2000. No NO_2 was detected from any of the stacks, which means that all NO_x is being released as NO. Similarly H_2S emissions were not detected.

Table 4-1: Measured Stack Emissions at JTPS

Stack	*Unit*	*Stack 1*	*Stack 2*
Units connected		1 and 2	3 and 4
Capacity	MW	450	400
Stack height	m	150	150
Inner diameter	m	4.5	4.5
Flue gas temperature	K	410	413
Exit velocity	m/s	20	20

Table 4-2: Analysis of Stack Flue Gas

	Unit 1	*Unit 2*	*NEQS*	*IFC Gideliens*	
Load	*125 MW*	*100 MW*			
Date	26 Jun	6 Jul			*Unit*
Flue gas temperature	284.6	281.1			°C
Ambient temperature	40.5	40			°C
Oxygen (O_2)	1.21%	3.45%			
Carbon dioxide (CO_2)	14.89%	13.20%			
Carbon monoxide (CO)	147.1	30.1	800		mg/Nm^3
Nitrogen dioxide (NO_2)	175.6	120.1	[1]	For NDA: 510 [4] For DA: 200	mg/Nm^3
Sulfur dioxide (SO_2)	2,523	4,806	[2]	For NDA: 200-850 For DA: 200	mg/Nm^3
Hydrogen sulfide (H_2S)	0	0	10		mg/Nm^3

Notes:

[1] Emission standards for NO_X is 130 Ng/J of heat input.
[2] Emission standard for SO_2 is 100-500 TPD, depending on airshed degradation.
[3] Data for dust emissions is not available.
[4] NDA = Non-degraded airshed; DA = Degraded airshed

4.2 General Description of the Proposed Plant

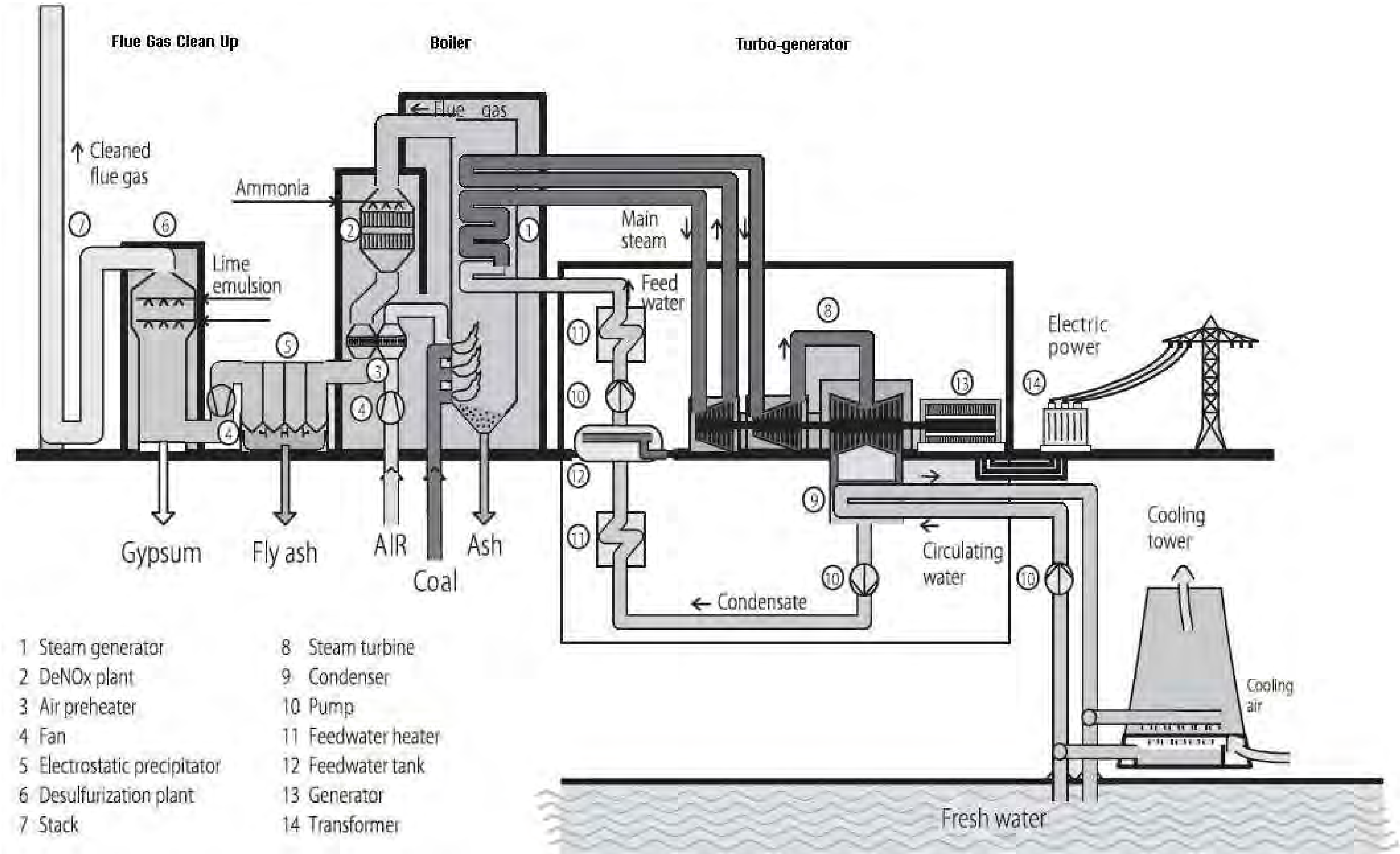
112. The Government of Pakistan (GoP) is proposing to develop a 600 MW power plant in the first stage with the possibility of expansion to 1,200 MW in the next stage-either immediately or in the near future. A block diagram of the power plant is shown in **Figure 4-1**. The major systems of the proposed plant include:

A. Coal handling and processing system
B. Super-critical boiler
C. Steam turbine and condenser
D. Electrical power generator and power export system
E. Flue gas treatment system
F. Cooling water system
G. Ash handling system
H. Utilities and waste management system.

113. Coal for the power plant will be received at the coal yard, part of the coal storage, processing and supply system (A). Within this system the coal will be processed for feeding into the boiler. The heat from the combustion of coal in the super-critical boiler (B) will be used to generate steam at high pressure. The steam will then be fed into the steam turbine (C), where it will rotate the turbine to generate mechanical energy. The steam, after passing through the turbine, will be condensed back to water and to be re-injected into the boiler. The rotating steam turbine will operate the power generator (D), which will generate electricity. The voltage of the electricity will then be increased or ‘stepped-up’ and exported through the high tension transmission system.

114. Flue gas from the boiler is normally laden with pollutants, oxides of nitrogen, particulate matter and sulfur dioxide. The gas will be passed through a series of treatment units (E) before being discharged to the atmosphere. In the treatment system, pollutants from the gas will be removed. Cooling water is required for condensation of the steam at the low-pressure end of the steam turbine. The water will be obtained from the cooling water system (F). The freshwater source for the proposed project will be the Indus River. Bottom ash from the boiler and fly ash from the flue gas treatment system will be collected and disposed of through the ash handling system (G). Finally, several supporting systems (H) are also required for plant operations. These include the freshwater treatment system for feeding the boiler and the effluent treatment and disposal systems for the wastewater generated by the plant.

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



115. Two 600 MW net power unit will be installed at the Jamshoro power station site, basic design parameters for which are listed below:

- Capacity: 2 x 600 MW net
  2 x 660 MW gross (nominal)
- Power technology: Pulverized coal firing in super-critical boilers
- Steam conditions: Main steam 24.1 Megapascal (MPa) at 593 ºC
  Single reheat steam 4.5 MPa at 593 ºC
- Fuel: Blended coal—subbituminous coal 80% (minimum), lignite (balance)
- Plant efficiency LHV: Gross 43.4% for subbituminous coal
  42.8% for subbituminous-lignite blend in 80:20 ratio.
- Cooling system: Natural draft cooling tower
- Emission controls: ESP efficiency > 99.9%
  FGD efficiency > 95%
  SCR efficiency > 80%

116. The new coal-fired power plant will be erected south of the existing Unit No. 4. It will consist of two 600 MW, super-critical, coal fired units, one unit will be installed in the first stage whereas the second unit will be installed in the second stage. The arrangement of the units will be similar to that of the existing units, namely the electrical transformers, turbine hall, boilers, ESPs, FGDs, and stack being placed from west to east, respectively. The coal receiving and storage yard will be to the south of the new generating units. The ash pond will be a slurry pipeline.

117. A residential colony will be constructed south of the plant's southern border fence. The new cooling towers for the units will be located east of their power block and to the north of the coal yard. Raw water will be taken from the Indus river in a newly constructed intake structure and pump house. Most of the wastewater will be collected in a basin, treated and reused to the greatest extent possible for coal dust suppression, ash handling and other purposes. Only a small amount from the cooling tower blowdown will be discharged back to the river.

4.3 Power Generation Technology

4.3.1 Super-critical Steam Generators

118. In order to achieve ever higher net plant efficiency in fossil fuel-fired power plants' thermal cycle, the main steam pressure and temperature employed have been steadily raised over the years. In the early 1920s, pulverized coal firing in boilers was first applied for power generation, with main steam pressure of 1.9 MPa (275 psig) and temperature of 293 °C. By the end of the 1950s, steam parameters had been continuously increased, with corresponding plant efficiency improvements. Babcock and Wilcox developed the once-through 'Universal Pressure' boiler to be used for subcritical and super-critical steam parameters. The first few super-critical power plants that did not require boilers with steam drums were put in operation in the 1950s, with steam conditions exceeding 30 MPa (4,350 psig) and 600 °C. The materials and metallurgy used in these plants, however, was not properly developed at the time, and these pioneering units had to be eventually derated and operated at lower temperatures.

119. From the 1960s through to the 80s, many super-critical power stations were built in the US, western Europe, Japan and Russia, most with steam parameters of 24.1 MPa (3,500 psig) and 537 °C (1,000 °F) with single reheat to 537 °C. Difficulties were encountered during the startup and control with multiple-valve operations in the first generation super-critical boilers, and consequently US utilities switched many units to subcritical with steam drum boilers.

120. The necessity of reducing flue gas emissions as well as increasing efficiency has, in the last two decades, led to the installation of new coal-fired plants with super-critical and ultra-supercritical steam generators. Introduction of in-line steam/water separators during startup has eliminated complicated valve manipulations necessary earlier. The development of materials suitable for high temperature operations has allowed the use of the higher steam parameters.

121. High-strength ferrite steels are now used for boilers, steam turbines, and high energy piping for steam temperatures of up to 565 °C. Research into materials suitable for even higher temperatures have resulted in austenitic steel and nickel-based super alloys, the use of which in the superheater and reheater of the boiler and high pressure turbine allows operation at steam temperatures above 600 °C.

122. Steam parameters for current large state-of-the-art fossil power plants can be divided into the following three categories:

- Subcritical: Pressures 15-17 MPa, temperatures 537 °C to 565 °C
- Super-critical: Pressures 24-26 MPa, temperatures 560 °C to 600 °C
- Ultra-supercritical: Pressures up to 31 MPa, temperatures 600 °C and higher.

123. With ultra-supercritical technology, increasing the throttle steam pressure from 16.5 MPa (2,400 psig) to 31 MPa (4,500 psig) will improve the heat rate by 2.5%, while increasing the temperature from 537 °C (1,000 °F) to 592 °C (1,098 °F) will improve it by about 3%.

124. In the past few years super-critical units have become the standard for large fossil power plants in Asia, with over 100 units of 600 MW or larger capacity in operation since 2002 in China alone. All critical components of these units, such as boilers and turbines, are based on technology transferred from western countries. In a matter of few years, China has become a major coal power equipment supplier and EPC contractor to the Asian power market due to its power plant experience, fabrication capability, and competitive prices.

125. Currently in China, most 600-660 MW units are super-critical with 24-25 MPa pressures and ~565 °C/565 °C temperatures. For larger units of 1,000 MW, ultra-supercritical units are often selected with higher steam parameters (26-27 MPa, and 600 °C/600 °C). The main limiting factor for higher pressures and temperatures is the availability and lead time in procuring the more exotic alloy fabrication materials.

126. India has embarked in large coal-fired power plant construction program using imported coal and, in some cases, blend of local coals. Many of the new units are of the ultra-supercritical type, ranging from 660 MW to 800 MW.

127. Over the years, two types of furnace water wall designs have evolved: the spiral furnace tube configuration and the vertical rifle tube configuration. The spiral furnace tube configuration allows more even heat flux to the tubes and facilitates the use of variable pressure and cycling operation, and has become the choice of European boiler manufacturers and their licensees. The vertical tube configuration with rifle tubes was

developed to simplify furnace fabrication, construction and maintenance, and allows full variable pressure and cycling operation with reduced pressure loss. Both furnace tube configurations are widely used, with equally good results.

128. The once-through super-critical boiler consists of water/steam circuit in which all water particles get heated, evaporated and superheated in one pass. In contrast to conventional subcritical boilers, once-through boilers do not have a steam drum and require advanced automation and control systems because of their relatively small water/steam volume as well as very pure boiler feedwater requirement (since they lack a drum in which impurities could deposit for blowdown from the boiler).

129. There are three main types of once-through boilers; Benson, Sulzer and Ramzin designs. The simplest and most common design is the Benson type, in which the point of complete evaporation varies with the load of the boiler. The temperature of the superheated steam is controlled by the fuel firing rate. The Sulzer monotube boiler uses a special pressure vessel, called the Sulzer bottle, for separating a low load and during startup. The steam downstream of the separator is always dry. The Sulzer boiler uses orifices to control the flow in the parallel water wall tubes. The Ramzin boiler has a spirally-wound furnace water wall design, which is now also used on Sulzer and Benson boiler designs. Ramzin boilers were mostly manufactured and used in countries of the former Soviet Union and in Eastern Europe.

130. In a pulverized coal boiler, the steam generator receives coal from the coal yard, then pulverizes it in coal mills to a fine powder about 1 mm in size which is conveyed by the primary air to the burners for combustion in the furnace to produce steam that drives the turbine and generator. The system consists of coal silos, pulverizers, burners, furnace, back pass, heating surfaces within the furnace and back pass, air heaters, soot blowers, forced draft fans, primary air fans, and induced draft fans.

131. In an atmospheric fluidized bed boiler, the coal is crushed to a 2-6 mm size and fed into a bed filled with sorbent or inert materials (limestone or dolomite), where it is burned in suspension in the bed. In a circulating fluidized bed boiler (CFB), some of the solids are entrained by the combustion gases to the upper furnace where a cyclone separates the solids and returns them to the furnace combustion zone. The presence of a bed with hot, solid materials in suspension in the furnace leads to quick ignition and burnout of the coal fed into the furnace. CFB boilers operate at lower combustion temperatures of about 750 ^{o}C (1,382 ^{o}F), while pulverized coal furnaces require gas temperatures of 1,050 ^{o}C (1,922 ^{o}F). The lower furnace temperatures in CFB result in lower NO_x formation during combustion. CFB technology allows combustion of low-grade fuels, is less sensitive to variations in coal quality, and can remove up to about 90% of sulfur oxides in the furnace without needing an expensive FGD (flue gas desulphurization) system.

132. Almost all fluidized bed boilers used are in the subcritical region, with the first super-critical fluidized bed unit built at Lagisza, Poland, with steam parameters of 28.3 MPa, main steam 563 ^{o}C and reheat to 582 ^{o}C. The Sichuan Baima Demon 600 MW CFB power station in China went into commercial operation in 2013, with the boiler designed and manufactured by Dongfang Boiler Group Co.

4.3.2 Plant Design Parameters

133. For the new Jamshoro 2 x 600 MW coal fired project, it is recommended to use a super-critical thermal cycle with main steam pressure at 24.1 MPa and reheat temperature of 593 ^{o}C. This will enable efficient use of the imported subbituminous

coals, lower greenhouse gas emissions, as well as reduction in SO_2, NO_x and ash production.

134. Since there are only a few large super-critical CFB boilers in operation, there is insufficient data to substantiate their operating and maintenance performance. Therefore, it is not recommended to select CFB over more proven pulverized combustion technology for the proposed 2 x 600 MW Jamshoro project.

135. The boiler system with single reheat can attain an efficiency of not less than 89.4% HHV while firing blended coal of 80% subbituminous and 20% Thar lignite. Each boiler will be sized to deliver 600 MW net electricity. The steam generator will be designed based on the following:

- Main steam pressure (at turbine inlet): 24.1 MPa
- Main steam temperature: 593 °C
- Reheat steam pressure: 4.5 MPa
- Hot reheat temperature: 593 °C
- Main steam flow @ boiler maximum continuous rating (BMCR):2,100 t/h
- Main steam flow @ guaranteed load: 1,800 t/h
- Feedwater temperature: 300 °C

136. The steam generator has been conservatively designed in view of the fact that it will burn Thar lignite in the coal blending. Thar lignite has low to moderate ash fusion temperatures and low propensity for slagging and foul. The most critical design parameters are those of the furnace. The following design parameters must be met:

- Plan area heat release rate: 40,000,000 kcal/h-m² of furnace plan area, which is the furnace width times depth.
- Burner zone heat release rate:[2] 1,400,000 kcal/h-m²
- Volumetric heat release rate:[3] 130,000 kcal/h-m².
- Effective projected radiant surface heat absorption rate:[4] 350,000 kcal/h-m².

137. The maximum furnace exit gas temperature will not exceed 1,100 °C. The maximum flue gas velocity through the convective sections will not exceed 22 m/s. The flue gas exit temperature from the air heater at all load conditions will not be lower than 10 °C above the sulfuric acid dew point temperature, or 130 °C.

138. The furnace enclosure, framing and ductwork design pressure will conform with US-NFPA 8502 or equivalent requirements for protection against explosion and implosion. Superheater, reheater and economizer tube sections will have in-line

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[2] The area used in the burner zone heat release rate is the flat projected area of the perimeter walls between an elevation 1.5 m below the centerline of the lowest burner row in service to 1.5 m above the centerline of the highest row of burners in service.

[3] The volume used includes the entire furnace and hopper up to the first convective section.

[4] The area used is the total projected area of the water wall, plus the area of a plane that is perpendicular to the gas flow where the furnace gases reach the first convection surface, plus the projected plan area of the surfaces of both sides of the platens and pendants, and plus the projected area of the furnace bottom.

arrangements. Convective tube elements will be arranged for easy cleaning with steam soot blowers. Tube banks will be arranged of not more than 2 m depth and not less than 1 m spacing between banks to allow access for inspection and repairs. The height of the tube banks will be such as to allow effective cleaning by soot blowers.

4.3.3 Coal Feeding and Pulverizer System

139. The boiler will be serviced by six coal silos. Their size will be established such that with five silo-pulverizer sets in operation, the steam generator will produce the design-guaranteed steam, while the sixth set is serviced or is on standby. The silos will be cylindrical vessels with a conical out hopper. The hopper will have a minimum 70^o slope from the horizontal. The capacity of five silos would provide for 12-hour operation at full load.

140. The silos will be made of steel plate lined with stainless steel. The silos will be supported on steel structures with adequate bracing and reinforcing members. Load scales will be provided under vertical columns for assessment of inventory in each silo. The silos will be fed with coal on the top by a traveling tripper conveyor. Each silo 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 these systems. Provisions will be made for injecting the silos with CO_2 gas when needed. Besides the main discharge opening leading to a gravimetric feeder and the pipe to the pulverizer unit, each silo will have an emergency door that will allow for dumping the coal on the floor in case of a fire in the silo, so that the dumped coal may be extinguished by portable fire extinguishers.

141. 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. All parts in contact with the coal will be fabricated with stainless steel. The electric motor driving the coal feeders will have variable frequency drive controls.

142. The pulverizer with vertical shaft roller design will consist of the shaft and three steel rollers, and electric motor drive, a gearbox velocity reducer, gear box lubricating system, hydraulic system for creating pressure on the roller assembly, hydraulic pump and accumulators. Each pulverizer will receive coal in pebble form, about 2 cm x 2 cm, and will grind it to a powder, about 80% 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 air/coal dust mixture will be maintained at 60 ^oC to 80 ^oC.

143. 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 size reduction. 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.

144. The burners will be of the staged combustion, low NO_x type. Additional airs for combustion will be the secondary air stream and the over-fire air. Shutoff gates will be provided on each mill when taken out for service 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.

4.3.4 Furnace

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

146. Finer ash particles (fly ash) is 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 will have membrane walls with fully welded tubes. The roof will also have membrane walls. Openings will be provided in 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 at least 60^{o} from the horizontal and so arranged that no obstruction exists that can impede the discharge of bottom ash.

147. Pendant and platen heat exchange surfaces are placed inside the furnace and the cross-over section from the furnace to the back pass. The back pass contains horizontal tube sections of economizer and selective catalytic reduction (SCR) system housing for NO_x reduction. The main air heaters will be vertical shaft, regenerative tri-sector type with flue gases flowing through one section, and the primary and the secondary air in 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.

4.3.5 Superheater and Reheater

148. 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 cleaning. Pendant tube sections, platens and wing walls will be arranged parallel to the direction of gas flow to minimize slag buildup.

149. There will be sufficient surface provided in the platen and pendant sections to maintain the furnace exit temperature bellow 1,100 ^{o}C at maximum boiler continuous rating and all other loads.

4.3.6 Economizer

150. 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, arranged in parallel with minimum clear spacing of one tube diameter. The economizer will be arranged with tube banks of not more than 2 m depth, with steam soot blowers between banks.

151. A pyramidal watertight hopper will be constructed facing the entire active area of the economizer. Hopper sides will be inclined at least 60^{o} to the horizontal, with a connection on the bottom to collect the coarse economizer fly ash.

4.3.7 Steam Generator Setting and Insulation

152. The steam generator will be balanced draft for outdoor installation with a roof cover and enclosed at the burner level. The design fuel is a blend of subbituminous coal with 20% lignite from the Thar region. The steam generator will be started-up, operated and shut down by remote control from the central control room using a distributed control system (DCS).

153. The furnace and back pass enclosure will include refractory insulation, welded steel plate fastened to the furnace tubes, and outer lagging of ribbed-type clad aluminum alloy with thickness not less than 1 mm. Furnace and rear pass enclosure walls will be suitable for water washing.

154. Hinged access doors, arranged to permit convenient and safe access for maintenance will be provided at 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 ^{o}C. All thermal insulation will be made from non-corrosive and non-asbestos materials.

4.3.8 Air Heaters

155. Two 50% capacity each vertical shaft regenerative-type air heaters will be provided to heat the primary and secondary air, taking heat from the exiting flue gases. 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 plate, not less than 12.5 mm thick, and braced to prevent deformation.

156. 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 laydown. The hot and intermediate sections will be made of carbon steel plate not less than 0.6 mm thick, and the cold end of low alloy corrosion-resistant steel plate not less than 1 mm thick.

157. 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.

158. A steam heater will be provided to prevent acid corrosion of the air heater cold end baskets and housing. As an alternative, cold end gas temperatures can be maintained by use of a hot air bypass into the cold end side, complete with isolation and control dampers.

4.3.9 Air and flue Gas Fans

159. The steam generator will be provided with two primary air (PA) fans, two secondary air forced draft (FD) fans, and two induced draft (ID) fans. The primary air 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 air and pulverized coal mixture to the

burners. The secondary air FD fans will take outside air, pass it through the tri-sector air heater, and then convey it to the wind boxes to support the combustion process.

160. The ID fans will draw flue gases from the combustion process, 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 indoors with sound attenuating screens at their inlets, and the ID fans will be located outdoors. All fans will be designed for continuous operation over their entire operating range without excessive vibration, surging or other undesirable characteristics.

161. 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 with maximum 30% excess air. The design margins are 1.2 times the flow and 1.44 times the pressure head of the guaranteed 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.

4.3.10 Soot Blowers

162. The steam generator 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 ^{o}C, and partially retractable blowers at gas temperatures of 540 ^{o}C and below. Where gas temperatures are 300 ^{o}C 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 ^{o}C, respectively.

163. 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.

4.3.11 Fuel Burning Equipment

164. A steam generator typically uses the following equipment in its fuel burning system:

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

165. The main burners will be of staged combustion, low NO_x type. The main burners will be sized and located so that the steam generator can be stably operated in the load range from the boiler maximum continuous rating (BMCR) to partial loads of 35% 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.

166. 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.

167. 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.

4.3.12 Ducts and Wind Boxes

168. 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.

4.4 Steam Turbine and Auxillaries

169. The main steam turbine will be a single reheat condensing, tandem-compound, 3,000 rpm, four-flow machine designed for operation with inlet main steam conditions of 24.1 MPa, 593 °C and reheat steam at 593 °C. It will have eight stages of steam extraction for feedwater heating: four low pressure, a deaerating, and three high pressure feedwater heaters. The steam turbine wil be nominally rated at 660 MW gross output at 10.2 kPa back pressure (corresponding to saturated temperature about 46.4 °C) with major design parameters as following:

- Main steam pressure: 24.1 MPa
- Main steam temperature: 593 °C
- Hot reheat steam pressure: 4.5 MPa
- Hot reheat steam temperature: 593 °C
- Main steam flow @ guaranteed load: 1,800 t/h
- Condenser pressure: 10.2 kPa
- Maximum turbine heat rate: 7,800 kJ/kWh

170. A turbine bypass steam path, with spray water and pressure reducing valves, will be provided to dump steam into the condenser in case of an emergency turbine trip. Additional major steam turbine auxiliary systems will include a lubrication oil system, gland seal system, rotor turning gear, control and protective valve system, and supervisory and control instrumentation.

4.5 Condenser and Condensate System

171. The surface condenser will receive exhaust steam from the low pressure turbines and condense it into liquid for reuse in the cycle. Water-cooled surface condenser is the dominant technology used in modern large central power stations. The surface

condenser will be maintained at a back pressure of 10.2 kPa and will serve the following functions:

- Provide low back pressure at the turbine exhaust to maximize the unit's thermal efficiency.
- Conserve the high purity water (condensate) for reuse in the boiler-turbine cycle to minimize 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, shutdown and emergency unit trip.

172. The condenser air evacuation system will consist of two mechanical vacuum pumps 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 taprogge 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.

173. 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 and neutralization and then used in ash sluicing to the disposal pond.

174. 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 5 mg/l.

4.6 Generator and Electrical System

175. The electric generator will be a totally enclosed, three-phase, 3,000 rpm, synchronous machine with hydrogen-cooled rotor. The cooling medium for the conductor-cooled stator windings will be either hydrogen or water. The main characteristics of the electric generator will be:

- Rated output: 660 MW, 776 MVA
- Power factor: 0.85
- Rated voltage: 22 kV or 24 kV, 3 phase, 50 Hz
- Terminal bushings: Neutral connect
- Terminal bushings basic impulse insulate level (BIL): 110 kV
- Hydrogen pressure in the generator: 400 kPa (58 psig) or higher
- Short circuit ratio: 0.55
- Winding insulation:Class F
- Efficiency: 99% or higher.

176. 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.

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

4.6.1 Excitation System

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

4.6.2 Generator Step-Up Transformer

179. The step-up transformer will transmit electric power from the electrical generator to the high voltage transmission system. The transformer will be located outdoors, and will be designed to operate in an environment characterized by an ambient air temperature range of between 10 °C and 45 °C. The step-up transformer will be connected to the electric generator by an oil insulated/cooled phase bus ducts and a generator circuit breaker. The transformer rating and design features will be as follows:

- Rating: 430/573/720 MVA
- Cooling: ONAN/ONAF/OFAF @ 55 °C rise
- Input voltage: 22-26 kV (LV)
- Output voltage: 500 kV with on-load tap changer (HV)
- Phase: 50 Hz, 3 phase
- Winding: HV wye, LV delta

180. The high voltage neutral will be solidly grounded to the plant grounding system. 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 65 °C 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.

4.6.3 Auxiliary Transformers

181. A unit auxiliary transformer and a startup transformer will be installed. The unit auxiliary transformer will provide power for all plant auxiliaries. It will take power from the electrical generator via the isolated bus duct tap-in ducts. The unit auxiliary transformer will be located outdoors, and its rating will be:

- Rating: 40/53/67 MVA
- Cooling: ONAN/ONAF/ONAF @ 50 oC rise
- Input voltage: 22-26 kV
- Output voltage: 6.6 kV
- Frequency:50 Hz, 3 phase
- Winding: HV delta, LV wye, with resistor ground.

182. For start-up, electric power for auxiliaries is taken from the electrical grid via the station start-up transformer. Four auxiliary (50% capacity, two sets for each unit) plus one start-up (100% capacity, one set for two units) will be installed. 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 with radiators cooling fans. The main characteristics will be

- Rating: 60/80/100 MVA
- Cooling: ONAN/ONAF/ONAN @ 55 oC rise
- Input voltage: 500 kV (HV)
- Output voltage: 6.6 kV (LV)
- Frequency:50Hz, 3 phase
- Winding: HV wye, LV delta, with HV neutral grounded to plant grounding system.

4.6.4 Generator Circuit Breaker

183. A generator circuit breaker will be installed between the generator and the step-up transformer. It will be used to synchronize the generator with the 500 kV electrical grid. The generator circuit breaker will be sulfur hexafluoride (SF_6) insulated, self-extinguishing, interrupting single-throw design with a pneumatic high-speed operating mechanism.

4.6.5 Medium Voltage Switchgear

184. The medium voltage 6.6 kV auxiliary system will distribute power to the low voltage load centers and to the 6.3 kV motors from either the unit auxiliary transformer or the unit startup transformer. The 6.6 kV switchgear will be rated to withstand and

interrupt the maximum short-circuit current within margins established by ANSI C 37.010. The full load current rating of the 6.6kV bus will be 5,000 A.

185. 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 be blocked in the event of a 6.6 kV bus fault, loss of voltage at the startup transformer, or a protective relay trip of the 6.6kV main breaker.

186. 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 6.6 kV switchgear will be located indoors. Open/close time of the breakers will be 0.2 sec.

4.6.6 Low Voltage Load Centers

187. This will consist of 6.6 kV/400 V unit substation dry-type transformers and 400 V switchgear and motor control centers. The transformers will be located indoors with two-winding, three phase, 50 Hz, insulation Class F, cooling AA/FA and LV grounding via resistor.

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

4.6.7 Electrical Motors

189. 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 6.6 kV switchgear, while motors smaller than 199 kW will be fed by the low voltage motor control centers. All motors will be built with class F insulation. Motors that smaller than 0.75 kW will be single phase, 230 V AC. Direct current motors will be powered by the 230 V DC system.

4.6.8 DC Power System

190. 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 four hours in the event of loss of AC power, and have sufficient current to feed all critical plant loads at the nominal voltage level.

191. 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. A total of 3 DC power systems will be installed, one for each unit and the third one for the switchyard.

4.6.9 Cable Systems

192. 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

193. 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

194. 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

195. 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 35,400 m^3/day per unit, with 33,600 m^3/day for evaporation and 1,800 m^3/day 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 4-3**.

Table 4-3: Circulating Water Chemistry

Parameter	*Makeup Water*	*Circulating Water*
Temperature, °C	35	45.6
pH	7-8.5	7-8.5
Conductivity, µmhos/cm	350-500	1,500-2,200
Suspended solids, mg/l	15-30	40-90
Total hardness, mg/l as $CaCO_3$	80-150	250-500
Total dissolved solids, mg/l	300-500	1,000-1,500

196. 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

197. 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.

198. 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 Jamshoro 2 x 600 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 Jamshoro project. Most large power units where no once-through cooling system is available use natural draft cooling towers for cooling circulating water.

199. 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 600 MW coal-fired unit will have a base diameter of about 110 m and a height of about 140 m.

200. 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

201. 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.

202. 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

203. 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 ^{o}C under all operating conditions.

204. The system will supply cooling water to the following:

- Main turbine lube oil coolers
- Generator hydrogen coolers
- Generator air-side seal oil cooler
- Generator hydrogen-side seal oil cooler
- Boiler feedwater pump turbine lube oil cooler
- Air compressor, inter- and after-coolers
- Sample coolers
- Condensate pump motor cooler
- Boiler auxiliaries coolers
- Hyolrogen/oxygen generator.

4.7.6 Chemical Treatment System

205. 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.

206. 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

207. The freshwater system will take water from the Indus River. The required quantity is about 40,000 t/day for one 600 MW unit, so the total freshwater requirement is about 80,000 t/day for the 2 x 600 MW project. 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

208. 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.

209. In locating the intake structure for the units, consideration will be given to the existence of the water intakes for Units 1, 2, 3 and 4 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 tons, capable of supplying water to both units for one day. 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.

210. 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.

211. 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.

212. 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 °C
- 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 $CaCO_3$: 80 to 150 mg/l

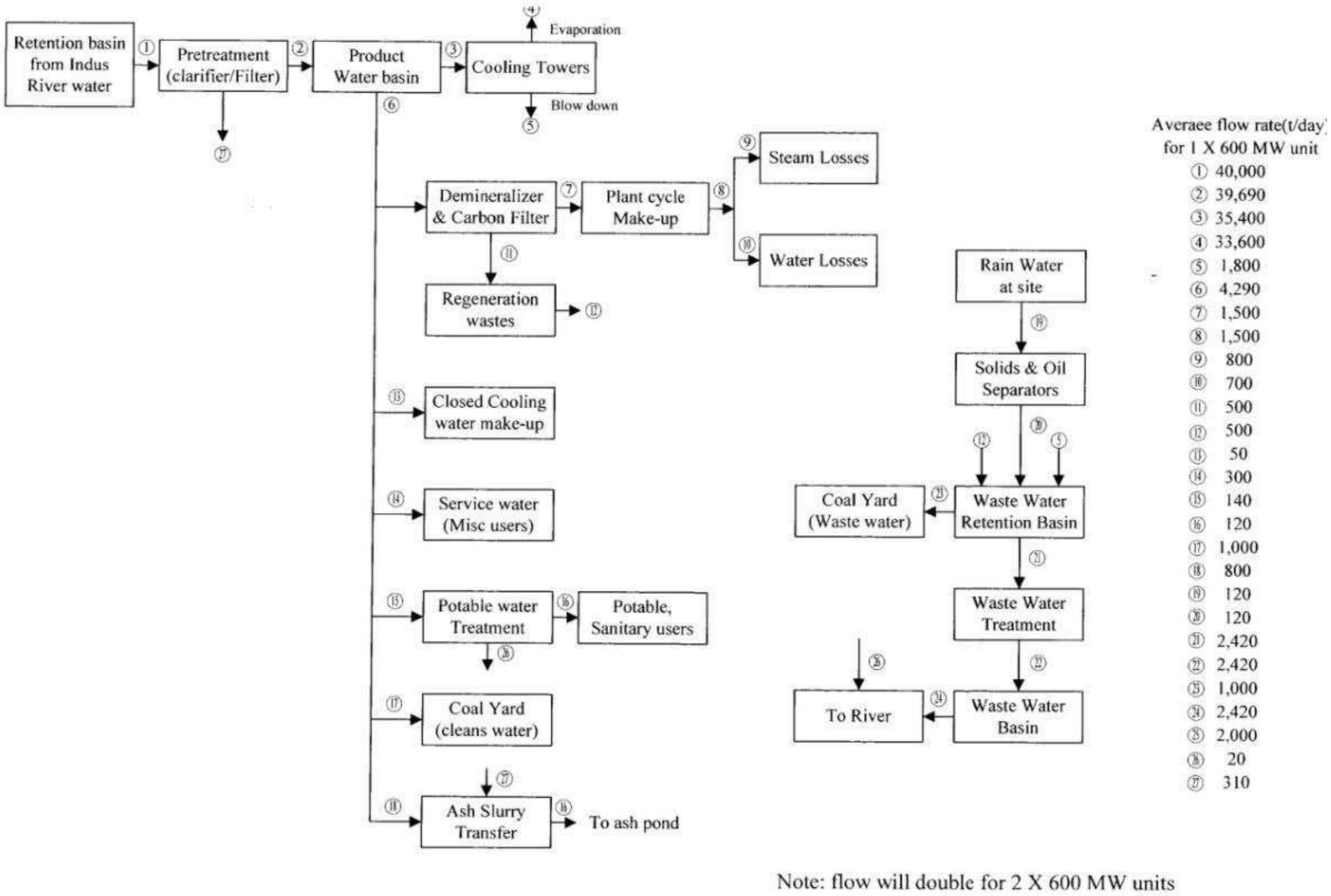
213. The reactor-clarifiers will be used to remove suspended materials. Each unit will consist of two large (30 m diameter and 4.5 m height) cylindrical concrete vessels, in which a central mixing and chemical addition zone will be located. The process takes several stages, the first being coagulation. 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.

214. The clarification process will produce two streams: the cleaned water that flows out of the unit at the top in a trough, and a 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.

215. 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.

216. 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 4-2**.

Figure 4-2: Proposed Water Supply System



217. 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.

218. 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 from 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.

4.9 Design Coal Specification and Blending

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

Table 4-4: Quality of Design Coal

Parameter	Subbituminous (e.g., INDO5(P))		Lignite (e.g., Thar)	
	Range	Selected Value	Range	Selected Value
C	50-65	50.0	28.0-37.4	28.0
H	1-3	1.0	1.6-301	1.6
O	30-50	30.0	6.6-10.5	6.6
S	<1	1.0	0.2-2.7	2.7
N	<2	2.0	0.2-0.4	0.4
Moisture	<26	26.0	44.9-50.4	50.4
Ash	<9	9.0	4.0-15.1	15.1
High Heating Value (HHV), kcal/kg	> 4,780	4,780	2,231-3,250	2,231

220. For the purpose of design, three different blending percentage of Lignite has been considered, namely 10%, 15%, and 20%. The fuel properties under these blending scenarios are shown in **Table 4-5**.

Table 4-5: Blended Fuel Properties

	Coal "E" Subbituminous 90% Lignite 10%	Coal "F" Subbituminous 85% Lignite 15%	Coal "G" Subbituminous 80% Lignite 20%
C	40.65%	39.96%	39.26%
H	0.90%	0.93%	0.96%
O	23.52%	22.67%	21.80%
S	1.00%	1.07%	1.15%
N	1.56%	1.51%	1.45%
Moisture	24.19%	25.38%	26.58%
Ash	8.17%	8.48%	8.80%
High Heating Value (HHV), kcal/kg	4,525	4,398	4,270

4.10 Coal Consumption

221. The total coal consumption will depend on the ratio of blending of subbituminous and Thar coals. The coal consumption for the 1,200 MW plant for three possible scenarios is shown in **Table 4-6**. In the first stage of 600 MW, the consumption will be half of that of the values shown in **Table 4-6**.

Table 4-6: Coal Consumption

Coal	Subbituminous	Lignite	Total
Daily Consumption (tons)			
Coal E 90:10	12,698	1,411	14,109
Coal F 85:15	12,355	2,180	14,535
Coal G 80:20	12,054	3,013	15,067
Annual Consumption at 85% Plant Factor (million tons)			
Coal E 90:10	3.94	0.44	4.38
Coal F 85:15	3.83	0.68	4.51
Coal G 80:20	3.74	0.93	4.67

4.11 Coal Handling System

222. The function of the coal handling system is to receive, store and deliver coal to the boiler silos. The coal handling system will be designed to serve primarily the new 2 x 600 MW net (2 x 660 MW nominal) super-critical units, but will be able in the future, with some modifications and equipment additions, to provide the coal needed for the conversion of any of the existing boilers at JTPS. Two types of coal will be used: imported subbituminous coal and lignite coal. These fuels will be blended before delivery to the boiler coal silos.

4.11.1 Coal Delivery and Storage

223. At full load, one 600 MW unit will consume coal at about 6,800 ton/day of 20% lignite and 80% subbituminous blended coal. At an 85% capacity factor, the annual coal consumption for one unit will be about 2.1 million ton/year, with 1.7 million ton of subbituminous and 0.4 million ton of lignite. Coal will be delivered to the site primarily by railroad car; however provisions will be made to receive, unload, and store coal transported by trucks as well.

224. Subbituminous coal will be imported and unloaded initially at Karachi Port. In order to be able to unload a ship in about three days (after which demurrage charges rise sharply), the port must have adequate facilities and space for unloading and storage of the entire shipment contents.

225. There are two types of coal cars used for railroad delivery: bottom unloading and fixed bottom cars. Bottom unloading cars have a mechanism that opens the hinged bottom to dump, by gravity, the contents into a hopper located below the car. These hinged bottom cars and their operating mechanisms usually require constant maintenance and repairs, with malfunctions leading to unwanted coal spills. Such cars may not be currently available in Pakistan; they are used in countries employing large internal coal shipments by rail.

226. The other method, which is recommended for this project, is the use of a rotary car dumper. This involves a car positioning system that puts individual railcars on the rotary dumper, which then locks the railcar in position, rotates and dumps the coal contained in the car into a hopper from where conveyers take the coal for storage. Railcars are usually provided with hinged couplings, so that the unloading can proceed without decoupling the cars from one another.

227. The railroad trains will have two or three locomotives and 50 cars of about 50 ton capacity each. Daily, three to four trainloads of 2,500 tons each will be delivered to the site for unloading coal to the storage yard in the first stage. The number will increase to six to seven trainloads in the second stage of 1,200 MW. If required, the unloading system can have the option of delivering the coal directly to the boiler after appropriate crushing, tramp iron removal, weighing, and analysis.

228. For the 1,200MW, a total of 540,000 tons of coal is to be stored at the plant at any given time to provide for the plant to operate for 40 days, in case the coal supply and delivery system is interrupted. The storage will be in two storage areas: an ‘active’ pile and a ‘dead’ (long term) storage pile. The active pile will be about 40,000 tons, based on three-day full-load coal consumption. The active pile will have a cover to protect it from rainwater for ready use. Dead storage will have a total holding capacity of about 500,000 tons, stacked in three piles each 10 m high and occupying an area of about 14 acres. The active coal pile will be continuously used, while the dead storage piles will allow separation by coal source and type. Reclaim from these piles will be dictated by the blending ratio required.

229. At the rail receiving area, the rail car positioning system will bring the cars in succession above the receiving hoppers; on top of these hoppers there will be a spaced bar cover to prevent excessively large lumps of coal into the hoppers. A travelling hammer mill breaker will be available to crush lumps in size for easier handling.

230. Two vibrating feeders under the receiving coal hoppers will deliver the coal into a 5,000 t/h, 2,000 mm conveyor belt that will transport the coal to a coal crushing house. A weigh scale and magnetic separator will be installed on this conveyor belt. In the

crushing house, a splitter gate will deliver the coal to one of two coal crushers, which will break it down to a size of about 40 mm.

231. From the breakers, the conveyor will put the coal on to the stacker/reclaimer conveyer belt for stakeout in the coal piles. An 'as-received' sampling system will take samples from the crushed coal and makes these samples available for laboratory analyses. The reclaim system will use 2 m wide conveyor belts, designed for reclaim at 5,000 t/h. The conveyers and adjacent metal walkways will be enclosed for ease of service/repair and to prevent dust emission during windy weather. The conveyer galleries will have illumination, dust collection at transfer points, and firefighting equipment.

232. The coal storage yard will be on level ground properly graded for drainage and compacted by bulldozer. To prevent rainwater seeping under the pile and into groundwater, the ground area of the coal yard will be covered with a layer of compacted impervious clad or cement, with rainwater drainage to the periphery where a water collection ditch will collect the water into a basin where it can settle out coal particles; the wastewater will be reused for dust suppression or ash sluicing.

233. Railroad spurs will be provided at the car unloading area for locomotive maneuver, and to hold a train while another is still unloading. The entire unloading operation of a 50 car train will take not more than three hours.

234. The coal yard will have two sets of bucket wheel stacker/reclaimers, each designed for stacking capacity of 5,000 t/h and reclaiming at 3,000 t/h. The stacker/reclaimer will be electric power-operated via flexible electric power cables. Each will have an operator cabin with communications to the plant operator.

235. There will be equipment for compacting the coal piles, including moving coal by dozers to the active coal piles. A coal handling equipment repair shop will be available for maintenance of mobile equipment and fixed installed devices, such as conveyer belts and crushers.

4.11.2 Coal Reclaim System

236. Coal for daily use will be taken from the active coal pile, where it will have been previously blended. The reclaimers will take the coal and transfer it on conveyer belts into a set of two crushers to reduce the size to about 30-40 mm. The conveyers will then bring the coal to the boiler silo filling gallery. The filling gallery will be enclosed to prevent rain and fugitive dust from entering and leaving, respectively.

237. The conveyer running over the coal silos will have a travelling tripper that may be positioned to discharge the conveyer belt flow to a specific silo. Level gauges in the coal silos will indicate when the respective silo is full, and signal to have the tripper moved to another silo. Six silos for the boiler will be provided, each with a 550 ton capacity. The silos will allow operation at full load for about 12 hours before refilling is needed.

4.11.3 Dust Suppression and Temperature Monitoring

238. To prevent contamination of the atmosphere with coal dust, a water spray system will be located at strategic locations at the coal yard for use by yard personnel, as needed. Fixed conveyer belts above ground, except those associated with the stacker/reclaimers, will be in enclosed galleries. The bucket wheel stacker/reclaimer will be provided with water tanks, spray hoses and nozzles to be used when fly dust

becomes a problem. Coal piles will be inspected daily for visible signs of hot spots. Temperature monitoring probes will be strategically located at the coal piles.

4.11.4 Coal Silo Design

239. The boiler coal silos will be cylindrical with a conical hopper. The hopper funnel will be angled at 60° to the horizontal to ease flow. The silo will be made of stainless steel-clad steel, with a corrosion allowance of 2 mm or more. Discharge from the silos will be through a gate valve with gravimetric feeder and coal pipe to the respective pulverizer.

240. Coal fire in the silos 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 silos' discharge piping should have an additional emergency system that allows for rapid dumping of the silo contents onto the ground to be dealt with by fire extinguishers.

4.12 Ash Handling and Disposal system

241. 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

242. **Table 4-7** provides the estimates for the ash and gypsum to be generated for both stages of the project. For the 600 MW, the quantity will be half of amount shown in the table. Assuming worst case of design coal, a blend of 80% subbituminous coal and 20% lignite (Blending Coal G in **Table 4-7**), and 85% plant factor, total ash production is estimated at 411,300 t/y (205,650 t/y for 600 MW) with fly ash at 349,600 t/y (174,800 t/y for 600 MW) and the rest being bottom ash. Production of FGD gypsum is estimated at 138,100 t/y (69,050 t/y for 600 MW).

243. During combustion in the furnace, bottom ash will fall down to the boiler bottom hopper form 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.

244. In the flue gas desulphurization (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 4-7: Ash and Gypsum Production

	Daily Production (kg)			Annual Product at 85% Plant Factor(t)		
	Bottom Ash	Fly Ash	Gypsum	Bottom Ash	Fly Ash	Gypsum
Subbituminous Coal	151,056	855,888	299,184	46,865	265,539	92,822
Coal E	172,896	979,824	359,856	53,641	303,990	111,645
Coal F	184,944	1,047,984	387,168	57,379	325,137	120,119
Coal G	198,864	1,126,992	445,056	61,698	349,649	138,079

4.12.2 Ash Disposal

245. All the waste streams including fly ash and bottom ash if not exported for commercial use will be sluiced or conveyed to a mixing vessel where water will be added and the product will be pumped to the ash pond through a corrosion/erosion resistant slurry pipeline. Ash to water ratio of 1:3-4 will be used. Gypsum will initially be stored in silos. Gypsum that cannot be recycled will also be transferred to the ash pond for storage. Physical characteristics and utilization options for ash and gypsum to be produced at the Project are discussed further in **Chapter 8**.

246. 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. The ash pond will consist of 25 m x 25 m segments for easier land reclamation. 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.

247. About 100 acres of waste land adjacent to JTPS site is being acquired by JPCL for ash disposal. With average of about 3.5 m below ground level, the site will have the capacity for disposal of about 5 years of ash and gypsum waste for the 1,200 MW project, assuming no utilization of ash for commercial purposes. In case the ash pile could be compacted and stabilized to a height of 7 meters, which appears likely but requires a closer study, the same site would allow ash disposal for 10 years. In case, the second stage is not commissioned immediately, the 100 acre site will be sufficient for 10 years, if the depth is 3.5 m and 20 years, if the depth is increased to 7 m.

248. As discussed in **Chapter 8**, ash utilization potential exists in Pakistan and therefore the quantity of ash to be disposed in the ash pond will be reduced. It is estimated that the ash disposal site at Jamshoro would be sufficient to accommodate ash disposal for 15 to 20 years, depending on the extent of commercial utilization of ash and gypsum produced at the Project. In addition, the height of the fill in the ash pond can be increased if required to increase the disposal volume.

4.13 Flue Gas Treatment System

4.13.1 Electrostatic Precipitators

249. The steam generator 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.

250. 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 6,000 ppm. The ESPs will be designed to have an efficiency of not less than 99.9% and will limit the outlet flue gas particulate loading to below 30 ppm 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).

251. 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.

252. The complete ESP, including casing and breaching, will be designed to be capable of withstanding an excursion flue gas temperature of 320 ^{o}C for 30 minutes, and a transient interval positive or negative pressure of not less than 89 cm of water column, with stresses not exceeding the yield point and without any permanent deformation. The ESP design velocity (maximum free velocity) will be not greater than 1.2 m/s. Breaching design velocity will not exceed 20 m/s. Flue gas conditioning by injection of substances is not an acceptable means of meeting the specified outlet dust loading.

253. 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 roof will be pitched for drainage and provided with suitable gutter and roof drain piping terminating at grade level. The casing wall will have a minimum thickness of 6 mm. 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.

254. Adequate access and platforms will be provided for maintenance, inspections, repair and testing. A minimum of two stairs will be provided for the ESP. Stairs will start at grade and extend to all platforms, walkways and roof. Walkways and stairs will be at least 92 cm wide. Hinged doors of at least 60 cm diameter, with gas tight seals will be provided, where necessary, to permit proper inspection, cleaning, maintenance and repairs. Doors having access to the interior will be equipped with mechanical interlocks to prevent opening while equipment is energized. Doors having access to high voltage equipment, such as rectifiers, high voltage bushings, etc., will be provided with a system of mechanical interlocks that will allow opening only when that section is de-energized.

255. The ESP transformer will be in accordance with ANSI C57.12.00 and will have adequate surge protection. The transformer fluid will have an ignition point of not less than 300 °C. Polychlorinated biphenyl (PCB) use will be prohibited. Rectifiers will be of the silicon type. A roof area weather enclosure will be provided to protect maintenance personnel and equipment from inclement weather. It will allow maintenance of transformer-rectifiers, rapper drives and other equipment on the roof while the remainder of the ESP is in operation.

256. Fly ash hoppers will be of pyramidal shape, with a valley angle not less than 60° to the horizontal. Hoppers will have a minimum wall thickness of 6 mm. The hoppers will be of carbon steel with a Type 304 stainless steel cladding. Each hopper will be equipped with high- and low-level switches for level indication and alarm.

257. 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.

258. Collecting plates will be at least 1.2 mm in thickness. Collecting electrode design will be such that the electrodes remain straight and free from warping after extended periods of operation. The entire precipitator will be insulated and lagged. Insulation will be asbestos free.

4.13.2 Flue Gas Desulfurization System

General

259. The flue gas desulfurization (FGD) system will be designed to treat the flue gas from a steam generator using primarily coal and heavy fuel oil as fuel for warm-up start up. It will be designed with efficiency not less than 95% to achieve performance requirements under all operating conditions between 40% and 100% of the maximum continuous rated capacity of the steam generator. The flue gas flow rate will be about 2 million Nm^3/hr. SO_2 emission, without treatment, will be about 1,500 ppm.

260. 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

261. 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.

262. The flue gas will be received from the ESP relatively dust free (<30 ppm) and at the higher temperature of 130 °C, or 10 °C above the sulfur dioxide dew-point. It will be cooled to about 90 °C 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.

263. 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 ^{o}C, or a temperature at least 10 ^{o}C 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 (SO_x, NO_x, CO, particulate matter) will be enhanced due to the absence of interfering water droplets.

264. 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 ^{o}C. 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 byproduct.

265. 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.

266. The process conditions will be controlled by maintiannig 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.

267. 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.

268. 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/Nm^3
- 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.

269. 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 18,544 kg/hr. Because of potentially high maintenance and plant availability requirement, the filter train will be supplied with a full spare unit.

270. 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.

271. 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.

272. 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.

273. The limestone slurry preparation subsystem will prepare a 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 a 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.

274. 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.

275. 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.

276. 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.

277. 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,.

278. 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.

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

280. 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 ^{o}C above its dew point or 90 ^{o}C, whichever is higher.

b. Quench vessel: will be designed to cool flue gas to about 60 ^{o}C 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/Nm^3, 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.

281. 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.

282. All ducts will be rigidly supported, adequately stiffened and bracketed to prevent vibration, and will be free from internal sharp edges or projections. Internal bracing will not be acceptable. Vanes and deflectors will be provided inside ducts and will be of special profile to ensure complete change of direction of flow with minimum turbulence.

283. Expansion joints, manufactured from corrosion-resistant material, will be provided at all locations, where required, to permit the free movement of the duct without distortion and without inducing excessive stresses where ducts connect to other equipment. Expansion joints will be nonmetallic flexible belt types of gas-tight construction, designed for the appropriate temperature and pressure conditions.

284. The duct material will be nickel alloy plate C-276 (N10276), or carbon steel A588 with a protective liner. The protective liner may be a minimum thickness of 1.6 mm N10276 bonded or clad to the A588, or other corrosion protection, such as flake gas-filled resin lining or similar. Contractor will provide proof of prior operating experience with the proposed lining material and with the specified method of application.

System Performance Requirements

285. The FGD system will be designed and guaranteed to achieve the following performance, when the steam generator 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 100 °C above its dew point or 900 °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.
- Produce gypsum with the following characteristics:
  - Gypsum ($CaSO_4.2H_2O$) dry basis >95%
  - Limestone ($CaCO_3$) dry basis <4%
  - Chlorides as Cl^- <100 ppm
  - Vanadium as V <25 ppm
  - pH between 7 and 9
  - Free water (% total weight) <10%
  - Whiteness >80%.

System Operation and Controls

286. 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.

287. 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.

288. 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

289. During combustion in boiler, nitrogen in the coal and in the air combine 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. Reducing these factors will decrease the quantity of thermal NOx formed. The

NOx conversion for coal combustion is affected by the availability of oxygen to react with the fuel nitrogen compounds in their gaseous state. The compounds that evolve from coal particles such as ammonia are unstable and reduce to harmless nitrogen gas under fuel-rich conditions, or to nitrogen dioxide (NO_2) under air-rich conditions. In order to reduce formation of both thermal and fuel NO_2 for pulverized coal firing, the following measures have to be considered:

- Coals with the lowest fuel nitrogen contents and the lowest fuel oxygen/nitrogen ratios generally will produce the lowest amount of NOx
- 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 minimizing the gas temperature throughout the furnace by using low-turbulent diffusion flames and large water cooled furnace.

NOx Control Methods

290. 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.

291. **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 used. 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 decreasing the gas temperature in the furnace.
- Fuel re-burning: It consists of injectingfuel 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. It is effective but has an increased capital cost. LNB can reduce NOx formation by almost 50%. There are many LNB designs which are 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 thatoptimizes the two methods and has a potential to achieve up to 70% NOx reduction.

292. **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 gas stream of the catalyst. The ammonia reacts with the NOx in the presence of the catalyst to form nitrogen and water vapor. This method can achievea very high

NOx reduction efficiency of up to 85%, but it requires high capital cost outlay and high operating costs. The catalyst can be plugged by the fly ash particles in the flue gas stream and generally requires replacement every 5 or7 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 narrow flue gas temperature range. It requires small capital cost and modest operating costs. The NOxreduction ranges between 15-40% and varies with the load.

Low NOx Issues

293. 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 fireside 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 acement additive.

294. To resolve the above, the boiler manufacturer has to provide injection of air at the water walls. This willprevent potential future damage. Most boiler manufacturers have combined low NOx burners, over fire air and gas recirculation thatreduce 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 meetslocal and international environmental standards.

295. Flue duct interfacing and space are allocated as shown in the plant layout for incorporating CCS system at a later time. ADB is presently in the process to apply for funding to make studies of CCS application options including survey of potential regional CO_2 users, use of CO_2 for reactivating oil wells and assessment of subsurface geology for CO_2 storage.

Recommended Approach for the Project

296. While current NOx emission requirement in Pakistan is relatively low, the project is subject to international standards imposed by global agencies including the World Bank. The proposed modern power technology for the project is expected to meet NOx emission level as it is anticipated to be below 200 mg/Nm^3 limit. SCR system of 80% efficiency will be installed at the site; the project will then have to rely on combustion technology plus SCR system to meet the international NOx emission requirement.

4.14 Gaseous Emissions and Waste

297. 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 4-8**.

Table 4-8: Emission of Gaseous Pollutants

	Without treatment (ppm)			With treatment (ppm)		
	SO_2*	**NOx**	**PM**	**SO_2***	**NOx**	**PM**
Subbituminous Coal	2,874 (2,364)	200	10,995	144 (118)	40	11
Coal E	3,456 (2,843)	200	11,999	173 (142)	40	12
Coal F	3,719 (3,059)	200	12,530	186 (153)	40	13
Coal G	4,275 (3,517)	200	13,847	214 (176)	40	14

Assumed efficiencies: FGD 95%, ESP 99.9%, NOx reduction 80%
* The values in paranthese are for typical sulfur composition of 1.5% in Thar Coal

4.15 Hazardous Waste Storage Facility

298. A Hazardous Waste Storage Facility (HWSF) will be constructed at site to store hazardous wastes, including asbestos and soot removed from the boilers. Further details on the design of the HWSF are included in **Chapter 8**.

4.16 Port Handling and Transportation of Coal

299. Imported coal will be brought by ships and then by train to JTPS. 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 road transportation out of this port avoids the congested routes out of Karachi. Further discussion on port and transportation options is included in **Chapter 8**.

5. Description of the Environment

5.1 Area of Influence

300. 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.

301. 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 available from secondary sources.

5.2 Physical Environment

5.2.1 Geology

302. 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 30 km to the west and the Jhimpir Fault, about 25 km to the southwest. 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

303. The elevation of the Study Area generally ranges between 15 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 (**Section 5.3.2**). The eastern half of the Study Area is part of the Indus River flood plain.

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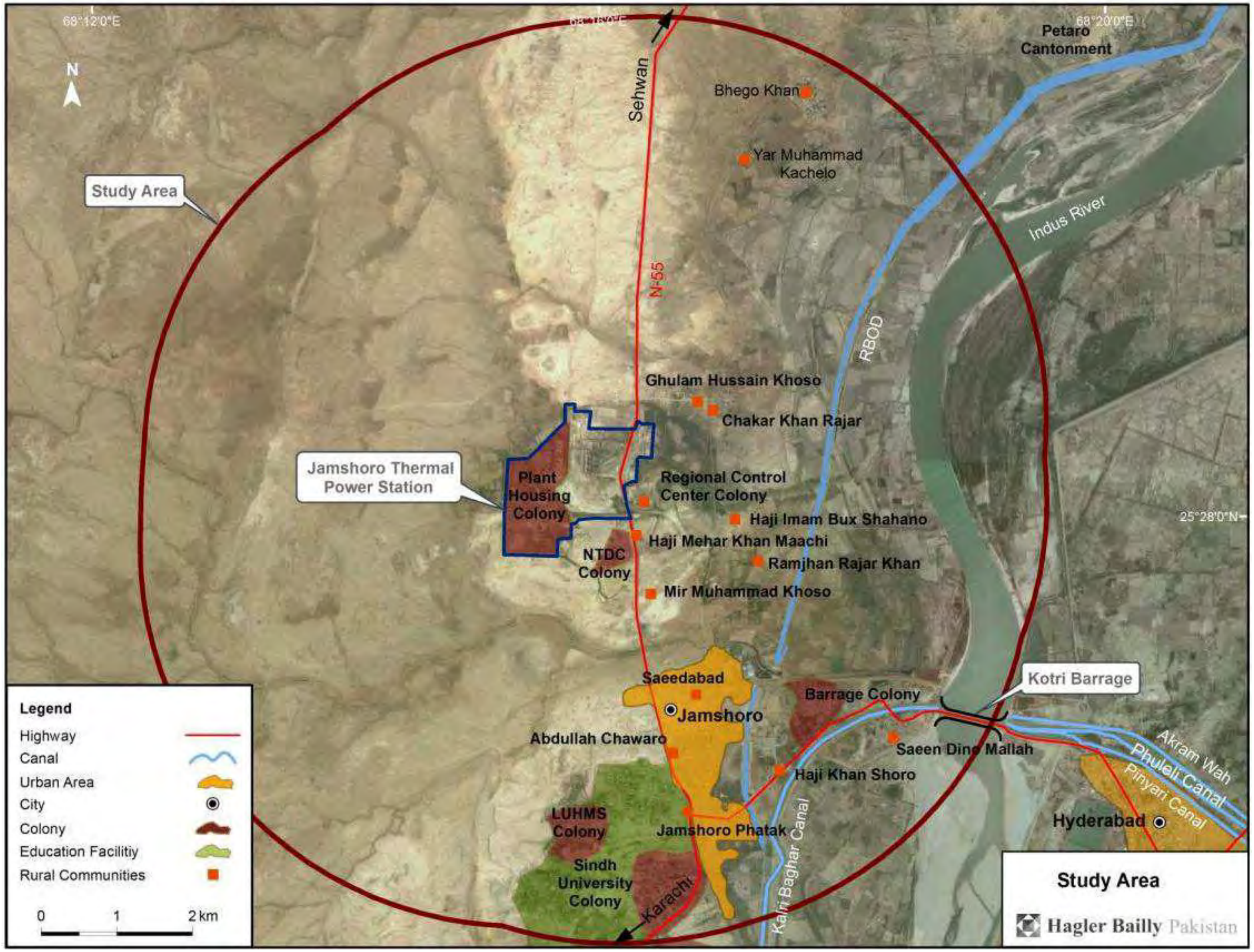
1 Geology and tectonics of Pakistan, Kazmi. A. H and Jan. M. Q, 1997

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

Figure 5-1: Study Area



304. There are two main land uses in the Study Area other than the JTPS. These are the agricultural land in the east and the urban and semi urban areas in the south. The Indus River floodplain has good alluvium soil and has been converted to productive farmlands. About 25% of the Study Area falls in this category of land use. The urban and semi-urban areas of Jamshoro are located south of the Study Area. These include the main town of Jamshoro and purpose-built campuses and the associated residential areas of several educational institutions including the University of Sindh and the medical university, LUHMS. 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

305. The Study Area has a very shallow soil cover. The soil map of Sindh[3] categorizes the area of the JTPS and its surrounding as 'rough mountainous land' whereas the area close to Indus River is categorized as loamy and seasonal flodded soil of river plains. The dominant soil group in both areas is Calicisols[4], which are loamy soils with accumulation of secondary calcium carbonates.

306. Chemical analysis of soil from areas within JTPS and in the Study Area outside JTPS was carried out to assess the contamination of the soil. The sampling and the results are discussed in **Chapter 6**. The soil within the boundary of JTPS shows contamination due to oil spills from oil decanting operations and storage, and due to open disposal of solid waste from the plant. The soil outside the boundary of JTPS is largely unaffected by existing plant operations.

5.2.4 Climate

307. 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.

308. The weather station closest to the Study Area is located at Hyderabad (25° 38' N, 68° 42' E), approximately 20 km southeast 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 °C. The winters are mild with temperature dropping to 20 °C 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 5-1** to **Table 5-3.** The annual and seasonal wind-roses are shown in **Figure 5–2**.

309. 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

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[3] *Soil Map of Sind 1:1,000,000*. Soil Survey of Pakistan, Lahore. 1978.

[4] Calicisols is a soil with substantial accumulation of lime.

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 is presented below:

Table 5-1: Temperatures 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

- 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 towards North in entire winter with an average speed of 1.4 meters per second (m/s) and shift to south west direction in the month of March and remains there for the rest 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 southwest 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 south west 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 towards southwest which changes its course towards north in the end of season.

Table 5-2: 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
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 5-3: Mean Wind in 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

5.2.5 Water Resources

310. Major water bodies in the Study Area include the Indus River, Kalri Baghar canal and the under construction RBOD. 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

311. The Indus River flows at a distance of about 3.7 km to the east of the plant site (**Figure 5–3**). 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 1,787 cumec. The 18-year monthly averaged flow data for the Indus River recorded from 1986-87 season to 2003-04 season at Kotri barrage is presented in **Table 5-4**. Average monthly flow is highest in August when it exceeds 7,500 cumecs. In December, the leanest month, the average flow is 213 cumecs. The Irrigation Department that manages the canal system allows the existing power plant to abstract 1.3 cumec of water from the Indus River. Four canals originate from Kotri Barrage, Kalri Baghar Canal on the right bank and Akram Wah, Phuleli Canal, and Pinyari Canal on the Left Bank. Of these, Kalri Baghar Canal partly falls in the Study Area. It has a designed flow of 255 cumecs and had an average flow of 87 cumecs between 1986-87 season and 2003-04 seasons.

312. 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

313. There are no significant groundwater resources in the Study Area. No village in the Study Area reported having functional groundwater wells. The presence of rocky outcrop and shallow alluvium soil in the western part of the river rules out the possibility of any groundwater aquifer.

Water Quality

314. Groundwater sampling was conducted in the Study Area to assess groundwater quality and possible contamination from the power plant. Effluent water streams and the quantities of effluents released form the plant are detailed in **Chapter 6**. Effluent from plant is released outside the boundary at several locations which has affected areas outside the plant. The main reason of open drainage of plant effluents outside the plant boundary is the overflow from the unlined evaporation ponds which are apparently not in use at present, and the blockage of the effluent drainage pipeline originally installed to drain the plant effluents into Indus River.

Figure 5–3: Surface Water Resources in the Study Area

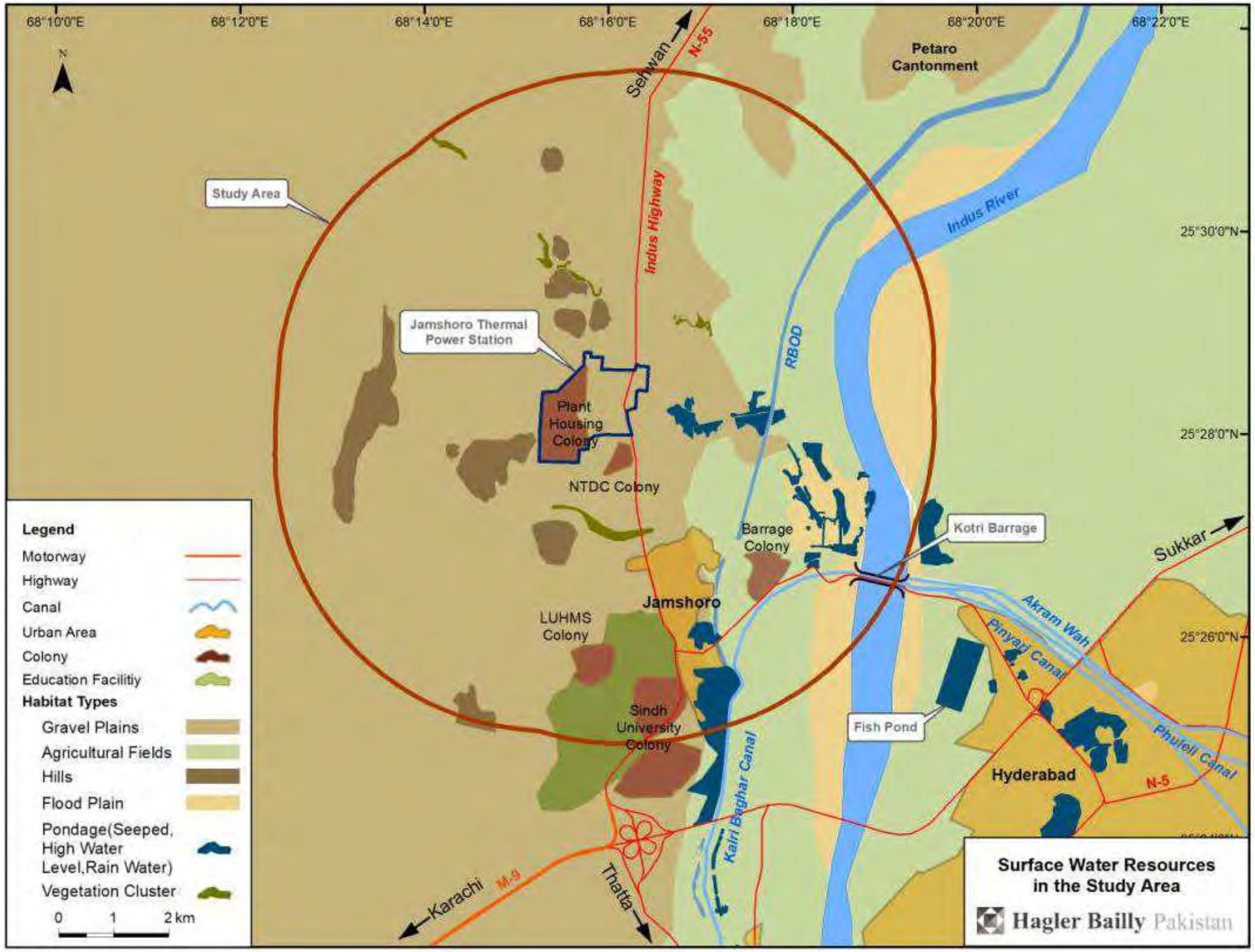

Table 5-4: Indus River Monthly Flow at Kotri Barrage

Month	Flow (cumec)*	
	Upstream	Downstream
Jan	369	161
Feb	305	91
Mar	465	105
Apr	648	427
May	1,005	565
Jun	1,535	741
Jul	4,056	3,227
Aug	7,517	6,826
Sep	3,905	3,276
Oct	1,035	586
Nov	387	110
Dec	213	68
Annual	1,787	1,349

* The difference in upstream and downstream flow is the volume diverted to canals

Source: Sindh Irrigation and Drainage Authority

315. One drinking water sample was collected from JTPS housing colony; groundwater sampling was conducted in the possible groundwater flow direction.

316. The drinking water and groundwater samples analysis results are provided in **Table 5–5**. Analysis of pesticides in drinking water is presented in **Table 5–6**.

317. Following are key observations from the analysis of the samples:

- The pH is within limits of the National Standards for Drinking Water (NSDW) for all the samples.
- All the parameters in the drinking water conform to the NDWS and WHO standards for drinking water quality. Both the Surface Water Samples JSW2 (Kalri Baghar Canal) and JSW1 (River Indus) also conform to the NDWS and WHO standards for metals[5]. The difference in concentrations of metals in the two samples is below the LOR. Pesticides were not detected in the Drinking Water Sample JDW1 drawn from the plant housing colony water supply.

[5] The river and canal water will not meet the NDWS overall due to presence of fecal coliform in the water.

Table 5–5: Drinking Water, Groundwater and Surface Water Quality Results

Parameters	Unit	LOR	NSDW[6]	WHO	Water Storage Tank	Kalri Baghar Canal	Indus River Upstream of Plant Intake
Ag	µg/l	1	–	–	<1		–
Al	µg/l	1	<200	200	148	91	7
As	µg/l	1	≤ 50	10	< 1	3	3
B	µg/l	10	300	300	146	150	97
Ba	µg/l	1	700	700	64	100	60
Cd	µg/l	1	10	3	<1	<1	<1
Cl	mg/l		<250	250	277	–	–
Cr	µg/l	1	≤ 50	50	<1	<1	<1
Cu	µg/l	1	2,000	2,000	<1	1	2
F	mg/l	0.1	≤ 1.5	1.5	0.5	–	–
Hg	µg/l	0.5	≤ 1	1	<0.5	<0.5	<0.5
Mn	µg/l	1	≤ 500	500	10	1	17
Ni	µg/l	1	≤ 20	20	<0.1	<1	<1
Pb	µg/l	1	≤ 50	1	<0.1	<1	<1
Sb	µg/l	1	<20	20	<1	<1	<1
Se	µg/l	1	≤ 10	10	<10	<10	<10
Zn	µg/l	5	5,000	3,000	<5	<5	15
CN	mg/l	0.05	≤ .05	0.07	<0.05		
BOD	mg/l	4	–	–		<4	<4.0
COD	mg/l	5	–	–	–	<5	<5.0
NH_3	mg/l	0.5	–	407	–	<0.5	<0.5
Nitrate	mg/l	0.1	–	–	–		0.22
$CaCo_3$	mg/l	1	<500	–	<1		
SO_4	mg/l	1	–	–	0.5		
TDS	mg/l	1	<1,000	<1,000	418	444	462.0
TSS	mg/l	4	–	1508	–	17	12.5
Phosphates	mg/l	0.1	–	–	–	<0.1	<0.1
Odor			Acceptable	Acceptable	Acceptable		
pH		0.1	6.5–8.5	6.5–8.5	7.2	7.2	7.3
Residual chlorine	mg/l	0.1	5–1.5 at source		<0.1		
Taste			Acceptable	Acceptable	Acceptable		
Color	CU	1			6		
Temp.	°C						
Turbidity	NTU	0.0	< 5 NTU	< 5 NTU	4		

6 S,R.O. 1062 (I)/2010, National Environmental Quality Standards for drinking water

7 S,R.O. 549 (I)/2000, National Environmental Quality Standards for Municipal and Liquid Industrial effluents

8 Ibid

Table 5–6: Analysis of pesticides in drinking water

Analysis Description	Lab I.D		231983
	Sample I.D		JDW 1
	Units	LOR	
	Date of Extraction		7/7/12
	Date of Analysis		11/7/12
Organochlorine Pesticides			
Alpha–BHC	ug/l	5	<5
Beta & gamma–BHC	ug/l	10	<10
Delta–BHC	ug/l	5	<5
Heptachlor	ug/l	5	<5
Aldrin	ug/l	5	<5
Heptachlor epoxide	ug/l	5	<5
Endosulfan 1	ug/l	5	<5
4,4-DDE	ug/l	5	<5
Dieldrin	ug/l	5	<5
Endrin	ug/l	5	<5
Endosulfan 2	ug/l	5	<5
4,4'-DDD	ug/l	5	<5
Endosulfan Sulfate	ug/l	5	<5
4,4'-DDT	ug/l	5	<5
Endrin Ketone	ug/l	5	<5
Methoxychlor	ug/l	5	<5
Organophosphorus Pesticides			
Dichlorvos	ug/l	5	<5
Dimethoate	ug/l	5	<5
Diazinon	ug/l	5	<5
Chlorpyrifos methyl	ug/l	5	<5
Malathion	ug/l	5	<5
Fenthion	ug/l	5	<5
Chloropyrifos	ug/l	5	<5
Pirimiphos ethyl	ug/l	5	<5
Chlorfenvinphos–E	ug/l	5	<5
Chlorfenvinphos–Z	ug/l	5	<5
Prothiofos	ug/l	5	<5
Ethion	ug/l	5	<5
Parathion	ug/l	5	<5
Parathion methyl	ug/l	5	<5

5.2.6 Air Quality

318. Other than the JTPS, there are no major stationary sources of gaseous emission in the Study Area. The Jamshoro urban area to the south of JTPS is the only other significant source of emission. 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:

- Kotri Industrial Area, with about 400 small to medium size industrial units, is about 12 km south of JTPS
- Lakhra Coal Power Plant is 25 km north of JTPS
- Urban areas of Hyderabad and Kotri to the south and southeast of the plant site at a distance of 10 to 15 km
- The highway network (M-9, N-5, and N-55) is the major non-stationary source of emission.

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

Measurement of Pollutants in Ambient Air

320. To assess the ambient air quality for the Study Area, measurements were undertaken at three locations around the plant site from June 26 to June 28, 2012 (**Figure 5–4.**). These locations were selected on their proximity to the plant site, wind direction of the plume as well as the location of sensitive receptors nearby, such as human settlements (power house and NTDC colony).

321. The wind direction was variable but mostly towards the east during the measurement. 24-hour concentrations of SO_2, NO_x, CO, Ozone (O_3), particulate matter of less than ten microns (PM_{10}), particulate matter of less than 2.5 microns ($PM_{2.5}$) and SPM were monitored in the Study Area. The results are shown in **Table 5-7**. With a variable wind direction in the pre-monsoon season (average wind direction is indicated in **Figure 5-4**), it is difficult to establish the relationship of the measured pollutant levels with the emission from the plant. However, the concentrations at Sampling Point JAQ2 are likely to show higher impact of emission from road traffic (primarily NO_x, SO_2, and CO) on highway N-55 downwind of the highway as compared to JAQ3 which was upwind of the highway. Given the observed wind direction and the location of the Sampling Points, the measured concentrations of pollutants are in all likelihood indicative of the background pollution levels and would have limited impact from the plant.

322. The applicable national environmental quality standards (NEQS) for ambient air quality are discussed in **Section 3-10**. In addition to these, ADB's SPS 2009 requires compliance of ADB funded projects with the World Bank Group's Environment, Health and Safety Guidelines (the IFC Guidelines discussed in **Section 3.7.2**). Accordingly, the ambient air quality observed data is compared with NEQS as well as the IFC Guidelines.

323. Comparison of the observed measurements with the *24-hour* limits of the NEQS (second column in **Table 5-7**) and the IFC guidelines (third column in **Table 5-7**) indicate that all parameters were within the 24-hour limits of the ambient air quality except $PM_{2.5}$ which exceeds the NEQS limit at Goth Chakar Khan Rajar and Khosa Goth.

Figure 5–4: Air Quality Measurement Location and Conditions

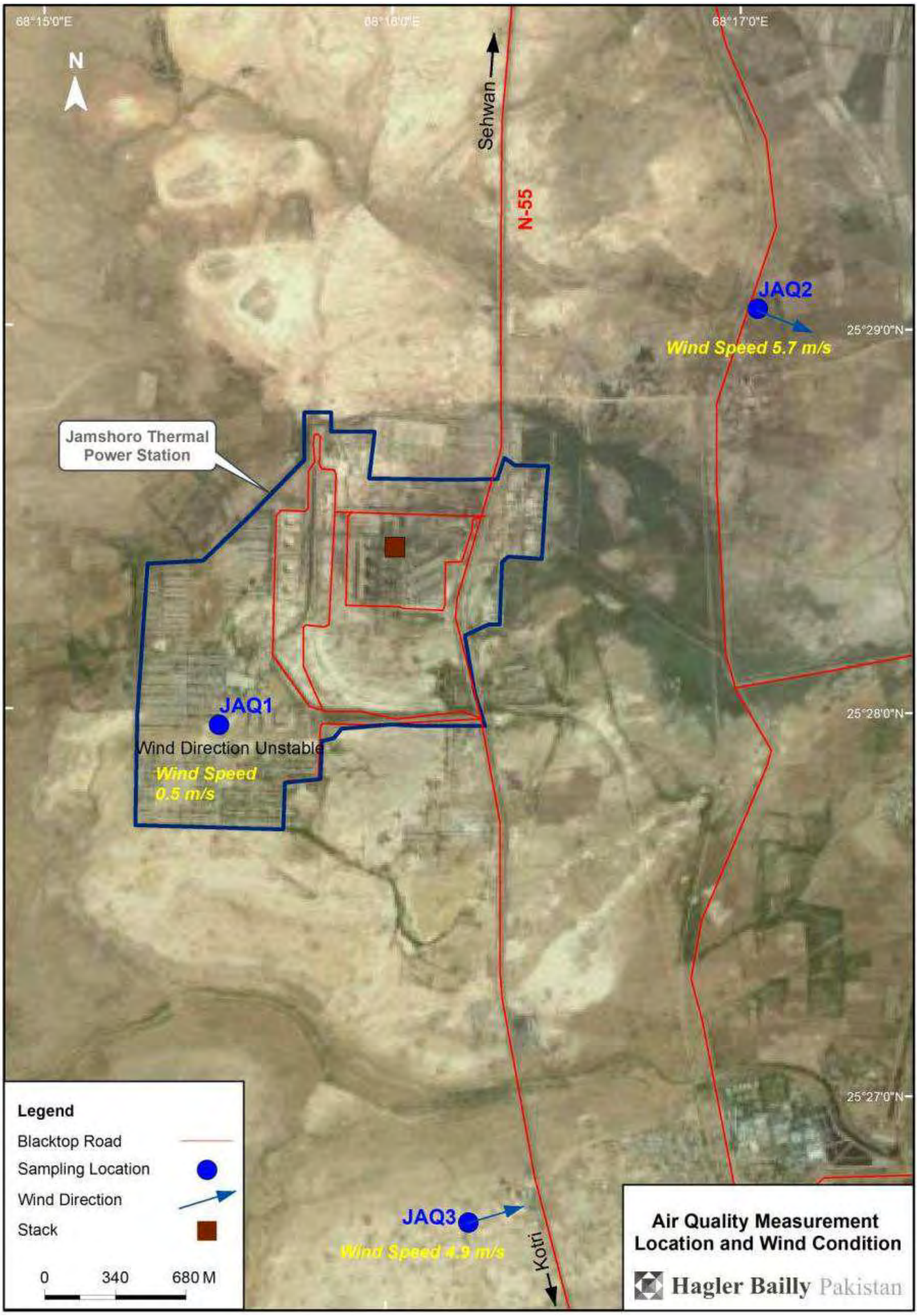

Table 5-7: Ambient Air Quality Monitoring Results – 24 Hours June 2012

Pollutant	NEQS[9]	IFC Guidelines	JAQ1	JAQ2	JAQ3
			Staff Colony	Goth Chakar Rajar Khan	Khosa Goth
SO_2 (µg/m^3)	Annual 80 24-hr 120	24-hr 125	26.9	42.5	32.8
NO_2 (µg/m^3)	Annual 40 24-hr 40	Annual 40 1-hr 200	8.8	35.3	33.1
NO (µg/m^3)	Annual 40 24-hr 80	–	20.1	27.0	10.7
CO (mg/m$^{3)}$	8-hr 5 1-hr 10	–	3.6	4.9	2.3
Ozone (µg/m^3)	1-hr 130	8-hr 160	16.3	16.8	15.3
PM_{10} (µg/m^3)	Annual 120 24-hr 150	Annual 70 24-hr 150	84	114	114
$PM_{2.5}$ (µg/m^3)	Annual 15 24-hr 35 1-hr 15	Annual 35 24-hr 75	35	47	60
TSP (µg/m^3)	Annual 360 24-hr 500	–	207.8	138.5	277.0
Lead (µg/m^3)	Annual 1 24-hr 1.5	–	0.0374	0.0361	0.0345

Note: A "–" in the third column indicates that IFC has not provided any guidelines for the parameter.

324. The concentrations of pollutant in ambient air are dependent on season. For example, ADB (2006)[10] has shown that the pollutant levels (SO_2, NO_x, PM_{10}, and ozone) in six cities of Pakistan is generally highest during summer and lowest in monsoon. Similar pattern is expected in Jamshoro Area also. The measured pollutant levels in Jamshoro, given in **Table 5–7**, were recorded in June 2012 just before onset of monsoon season. The measured levels are likely to be on the higher side compared to the annual average for the same location. With this assumption, it is deduced that the measured pollutant levels of all parameters (shown in **Table 5-7**) are within the annual limits with two exceptions. $PM_{2.5}$ exceeds the annual limit for both NEQS and IFC Guidelines and PM_{10} exceeds the IFC Guidelines.

325. Pollution related to NO_x, SO_2, and CO is mainly associated with anthropogenic activities such as industry and transport. Background concentrations of these pollutants can therefore be estimated through air quality modeling taking the emission from known sources into account. Results of this modeling exercise are reported in **Section 9.3**. The measured levels of PM_{10} and $PM_{2.5}$ in the background were close or above the applicable air quality standards and guidelines. These pollutants in a desert and windy

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9 S,R.O. 1062 (I)/2010, National Environmental Quality Standards for Ambient Air

10 Asian Development Bank. 2006. *Country Synthesis Report on Urban Air Quality Management: Pakistan*. http://cleanairinitiative.org/portal/sites/default/files/documents/pakistan_0.pdf (Date Accessed: August 20, 2013).

environment are more likely to be of natural origin, and therefore it is not possible to develop estimates for background concentrations through modeling. A literature search was therefore carried out to establish the background concentration of these pollutants.

Background Levels of PM_{10} and $PM_{2.5}$ in Pakistan

326. To investigate the seasonal variation of the PM_{10} and $PM_{2.5}$, data on total suspended particulate matter (SPM), PM_{10} and $PM_{2.5}$ from all available sources have been collated (**Appendix 3**). Thirty different reports were used to develop this database of 219 data points covering both rural and urban areas in about 25 districts of the country. In all, more than 5,000 days of data collection is reported. Unfortunately, more than 97% of the data is from urban areas or collected near highways. Although, the data can be used to infer the variations but is not sufficient to give the background PM_{10} levels in rural areas to high degree of accuracy. The summary of the data is shown in **Table 5-8**.

Table 5-8: Summary of PM data monitored in Pakistan

	Number of Data Days			Weighted Average (µg/m^3)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Annual						
Urban	4774	126	56	89.5	295.3	1855.1
Rural	30	62	20	38.8	156.6	200.0
Seasonal						
Urban						
Spring	19	43	4	136.0	305.0	885.3
Summer	24	14	5	93.0	215.9	717.2
Monsoon	28	12	0	37.1	168.4	
Post-Monsoon	22	11	0	48.0	212.4	
Winter	177	17	1	182.2	166.1	514.0
Rural						
Spring	0	4	0		88.2	
Summer	22	23	5	40.2	203.9	172.3
Monsoon	2	16	2	41.6	147.7	52.0
Post-Monsoon	0	0	0			
Winter	2	3	0	31.9	67.5	

Notes: Some of the data sets included in annual data is excluded from seasonal data because season or date for data collection was not reported in sources.

327. It has been argued that dust levels in Pakistan are naturally high due to dry conditions.[11] A source apportionment study carried out in Lahore[12] indicated that 68-

[11] See for example, JICA Report. http://www.environment.gov.pk/pub-pdf/3city-inv.pdf (Date Accessed: August 20, 2013)

[12] Zhang. Y., et al. 2008. Daily Variations in Sources of Carbonaceous Aerosol in Lahore, Pakistan during a High Pollution Spring Episode.. Vol. 8, No. 2, pp. 130-146. http://www.aaqr.org/VOL8_No2_June2008/2_AAQR-07-09-OA-0042_130-146.pdf (Date Accessed: August 20, 2013)

89% of PM_{10} in ambient air is from re-suspended soil and dust. The re-suspended solid includes natural dust and dust from traffic movement. Similar results have been reported from neighboring India where environmental conditions are similar.[13] In the Jamshoro area both these sources are likely to contribute. However, contribution from the natural sources is likely to be more significant as the observation points were either upwind or not close to the highway.

328. The calculation for the expected annual background PM_{10} and $PM_{2.5}$ levels in Jamshoro area is shown in **Table 5-9**. The calculation was based on data for rural areas, which would be somewhat conservative in view of the peri-urban nature of the setting. These estimates for background concentration of PM_{10} and $PM_{2.5}$ were used for modeling and prediction of air quality discussed in **Section 9.4**.

Estimate for Background PM_{10} and Comparison with Standards and Guidelines

329. The estimated annual background level of 69 µg/m^3 for PM_{10} is below the NEQS limit of 120 µg/m^3, and closer to the IFC Guideline of 70 µg/m^3. It can therefore be concluded that the Project cannot realistically meet the PM_{10} limit for IFC.

Estimate for Background $PM_{2.5}$ and Comparison with Standards and Guidelines

330. The estimated annual background level of 43 µg/m^3 for $PM_{2.5}$ is considerably above the NEQS limit of 15 µg/m^3, and above that of the IFC Guideline of 35 µg/m^3. It is therefore concluded that the Project cannot realistically meet the $PM_{2.5}$ limit prescribed by both NEQS and IFC Guidelines.

331. A review of the NEQS for $PM_{2.5}$ and the regional practice indicates that:

- The NEQS 1-hr limit for $PM_{2.5}$ is inconsistent with the annual limit. As shown in **Table 5-7**, the limit for 1-hr (15 µg/m^3) is the same as the annual limit. This is contrary to the practice world-wide where the limits for longer time frame are always lower than that of a shorter time frame to allow for variations over time.[14] Similarly, the NEQS 1-hr limit of 15 µg/m^3 for $PM_{2.5}$ is inconsistent with the 24 hour limit of 35 µg/m^3.
- The ambient air quality standards of other countries in the region are reflective of the high $PM_{2.5}$ levels in the ambient air. The annual limits for $PM_{2.5}$ in India and Sri Lanka are 40 µg/m^3 and 25 µg/m^3 respectively. Similarly, the 24-hr limits for $PM_{2.5}$ in these countries are 60 and 50 µg/m^3 respectively. Given the high natural background particulate levels in Pakistan where environmental conditions are somewhat similar to those in India and the current level of controls on industrial and vehicular emissions, it is unlikely that compliance with the NEQS annual limit of 15 µg/m^3 for the $PM_{2.5}$ can be achieved in any part of Sindh in the near future.

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[13] T. Pachauri, et al. in *Aerosol and Air Quality Research*, 13: 977–991, 2013 have reported that $PM_{2.5}$ levels in Agra is 308 and 91 µg/m^3 for traffic and rural sampling sites respectively. After subtracting the organic and elemental carbon (contributed by biomass burning and vehicular emission), the background level in rural area is still 38 µg/m^3.

[14] Higher pollutant concentrations are permitted for shorter intervals only and prolonged stress to receptors over a longer period of time is avoided by prescribing a lower limit for an extended period of time. The average for a longer period cannot also mathematically be higher than the maximum figures for the shorter intervals.

332. The project proponent has, therefore, formally approached the Environmental Protection Agency of the Government of Sindh to review the $PM_{2.5}$ limits in the NEQS and to rationalize them, and the subject is presently under discussion. The Environment Department has indicated willingness to undertake a review of the $PM_{2.5}$ limits in view of the evidence and discussion presented in this EIA. It may be noted that following the 18th Amendment in the constitution of the country, environment is a provincial subject and setting of the environmental standards falls in the jurisdiction of the provincial government. The Government of Sindh is therefore now empowered to review the environmental standards set previously at the national level in view of the environmental conditions, policies, and priorities in the province.

Table 5-9: Estimation of Background PM_{10} and $PM_{2.5}$ Levels in Vicinity of JTPS, µg/m^3

	Reported Levels in Rural Areas (See Table 5-8)	Estimated Values for Jamshoro Area	Explanation for Estimated Values for Jamshoro Area	Duration of Season (months)
$PM_{2.5}$				
Spring		37.6	Note 1	2
Summer	40.2	47.3	Note 2	3.5
Monsoon	41.6	49.0	Note 3	2
Post-Monsoon		47.3	Note 4	1
Winter	31.9	37.6	Note 3	3.5
Weighted Average		**43.1**		**12**
PM_{10}				
Spring	88.2	45.0	Note 3	2
Summer	203.9	104.0	Note 2	3.5
Monsoon	147.7	75.3	Note 3	2
Post-Monsoon		104.0	Note 4	1
Winter	67.5	34.4	Note 3	3.5
Weighted Average		**69.1**		**12**

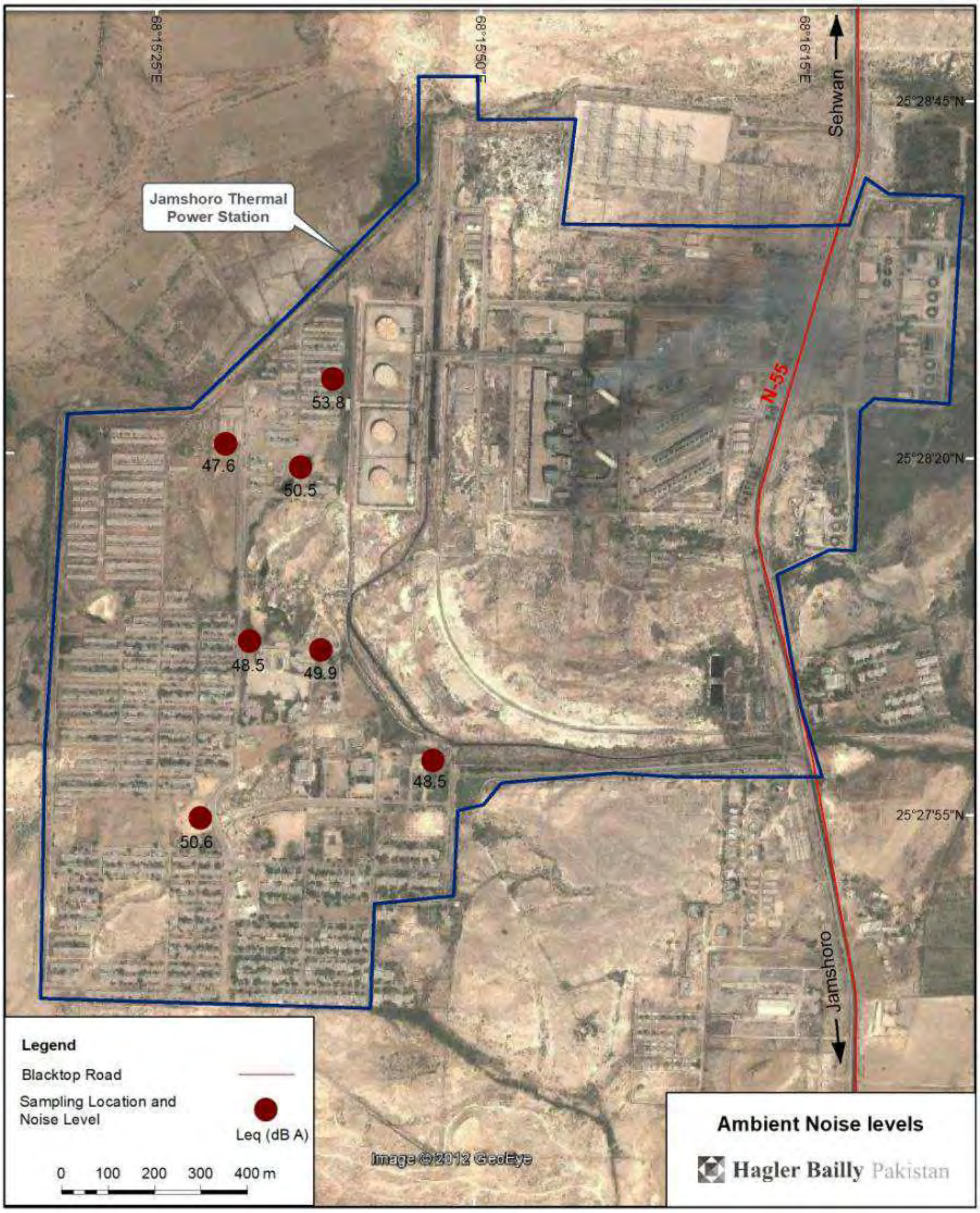
Explanations Notes:

1. Assumed to be the same as Winter estimated value
2. As the measurements were done in summer (**Table 5-7**), this value is assumed to be equal to the average of the measured value at three locations
3. Calculated on the assumption that the ratio of Summer Value and Monsoon Value in Jamshoro is the same as in the reported values. It is thus calculated as follows: Monsoon Value = Measured Summer Value (47.3) / Reported Summer Rural Value (40.2) X Reported Monsoon Value (41.6). from reported levels by multiplying it by the same ratio of observed and reported levels in summer
4. Assumed to be the same as Summer measured value

5.2.7 Noise

333. Noise data were collected from the nearest receptor, the housing colony of JTPS. The results are shown in **Figure 5-5**. The data was collected in low wind conditions to ensure representative values. All values are within the NEQS daytime value of 55 dB(A).

Figure 5-5: Ambient Noise levels



5.3 Ecology

334. The Study Area for the ecological study consists of the Thermal Power Station Jamshoro and a 5 km buffer zone around it (**Figure 5-6**) to account for an area in which the ecological resources may be impacted by the project related activities including sound, vibrations, air quality, and water quality.

335. 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 and birds
  - Identification of key species, their population and their conservation status in the area.
  - Reports of wildlife sightings and fish captured in the Study Area by the resident communities.
- Data analysis to determine baseline biodiversity and to evaluate whether any potential critical habitat and ecosystem services were present in the Study Area.

336. A field survey was conducted from June 21, 2012 to June 23, 2012. The sampling locations for vegetation, mammals, reptiles and birds are shown in **Figure 5-6**.

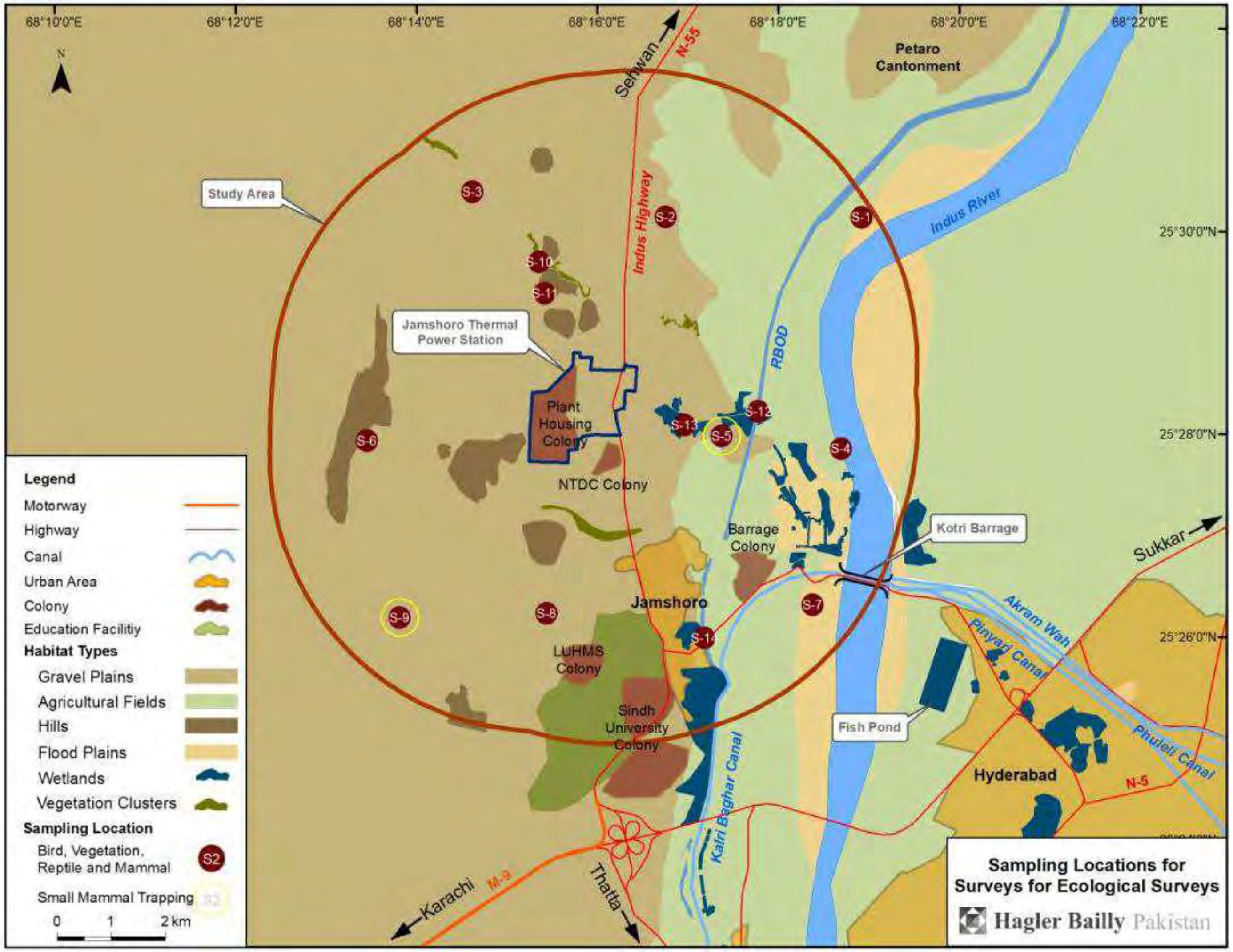
5.3.1 Methodology

337. The survey was carried out in June to coincide with the summer season when the vegetation has sprouted fully, and the flowering and fruiting conditions of the flora can be observed. In addition, maximum activity of the herpeto-fauna and mammals as well as summer migratory birds can be observed during the summer months. Even though the survey could not observe the winter migratory birds, there is sufficient secondary information available in literature regarding the migratory bird species that visit the Study Area and its vicinity[15]. Secondary information was used in compilation of this report.

338. The Study Area map was marked with a grid of 4 x 4 km and sampling points were marked in the center of each grid square. These sampling points were then adjusted to ensure that all habitats were adequately represented. These points were sampled for ecological resources: vegetation, mammals, reptiles and birds. In the field, some additional sampling points were identified and sampled in micro-habitats such as wetlands and vegetation clusters. These include Sampling Points 10, 11, 12, 13 and 14 (**Figure 5-6**).

15 Pakistan Wetlands Migratory Birds Census Report, 2012.

Figure 5-6: Sampling Locations for Surveys for Ecological Surveys



339. The sampling methods used for the field surveys along with the literature references used, are described in detail in **Appendix 4**. The following sampling activities for vegetation, mammals, reptiles, birds and fish, were carried out.

- Vegetation was sampled via a rapid assessment stratified approach, using three quadrats at each sampling site of 10 × 10 m to measure presence, cover and abundance.
- Mammals were sampled using diurnal 300 × 20 m sign survey plots recording footprints, dropping, burrows and dens. The presence and relative abundance of rodents was confirmed by live trapping.
- Reptiles were sampled by active searching and visual encounter surveys within 300 x 20 m search plots. Reptile survey data was analyzed for species diversity and abundance.
- Birds were sampled from 300 × 50 m plots using binoculars.
- A literature review was conducted for the fish fauna found in the, channels, canals and river located in the vicinity of the power plant. Secondary sources including previous EIAs reports were also consulted for this purpose. In addition, anecdotal information regarding the fish species found in the river was collected by a fish expert from fishermen and locals

340. Google Earth™ images were used to initially delineate spatial distribution of habitat types within the Study Area. Habitats were classified by geo-morphological and other abiotic characteristics with consideration for variations within habitat types. Geomorphology is an acceptable habitat classification approach in arid landscapes (Swanson et al., 1988)[16] (McAuliffe, 1994)[17]. Observational survey data was also supplemented with interviews of local people and available literature reviews. The results from this data analysis are summarized below.

341. The conservation status of the species identified were determined using criteria set by the IUCN Red List of Threatened Species (IUCN Red List, 2012)[18] and the Convention on International Trade in Endangered Species (CITES) appendices[19]. The status of mammals in the Pakistan's Mammals National Red List 2006[20] was also noted.

342. The presence of critical habitat was determined in accordance with IFC Performance Standards definitions[21].

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[16] Swanson, F.J., Kratz, T.K., Caine, N., 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. Bioscience, Vol. 38, No 2 pp 92-98

[17] McAuliffe, J.R. (1994) Landscape evolution, soil formation, and ecological patterns and processes in Sonoran Desert bajadas. Ecological Monographs 64, pp 111–148.

[18] IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1. 'www.iucnredlist.org'. Downloaded on 26 June 2012.

[19] UNEP-WCMC. 26 June 2012. UNEP-WCMC Species Database: CITES-Listed Species.

[20] Status and Red List of Pakistan Mammals. 2006. Biodiversity Programme IUCN Pakistan. This list is not officially recognized by the Government of Pakistan and is referenced in this report to provide an indication of species that may be assigned a conservation status subject to further research, and evaluation by the Government of Pakistan.

[21] 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.

5.3.2 Vegetation

343. There are four phytogeographical regions in Pakistan. The Study Area falls into the Saharo-Sindian region. This region is considered poor in vegetative diversity; despite its large size, only 9.1% of the known 5,738 floral species of Pakistan are found in this region (Rafiq and Nasir 1995)[22]. The vegetation of this region is typical of arid regions and consists of xerophytic species that are adapted to extreme seasonal temperatures, moisture fluctuation, and a wide variety of soil conditions.

344. The Study Area is flat land with the average altitude ranging between 20 to 45 m above mean sea level. Elevation of the Indus River is 15 m on the banks with agricultural fields located mainly in the flood plain. The river is located approximately 3.7 km east of the Thermal Power Station. Smaller sedimentary hills are located in the west and south-west. These hills reach a maximum altitude of around 100 meters. Small wetlands, some caused by the waste water from the Project, can be observed on the eastern side of the Project. A small vegetation cluster is located approximately 1 km south of the Project. The western side of the Study Area is dominated by gravel plains. Drainage channels cut through the gravel plains to drain the rain water. (**Figure 5–3**).

345. During the June 2012 survey, sampling was conducted at 14 points, of which four (4) were in agricultural fields, five (5) in gravel plains, three (3) in wetland, one (1) in vegetation cluster and one (1) in hills. 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 include *Acacia senegal, Prosopis cineraria, Aerva javanica, Leptadenia pyrotechnica, Salvadora oleoides, Ziziphus nummularia* and *Calotropis procera.* The vegetation of the Indus River bank mostly composed of prenial sherbs of *Tamarix dioica* and *Alhagi camelorum*. *O*ther vegetation species observed in the Study Area include *Seddera latifolia, Ziziphus nummularia, Commiphora wightii, and Fagonia indica. Blepharis scindicus Periploca aphylla, Ziziphus nummullaria*.

346. Based on the geomorphology, soil characteristic and vegetation communities observed, the Study Area can be classified into four main habitats, gravel plains, hills, agricultural fields and wetlands. Photographs of different habitats in the Study Area are provided in **Figure 5-7.**

Gravel Plains

347. Gravel plains constitute 53% (including 4% of the settlements area) of the total habitat of the Study Area (**Figure 5-8**). This habitat is characterized by low-lying undulating plains. The vegetation in this habitat is relatively sparse. The vegetation degradation in this habitat was observed due to grazing and browsing by domestic livestock, and also due multiple access track made by local vehicles for borrowing purposes. The dominant plant species of this habitat include *Prosopis juliflora, Zygophylum sp., Capparis decidua, Salvadora oleoides* and *Fagonia indica*.

348. Few vegetation clusters in some local depressions were also observed in this habitat and were labeled as a micro-habitat. In this micro-habitat, the vegetation cover was higher than in other areas of gravel plains. The dominant species in this include *Tamarix dioica, Ziziphus nummularia, Acacia nilotica* and *Prosopis juliflora*.

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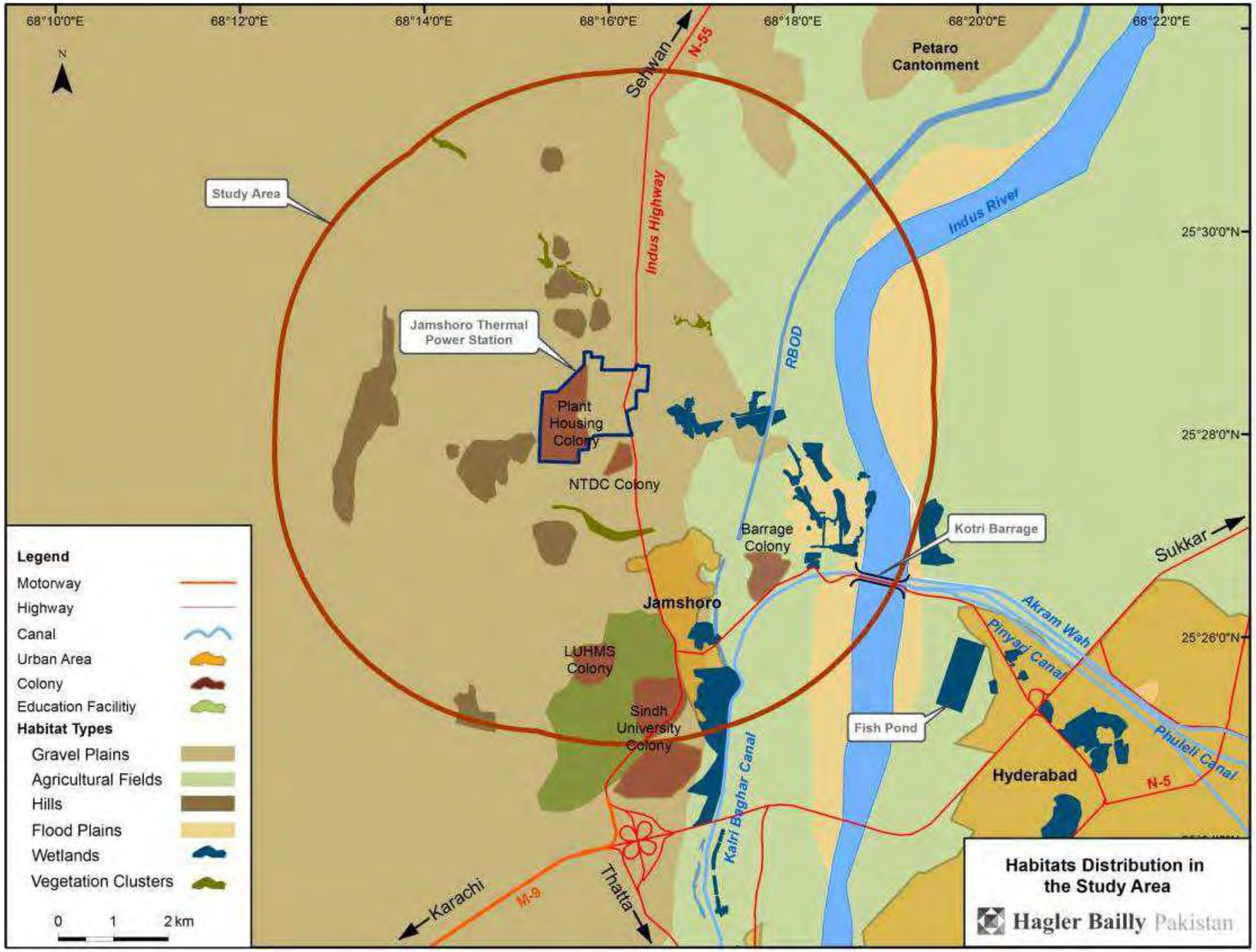
[22] Rafiq, Rubina A., and Nasir, Yasin J. 1995. Wild Flowers of Pakistan, Oxford University Press.

Figure 5-7: Photographs of Habitats in the Study Area

A. Agricultural Fields along the River Bank
B. Gravel Plains West of Power Plant
C. Hills North of Power Plant
D. Wetland Fed by Waste Water from the Plant
E. Wetland at Indus River
F. Wetland Created by Under Construction RBOD
G. Vegetation Cluster in Gravel Plains

Figure 5-8: Habitats Distribution in the Study Area



Agricultural Fields

349. Agricultural fields constitute 31% of habitats of the Study Area (**Figure 5-8**) 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 is present along the edges of the fields. The dominant plant species observed in this habitat are *Alhagi camelorum, Tamarix dioica, Saccharum sp., Sida fruticosa, Salvadora oleoides, and Zygophylum sp*.

350. Flood plains constitute 2% of the total habitat of the Study Area (**Figure 5-8**) and are present along the river at the edge of agricultural fields. Some of these areas are brought in to cultivation during the low flood season while the others are not cultivated at any time of the year. However, since they constitute only a small percentage of the Study Area, they were labeled as a microhabitat and included in the Agricultural Fields for purpose of this study. This habitat comes under water during high flood and the vegetation in this habitat is relatively thick with thin floral diversity. The dominant species in this include *Tamarix dioica, Acacia nilotica* and *Prosopis juliflora.* Local people; use *Acacia nilotica* and *Prosopis juliflora* as fuel wood source in the project study area. The browsing pressure by local domestic livestock was also visible in this habitat.

Hills

351. The hills cover less than 4% of the Study Area (**Figure 5-8**). Vegetation cover in this habitat is thin and degraded due to over grazing/browsing and fuel wood extraction. The common and dominant plant species in this habitat type are *Acacia senegal, Rhazia stricta, Seddera latifolia* and *Commiphora wightii*.

Wetland

352. This habitat covers 6% (including Indus River) of the Study Area and is mostly found within the agricultural fields and along the Indus River. Some wetlands were observed near the evaporation pond formed by the disposal of waste water from the plant and seasonal flood. The vegetation in this wetland is very thick and mostly composed of *Typha sp.*and *Phragmites sp.* The vegetation on the Right Bank Outfall Drain (RBOD) of these habitats is degraded due to over browsing by domestic livestock. Some part of RBOD is without any type of vegetation. The vegetation of wetlands that occur near or along the Indus River are relatively thin in floral diversity and vegetation cover as compared to the wetlands fed by waste water from the plant. The main reason of this may cause due to fisher men that using bank vegetation as fuel wood and in some cases for commercial purpose too. The grazing pressure in over this entire habitat was prominent. The overall vegetation cover in this habitat is high as compared to other habitats in the Study Area The dominant plant species of this habitat include *Typha sp., Phragmites sp., Prosopis juliflora , Tamarix dioica* and *Alhagi camelorum*.

353. **Appendix 4** (**Table 4-1**) provides a list of plant species observed in the Study Area during the June 2012 survey.

354. **Appendix 4** (**Table 4-2**) provides a summary of sampling points by habitat type. It presents the vegetation cover, relative cover, frequency, relative frequency, density and relative density and importance value Index (IVI) of plant species.

Conservation and Protection Status

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

356. **Determination:** No threatened or endemic plant species are present in the Study Area. None of the plant species observed were endemic, their distribution is not limited to any specific site or habitat type, and their distribution is widespread.

5.3.3 Mammals

357. A total of 21 mammal species have been reported from the Study Area and its vicinity[23]. These include members from Family Canidae, Ericinaceidae, Felidae, Herpestidae, Hystricidae, Leporidae. Among the river mammals, a dolphin species from Family Platanistidae[24] and an otter from Family Mustellidae[25] have been reported from the Indus River mostly upstream of Kotri barrage. Small mammals reported from the Study Area include species from Family Muridae, Sciuridae, Soricidae[26]. A complete list of the mammals and small mammals reported from the Study Area is provided in **Appendix 4** (**Table 4-3**).

Overview of Abundance and Diversity

358. During the June 2012 survey, sampling was conducted at 14 points, of which four (4) were in agricultural fields, five (5) in gravel plains, three (3) in wetland, one (1) in vegetation cluster and one (1) in hills.

359. A total of 25 signs belonging to four (4) species were seen in the Study Area. These included signs of the Asiatic Jackal *Canis aureus*, Indian Crested Porcupine *Hystrix indica*, Desert Hare or Indian *Hare Lepus nigricollis* and signs of a fox species *Vulpes sp.* that could not be identified on the basis of signs alone. The maximum number of mammal signs were seen in the agricultural fields followed by wetlands. The maximum number of signs observed belonged to the *Vulpes sp.* No mammal signs were observed in the vegetation clusters or hills. The maximum abundance was observed at Sampling Point 4 while the maximum diversity was observed at Sampling Point 7. Both these sampling points were located in agricultural fields. No large mammals were sighted in the Study Area.

360. A total of 4 (four) small mammals were trapped in the Study Area. These include Balochistan Gerbil *Gerbillus nanus*, House Rat *Rattus rattus*, Indian Gerbil *Tatera indica* and Soft-furred Metad *Millardia meltada.*

361. **Appendix 4** (**Table 4-4**) 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 the June 2012 survey. **Appendix 4** (**Table 4-5**) shows the abundance of mammal signs observed in the different habitats of the Study Area.

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[23] Ghalib, SA.,Hasnain, SA. and Khan, AR. 2004. Current status of the mammals of Sindh.J.nat.hist.Wildl. 3(1):16.

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

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

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

Conservation and Protection Status

362. Signs of the Asiatic Jackal *Canis aureus* and a fox *Vulpes sp.* were observed in the Study Area. Even though it is not possible to identify the fox species from the signs alone, keeping in view the geographical location, it is most likely to be the Bengal Fox *Vulpes bengalensis*. Signs of the Indian Crested Porcupine *Hystrix indica* were also observed in the Study Area. Among the river mammals, the mammals of conservation importance reported from the Study Area include the Smooth Coated Otter *Lutrogale perspicillata* and the Indus Blind Dolphin *Platanista minor*.

363. The Asiatic Jackal *Canis aureus* is included in Appendix III of the CITES Species List[27] and listed as Near Threatened in Pakistan's Mammals National Red List 2006[28]. The signs of this species were observed at Sampling Points 1, 4, 8, 9 and 13 in the Study Area.

364. The Bengal Fox *Vulpes bengalensis* is placed in Appendix III of the CITES list and listed as Near Threatened in the Pakistan's Mammals National Red List 2006. Signs of a fox species were observed in the Study Area at Sampling Points 1, 4, 2, 3, 9 and 13 during the June 2012 survey.

365. The Indian Crested Porcupine *Hystrix indica* is listed as Near Threatened in Pakistan's Mammals National Red List 2006. Signs of this species were seen in the Study Area at Sampling Points 5 and 7.

366. The Smooth-coated Otter *Lutrogale perspicillata* has been reported from the vicinity of the Study Area[29] but the population recorded is low in number.[30] It was not seen in the Study Area during the survey of June 2012. It is listed as Vulnerable in the IUCN Red List 2012.

367. The Indus Blind Dolphin *Platanista minor* is listed as Endangered in both the IUCN Red List 2012 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[31] (**Figure 5-9**). 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 [32].

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27 UNEP-WCMC. 26 June 2012. UNEP-WCMC Species Database: CITES-Listed Species

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

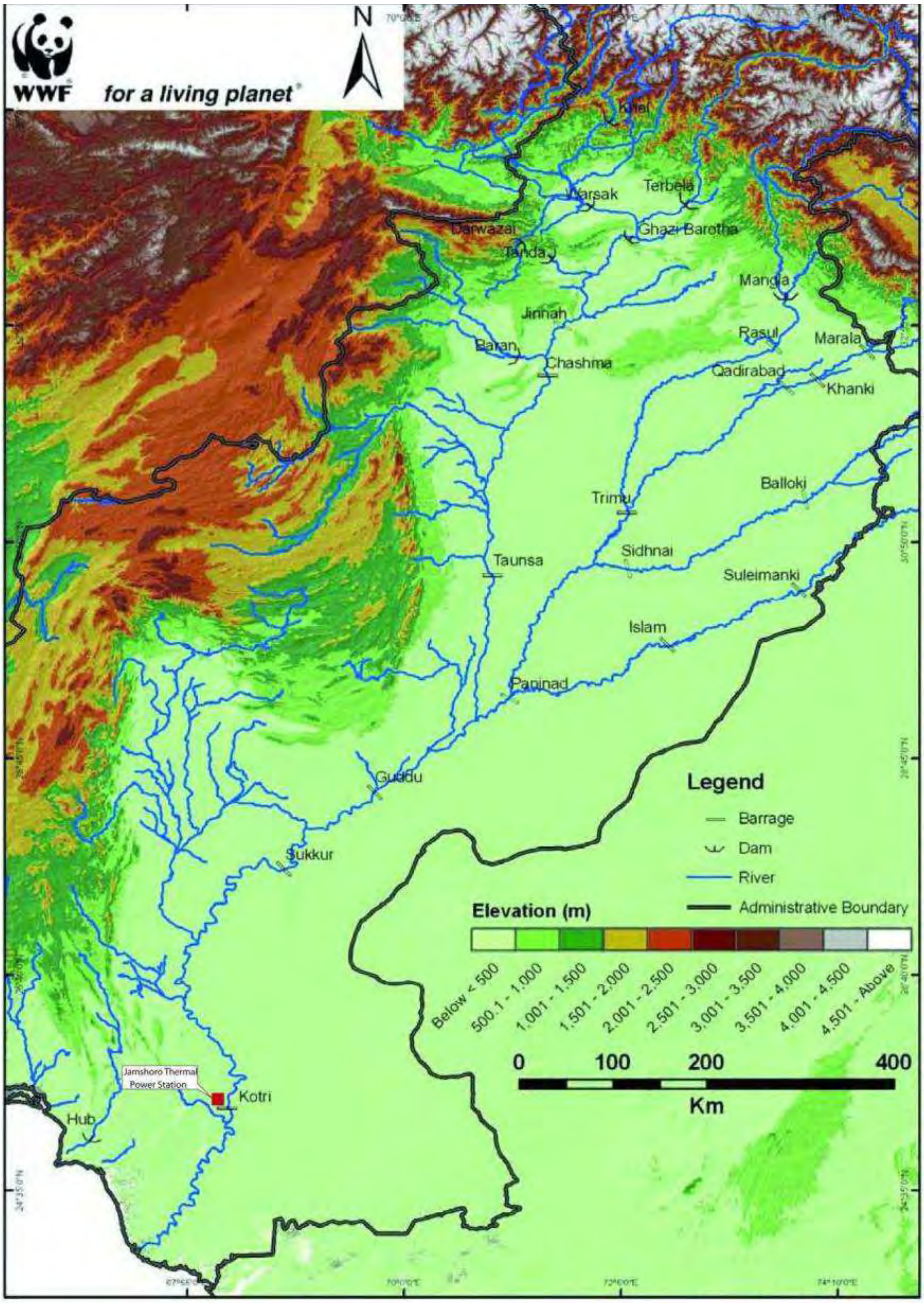
29 Gachal, G. S., Memon, Z., Qadir, A. H., Yusuf, S. M. and Siddiqui, M. 2007. Ecological Impact on the status of Otter (Lutrogaleperspicillata). Sindh Univ. Res. J., 39(2): 19-26.

30 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

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

32 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.

Figure 5-9: The Indus River system with Major Head works



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

368. In 2001 a comprehensive survey of the entire range was conducted. The total population size was estimated as 1,100 in approximately 1,000 km of river[33]. Nearly the entire population (99% of the animals) occurred in only 690 linear kilometer, which implies roughly an 80% reduction in the area of occupancy since the 1870's[34] .The factors for decline include water pollution, poaching, fragmentation of habitat due to barrages, and dolphin strandings in the irrigation canals[35]. 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 1,293 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[36]. A small population of 4 – 6 specimens was recorded near Kotri barrage.[37] This dolphin was not seen during the survey of June 2012 in the Study Area.

369. **Determination:** Two mammals of the Study Area that are included in the IUCN Red List are the Smooth-coated Otter *Lutrogale perspicillata* and the Indus Blind Dolphin *Platanista minor*. The latter is also endemic to the sub-continent. However, the dolphin population is small in number and specimens of these species are not restricted to this stretch of the Indus River and have been reported from other parts of the river as well. Therefore, their distribution is not restricted to a particular site and their distribution is widespread.

5.3.4 Reptiles and Amphibians

370. **Appendix 4** (**Table 4-6**) provides a list of reptile species reported from the Study Area. Two species of turtles, nine species of snakes, six species of lizards and two species of amphibians have been reported from the Study Area. The turtle species include the Indian Flap shell Turtle *Lissemys punctata* and Spotted Pond Turtle *Geoclemys hamiltonii*. The snake species reported include the Indian Cobra *Naja naja*, Spotted Wolf Snake *Lycodons triatus*, Common Sand Boa *Eryx johnii*, Saw scaled Viper *Echis carinatus*, Russel's Viper *Daboia russelii*. Common lizards of the Study Area include the Indian Monitor Lizard *Varanus bengalensis*, Indian Spiny tailed Lizard *Saara hardwickii*, Indian Garden Lizard *Calotes versicolor.*

Overview of Abundance and Diversity

371. During the June 2012 survey, sampling was conducted at 14 points, of which four (4) were in agricultural fields, five (5) in gravel plains, three (3) in wetlands, one (1) in vegetation cluster and one (1) in hills.

372. A total of 16 reptile individuals belonging to four (4) species were sighted in the Study Area during the June 2012 survey. The species observed include the Indian Fringe-toed Sand Lizard *Acanthodactylus cantoris,* Cholistan Desert Lacerta, *Eremias*

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

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

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

36 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

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

cholistanica, Brilliant Ground Agama *Trapelus agilis* and the Indian Spiny-tailed Ground Lizard *Saara hardwickii.*

373. The maximum reptile abundance was observed in the gravel plains followed by the agricultural fields. No reptiles were observed in the wetlands, vegetation cluster or hills. The Indian Spiny-tailed Ground Lizard *Saara hardwickii* was the most abundantly observed reptile in the Study Area.

374. **Appendix 4** (**Table 4-7**) provides a summary of sampling points by type of habitat, number of sightings, and the number of species sighted. **Appendix 4** (**Table 4-8**) shows the abundance of reptiles in the Study Area for all habitat types.

Conservation and Protection Status

375. The two reptiles of conservation importance observed in the Study Area include the Cholistan Desert Lacerta *Eremias cholistanica* that is endemic to Pakistan and the Indian Spiny-tailed Ground Lizard *Saara hardwickii* that is included in CITES Appendix II.[38]

376. 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 (Minton 1966).[39] This species is included in CITES Appendix II[40] because of its attractiveness in global wild pet trade. It was seen in the study Area during the June 2012 survey at Sampling Points 3, 4, 6, 8 and 9.

377. The Cholistan Desert Lacerta *Eremias cholistanica* has been named after the Cholistan Desert of Pakistan. It is included in Appendix II of the CITES Species List. It was seen in the Study Area at Sampling Point 3.

378. **Determination:** No threatened reptiles were determined to be resident on the Study Area. None of the observed species were included in the IUCN Red List 2012. One species is included in the CITES Species List while one species is endemic to Pakistan. However, their distribution is not limited to any specific site or habitat type, and their distribution is widespread.

5.3.5 Birds

379. **Appendix 4** (**Table 4-9**) provides a list of bird species reported from the Study Area. 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 area include Indian Pond Heron *Ardeola grayii*, Common Moorhen *Gallinula chloropus*, Little Egret *Egretta garzetta*, Black-shouldered Kite *Elanus caeruleus*, 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*

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38 UNEP-WCMC. 26 June 2012. UNEP-WCMC Species Database: CITES-Listed Species

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

40 UNEP-WCMC. 26 June 2012. UNEP-WCMC Species Database: CITES-Listed Species.

macrocercus, House Crow *Corvus splendens*, Common Myna *Acridotheres tristis*, Bank Myna *Acridotheres ginginianus* etc.[41]

Overview of Abundance and Diversity

380. During the June 2012 survey, sampling was conducted at 14 points, of which four (4) were in agricultural fields, five (5) in gravel plains, three (3) in wetlands, one (1) in vegetation cluster and one (1) in hills.

381. **Appendix 4** (**Table 4-10**) provides a summary of sampling points by habitat type, number of sightings, and number of species sighted during the June 2012 surveys. **Appendix 4** (**Table 4-11**) lists the number of birds sighted of each species by habitat type for the June 2012 survey. A total of 451 bird individuals belonging to 25 species were observed during the June 2012 survey. The maximum bird abundance was observed in the wetlands followed by the agricultural fields. No birds were observed in the hills. The maximum bird diversity was observed in agricultural fields. 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*. The maximum bird abundance was seen at Sampling Point 14 in wetland. The maximum bird diversity was seen at Sampling Point 1 in agricultural fields.

Importance of Study Area for Migratory Birds

382. 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.

383. 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 as the Green Route or more commonly Indus Flyway, one of the important migratory routes in the Central Asian - Indian Flyway[42]. (**Figure 5-10**). 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.[43] Some of these birds stay in the lakes but majority migrate to coastal areas.

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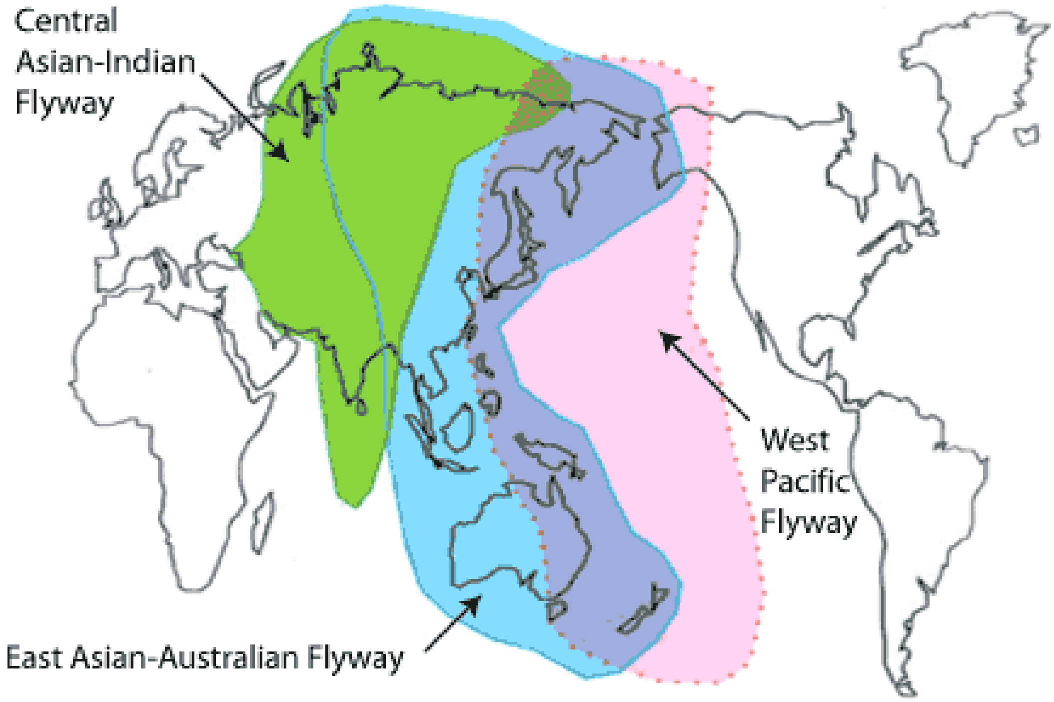
41 Grimmett R, Roberts TJ, Inskipp T (2008) Birds of Pakistan, Yale University Press

42 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.

43 Pakistan Wetlands Programme. 2012. Migratory Birds Census Report.

Figure 5-10: Asian Migratory Birds Flyways



384. A number of migratory birds have been reported from the Stuyd Area and its vicinity. The winter visitors include the Grey Heron *Ardea cinerea*, Common Teal *Anas crecca*, Northern Shoveler *Anas clypeata*, Common Coot *Fulica atra*, Common Pochard *Aythya ferina*, Eurasian Wigeon *Anas penelope,* Gadwall Anas *strepera,* Garganey *Anas querquedula*, Mallard *Anas platyrhynchos*, Eurasian Sparrow Hawk *Accipiter nisus*, Osprey *Pandion haliaetus,* Peregrine Falcon *Falco peregrines,* Common Sandpiper *Actitis hypoleucos*, Black-headed Gull *Larus ridibundus*, Common Greenshank *Tringa nebularia*, Caspian Gull *Larus cachinnans*, and White Wagtail *Motacilla alba personata.*[44]

385. The summer migrants include the Small Pratincole *Glareola lactea,* Indian Skimmer *Rynchops albicollis* and Chestnut-shouldered Pretonia *Petronia xanthocollis*. They were not observed in the Study Area during the June 2012 survey.

386. The passage migrants include the Yellow wagtail *Motacillaflava,* Blyth's Reed Warbler *Acrocephalus dumetorum*, Rosy Starling *Sturnus roseus* and *Grus grus*. These species are irregular year round visitors to the Study Area. They were not observed in the Study Area during the June 2012 survey.

387. The Study Area is not declared as a protected wetland Ramsaar site.[45] It is also not part of a game sanctuary or game reserve. Since the Study Area is located very close to the coast, most of the migratory birds do not use it as a breeding and nesting

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[44] Pakistan Wetlands Programme. 2012. Migratory Birds Census Report.

[45] 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.

area but merely as a resting ground on their way to coastal areas where there is greater food and habitat available.

Conservation and Protection Status

388. The only bird of conservation importance found in the Study Area was the River Tern *Sterna aurantia.* This is a common resident species in the area around the River Indus and its tributaries.[46] It is listed as Near Threatened in the IUCN Red List 2012.[47] It was seen in the Study Area at Sampling Points 1, 3, 4, 5, 7, 12 and 14.

389. Even though the Study Area is visited by both summer and winter bird migrants, most of the birds use it only as a temporary resting ground and the Study Area is not a breeding ground for most of these migratory birds.

390. **Determination**: No threatened bird species were determined to be resident in the Study Area. One bird species is listed as Near Threatened in the IUCN Red List. However, its distribution is not limited to any specific site or habitat type and its distribution is widespread. Moreover, the area is not critical for the survival of migratory birds.

5.3.6 Fish

391. A complete list of the fish reported from the Study Area and adjoining areas is given in **Appendix 4**. (**Table 4-12**). Photographs of some of the fish species and fishing activities in the Study Area are shown in **Figure 5-11** and **Figure 5-12,** respectively. At least 49 fish species have been recorded from the reaches of the River Indus near the Study Area and its environs.[48] 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).

392. Most of the species are common but the species *Chitala chitala*, *Macrognathus pancalus* and *Tenualos ailisha* are rare in the area. Species *Chitala chitala* and *Macrognathus pancalus* are generally rare throughout the country while the species *Tenualos ailisha* is rare in the Study Area due to overfishing in the breeding season, scarcity of water and destruction of breeding grounds. The commercially important species are facing very high fishing pressure as the number of fishermen is high as compared to the available fish resource in the area. This was confirmed in interviews with local fishermen during the June 2012 survey who claimed that the use of illegal mesh size by some fishermen, shortage of water in the barrage areas due to diversions into canals for agriculture, and an increase in the number of fishermen in the area is responsible for this decline. The legal mesh size allowed for fishing is 3.8 cm (1.5 inches). In order to collect more and more fish, the there is a tendency among fishermen to use nets of smaller mesh sizes to maximize the catch. Regulation of mesh size has been widely used for controlling the minimum commercial size in protected fish populations. Generally Mrigal *Cirrhinus mrigal*a, Rohu *Labeo rohita*, and Calbasu *Labeo*

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[46] Grimmett, R., Roberts, T., and Inskipp, T. 2008. Birds of Pakistan, Yale University Press

[47] IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1. 'www.iucnredlist.org'. Downloaded on 26 June 2012.

[48] Hussain, Z., (1973) Fish and fisheries of the lower Indus basin (1966-67), Agric. Pakistan, (24): 170-188

calbasu of less than one kilogram 1 kg in weight, and Catla *Gibelion catla* of less than 4 kg in weight is prohibited for fishing in lakes and reservoirs.

Figure 5-11: Some Common Fish Species Observed in the June 2012 Survey

Reba Carp *Cirrhinus reba*

Kuria Labeo *Labeo gonius*

Mozambique Tilapia *Tilapia mosambiqa*

Rohu *Labeo rohita*

Freshwater Shark *Wallago attu*

Rita Catfish *Rita rita*

Hilsa Shad *Tenualosa ilisha*

Humped Featherback *Chitala chital*a

Figure 5-12: Fishing Activities in the Study Area (upstream of Kotri Barrage)

393. Interviews with the fishermen community and the fish whole sale sellers during the June 2012 surveys revealed that about 150-200 large boats and 350-400 small boats are operating in the area (about 10 km upstream and 10 km downstream of Kotri barrage) and some 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. 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).

394. Fish survival, growth and productivity are dependent on both biological and environmental factors. The latter can be distinguished as edaphic (which includes water quality) and morphometric (which includes lake and stream morphology).[49] The presence of toxic metals from industrial sources can have a detrimental impact on the aquatic fauna including amphibians, fish, algae and aquatic invertebrates.

Importance of Study Area for Aquatic Fauna and Fish

395. Kotri Barrage is the last water reservoir on the River Indus before it flows into the Arabian Sea. Below Kotri, the water level fluctuates tremendously and the influence of brackish water has increased to variable extents and therefore aquatic diversity is comparatively lower. However, 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.

Conservation and Protection Status

396. Among the fish species reported from the Study Area, the species *Chitala chitala, Ompok pabda, Ailia coila, Wallago attu,* and *Bagarius bagarius* as well as the exotic fish *Oreochromis mossambicus* are listed as Near Threatened in the IUCN Red List 2012.

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[49] Howells G.D., David J. A. Brown, Sadler K., "Effects of acidity, calcium, and aluminium on fish survival and productivity", Journal of the Science of Food and Agriculture, Vol. 34, 1983, pp. 559-570.

The exotic fish, *Cyprinus carpio,* is listed as Vulnerable. Other than the *Chitala chitala,* all the other fish species with conservation importance are common in the Study Area.

397. **Determination**: There are two fish species reported from the Study Area that are included in the IUCN Red List 2012. However, most of them are commonly seen in the Study Area. Moreover, their distribution is not limited to any specific site or river habitat type and their distribution is widespread.

5.3.7 Critical Habitats

398. International Finance Corporation (IFC) Performance Standards[50] recognizes critical habitat as areas designated by various organization as having special significance for high biodiversity value. These include:

- Areas protected by the International Union for Conservation of Nature (Categories I-VI);[51]
- wetlands of international importance (according to the Ramsar convention);[52]
- important bird areas (defined by Birdlife International);[53] and
- biosphere reserves (under the UNESCO Man and the Biosphere Programme;[54]

399. No area in any of the above categories fall in the Study Area.

400. The Sindh Wildlife Protection Ordinance 1972, empowers the government to declare areas of ecological significance as protected. The law provides three different types of such areas, the national park, the wildlife sanctuary and the game reserve. No such area located within the Study Area.

401. In addition, IFC's Performance Standard 6 defines Critical Habitats with respect to certain biodiversity related characteristics. These definitions and a discussion with respect to the Study Area are given below:

- Habitat of significant importance to Critically Endangered and/or Endangered species

  The only species of the Study Area listed as Endangered in the IUCN Red List 2012 is the Indus Blind Dolphin *Platanista minor*. However, the dolphin population reported from the Study Area and its vicinity is small. Moreover, this species is not restricted to this stretch of the Indus River and has been reported in greater abundance from other parts of the river as well[55]. Therefore, the distribution of the Indus Blind Dolphin *Platanista minor* is not restricted to a particular site and their distribution is widespread. The stretch of the river included in the Study Area is thus not critical for the survival of this endangered

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50 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.

51 IUCN. 1994. Guidelines for *Protected Areas* Management *Categories*. *IUCN*, Cambridge, UK.

52 Ramsar Convention, or Convention on the Wetlands of International Importance, Administered by the Ramsar Secretariat, Geneva, Switzerland

53 Birdlife International, UK

54 Administered by International Co-ordinating Council of the Man and the Biosphere (MAB), UNESCO.

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

species. However, preserving the habitat of this species from any project related impacts would be of concern.

- 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 the Study Area is visited by both summer and winter migrants, it is used as a temporary resting ground and is not a breeding or nesting area. There is nothing to indicate that the Study Area is critical for the survival of these migratory birds. 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; or

- Areas having biodiversity of significant social, economic or cultural importance to local communities

  Members of the local community are dependent on the river for fishing that provides a source of livelihood for them. Other than fishing, although, the area is of importance to residents in terms of ecosystem services (such as water and vegetation for grazing), it has no unique biodiversity value of social or cultural importance to the community.

402. **Determination**: There is no critical habitat present on the Study Area.

5.3.8 Limitations of the Study

403. The limitations for the ecological baseline are as follows:

- Difficulty in observing large carnivores due to their elusive and predominantly nocturnal nature.
- Inability to carry out nocturnal surveys for security reasons; and
- Predominance of hard substrates making large mammals tracks more difficult to identify

404. However, since the Study Area is located in a disturbed habitat, a large population of carnivore mammals and nocturnal species is not likely to occur at this site and these limitations are not.

5.4 Socioeconomic Environment

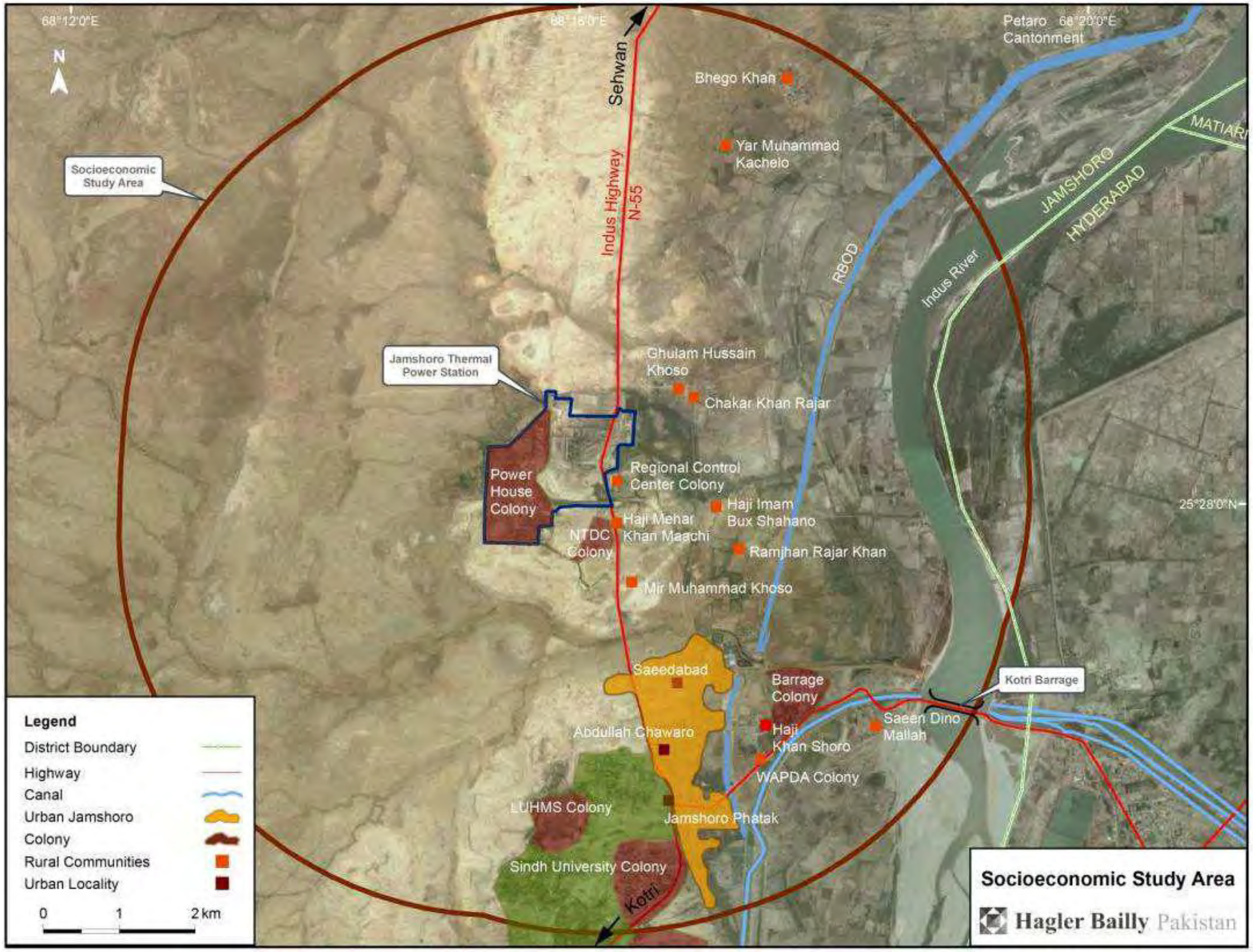
405. Baseline investigations were undertaken to document the existing socioeconomic conditions of the population that can be affected by the Project activities. The results of the socioeconomic baseline investigations are documented in this section of the report.

5.4.1 Delineation of Study Area

406. 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 more the settlements located closer, up to 5 km, to the Project facilities. For this, a study area of five km 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. This is referred to as the Socioeconomic Study Area in this report. The Socioeconomic Study Area is shown in **Figure 5-13**.

407. 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.

Figure 5-13: Socioeconomic Study Area



5.4.2 Overview

408. The Socioeconomic Study Area falls within the Kotri taluka[56] of Jamshoro district, Sindh Province. Kotri taluka is relatively developed in comparison to the other four talukas of Jamshoro district and is home to headquarter of the district, Jamshoro town.

409. The population clusters falling within the Socioeconomic Study Area can be broadly classified as:

- Rural – these are small villages located alongside the Indus Highway and in the outskirts of Jamshoro town. The rural segments of the Socioeconomic Study Area are more vulnerable to changes in the socioeconomic environment brought about by the Project, owing to lower income levels and access to facilities in comparison to the other segments. Further detail on the conditions in the rural areas are provided in the sections to follow;
- Urban – this comprises of a dense contiguous population belt that forms the main Jamshoro town. The sub localities of Jamshoro town that fall under this classification are Jamshoro Phatak, Abdullah Chawaro and Saeedabad. The urban areas of the Socioeconomic Study Area have better access to facilities and higher incomes relative to the rural parts of the Socioeconomic Study Area;
- Colonies – most of these are planned residential colonies established by various institutions operating in the Socioeconomic Study Area. The colonies have an independent administrative setup, which is run by the parent institution and is not overseen by the municipal authority. Being smaller population units to administrate, the colonies are usually well-equipped in terms of main urban services and facilities, such as, water supply and sanitation. The colonies and the urban areas together constitute the more developed and better-off segments of the Socioeconomic Study Area;

410. The rural, urban and colony areas of the Socioeconomic Study Area are identified in **Figure 5-13**.

5.4.3 Data Collection and Organization

411. Primary data at the settlement and household levels was collected through a survey conducted in June 2012. The rural areas form the more vulnerable population segments of the Socioeconomic Study Area. To determine the prevailing poverty levels in the rural segments, a household survey was implemented, which focused on obtaining information on household income levels, types of occupations and, age and gender profile. In addition to the household survey, a settlement questionnaire was implemented in the rural, urban and colony areas to ascertain presence and accessibility levels to various social and physical infrastructure. The survey coverage is summarized in **Table 5-10** whereas the location of the surveyed settlements is shown in **Figure 5-14.**

[56] Taluka is an administrative subdivision of a district. The term taluka is specific to Sindh and is referred to as tehsil elsewhere in Pakistan.

Table 5-10: Coverage of Socioeconomic Survey

	Rural	Urban	Colony
Coverage of the Settlement Survey			
Total Number of Settlements	10	3	7
Settlements Surveyed	6 (60%)	1 (33%)	5 (71%)
Total Population	31,048	74,850	45,325
Population of the Surveyed Settlements	23,648 (76%)	4,000 (5%)	33,825 (75%)
Coverage of the Household Survey			
Total Number of Households	3,891	9,600	5,730
Households Surveyed	29 (0.7%)	3 (0.4%)	8 (0.2%)
Population of the Surveyed Households a	298 (1.0%)	33 (0.4%)	62 (0.2%)

412. Published data at the provincial, district and, where available, taluka levels was used to understand socioeconomic baseline conditions at for the broader region.

413. The discussion in this section has been presented separately for the rural, urban and colony areas of the Socioeconomic Study Area, to capture the differing socioeconomic settings.

5.4.4 Settlement Layout

414. Views of a typical rural, colony and urban area in the Socioeconomic Study Area are shown in **Figure 5-15**. As evident from the satellite view, the rural locality of the Socioeconomic Study Area has an unplanned layout, which is characteristic to the rural areas of Pakistan. The layout of the urban areas is still reminiscent of their rural origin, as it does not present the grid arrangement, which is typical to urban areas in Pakistan. However, the urban areas are much densely populated than the rural areas. In comparison to urban areas, colonies have a more planned layout. The population density of colonies varies, depending on the staffing needs of the parent institutions.

Figure 5-14: Location of Surveyed Settlements in the Study Area

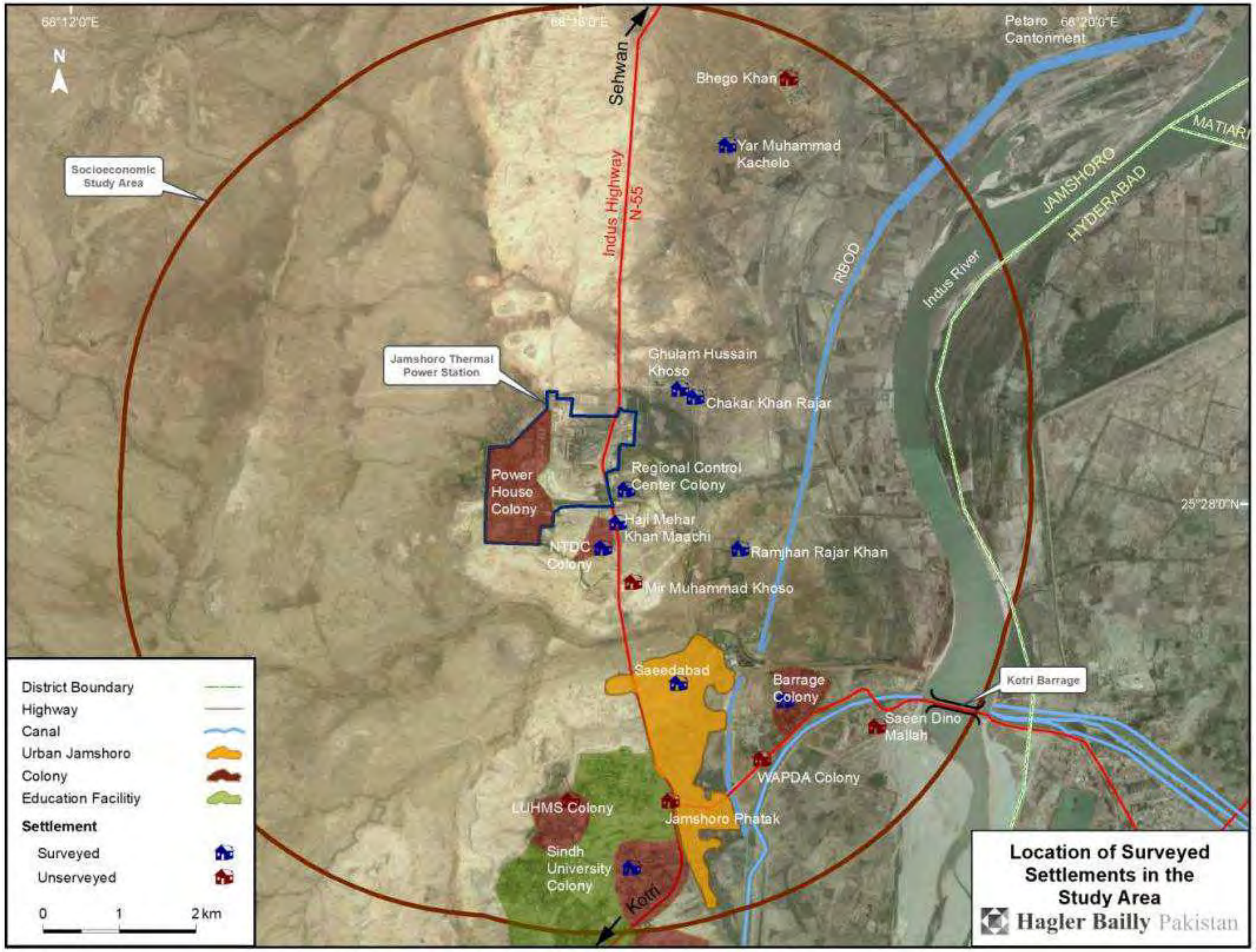
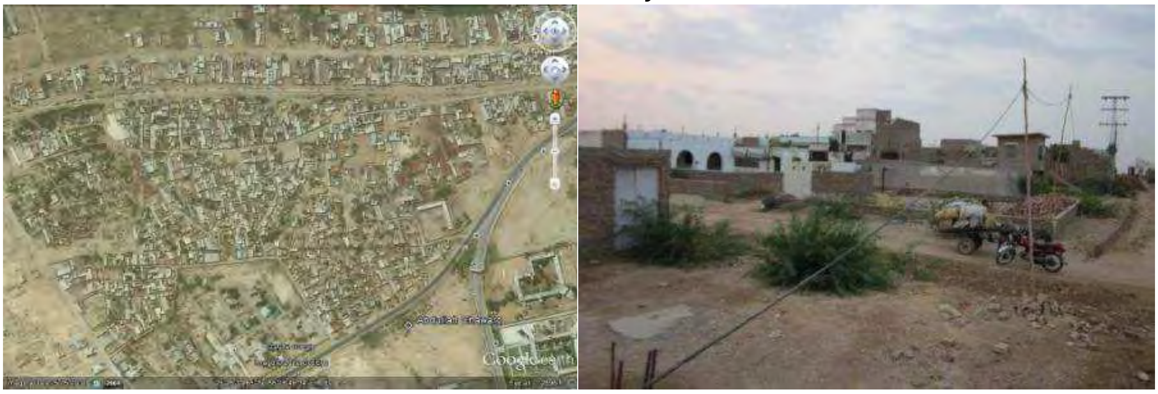


Figure 5-15: Satellite Views of Settlements in the Socioeconomic Study Area

Satellite Views	***Images***

Rural Locality



Urban Locality

Colony

5.4.5 Demography

415. **Table 5-11** draws a comparison between the population and settlements sizes of the rural, urban and colony areas. Population residing in urban areas constitutes the largest share in the total population of the Socioeconomic Study Area; forming 49% share. Population in colonies constitutes 30% of the Socioeconomic Study Area population and the remaining 21% is rural. The rural settlements are much smaller in size in terms of population. On the average 3,105 persons reside per rural settlement, which is nearly eight times smaller than the size of a typical urban locality in the Socioeconomic Study Area and half the size of a typical colony. The largest rural

locality, Saeen Dino Mallah, has a population of 12,000 persons, whereas the largest urban locality, Jamshoro Phatak has a population of 43,350 persons.

Table 5-11: Population and Settlement Size in the Socioeconomic Study Area

	No. of Settlements	Population Distribution		Settlement Size		
				Average	Maximum	Minimum
Rural	10	31,048	21%	3,105	12,000	60
Urban	3	74,850	49%	24,950	43,350	4,000
Colony	7	45,325	30%	6,475	21,675	300
Socioeconomic Study Area	**20**	**151,223**	**100%**	**7,561**	**43,350**	**60**

Household Size

416. A household functions as a single unit in terms of earning and allocating its resources. The average size of the rural household in the Socioeconomic Study Area was 10.3, which is higher than that of Jamshoro district, 5.9, and rural Sindh, 7.0.[57] Possible reasons for this could include the extended family concept that prevails in the area, in which family members other than parents and children are considered part of the household and higher fertility rates.

417. The average household size in the urban and colony areas was 8.7, which is lower than rural household size in the Socioeconomic Study Area and higher than that of urban Sindh, 6.5.[58] Possible reason for the higher size in comparison to the average for urban Sindh could be higher fertility.

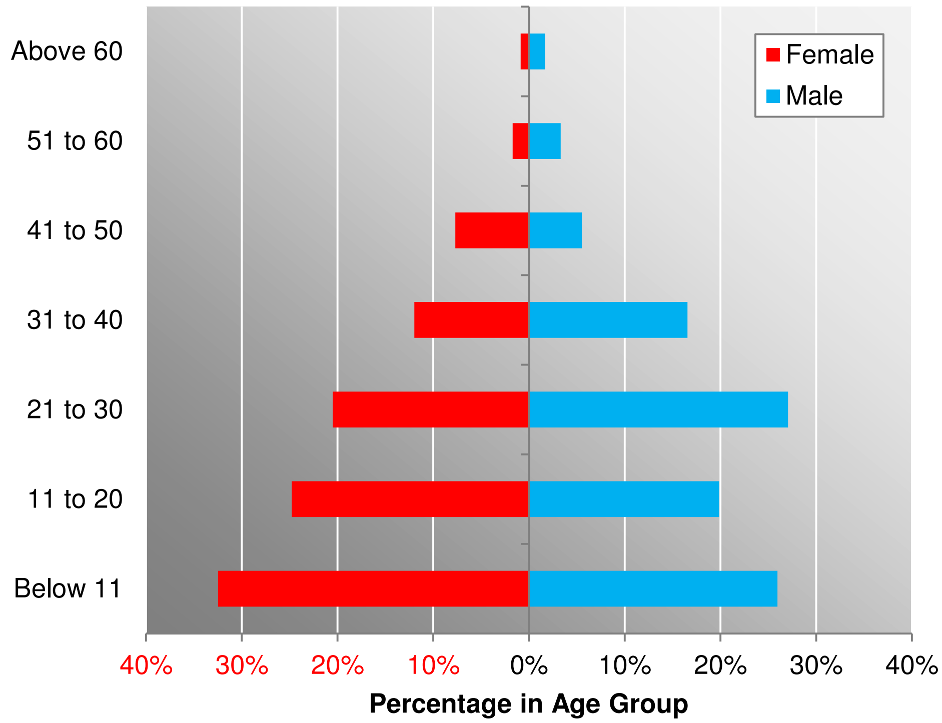
Age and Sex Composition

418. The population pyramid for the surveyed rural population is given in **Figure 5-16**. The broader base of the age-pyramid specifies a younger population. The median age of the surveyed population was 20 years. The age structure shows a relatively large number of children of ages 11 years and younger, accounting for 28.5% of the population. Population above 60 years was found to be only 1.3%, which suggests a lower life expectancy in the rural households of the Socioeconomic Study Area.

57 Pakistan Floods 2010 – Jamshoro District Profile. December 2010. United Nations Office for the Coordination of Humanitarian Affairs (OCHA). http://floods2010.pakresponse.info/DistrictProfiles.aspx (Date Accessed: June 26, 2012).

58 PSLM, 2008

Figure 5-16: Age and Sex Composition of Surveyed Rural Population



419. The age and sex composition of the urban and colony populations is similar to that observed in the rural areas. The median age is 20 years and a relatively large number of the population are children of ages 11 years and younger, accounting for 30% of the population. Population above 60 years was found to be only 3%, which suggests a higher life expectancy in comparison to the rural households of the Socioeconomic Study Area.

420. The sex ratio of the surveyed rural population was 155, which could be due to presence of immigrants in search of better educational and job opportunities due to the proximity of the rural areas to Jamshoro town. This observation is backed by the pronounced gender imbalance in the age bracket 21 to 40 years. Primary data collected from the field also shows a higher tendency towards in-migration than out-migration in the Socioeconomic Study Area. The migrants are mainly from interior Sindh districts of Khairpur, Dadu and Tando Mohammad Khan.

421. The sex ratio of the surveyed urban and colony populations was 139, which is lesser than that in the urban and colony areas. Migration is also reported in the urban and colony areas, mainly inward migration, in search of jobs. However, the job-seekers tend to migrate with their families, which is why the gender imbalance is less pronounced in the urban and colony areas.

Dependency Ratio

422. The dependency ratio is an age based population ratio between those typically in the working age groups that form the labor force and those in age groups that typically depend on the labor force. Dependents include children below 15 years of age and the geriatric above 60 years, and the labor force is the population between ages 15 and 60.

It is expressed as the ratio of dependents to every 100 members of labor force. This may not accurately specify dependency in the population, as it does not incorporate handicapped people or cases of child labor. The dependency ratio in the rural segments of the Socioeconomic Study Area was estimated at 61. This indicates the presence of adequate labor-force to provide for the economically dependent. The dependency ratio in the urban and colony segments of the Socioeconomic Study Area was estimated at 63. This indicates the presence of adequate labor-force to provide for the economically dependent

5.4.6 Ethnicity and Religion

423. Up to 95% of Jamshoro'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 than one percentage being Hindus. Muslims of the Socioeconomic Study Area belong to Sunni sect of Islam, with only a minority belonging to the Shia sect.

424. The influence of spiritual leaders is widespread in the Socioeconomic Study Area. People are into saint veneration and often undertake pilgrimage to the graves of their saints.

425. Ethnic differences do not exist in the Socioeconomic Study Area. Only a few castes prefer to keep to themselves and socialize more in their own caste. Otherwise inter-caste marriages and other social exchanges amongst the castes are common. Nearly, 23 Muslim and two Hindu castes were reported in the Socioeconomic Study Area. The largest caste is the Solangi caste, which form 43% of the Socioeconomic Study Area's population.

426. The main languages spoken in Jamshoro District are Sindhi, Balochi, Pashto, Punjabi and Saraiki. Within the Socioeconomic Study Area, majority of the population speaks Sindhi and Balochi. Other languages spoken include Punjabi, Hindko, Saraiki, Marvari and Jabli.

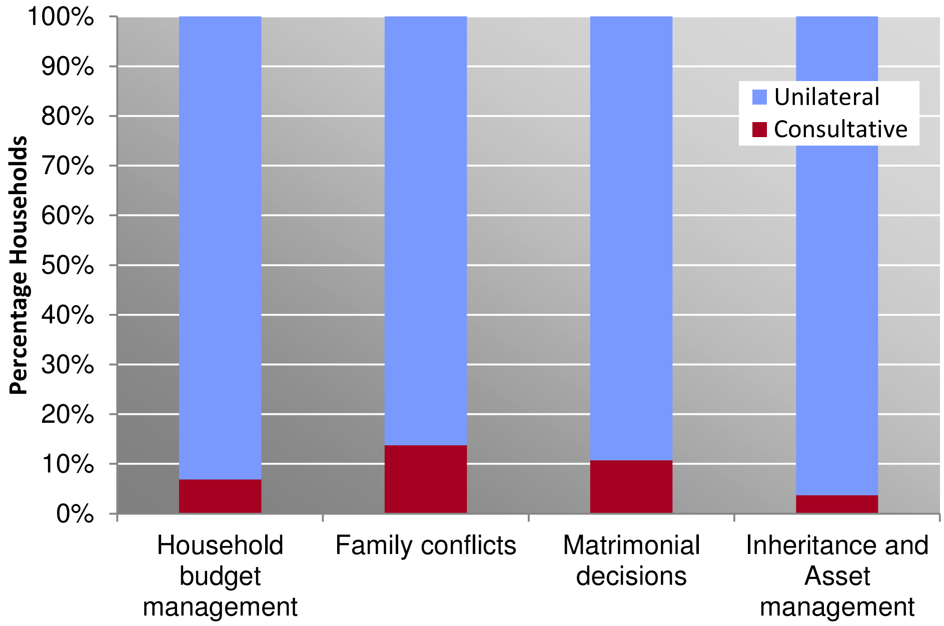
427. With respect to ethnicity and religion, no variations were observed in the rural, urban and colony areas of the Socioeconomic Study Area.

5.4.7 Gender Roles

428. The society in rural Sindh is patriarchal. 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 male. The male members govern household decision making process and are responsible to represent the household in the neighborhood and larger society.

429. **Figure 5-17** shows the distribution of surveyed rural households by decision-making mechanisms. The information suggests a higher trend in taking unilateral decisions. According to the survey data, only 13% of the household heads that took consultative decisions, in which they consulted with their father and brother. Women and other family members are not consulted in matters pertaining to household budget and family conflicts. Only 15% of surveyed households reported consultation with daughters in their marriage decisions.

Figure 5-17: Decision Mechanism in Surveyed Rural Households



430. The urban and colony societies are relatively flexible in comparison to the rural society and tend to involve women in decision-making process, but still maintain male dominance in decision-making. This is due to higher education levels amongst women in these areas (see **Chapter 10a**, Education ahead). Women with time have also started working to support the household (see **Chapter 11**, Economy and Income Levels, ahead).

5.4.8 Crime Incidence, Law Enforcement and Conflict Resolution

431. There are 18 police stations in Jamshoro district, four of which are in Kotri taluka. Two police stations and two police check posts are located in the urban and colony areas of the Socioeconomic Study Area. The law and order situation in the Socioeconomic Study Area is generally peaceful. Respondents reported minor thefts and robberies in the urban and colony areas.

432. The occurrence of disputes and conflicts is minimal in the Socioeconomic Study Area. In the rural areas, the leader or *wadera* and the spiritual leaders hold influence in resolving conflicts and maintaining peace. Most of the rural areas did not report any conflicts but stated that if a conflict were to arise, the *wadera* would be approached to resolve it.

5.4.9 Physical Infrastructure

433. Kotri taluka being the hub of all economic, political, religious and district government activities of Jamshoro district, has relatively well developed infrastructure in comparison to the other four talukas of Jamshoro district. The communication network of the taluka is well developed. Kotri taluka has four railway stations namely Kotri,

Jamshoro, Bulari and Petaro. The taluka has three post offices and two main telephone exchanges.[59] Internet access is available in colonies only.

Accessibility and Communication

434. Access to Kotri taluka is possible by road. The closest airport is located in Hyderabad city, which is situated at a distance of 20 km from Jamshoro town. Passenger vans go across different parts of Kotri taluka, travelling through the three main roads running through the taluka, i.e., the M-9 Motorway, National Highway-5 and National Highway-55. The National Highway-5 connects Kotri taluka to Hyderabad city whereas National Highway-55, also known as the Indus Highway, connects the taluka to rest of the district and Punjab province. The road network running through the Socioeconomic Study Area is shown in **Figure 5-18** and **Figure 5-19**.

435. All areas of the Socioeconomic Study Area can easily be accessed through the National Highway-55. The common means of transport include public buses, rental cars, jeeps and pickups. Unsealed roads and dirt tracks also run through the Socioeconomic Study Area, interconnecting the rural localities (**Figure 5-18**).

436. Cellular phones are the main mode of communication for the people of the Study Area as up to 90% of the settlements have mobile network coverage. There are four post offices in the Socioeconomic Study Area, two of which are located in the rural areas.

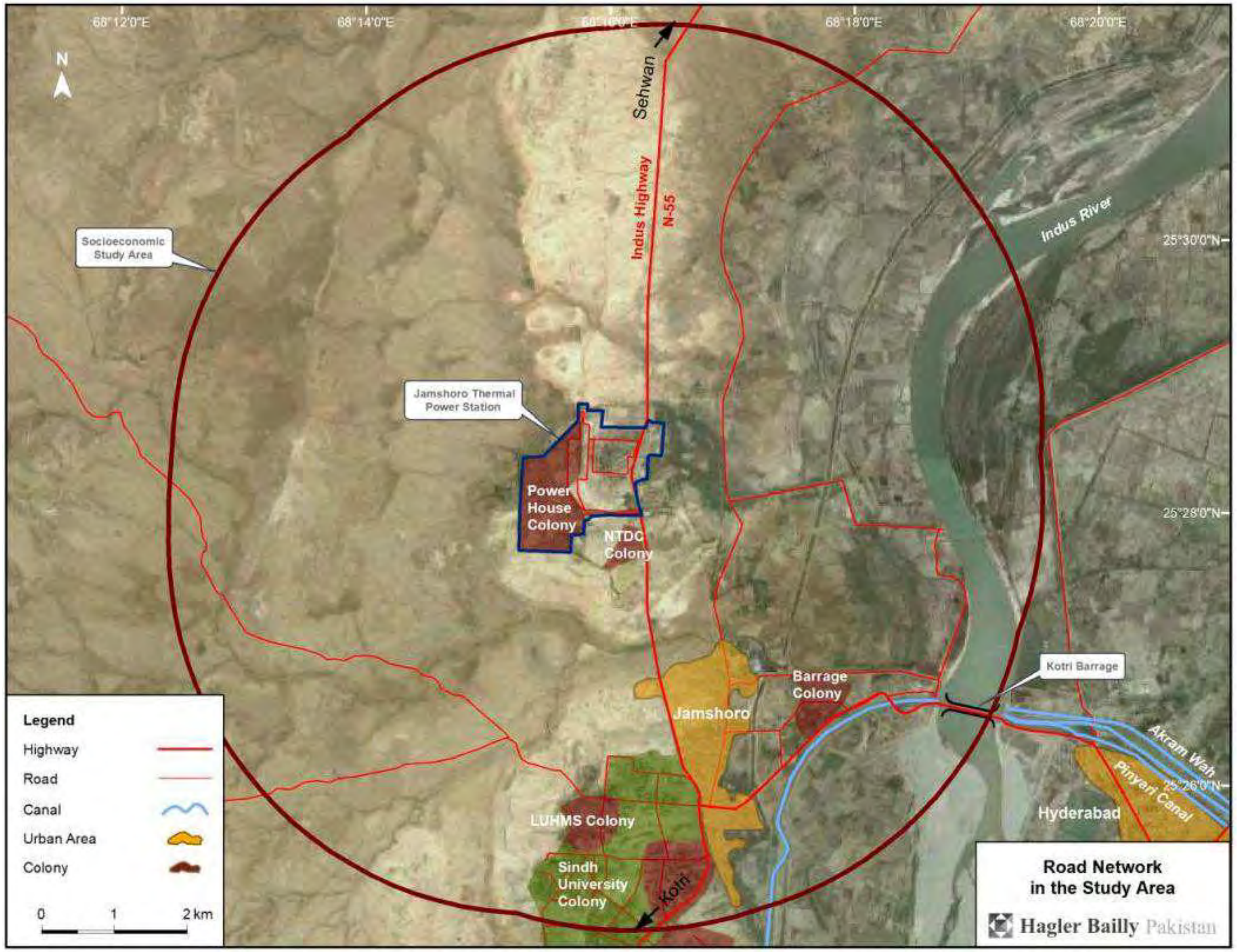
Figure 5-18: Views of Roads in Socioeconomic Study Area

View of Blacktop Road

View of Dirt Track

59 District Government Jamshoro, http://www.jamshoro.com.pk/Glance.htm (Date Accessed: June 26, 2012)

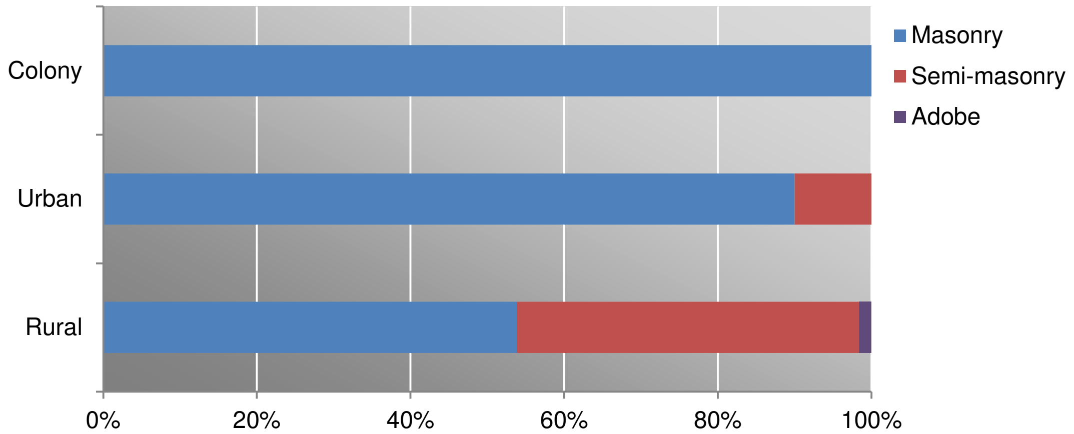
Figure 5-19: Road Network in the Study Area



Housing

437. Housing conditions in the Socioeconomic Study Area are generally good. All the housing structures in the colonies are masonry. The housing structures in the rural areas are also mostly masonry or semi-masonry (**Figure 5-20**), which is different from the typical village setting observed elsewhere in Sindh province.

Figure 5-20: Distribution of Housing Structures in Socioeconomic Study Area by Housing Type



Water Supply and Sanitation

438. 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 through hand pump and 12% through motor pumps. Remaining 21% and 15% use dug wells and other sources, respectively. The Kotri Barrage is one of the oldest barrages in the Kotri taluka. This barrage through a 20 km long feeder canal provides water for irrigation purposes.

439. The main source of drinking water in the Socioeconomic Study Area is river water, which is pumped from the river and supplied to the settlements through pipelines. households in the urban and colony areas is supplied to each household. In the rural areas, the pipeline feeds into a central storage tank from where the households draw water in large water coolers, for drinking purposes. In some villages, the water is cleaned using filter systems installed by various NGOs (**Figure 5-21**). Some villages receive their water supply from the JTPS facility and the Sandoz pharmaceutical plant located in the Socioeconomic Study Area. No wells were reported in the areas.

440. There is no effluent disposal and treatment system reported in the surveyed settlements. According to the findings of the field survey, pit latrine system was available in all rural areas.

Power Supply and Fuel Consumption

441. All settlements in the Socioeconomic Study Area are connected to the national grid. Firewood is used in the rural areas for cooking and water heating purposes. Rural areas near the Jamshoro town have access to natural gas network. All colony and urban areas have access to the natural gas supply system.

Figure 5-21: Water Supply System in Villages of Socioeconomic Study Area

Central water storage tank in village

Filter in village

5.4.10 Social Infrastructure

442. Social infrastructure comprises of the health and educational service provisions in the Socioeconomic Study Area.

Health

443. Health services in Jamshoro district are mainly provided through basic health units (BHUs), rural health centers (RHCs) and hospitals that are equipped for primary health care services and to some extent comprehensive emergency obstetric care services. [60] There are four hospitals in the district, one located in each taluka, five RHCs, 16 BHUs and six government dispensaries.[61]

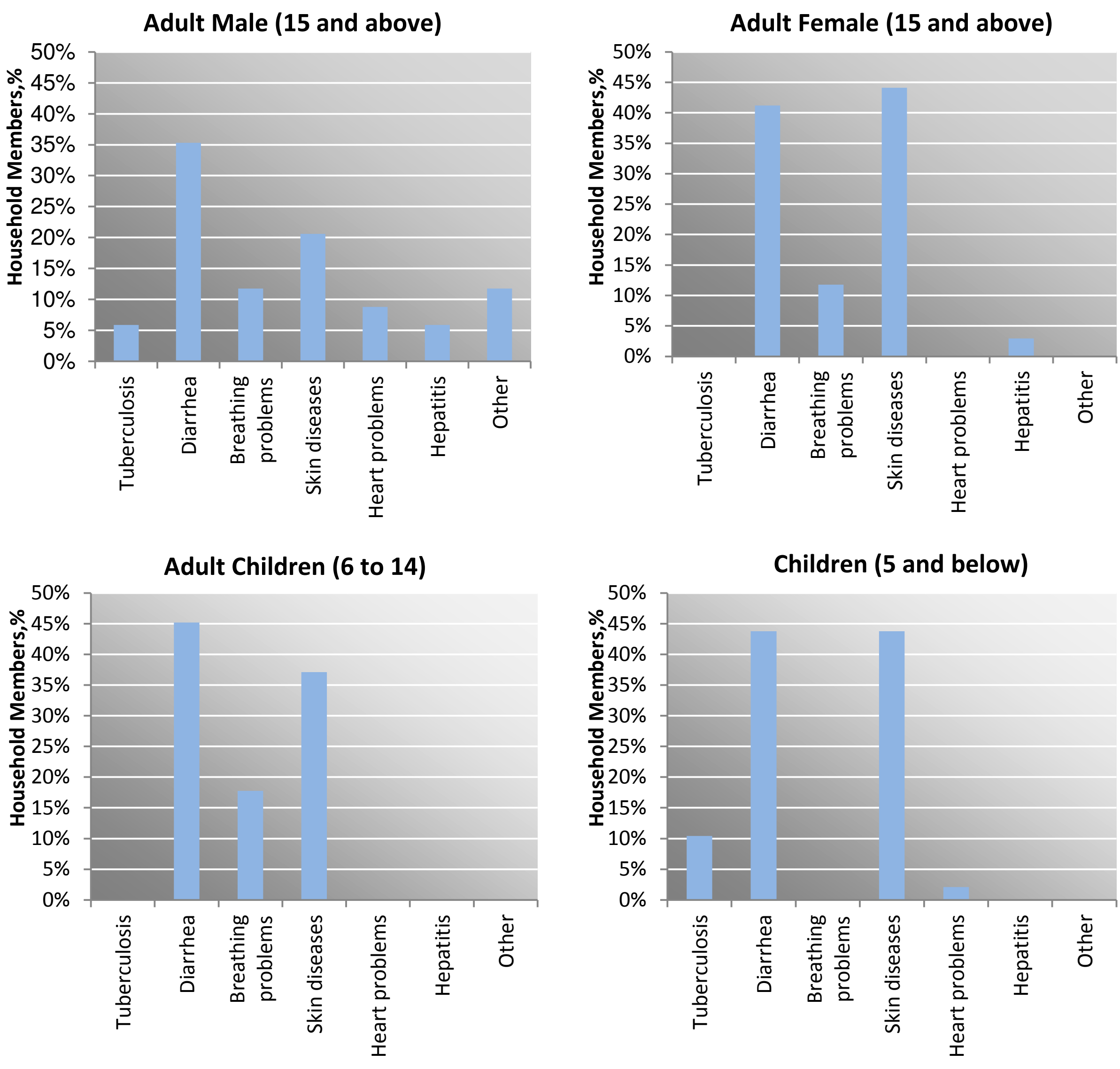
444. The Socioeconomic Study Area has one of the major hospitals, Liaquat University of Health and Medical Sciences Hospital (LUHMS), of the province. There is no health facility in the rural areas of the Socioeconomic Study Area, only one dispensary was reported in village Haji Khan Shoro. The residents of rural areas have to travel to urban and colony areas for health facilities, mostly the LUHMS hospital. Private clinics are operating in urban areas (Jamshoro Phatak and Saeedabad) and colonies (the Barrage and Sindh University Colony) providing primary health facilities, while in case of emergencies people move to LUHMS Hospital.

445. Common health problems identified in the rural households are shown in **Figure 5-22**. Diarrhea and skin diseases are the most common health problem among all age groups and gender. Breathing problems were reported in the adults and adult children (ages six and above). In the urban and colony households, mainly cases of hepatitis and diabetes were reported. Presence of diarrhea in the rural segments of the Socioeconomic Study Area suggests unhygienic conditions and unclean drinking water.

[60] Emergency obstetric care (EmOC) refers to the care of women and newborns during pregnancy, delivery and the time after delivery

[61] District Government Jamshoro, http://www.jamshoro.com.pk/Glance.htm (Date Accessed: June 26, 2012)

Figure 5-22: Common Health Problems Reported in the Surveyed Rural Households



Education

446. 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. According to the district education profile of Jamshoro, in 2011, there were 820 primary schools, 30 middle schools, 34 secondary schools, and five high schools in the district.[62] Kotri taluka has 210 primary schools, four middle schools, eight high schools, two colleges, one each for boys and girls, three training institutions and a cadet colleges located in Petaro. Kotri taluka is ranked higher in education than rest of the talukas due to the presence of three major universities of

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62 District Education Profile 2010-11, Reform and Support Unit, Education and Literacy Department Government of Sindh, Karachi

the province, namely, Sindh University, Liaquat University of Medical and Health Sciences, and Mehran University of Engineering and Technology, all located in the district headquarter, Jamshoro town and within the Socioeconomic Study Area. Schools, both private and government, are located in all the colonies and some of the settlements. Settlements only have primary schools.

447. The number of educational institutions in the colonies, urban and rural areas is given **Table 5-11**. Only two institutions providing intermediate level (grade 11 and 12) of education were reported one each in Barrage Colony and the colony of JTPS. Of the total primary schools, 15 are mix schools, three boys and three girls' schools. Only one madrassah (religious school) for boys was reported in Wapda Colony.

448. Results of the settlement survey show that the number of boys enrolled at primary and middle level is higher as compared to girls in the overall Socioeconomic Study Area. Compared to both the urban (42%) and rural (38%) areas of the Socioeconomic Study Area, enrollment of girls is higher in the colony (53%), which shows that the people in colonies encourage girls to attend school,

Table 5-12: Educational Institutions in Socioeconomic Study Area

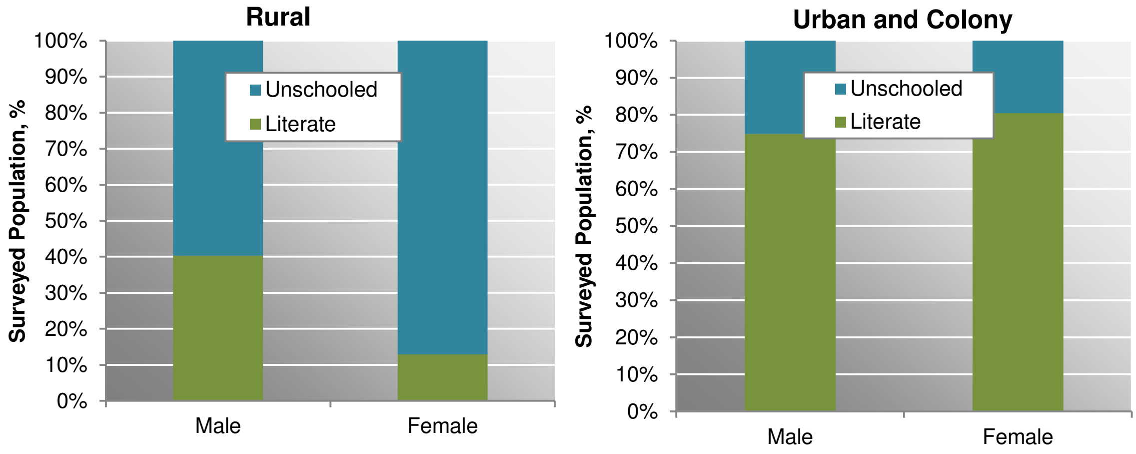
	Urban and Colony	Rural	Total
Primary	15	6	21
Middle	5	–	5
Intermediate	2	–	2
Graduate and above	3	–	–

449. In 2011, the literacy rate in Jamshoro district was lower (44%) when compared to overall Sindh (59%). Of the total population, 57% of the male and 28% of the female population was reported literate. Only 48% of population of the Jamshoro district has ever attended school which is low when compared to the percentage of Sindh province, i.e., 60%.[63]

450. The overall literacy rate in the surveyed rural households was 29.9%, which is much lower in comparison to the literacy observed in the urban and colony areas at 60%. The rural (**Figure 5-23**) display a significant gender disparity, with female literacy being three times lower than male literacy, in population aged 10 years and above. In contrast the urban and colony area male-female literacy rates are higher and similar amongst the genders.

[63] PSLM, 2011

Figure 5-23: Male-Female Literacy in Surveyed Households



451. The gender wise level of education attained by the surveyed population of ages 10 years and above is illustrated in **Figure 5-24**. In females, highest educational attainment in the rural areas was primary level (nearly six years of schooling), whereas in males, educational attainment up to intermediate level (nearly 13 years of schooling) was reported. In comparison, educational attainment was observed to be much higher in the urban and colony areas.

5.4.11 Economy and Income Levels

452. Sindh plays a pivotal role in the national economic and development agenda. It has the highest concentration of urban population at 49%,[64] as compared to an overall country average of 37%, making it the most urbanized and economically developed of the provinces of Pakistan.[65] The urban and colony economies of the Socioeconomic Study Area are representative of the developed Sindh, and are largely services-based; only few people being employed in the industrial and agriculture sectors. Employment at JTPS and its associated facilities, local hospitals, local universities, and local district government form the main sources of occupations for the urban and colony populations.

453. The rural economy is largely based on laboring services and agriculture. Laborers work on daily wages taking up any labor work available. Types of labor work include off-farm labor, construction labor and labor at hotels and bus stops. The distribution of the surveyed rural population by occupation types and the average monthly income by occupations are provided in **Figure 5-25**.

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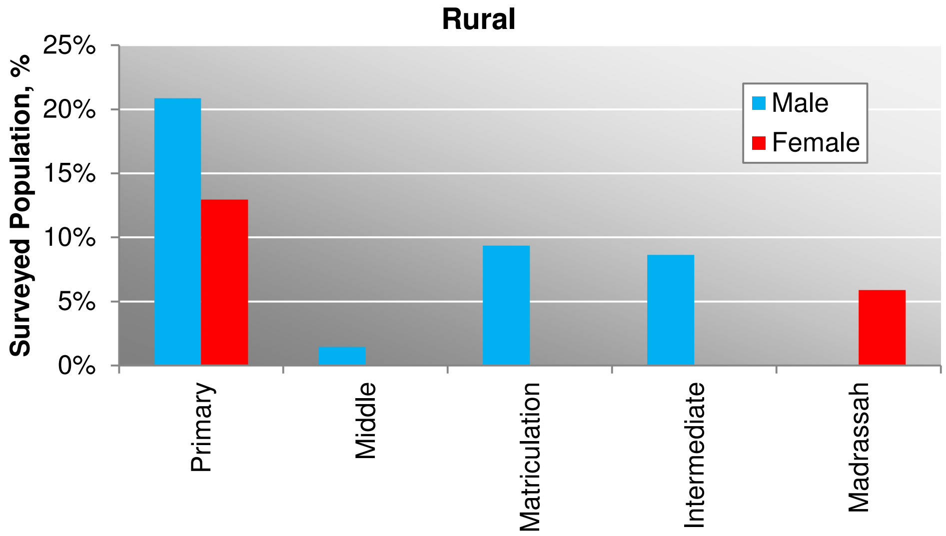
[64] Government of Sindh Official website, http://www.sindh.gov.pk/aboutsindh.htm, (Date Accessed: September 19, 2011)

[65] Pakistan Economic Survey, FY2011, Finance Division, Government of Pakistan

Figure 5-24: Educational Attainment in Surveyed Households in Ages 10 years and above



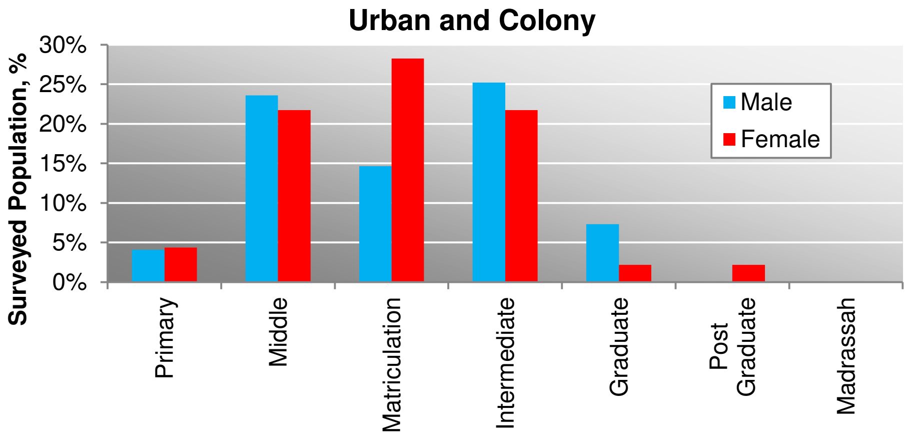
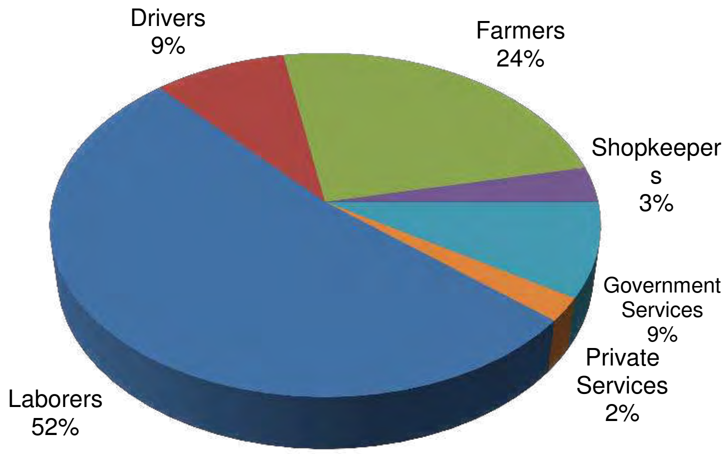
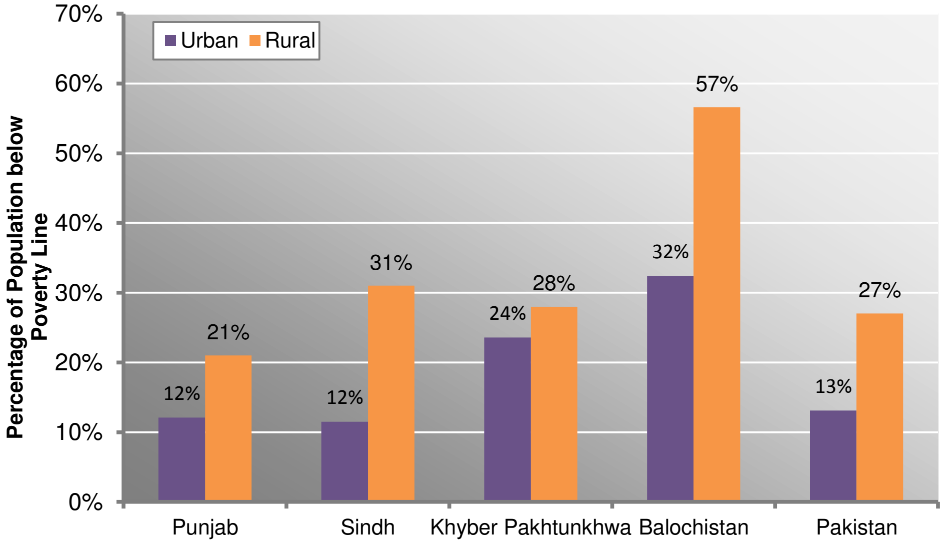


Figure 5-25: Types of Occupations in Surveyed Rural Households



454. Poverty incidence in Sindh and other provinces of Pakistan is shown in **Figure 5-26**. After Balochistan, Sindh has the highest rural poverty incidence at 31%.

Figure 5-26: Poverty in Pakistan, FY2006



455. The poverty line of Pakistan is based on a consumption of 2,350 calories per adult equivalent per day. The latest estimate of the inflation-adjusted poverty line for 2006 as reported in the FY2008 Economic Survey of Pakistan was PKR 944 per adult equivalent per month.[66] Inflating this number for inflation estimates from FY2007 to FY2012, the poverty line of Pakistan in FY2012 has been calculated as PKR 1,942. Based on this estimate for poverty line, 41% of the surveyed rural households fall below the poverty line. Poverty levels are lower in the urban and colony areas of the Socioeconomic Study Area.

5.4.12 Agriculture

456. Approximately 68% of the land in the Study Area is cultivated. Agriculture is practiced in the flood plains along the River Indus in a belt extending to two to three km from the riverbank (**Figure IV-24**). Irrigation is mainly by water pumped from the river. Land holdings range from seven to 10 acres for smaller farms to 20 to 30 acres for medium sized farms. Typically, each village has a landlord that owns most of the land around the village, which could be as much as 80 to 100 acres. These landlords tend to be influential and employ labor to work on the farms. Sharecropping is also prevalent, where the tenants provide all the labor and cash inputs, and are typically entitled to five to 10% of the produce. Crops account for 75% to 85% of the cultivated area. Principle crops in the Study Area are cotton and fodder in the summer and wheat in the winter. Vegetables and fruits are also grown through the year, mainly tomatoes and chilies, and melons. The yields for cotton and wheat are comparatively similar to the country average of 725 kg/hectare for cotton and 2750 kg/ hectare for wheat.[67] Agricultural land is prone to flooding, and loss of crops was extensive in the floods of 2010. Views of agricultural land in the Socioeconomic Study Area are shown in **Figure 5-27**.

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[66] Pakistan Economic Survey, FY2007-08, Finance Division, Government of Pakistan

[67] Pakistan Economic Survey, 2011

Figure 5-27: Views of Agricultural Field in Socioeconomic Study Area

Views of Agriculture Field

Views of Water Logged Land

457. In some communities, the agricultural land is water logged. Goth Haji Imam Bux Shahano complained that the effluent discharge channel of the JTPS is the cause for water logging.

5.4.13 Conclusions

458. The rural segments of the Socioeconomic Study Area are more vulnerable to changes in the socioeconomic environment brought about by the Project, owing to higher poverty levels (41%). 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.

459. 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 Jamshoro

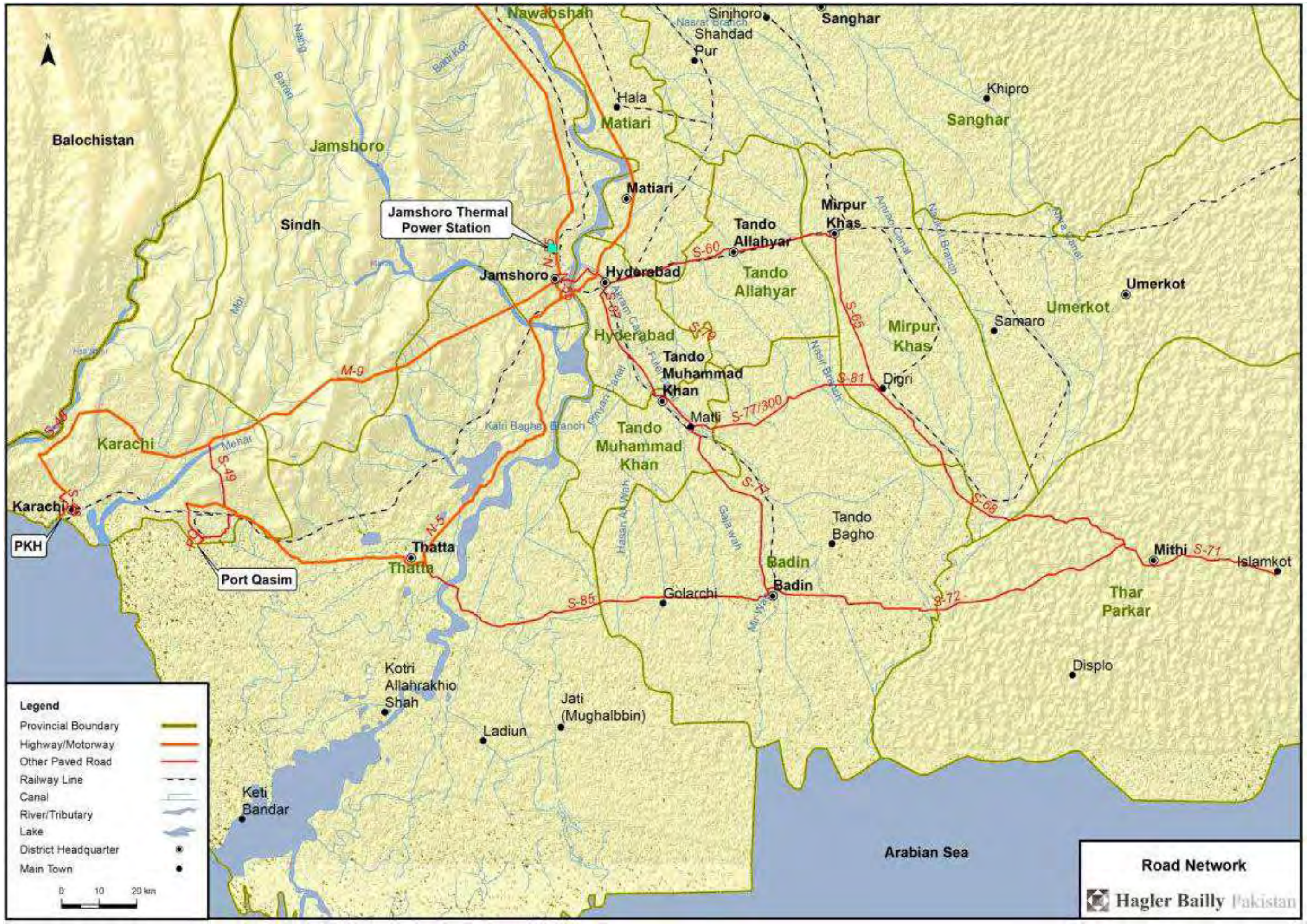
460. Equipment for the power plant will enter Pakistan either through Karachi Port (KPT) or Port Bin Qasim. Imported coal will be transported from Port Qasim to JTPS by train wagons. JTPS is connected to the national rail network through a connection to the Kotri-Dadu track.

461. For the transportation of equipment and material from the ports to JTPS two road options are the M-9 (Super Highway) and the National Highway N-5. The total distance using M-9 from KPT to JTPS is about 170 km and about 200 km using N5 through Makli. While distance from Port Bin Qasim using M-9 is about 150 km and about 190 km via N-5. The routes are shown in **Figure 5-28**. The detailed traffic data is included in **Appendix 5**.

5.5.2 Thar to Jamshoro

462. The indigenous coal, if sourced from Thar, will be transported to Jamshoro by rail for which network will have to be extended to Thar. Studies for route selection are being conducted by Pakistan Railways.

Figure 5-28: Road Network



6. Issues Related to Existing Plant and Corrective Actions

6.1 Identification of Significant Environmental Aspects

463. Environmental assessment of the projects which involve existing facilities require the EIA to cover the potential environmental impact of proposed activity and to address any environmental issues of the existing facilities. To realize this, ADB requires that an environmental audit of the existing facilities be undertaken to identify past or present concerns related to impacts on the environment, involuntary resettlement, and indigenous peoples and to demonstrate that the past actions were in accordance with ADB's safeguard principles. If the audit identifies non-conformance, plans for appropriate remedial measure are to be developed to address outstanding issues. The results of environmental audit undertaken to address the existing issues are included in this section.

464. In **Table 6-1**, the potential environmental issues of the existing facilities are discussed. Each of the potential impacts are discussed in the following sections.

Table 6-1: Potential Environmental and Socioeconomic Impacts of the Existing Plant

Plant Activity	Issue	Impacts and Risk (H=High, M=Medium, L=Low)	Discussion
Oil decanting at plant site	Spillage of oil in the decanting area	• Contamination of soil in the decanting area (H) • Contamination of the groundwater (L) • Contamination of the surface water from surface run-off from the plant site (M)	Spillage of fuel oil from decanting operations is extensive and widespread, and hydrocarbons in the soil have accumulated ever since the plant went into operation. Overflow from the oil sumps and materials removed during cleaning of oil storage tanks have also accumulated on the ground. Fuel oil contains heavy hydrocarbons which diffuse relatively slowly in subsoil in comparison to lighter petroleum products such as diesel. The risk of the oil seeping through the soil and contaminating the groundwater is therefore low, the contamination of soil notwithstanding. Owing to high salinity of natural groundwater in the Study Area in general, the local community in the plant vicinity does not use groundwater. Impact on the local community due to any deterioration in groundwater quality is therefore not anticipated.
Cleaning and maintenance of boiler and other equipment	Waste is dumped in open areas within the plant boundary. The waste is not classified and may contain hazardous material such as asbestos, which is part of some of the old equipment	• Solid waste dumping in the open area is contaminating the soil and leachate from the sumps which may affect the groundwater (L) • Deterioration of air quality (L) • Contamination to the surface water from surface run-off from the plant site (M)	Soot and other material from cleaning and maintenance of boilers and asbestos cement sheets removed from cooling towers during maintenance are presently being dumped at a number of locations within the plant boundary. Asbestos sheets are also found in the abandoned buildings. There is risk of leaching of heavy metals from the waste into soils and getting transported into depressions and water bodies outside the plant boundary.
Wastewater discharge from the plant	Release of water form boilers and demin plant and water contaminated with oil outside the plant boundary through open unlined drains as the exiting evaporation pond that was designed to handle these effluents is dysfunctional.	• Soil and groundwater contamination (M)	Cooling system effluent meets NEQS. However oil contaminated water is released outside the north western boundary of the plant adjacent to the road tanker decanting area which is resulting in soil contamination.

Plant Activity	Issue	Impacts and Risk (H=High, M=Medium, L=Low)	Discussion
	Release of clarifier/coagulator blow down and cooling water blow down through open unlined channels results in formation of unregulated ponds in the surrounding areas	• Land outside the boundary where effluent is drained is impacted (M)	In the original design the clarifier/coagulator blow down and cooling water blow down were drained through a pipeline into the Indus River. This pipeline is damaged and not in use, and a dug channel is used for draining the effluent. While some of the effluent tis used for agriculture, water spreads outside the plant boundary into depressions. The groundwater is not used for drinking in the area, but inundation of land is extensive.
Emission of combustion products	Discharge of pollutants from the existing stacks deteriorates air quality	• Impact on health of the populations residing in the vicinity of the plant from exposure to pollutants released by the plant (H)	The plant uses HSFO that contain typically 3% to 3.5% sulfur which gets converted to sulfur dioxide during the combustion process. Unless the emission control equipment is installed, the plant will continue to pollute the surrounding air quality.
Discharge of wastewater from housing colony	Effluent from colony is released without treatment and does not meet NEQS	• Land outside the boundary where effluent is drained is impacted. Farmers that use water for agriculture are exposed to pathogens in the wastewater (M)	Waste from a municipal or residential area needs treatment before it can be used for agriculture or released from the boundary of the residential area.
Disposal of solid waste from housing colony	Colony's solid waste is dumped in open areas inside the colony boundary	• Leaching and run off from the waste can contaminate surface and ground water resources. The waste is an eye sour and causes odor (M)	The waste needs proper disposal.
Emission of noise	Noise level in the plant area exceeds the occupational safety based limits	• Exposure of plant staff to noise that exceeds NEQS limits (M)	The occupational safety issue can be addressed by proper occupational safety measures.

Plant Activity	Issue	Impacts and Risk (H=High, M=Medium, L=Low)	Discussion
General plant operations and maintenance	Occupational safety	• Injuries to plant staff from accidents and lost work hours (M)	Safety management is standard industry practice and legal responsibility of plant management. Systems, procedures and practices for housekeeping are not documented and formally implemented at the plant.
	General house keeping	• Poor housekeeping can adversely impact the efficiency of environment, health, and safety management at plant (L)	Procedures and practices for housekeeping are not streamlined or standardized at the plant.
	Unaddressed grievances of Project stakeholders due to absence of grievance redress mechanism	• Ill will of local people towards the Project (M)	While the grievances are addressed on occasional basis, a formal system for addressing the grievances to ensure that closures on the issues are achieved expeditiously is required.

6.2 Discharge of Untreated Wastewater from the Plant

465. Plant effluent includes cooling tower discharge, boilers' blowdown, laboratory waste, plant washing wastewater, water from oil-water separator at the oil decanting area. The impacts of existing practices related to treatment and disposal of plant effluents other than those related to oil decanting and storage and corrective measures proposed are discussed in this section. Impacts related to oil decanting and storage are addressed separately in **Section 6.6**.

466. Groundwater sampling was conducted in the Study Area to assess groundwater quality and possible contamination from the power plant. Effluent water streams and the quantities of effluents released form the plant are detailed **Figure 6-1**. Effluent from plant is released outside the boundary at several locations which has affected areas outside the plant (**Figure 6-2**). The locations of the samples (**Figure 6-3**) were selected to ensure coverage of the Study Area. Three effluent wastewater samples were collected from overflow from evaporation ponds, and one from the main open channel draining the effluent from the plant cooling system into River Indus. Groundwater sampling was conducted in the possible ground water flow direction. Rationale for location of sampling points is summarized in **Table 6–2.**

467. Sampling was carried out in the month of June 2012. Laboratory chemical analysis were undertaken by ALS Malaysia (ISO 17025:2005 accredited), who undertook internal quality assurance/quality control (QA/QC) including analysis of reference samples, laboratory duplicates and method blanks. The samples from the field survey were analyzed for different parameters. These included physiochemical parameters, such as pH, dissolved oxygen, bicarbonates, chlorides, and sulfates, and heavy metals (iron, aluminum, cadmium, chromium, cobalt, manganese, mercury, nickel, lead selenium, and zinc). Arsenic content in the drinking water was also monitored for the field samples. The groundwater samples analysis results are provided in **Table 6–3**.

468. Effluent from plant is released outside the boundary at several locations. The main reason of open drainage of plant effluents outside the plant boundary is the overflow from the unlined evaporation ponds which are apparently not in use at present, and the blockage of the effluent drainage pipeline originally installed to drain the plant effluents into Indus River.

469. Analysis of effluent water is presented in **Table 6–4.** Following are key observations from the analysis of the samples:

- The pH is within limits of the National Standards for Drinking Water (NSDW) for all the samples.

Figure 6-1: Plant Water and Wastewater Circuit

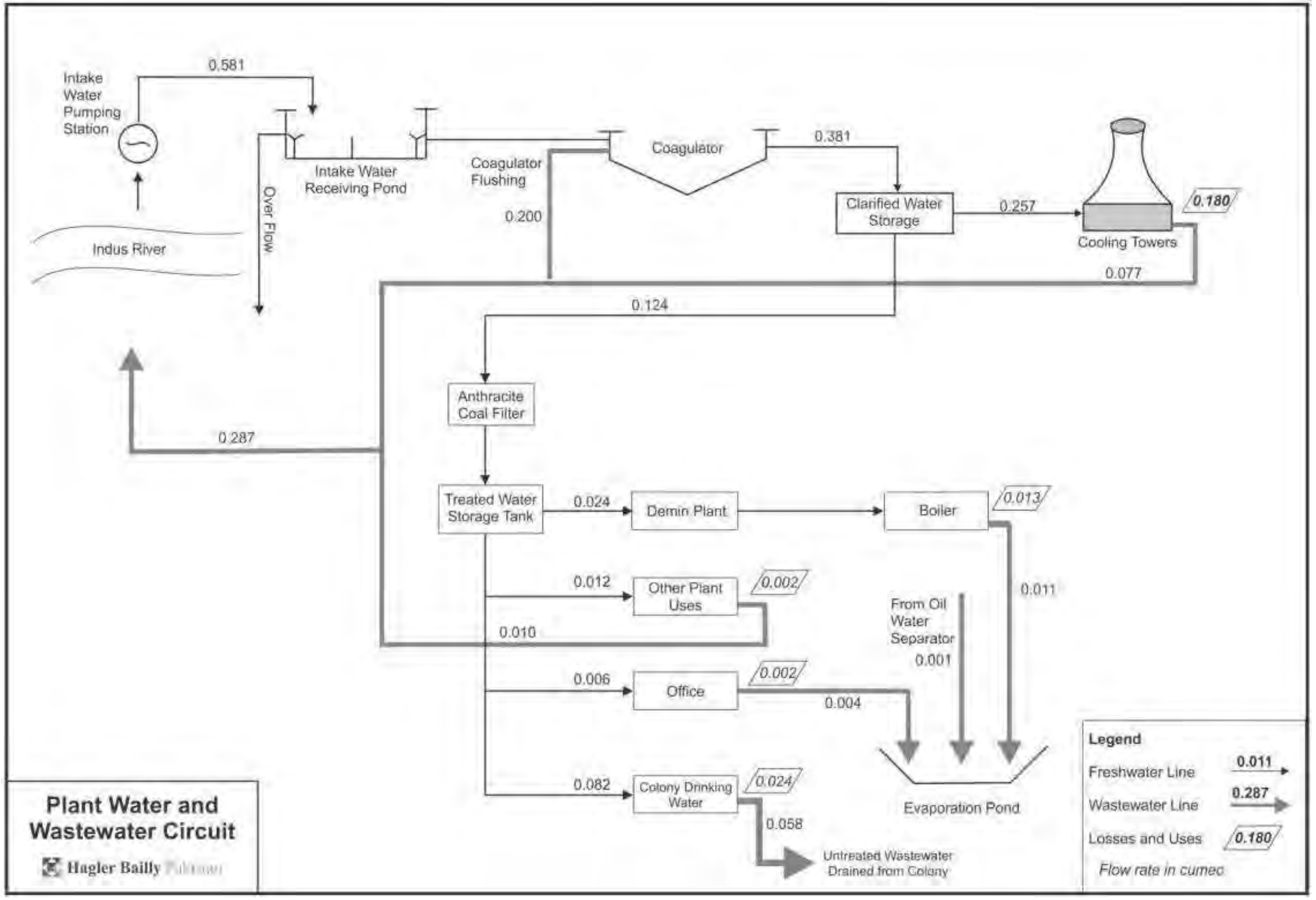


Figure 6–2: Areas Affected by Plant and Housing Colony Effluent Water

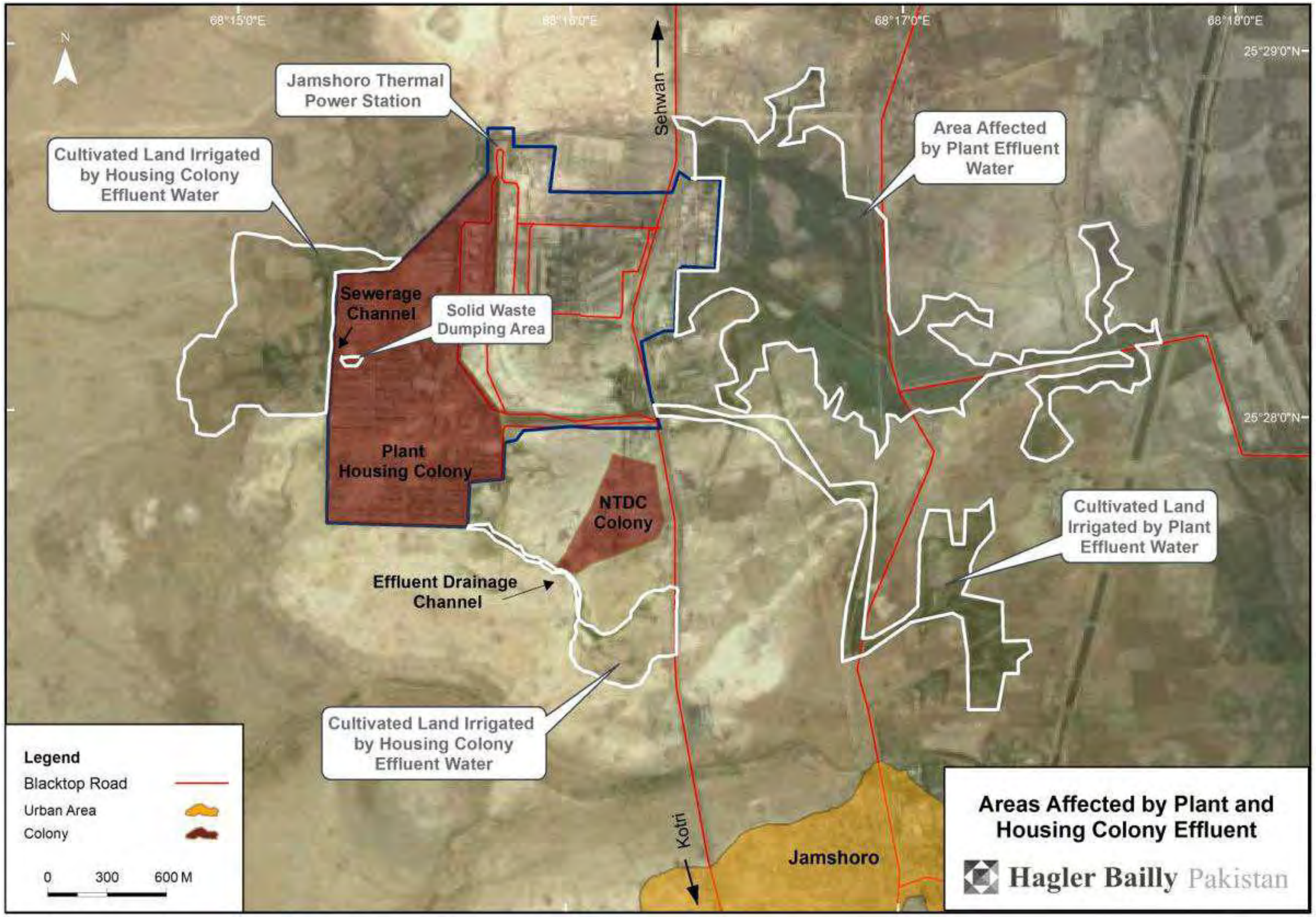


Figure 6–3: Environmental Sampling Locations

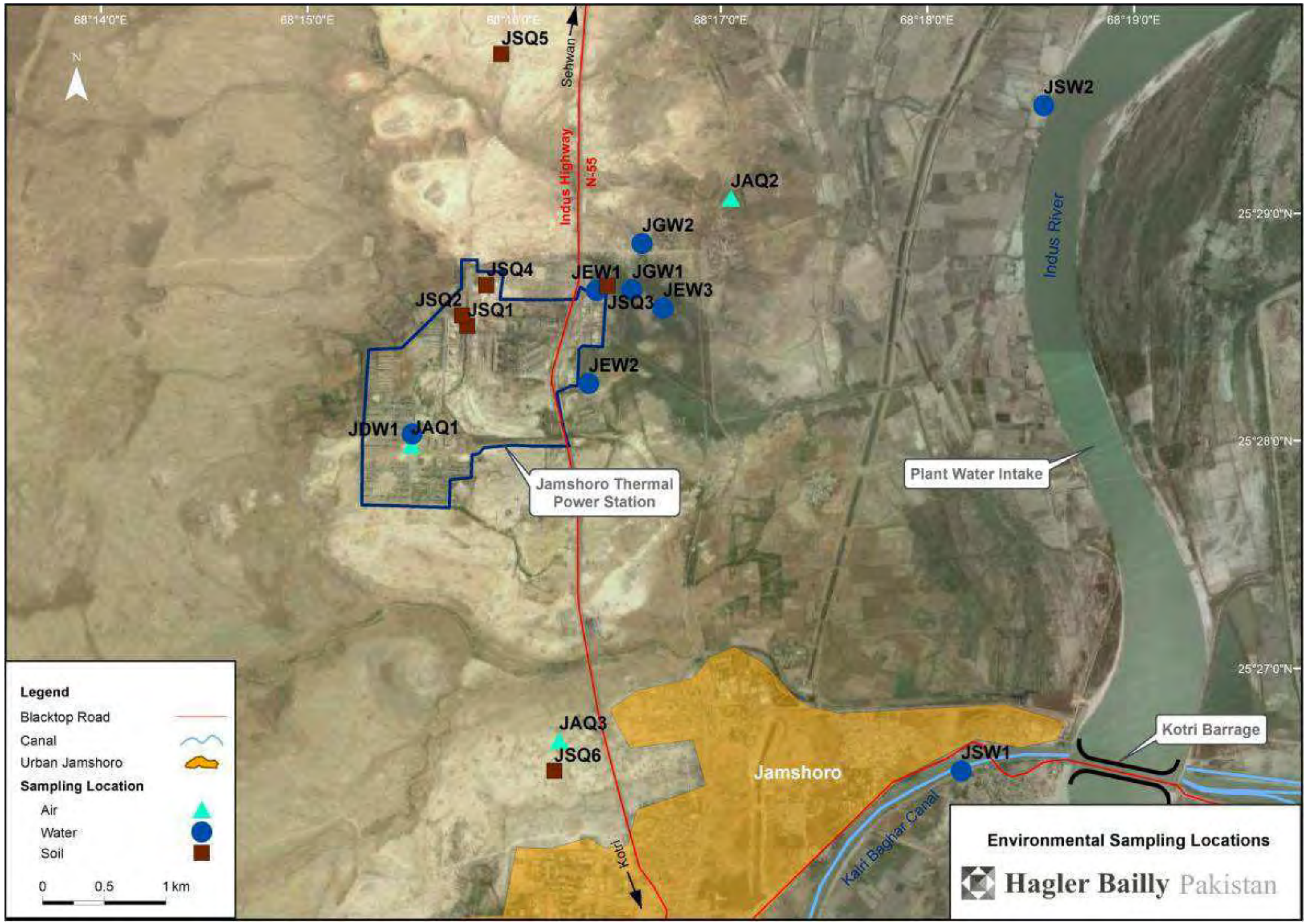


Table 6–2: Locations of Sampling Points for Water

No.	Type of Sample	Sample ID	Location	Coordinates	Comments
1	Groundwater	JGW1	Effluent channel outside the north east corner of plant boundary	25°28'39.5"N 68°16'34.6"E	Sample taken close to the effluent channel to check contamination of groundwater due to seepage from plant effluents
2	Groundwater	JGW2	150 m north of effluent channel outside the north east corner of plant boundary	25°28'51.8"N 68°16'37.9"E	Sample taken at a distance from effluent drain to check if contamination of groundwater due to seepage from plant effluents has spread locally
3	Plant Effluent Water	JEW1	Channel draining boiler and other plant effluents into the evaporation pond located outside the north east corner of plant boundary	25°28'39.0"N 68°16'24.0"E	Sample taken to check if the effluent meets the NEQS
4	Plant Effluent Water	JEW2	Effluent from the plant cooling water system located outside plant boundary wall east of the cooling water treatment area	25°28'14.6"N 68°16'22.7"E	Sample taken to check if there could be a threat to groundwater resources from seepage from the release of the effluent into depressions outside the plant boundary.
5	Plant Effluent Water	JEW3	Combined effluent from the boiler and other plant sources and plant cooling water system located outside the north east corner of plant boundary about 800 m downstream of JEW2	25°28'33.9"N 68°16'43.8"E 68°18'11.0"E 68°18'33.6"E	Sample taken to check if the effluent meets the NEQS and if there could be a threat to groundwater resources from overflow from the evaporation ponds.

Table 6–3: Groundwater Quality Results

Parameters	Unit	LOR	NSDW[1]	WHO	Sample JGW1 (Close to Evaporation Pond Overflow Channel, at 1m Depth)	Sample JGW2 (150 m from Evaporation Pond Overflow Channel, at 1.9 m Depth)
Ag	µg/l	1	–	–	<1	<1
Al	µg/l	1	<200	200	–	–
As	µg/l	1	≤ 50	10	< 1	< 1
B	µg/l	10	300	300	632	1,320
Ba	µg/l	1	700	700	48	26
Cd	µg/l	1	10	3	<1	<1
Cl	mg/l		<250	250	396	4,110
Cr	µg/l	1	≤ 50	50	<1	2
Cu	µg/l	1	2,000	2,000	2	<1
F	mg/l	0.1	≤ 1.5	1.5	1.8	4
Fe	µg/l	10	–	–	30	11
Hg	µg/l	0.5	≤ 1	1	<0.5	<0.5
Mn	µg/l	1	≤ 500	500	0.242	0.024
Ni	µg/l	1	≤ 20	20	3	5
Pb	µg/l	1	≤ 50	1	<1	<1
Sb	µg/l	1	<20	20	–	–
Se	µg/l	1	≤ 10	10	<10	13
Zn	µg/l	5	5,000	3,000	<5	6
CN	mg/l	0.05	≤ .05	0.07	–	–
BOD	mg/l	4	–	–	–	–
COD	mg/l	5	–	–	–	–
NH_3	mg/l	0.5	–	402	–	–
Nitrate	mg/l	0.1	–	–	–	–
$CaCo_3$	mg/l	1	<500	–	–	–
SO_4	mg/l	1	–	–	669	2,840
TDS	mg/l	1	<1,000	<1,000	2,160	9,450
TSS	mg/l	4	–	1503	–	–

1 S,R.O. 1062 (I)/2010, National Environmental Quality Standards for drinking water

2 S,R.O. 549 (I)/2000, National Environmental Quality Standards for Municipal and Liquid Industrial effluents

3 Ibid

Parameters	Unit	LOR	NSDW[1]	WHO	Sample JGW1 (Close to Evaporation Pond Overflow Channel, at 1m Depth)	Sample JGW2 (150 m from Evaporation Pond Overflow Channel, at 1.9 m Depth)
Phosphates	mg/l	0.1	–	–	–	–
Odour			Acceptable	Acceptable	–	–
pH		0.1	6.5–8.5	6.5–8.5	7.0	7.1
Residual chlorine	mg/l	0.1	5–1.5 at source		–	–
Taste			Acceptable	Acceptable	–	–
Color	CU	1			–	–
Temp.	^{o}C				37	37
Turbidity	NTU	0.0	< 5 NTU	< 5 NTU	–	–

Table 6–4: Effluent Water Quality Results

Parameter	Unit	LOR	NEQS[4]	Sample			
				Sample ID	JEW1	JEW2	JEW3
				Location	Evaporation Pond	Water Disposal channel	Evaporation Pond Overflow
Ag	ug/l	1			<1	<1	<1
Al	ug/l	1					
As	ug/l	1			2	1	<1
B	ug/l	10	6,000		271	156	305
Ba	ug/l	1	1,500		117	71	78
Cd	ug/l	1	100		<1	<1	<1
Cl	mg/l	5	1,000		220	156	370
Cr	ug/l	1	1,000		1	<1	<1
Cu	ug/l	1	1,000		18	1	<1
F	mg/l	0.1	20		8	7	15
Fe	ug/l	10	2,000		99	30	16
Hg	ug/l	0.5	10		<0.5	<0.5	<0.5
Mn	ug/l	1	1,500		19	14	<1
Ni	ug/l	1	1,000		3	<1	3
Pb	ug/l	1	500		<1	<1	<1
Sb	ug/l	1					
Se	ug/l	1	500		<10	<10	<10

[4] S,R.O. 549 (I)/2000, National Environmental Quality Standards for Municipal and Liquid Industrial effluents

Parameter	Unit	LOR	NEQS[4]	Sample			
				Sample ID	JEW1	JEW2	JEW3
				Location	Evaporation Pond	Water Disposal channel	Evaporation Pond Overflow
Zn	ug/l	5	5,000		12	<5	<5
Detergents as MBAS	mg/l	0.05	20		0.14	0.11	0.05
SO_4	mg/l	1	600		317	108	268
TDS	mg/l	1	3,500		797	568	1,350
TSS	mg/l	1	150		1	1	1
Nitrate	mg/l	1					
Phosphate	mg/l	1					
BOD	mg/l	5	80		55.78	15.98	7.13
COD	mg/l	4	150		157.92	48.88	18.80
NH_3	mg/l	<5	40		<0.5	<0.5	<0.5
pH			6 to 10		7.10	7.20	7.30
Temp	^oC		40		37.00	37.00	37.00

- Effluent water quality represented by Effluent Water Samples JEW2, main effluent channel carrying water to the river, and JEW3, evaporation pond overflow, is well within the limits set by the NEQS for all categories. The only exception is COD in the evaporation pond overflow as indicated by Effluent Water Sample JEW1 taken at the evaporation pond which was observed to be slightly above the NEQS. The COD in this sample was observed at 158 mg/l in comparison to the NEQS limit of 150 mg/l. This effluent stream will not be drained into the river following the rehabilitation of the evaporation pond as proposed in **Section 6.2.2**. The BOD and COD of the main plant effluent stream that carries the plant effluent to the river, Effluent Water Sample JEW2 (water disposal channel, BOD 16 mg/l, COD 49 mg/l) and JEW3 (evaporation pond overflow, BOD 7 mg/l, COD19 mg/l), are, however, well within the NEQS limits.
- Effluent water also meets the NDWS limits for heavy metals[5], again except in the case of the evaporation pond overflow (Effluent Water Sample JEW3) where boron was detected at 305 µg/l as compared to NDWS limit of 300 µg/l. Boron contamination in the main effluent channel carrying the water to the river (Effluent Water Sample JEW2) was observed at 156 µg/l.

470. In conclusion, the effluent water meets the NEQS and NDWS, except for COD and boron which were observed to be marginally above the applicable standards.

6.2.1 Cooling Tower Blow Down and Clarifier/Coagulator Blow Down

471. The river water is used in the cooling tower and discharged back into the river after use. In the original plant design, the cooling tower effluent was transported to the river by means of a steel pipe. This piping system was damaged during the first five years of plant operation, and subsequently a channel with stone pitching on the slopes was constructed to drain the cooling tower effluent into the river. The stone pitching is badly damaged resulting in the spread of effluent to the surrounding areas and formation of localized unregulated ponds and wetlands which have affected areas outside the plant (**Figure 6–2**). This water is also used for irrigation in some areas. The main reason of open drainage of plant effluents outside the plant boundary is the blockage of the effluent drainage pipeline originally installed to drain the river water treatment plant (clarifier/coagulator blow down) and cooling tower effluent into Indus River. Photographs of areas affected by the open drainage of plant effluents are included in **Figure 6–4**. Communities have complained about land degradation from the seepage. The land degradation can be seen on satellite image (Google Earth). It is extensive near the plant and extends all the way to the river.

472. Faunal species such as amphibians, fish and turtles reside in these ponds and wetlands. Irregular flow of this water as well its quality could impact these species. However, no species of conservation concern have been reported from these wetlands. The migratory and resident birds prefer to visit the river, rather than these wetlands, where greater abundance of food and shelter is available. As long as the quality and flow of this water is regulated by the Project, this impact is not expected to have any significant impact on ecology.

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5 The effluent water does not meet the NDWS overall due to presence of other contaminants such as BOD and COD.

Figure 6–4: Photographic Evidence of Land Affected by Effluent Water

Ponds created by plant effluent discharged

Vegetation growth in unlined evaporation pond

Open discharge of oily waste water

Oil drained from decanting area

473. The following corrective measures will be undertaken:

- The plant wastewater system will be revamped to ensure that the cooling tower effluent is segregated from other plant wastewater. The cooling tower effluent is NEQS compliant and the segregation will ensure that it remains so. However, if it can ensured that mixing of one or more other waste streams will not result making the effluent non-compliant with the NEQS, such mixing may be undertaken.

- A pipeline for transport of effluent from the plant to the river will be installed, as in the original design of the plant, which was operated for about first five years after the plant was commissioned, and then abandoned.
- As the effluent meets the NEQS and is suitable for agricultural use, the option of regulated discharge for agricultural use will be considered. Any release of water for agricultural or environmental purposes will be controlled by the plant by providing outlets for the purpose in consultation with the farmers and local wildlife authorities.
- Uncontrolled release of water will be avoided.

6.2.2 Effluents from Boilers, Demin Plant, and Laboratory

474. The current system was designed to discharge the wastewater from boilers, laboratory and other minor streams including oil contaminated water to an evaporation pond located on the east of the plant in the utilities area. However, the whole system has completely deteriorated. Due to lack of maintenance and growth of weeds and grass in the evaporation pond, the pond is no more functional and is unsuitable for any evaporation. The effluent is instead discharged to an open ditch located near the evaporation pond. The effluent seeps and overflows from the ditch to the surrounding land.

475. Groundwater Samples JGW1 and JGW2 represent ground water extracted at a depth of about 2m in the proximity of the drain carrying effluent discharged from the plant into the evaporation pond area. The two sub–surface samples have similar quality. Both of them are high in salt contents (boron, chloride, sulfate and TDS). However, the heavy metal contents are within the limits indicating that the high salt content is due to natural conditions and is unlikely to be caused by the effluent from the evaporation pond. The community does not use groundwater for drinking in this area as the groundwater is saline as indicated by TDS of 9,450 mg/l for Groundwater Sample JGW2 (**Table 6-2**) located close to a settlement.

476. The evaporation ponds may attract mammals which could drink this contaminated water and become exposed to health risks. Ingestion by small mammals and birds may also lead to bioaccumulation of toxins within the food chain. Bird species that may be present in close proximity to the site are susceptible to this impact. However, these birds are highly susceptible to disturbance and are likely to avoid areas affected by the power plant activities. Migratory birds passing the site will also be susceptible to contaminated water during the migration period.

477. The following measures will be undertaken:

- The plant wastewater system will be revamped to ensure that potentially hazardous and non-NEQS compliant effluent is segregated as in the original design. As indicated in **Table 6-5**, this will include waste water from the boilers and demin plant, oily water waste, discharge of the septic tank for the treatment of the office waste water.
- The evaporation pond will be reconstructed. It will be a ‘zero-discharge’ system which means that it will be sized to ensure that it can receive all hazardous wastewater from the plant without the need to discharge to the surrounding areas or the Indus River.

- The pond will be lined to avoid seepage from the pond and potential contamination of the surrounding land.

Table 6-5: Plant Water Balance

	Existing Status (m^3/sec)	Original Design (m^3/sec)
Total Supply	**0.581**	**0.986**
Distribution		
Cooling Water System	0.257	0.522
Silt Removal	0.200	0.340
Boilers	0.024	0.024
Other Plant Uses	0.012	0.012
Offices	0.006	0.006
Housing Colony	0.082	0.082
Total Distribution (A)	**0.581**	**0.986**
Waste Generated		
Coagulator Blow Down	0.200	0.340
Cooling Tower Blow Down	0.077	0.078
Other Plant Wastewater	0.010	0.010
Total Returned to the River (B)	**0.287**	**0.428**
Boiler Blow Down and Demin Plant Waste	0.011	0.011
Office Septic Tanks	0.004	0.004
Water from Oil-Water Separators	0.001	0.001
Total to Evaporation Pond (C)	**0.016**	**0.016**
Wastewater Drained Outside from Housing Colony (D)	0.058	0.058
Total Wastewater (EB+C+D)	**0.361**	**0.502**
Losses, Evaporation and Uses		
Cooling Tower Evaporation	0.180	0.444
Other Losses and Uses	0.041	0.041
Total (F)	**0.221**	**0.485**
Total Waste and Losses (E+F) (Except Water from Oil-Water Separators)	**0.581**	**0.986**

6.3 Municipal Wastewater

478. The municipal wastewater from the JTPS staff housing colony is presently pumped out of the colony. No analysis of the effluent is available; however, given the nature of the effluent it is likely to be non-compliant with the NEQS. The main issues are likely to be with fecal coliform, biological oxygen demand (BOD) and chemical oxygen

demand (COD). The effluent is used for agricultural purposes by the community located adjacent to the colony boundary. As the farm workers come in contact with the effluent, they are potentially exposed to harmful substances which are likely to affect their health.

479. To address this issue following measure will be undertaken:

- A small wastewater treatment plant will be installed in the housing colony. It will have a capacity to treat about 207 m^3/h of domestic waste water. The effluent after treatment will be provided to community, as now, as they depend on the flow for their sustenance.

6.4 Air Emission from Stacks

480. The existing power plant has four units, three are dual fired i.e., can operate on both furnace oil and gas and one operates only on the fuel oil. As discussed in **Chapter 2**, there is shortage of natural gas in the country and the power plant is primarily running on HSFO. The flue gas from the existing plant operations may contain harmful pollutants that may impact the flora and fauna of the area. The migratory and resident birds that pass through the area and the reptilian species of the deserts located on the western side of the power plant are likely to be affected. The sulphur dioxide emission from the existing stacks is in excess of 2,500 mg/Nm^3 which is not only far in excess of IFC emission guidelines (200 mg/Nm^3) but also results in serious ambient air quality issues.

481. To address this issue following measure will be taken:

- Two FGDs will be installed, one on each stack of the existing power plant.

6.5 Solid and Hazardous Waste

6.5.1 Solid Hazardous Waste from the Power Plant Operation

482. Plant generates various types of waste. Some of these are potentially hazardous. Potential hazardous waste include:

- Asbestos in the scrap piles located in the plant. Additional asbestos may be discarded during rehabilitation work.
- Soot removed from the boilers, which is at present dumped in open area near the fuel oil tanks.

483. As part of the baseline, soil samples were collected from Study Area for analysis. The soil samples were collected from a) within the plant to identify any possible seepage and contamination from the operations of the existing plant and b) two locations to the north and south of the Plant to describe the baseline conditions of the Study Area. The sampling locations are shown in **Figure 6–3**.

484. The samples were analyzed for metals and petroleum hydrocarbon. There are no regulatory criteria for soils. To provide the context to discuss the soil analysis results for metals and understand if there are any environmental or health risk, the target limit for metals in the soil is set as three times the average abundance of metals in the earth's crust. A parameter is considered 'elevated' if its concentration in the soil sample is more than three times its average crustal abundance. Soil analysis results (**Table 6-6**) shows that the concentration of all parameters, except lead, in the background samples (JSQ5 and JSQ6) are within the target limit. The results of the four samples collected from the plant area show evidence of soil contamination. The concentration of barium, chromium,

copper, iron, lead, manganese, nickel and zinc in the soil samples collected from the plant are higher compared to the background soil samples by about 2 to 10 times. However, except lead, all parameters are within the target limit.

485. The main concern is regarding lead. The average concentration of lead in the background Soil Sample JSQ5 taken at a depth of 2 m is 67 milligram per kilogram (mg/kg), more than two times the average crustal abundance of 30 mg/kg. Soil Sample JSQ6 taken in the town of Jamshoro at a depth of 0.5 m shows a lead concentration of 87 mg/kg, possibly indicating the impact of lead deposits associated with transport fuels. In the samples collected from the plant the concentration of lead is as much as 6 times higher. This is, on average, 10 times higher than the average crustal abundance.

486. Soil contamination has taken place at the plant site due to dumping of waste. The sites that are contaminated due to fuel oil spills and open stockpiling of solid waste by the operation and maintenance of the existing plant are shown in **Figure 6–5.** Lead contamination could originate from both solid waste and fuel oil spills.

487. Presently there is no system for identification and containment of hazardous waste. Asbestos rope is presently used for insulation of piping in the boiler area. Corrugated cement asbestos sheets are also being used on the sides of the water cooling structures to prevent drift losses. Estimated quantities of asbestos that are installed in the plant equipment and buildings and stockpiled mainly at the solid waste dumping area and at scattered locations at the plant site are summarized in **Table 6-7**. About 4.7 tonnes of asbestos sheets are piled up mainly in the dumping area, while 67 tonnes are installed in the cooling towers. Residues from cleaning of boilers including soot removed from the boilers are dumped in the solid waste disposal area located north of the oil storage and decanting. The quantity of the boiler soot dumped at the plant site is estimated at 22 tonnes. **Table 6-8** provides the analysis of the boiler soot. Concentration of nickel was observed to be 1,221 mg/kg compared to about 6 mg/kg in the background Soil Samples JSQ5 and JSQ6 outside the plant site, and 270 mg/kg corresponding to the three times the crustal abundance. This indicates a need for containment of the boiler soot in the ash pond or a lined hazardous waste storage facility.

Table 6-6: Soil Analysis Results

Parameters	Units	LOR	Three times Crustal abundance	Samples						
				Sample ID	JSQ1	JSQ2	JSQ3	JSQ4	JSQ5	JSQ6
				Location	Oil decanting Area	Oil-water separation pond	Evaporation pond	Soot disposal site	Goth Firi Khan Khoso	Jamshoro City
Depth of Sample					**2m**	**2m**	**1m**	**2m**	**2m**	**0.5m**
Moisture @ 103 ^{o}C	%	0.1			11.8	12.2	27.9	3.3	6.7	1.4
Arsenic	mg/kg	1	6.3		<1	<1	<1	<1	<1	<1
Barium	mg/kg	5	1,020		34	33	84	26	10	14
Boron	mg/kg	5	26.1		<5	<5	<5	<5	<5	<5
Cadmium	mg/kg	0.05	0.5		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	mg/kg	0.05	420		29.0	26.2	32.7	35.3	18.6	13.1
Copper	mg/kg	0.5	204		19.8	15.8	40.6	15.4	3.5	4.8
Iron	mg/kg	0.5	189,000		44,300	35,200	30,600	19,500	4,150	4,480
Lead	mg/kg	1	30		351	231	412	136	48	87
Manganese	mg/kg	1	3,300		6	4	16	3	<1	<1
Nickel	mg/kg	0.5	270		19.7	15.4	43.3	46.7	5.2	7.6
Selenium	mg/kg	5*	0.225		<5	<5	<5	<5	<5	<5
Silver	mg/kg	1*	0.225		<1	<1	<1	<1	<1	<1
Zinc	mg/kg	0.5	237		46.1	35.1	66.7	34.2	8.2	9.4
Mercury	mg/kg	0.5*	0.267		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Petroleum Hydrocarbon (TPH)										
TPH (C6-C9 fraction)	mg/kg	5			<5	<5	<5	<5	<5	<5
C10-C14 fraction	mg/kg	50			<50	699.0	<50	<50	<50	<50
C15-C28 fraction	mg/kg	100			<100	12,500	<100	<100	<100	<100
C29-C36 fraction	mg/kg	100			<100	8,500	<100	<100	<100	<100

* The samples were tested to standard levels of detection only. The results indicate that there are no major alarms and secondly the remaining metals analysis was sufficient to establish trend.

Figure 6–5: Photographic Evidence of Potential Land Contamination

Asbestos waste

Boiler soot

Boiler soot

Table 6-7: Inventory of Hazardous Waste

Sr.	Location	Number of Sheets	Unit Weight kg	Total Weight kg
Asbestos Sheets				
1	Solid Waste Dump	112	42	4,704
2	Unit-1s Cooling Tower, Longitudinal	672	42	28,224
3	Unit-1 Cooling Tower, Latitudinal	224	42	9,408
4	Construction Camp (Abandoned) Hall 1	175	42	7,350
5	Construction Camp (Abandoned) Hall 2	175	42	7,350
6	Construction Camp (Abandoned) Hall 3	175	42	7,350
7	Construction Camp (Abandoned) Hall 4	175	42	7,350
			Total	**71,736**

Table 6-8: Analysis of the Boiler Soot

Elements	Concentrations (µg/g)	LOD
As	ND	0.50
Cd	ND	0.09
Cr	43	0.21
Cu	43	0.35
Fe	96112	0.34
Mn	404	0.10
Ni	1221	0.50
Pb	5	0.27
Se	ND	0.50

* LOD - Limits of Determination; ND – Not Detected

488. A hazardous waste facility will be developed at the plant near the switchyard to safe disposal of potentially hazardous waste. The measures that will be taken are as follows:

- All potentially hazardous waste in the plant will be identified
- Hazardous waste will be segregated from other type of waste
- A temporary storage area for asbestos will be developed which will fenced. Access to the area will be control.
- An awareness campaign will be undertaken for the workers regarding the hazardous wastes.

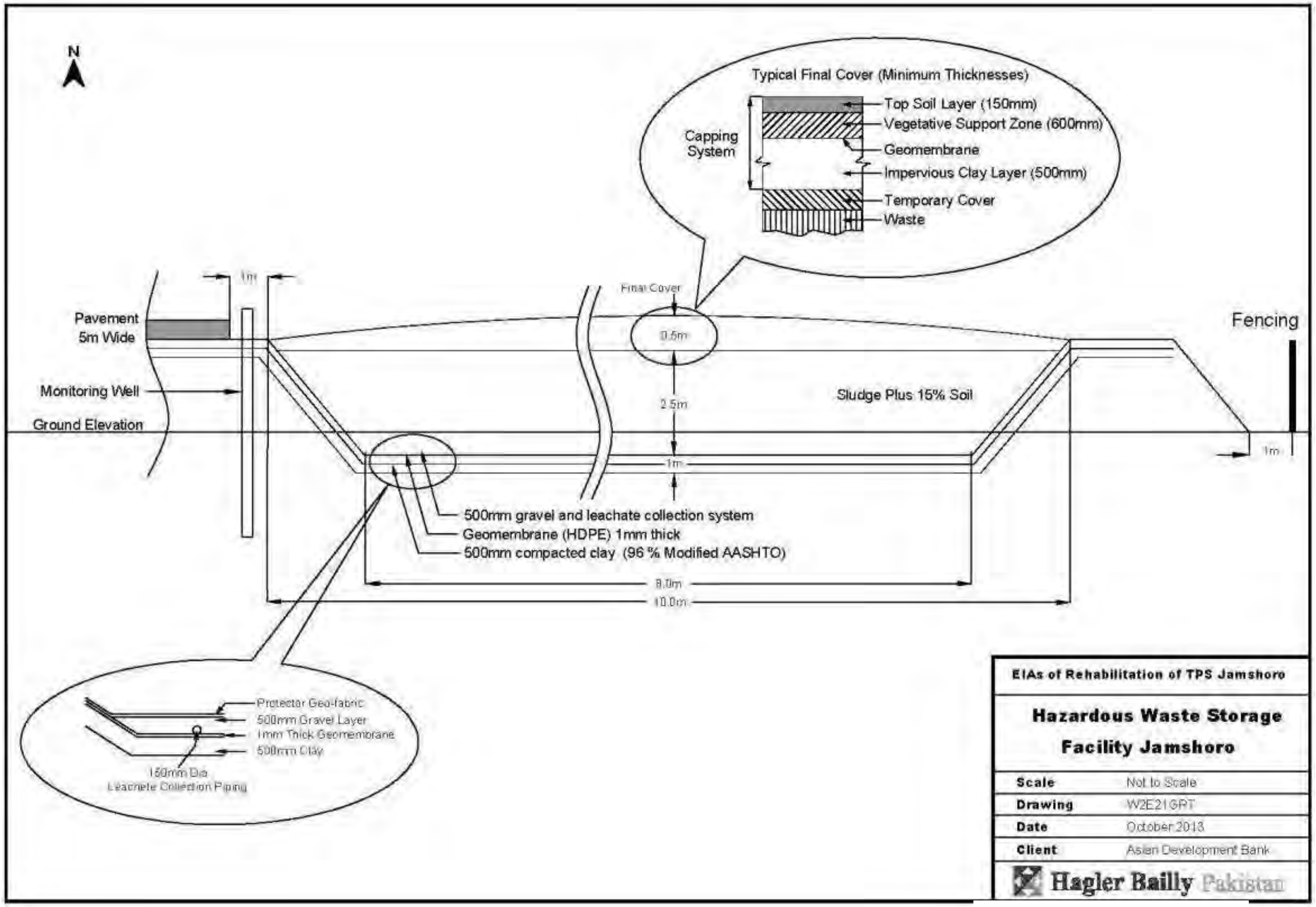
- Safe handling procedures will be developed for each type of waste. The procedures will be written and will be in English as well as vernacular languages.
- All storage areas for the hazardous waste will be clearly marked with a proper hazard sign.
- Appropriate personal protection equipment (PPE) will be provided to the staff who will be handling the hazardous waste.

489. Design of a facility to store about 500 m^3 of hazardous waste is illustrated in **Figure 6-6.** The facility will have a capacity of approximately 500 m^3 of waste. The facility will cover an area of 400 m^2 and essentially consist of:

- One cell, 20 m $\times$ 10 m with working depth of 3.0 m
- Leachate collection sump
- Storm water management, and
- Monitoring wells
- Fencing and access

490. The leachate or storm water, if any, will be collected and pumped to the evaporation ponds located at the plant site. A geological barrier will be established, consisting of a 0.5 m thick layer of either compacted clay (96% modified and with a hydraulic conductivity of 1×10^{-9} m/s or less), or bentonite-enriched sand. The leachate sealing system will consist of a flexible geomembrane liner (1-mm-thick, multilayer HDPE) laid above the compacted clay. Minimum bottom slopes of the liner will be 2% towards drainage lines. The leachate collection system will consist of a drainage layer and leachate collection pipe work, sumps and pumps. A fenced boundary will be required to restrict access to the facility. All areas identified as hazardous or containing plant and equipment within the site will be enclosed. An operations and maintenance plan will be prepared and include the operations and maintenance procedures for the facility.

Figure 6-6: Hazardous Waste Storage Facility Jamshoro



6.5.2 Solid Waste Management of Colony and Office Waste from the Power Plant

491. The JTPS staff housing colony generates an estimated 750 tons of solid waste annually. As there is no proper disposal system, the waste is scattered around the colony. There is currently no solid waste management system in place at the power plant either to manage waste generated in the plant offices. The waste dumps can be seen in different location of the plant and the colony (**Chapter 5**). The solid waste is presently being disposed of in the dug pits which are later covered by soil. There is no municipal solid waste disposal facility available in the vicinity of the plant where the waste can be sent for disposal. Aspects resulting from no solid waste management are:

- Contamination of surface and sub-surface soil by leaching from the dumps
- Contamination of surface water in case of runoff
- Transportation of contamination from leaching to the ground water aquifer
- Possible attraction of scavengers to the solid waste dumps
- Attraction of pests to the waste dumps resulting in spread of disease vectors
- General nuisance and odor

492. A properly designed landfill to cater for the plant needs will be developed. Other mitigation measures will include:

- Collection of waste on daily basis from the colony houses and office premises of the plant
- Placement of bins in the key area with proper labeling for the type of waste to be thrown in the bin and segregation of waste
- Awareness campaigns on municipal waste management including segregation, reuse and recycling

6.6 Oil Decanting

493. The fuel oil used for the power plant since 1991 was transported through the rail network until 2003 and using road tanker since then. The inefficient fuel decanting system resulted in leakages which contaminated the surface and sub-surface soil. Although, there is no evidence of presence of shallow groundwater aquifer in the area and the risk of contamination of any deep aquifer is insignificant due to presence of rocky outcrop, contamination of soil does constitute a risk to the environment. Surface run-off from the contaminated soil can carry the oil to other areas and affect the surrounding land.

494. Presently the spillage from the oil decanting operations is routed to an unlined pit (**Figure 6-7**) where oil and water are separated and the oil is returned to the storage tanks. The separated and oil contaminated water is pumped out into an open drain that ultimately flows into the drainage from the plant at the evaporation ponds. It is understood that JTPS has recently procured a spilled oil collection and drainage system for the decanting station. However, a proper API separator is still required to replace the unlined pit.

Figure 6-7: Unlined Pit Used for Oil-Water Separation

495. Total petroleum hydrocarbon was not found in the background samples and three out of four samples from the plant site. Boring was conducted to study the depth of oil contamination, and the color of the samples was observed. The depth of contamination in the area contaminated by fuel oil spills is illustrated in **Figure 6–8**. The soil samples collected from oil water separation pond area indicates presence of higher hydrocarbon (C10-C38) in the soil at a depth of 1-2 m. Depth of contamination at other locations mainly along the track of the tank lorries and railway wagons carrying oil, and the oil decanting area generally varies from 0.3 m to 1.0 m. The contamination levels vary in different areas. Further, some of the contaminated soil near the oil decanting area is covered with fresh soil. The geo-technical analysis of the sub-surface lithology available with the JPCL indicates that nearly limestone is present at shallow depth. Therefore it is likely that the contaminated soil is contained, sitting on hard rock.

496. Detailed assessment was carried out **(Appendix 6)** in order to determine the precise extent of the soil contamination in the plant site (quantity of contaminated soil and the concentration of oil in the soil). The assessment also evaluated the risk of groundwater contamination and hazards to the community and the environment from the contaminated soil. Where, rationale for leaving the soil in the ground because it is contained can be found, a decision can be taken on whether to remove the contaminated soil for remediation or to leave it in place. Based on the assessment it was determined that the total quantity of contaminated soil is approximately 38,900 cubic meter (m^3) with contamination in excess of 23,000 mg/kg. In addition about 30,000 m^3 of soil has low contamination (on average 2,000 mg/kg). This comprises the surface contamination near the decanting area and on roads and subsurface contamination. No groundwater was found during the assessment and in most cases hard rock was encountered below the surface. The bulk of the sub-surface contaminated soil is located

near the northern boundary on land adjacent to the land that is planned to be purchased for ash pond. If this land is purchased, the sub-surface soil is likely to be contained and not pose any threat to environment. On the other hand, if this land is not purchased, the soil must be removed and remediation be undertaken. If it is decided that removal is required a soil remediation plan will be developed to dispose of the oil contaminated soil. The surface contaminated soil will be collected and disposed of in the hazardous waste facility to be developed at the plant.

Figure 6–8: Soil Contamination Sites

497. The following corrective measures are planned:

- JPCL will ensure that the spilled oil collection and drainage system for the decanting station is commissioned not later than June 2014.
- Until the spilled oil collection and drainage system is installed, drip pans will be provided at the decanting station to prevent further spills on soil.
- The concerned staff will be provided training in prevention of spills.
- The surface contaminated soil from the decanting area will be collected and stored in a secured place for future disposal.
- The subsurface contaminated soil will be cleaned preferably through bio-remediation, in case the adjacent land is not purchased.
- During ash pond development, the contaminated soil area will be inspected and if necessary, containment wall be constructed to prevent any lateral spread.

6.7 Occupational Health and Safety and Housekeeping

498. In general, occupational health and safety procedures are not being followed at the Plant. This results in unnecessary exposure of the workers to various types of occupational hazards including noise. Use of PPEs, safety criteria for heated surface, working at heights and entering confined spaces[6] entry are standards procedures worldwide.

499. A complete occupational health and safety management system will be developed at the plant. At the minimum, the components of the system will include:

- It will be ensured that PPE are available
- Development of safety standards for heated surface, working at heights at confined spaces, scaffolding, ladders, cranes, and workshop
- Training in use of PPE.
- Identification of areas in the plant noise level regularly exceeds 85 dB(A), demarcation of the are through signs and markings on the floor, and the mandatory requirement to wear ear protection in these areas.
- Development of general housekeeping procedures. This may include for example, storage yard, signage, demarcation, provision of spill control equipment, provision of waste bin, segregation of waste.

6.8 Extraction of Water from the River

500. Water is extracted from the Indus River and used for cooling in the JTPS. The existing power plant requires about 1.0 m^3/s of water from the River Indus when

[6] “Confined space" means a space that:

Is large enough and so configured that an employee can bodily enter and perform assigned work; and
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
Is not designed for continuous employee occupancy.

operating at full capacity[7]. Of this, an estimated quantity of 0.5 m^3/s or about 60% of the inflow is returned to the river[8]. The net extraction of water by the power plant is therefore estimated at 0.5 m^3/s at full capacity. River flow upstream of Kotri barrage[9] varies from a monthly average level of 7,517 m^3/s in August, to a monthly average level of 213 m^3/s in December. Water extracted by the power plant is therefore 0.2% 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 1.7%. 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.

6.9 Quality and Temperature of the Effluent Discharged into the River

501. Higher pollutant concentrations can occur in the area immediately downstream of the point of discharge of water by the Project. Samples of river water were taken before and after the extraction as well as return of water to the river by the Project. **Figure 6-3** shows the points where samples were taken during the July 2012 Survey. The upstream sample was taken at a point about 200m from the plant water intake system. The downstream sample was taken from the Kalri Baghar Canal on the right bank of the Kotri barrage approximately 3.5 km downstream of the point where the water from the power plant is discharged. Both the samples show that the quality of river water is appropriate for supporting the ecology in the river. As discussed earlier, level of key pollutants observed in the plant effluents returned to the river were <5 mg/l and <4 mg/l (below minimum detection limit) for BOD and COD respectively, while the toxic metals, nitrates, and phosphates were well below the NEQS limits. The concentrations of toxic metals in the plant effluents were also observed to be below the National Standards for Drinking Water.

502. The temperature of the water discharged by the plant was observed to be about only 0.5°C above that of the river water in the June 2102 survey, which is estimated to increase to 1.1°C when the plant operates at full capacity. Following rehabilitation of the cooling towers, the net heat release into the Indus River will decrease due to increase in evaporative heat transfer in the cooling towers. The increase in temperature of the effluents returned to the river is therefore estimated to drop to 0.7°C after rehabilitation. The temperature of effluent water discharged into the river is not expected to cause any detectable impact on the river fauna. As discussed earlier**,** the plant effluent also meets the NEQS[10] limits for temperature. Modeling of thermal plume assuming a worse case temperature difference of 2°C between the river water temperature and that of the effluent water and low flow conditions during a drought period in winter was conducted to assess the extent of penetration of the plume relative to the available habitat in the river.

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7 Water taken from the river was reported at 0.35 cumec when only one power generating unit was operating during the June 2012 survey.

8 From sampling conducted in June 2012 when only one of the power generation units was operating, TDS in the river water were about 430 mg/l, while TDS were 570 mg/l in the effluent water consisting of cooling tower blow down and water returned from the water treatment plant. A TDS of only 570 in the effluent water indicates an excessive level of blow down, which could be attributed to a low plant utilization factor. An estimate of 50% is return is conservative based on the current practice of a high level of blow down, and will result in TDS of the order of 1,000 mg/l in the effluent water.

9 Data provided by Sindh Irrigation and Drainage Authority (SIDA) for the period 1986-2004.

10 The NEQS specify a drop of temperature to within 3°C at a distance of 100 m of the ambient from the point of discharge.

United States Environmental Protection Agency's model *Visual Plume*[11] was used. The model is designed for simulation of surface water jets and plumes, mixing zone analyses, and other water quality applications. **Table 6-9** provides the parameters that were used for modeling the cooling water discharge from JTPS into the Indus River.

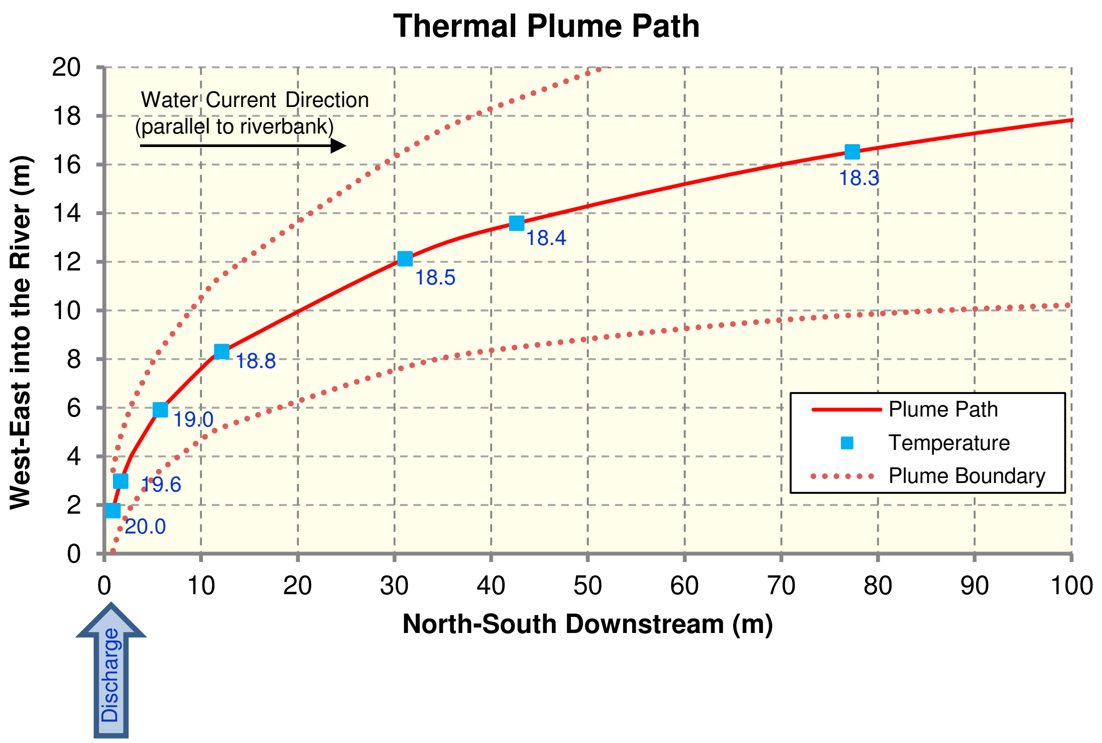
503. **Figure 6-9** illustrates the results of the thermal plume modeling. A temperature of 0.5°C above that of the river water temperature is reached within a distance of 31 m downstream from the point of discharge, at a point which is 12 m from the river bank.

Table 6-9: Plume Model Input Parameter

Parameter	**Input Value**
Discharge Channel Width	2 meters
Discharge Channel Depth	0.3 meters
Angle of Discharge[a]	90 degrees
Region of Interest	1000 meters
Port Depth[b]	0 meters
Effluent Flow	0.428 m^3/s
Effluent Salinity	997 kg/m^3
Effluent Temperature	24°C
Water Current Speed (m/s)	0.3 m/s
Current Direction	Parallel to shore, towards north
Ambient water density	997 kg/m^3

[11] Dilution Models for Effluent Discharges, Visual Plumes Ver. 1.0, Ecosystems Research Division, NERL, ORD, United States Environmental Protection Agency. Release date August 2001. Downloaded from http://www.epa.gov/ceampubl/swater/vplume/

Figure 6-9: Results of the Thermal Plume Modeling



504. In the above analysis it is assumed that during the cooling tower operation in winter the cooling tower blow down is 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. The present practice is not permissible as it adds to the heat load transferred to the river and adds to the thermal stress on the river ecology when water at a temperature higher by about 10° C compared to that at the inlet of the cooling tower is returned to the river. The following are the key mitigation measure that will be incorporated:

- Cooling towers will be revamped to reduce the thermal load on the river and to minimize the quantity of water extracted from the river for plant use.
- 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.

6.10 Impacts on Ecology

505. There are several fish species observed in the Study Area and the local fishermen depend on these fish for their livelihood. In addition, some population of Indus Blind Dolphin *Platanista minor,* is also found between in Indus River between Sukkur and Kotri. However, the prime habitat of this mammal is between Guddu and Sukkur, which is also a protected area. If the effluent water discharged to the river is contaminated with toxins and heavy metals, it can impact the macro-invertebrates, algal species as well as have a negative impact on fish abundance and diversity. Eventually, the fish tissues can become contaminated and render the fish inedible. Presence of toxins in the river water can also potentially affect the population of the Indus Blind

Dolphin. Implementation of mitigation measures listed for the existing plant as detailed in this chapter will contribute significantly to lowering the impacts of the plant on the ecological environment. Potential impacts due to the existing plant on ecology following rehabilitation are summarized below.

506. As discussed in **Section 6.8** above, net extraction of water by the existing power plant is estimated at 0.5 m^3/s at full capacity, which under worst case drought conditions will not exceed 1.7% of the flow of the river. The impact of this level of change in flow on the geomorphological and hydraulic parameters and consequentially the aquatic fauna due will therefore be very minor.

507. As discussed in **Section 6.9** above, the level of key pollutants in the effluent returned to the river from the plant will remain well below the NEQS limits, and concentrations of toxic metals in the plant effluents are below the National Standards for Drinking Water. The river ecology is not at risk on account of higher point concentrations of pollutants discharged by the existing power plant into the river. Interviews with local fishermen also reveal that there is no significant difference in the fish catch upstream or downstream of where this water is discharged. The magnitude of the impact of the quality and temperature of the plant effluents discharged into the River Indus on the aquatic ecology is therefore minor and the significance low.

508. As discussed in **Section 6.9** above, the temperature of the effluent discharged into the river will be 2.0 ^{o}C above that of the river in the worst case in winter when the river flow is at minimum. A temperature of 0.5^{o}C above that of the river water temperature will be reached within a distance of 31m downstream from the point of discharge, at a point which is 12m from the river bank. Comparing with the width of the river of the order of 500 m in the dry season, the magnitude of the impact of the quality and temperature of the plant effluents discharged into the River Indus on the aquatic ecology will remain minor and the significance will be low. Slightly warmer water at the plant effluent outlet in the river in winter will not stress the aquatic species as they will not be exposed to a temperature outside their tolerance range.

509. Birds and mammals are not expected to be attracted to the ash pond or the evaporation 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.

6.11 Socioeconomic Impacts

510. The impacts of existing plant relate mainly to generation of effluent and emissions from the plant, which can cause health issues for the local people. The resulting health expenditures can constrain the household budget and reduce availability of income for other expenditures. The poor households can be affected more severely due to this. To ensure that such impacts are avoided, the Project is designed to meet the required standards for air and water quality as discussed in **Chapter 9**.

511. The effluent is channeled to the Indus River via an unlined channel, which over the time has leaked in multiple places, creating stagnant water and wetlands in the surroundings and affecting use of the adjacent land for agricultural purposes. In particular, residents of Goth Haji Imam Bux Shahano, a village located adjacent to the effluent discharge channel, complained that their agricultural land is no longer cultivable

due to unregulated drainage of effluent water from the plant (see **Chapter 7** on stakeholder consultation). The mitigation measures to avoid this impact have been discussed earlier in this chapter. The mitigation consists of installation of pipeline to transport the effluent from the plant to the River Indus to prevent impact on the land adjacent to the pipeline. Controlled supply of water for irrigation purposes from this pipeline in consultation with the local farmers is recommended.

512. The grievances of the people pertaining to the generation of effluent and emissions from the existing plant facility have remained unaddressed, which suggests a lack of organizational capacity to manage community relations. During the consultations conducted for the purposes of the EIA, the local communities voiced the concern that their grievances against the Project remain unaddressed despite their efforts to bring them to the notice of the plant authorities. It is proposed that organizational capacity be upgraded to manage community issues and relations (details **Chapter 7**). In addition, a grievance redress mechanism is proposed for the Project, which will help generate good will for the Project amongst the local population.

7. Information Disclosure, Consultation, and Participation

513. 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.

7.1 Framework for Consultations

514. 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 ADB's safeguard policy (SPS 2009).[1]

7.1.1 ADB Safeguard Policy Statement

515. Public consultation is mandated under Asian Development Bank's Safeguard Policy Statement (SPS 2009).[2]

SPS 2009 on Pubic Consultations

The borrower/client will carry out meaningful consultation with affected people and other concerned stakeholders, including civil society, and facilitate their informed participation. Meaningful consultation is a process that (i) begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle; (ii) provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people; (iii) is undertaken in an atmosphere free of intimidation or coercion; (iv) is gender inclusive and responsive, and tailored to the needs of disadvantaged and vulnerable groups; and (v) enables the incorporation of all relevant views of affected people and other stakeholders into decision making, such as project design, mitigation measures, the sharing of development benefits and opportunities, and implementation issues. Consultation will be carried out in a manner commensurate with the impacts on affected communities. The consultation process and its results are to be documented and reflected in the environmental assessment report.

7.1.2 Pakistan Environmental Protection Act 1997

516. Public consultation is mandated under Pakistan's environmental law. The Federal Agency, under Regulation 6 of the IEE-EIA Regulations 2000, has issued a set of guidelines of general applicability and sectoral guidelines indicating specific assessment requirements. This includes Guidelines for Public Consultation, 1997 (the 'Guidelines'), that 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 identification of those indirectly affected is more difficult, and

1 Safeguard Policy Statement, Asian Development Bank, June 2009

2 Safeguard Policy Statement, Asian Development Bank, June 2009

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: '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;
- 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'.

7.2 Consultation Methodology

517. Consultations with the Project stakeholders were conducted in two phases:

- The scoping consultation was undertaken in the last week of June 2012. The main document for distribution to stakeholders during the consultations was the Background Information Document (BID) that informed the stakeholders about the EIA process and provided a background about the Project. The BID was made available in English, Urdu and Sindhi to suit the language preferences of different stakeholders. The BID for the Project is included in **Appendix 7**.
- The feedback consultation undertaken in June 2013. For this separate meetings were held in the communities, whereas two meetings were held in JTPS in which the institutional stakeholders were invited. Additional meetings were held in Karachi for some stakeholders. The material that was used for the consultation is included in **Appendix 7**.

7.2.1 Stakeholder Consulted

518. Stakeholders are groups or individuals that can affect or take affect from a project's outcome. SPS 2009 specifically identifies affected people, concerned nongovernment organizations (NGOs) and government as prospective stakeholders to a project. Affected communities include population that is likely to be affected by the Project activities. Potential impacts of the Project on the local environment include

disturbances and changes to the physical and biological environment, such as, land transformation, noise disturbances, and air and water quality issues. These disturbances can result in indirect socioeconomic impacts, such as, physical or economic displacement. These impacts are expected to reduce with the increased distance from the Project facilities. Based on this the communities affected by the Project activities (the 'Potentially Affected Communities') were identified as those located within five km of the Project site. In addition to the Potentially Affected Communities, local government and local NGO officials were also consulted.

519. **Table 7-1** lists the Project stakeholders consulted. Consultation were conducted in representative number of communities while ensuring that people from various segments of the society participate in the consultation, to ensure proper coverage of possible stakeholder concerns. **Figure 7-1** shows location of stakeholders consulted from near Project site.

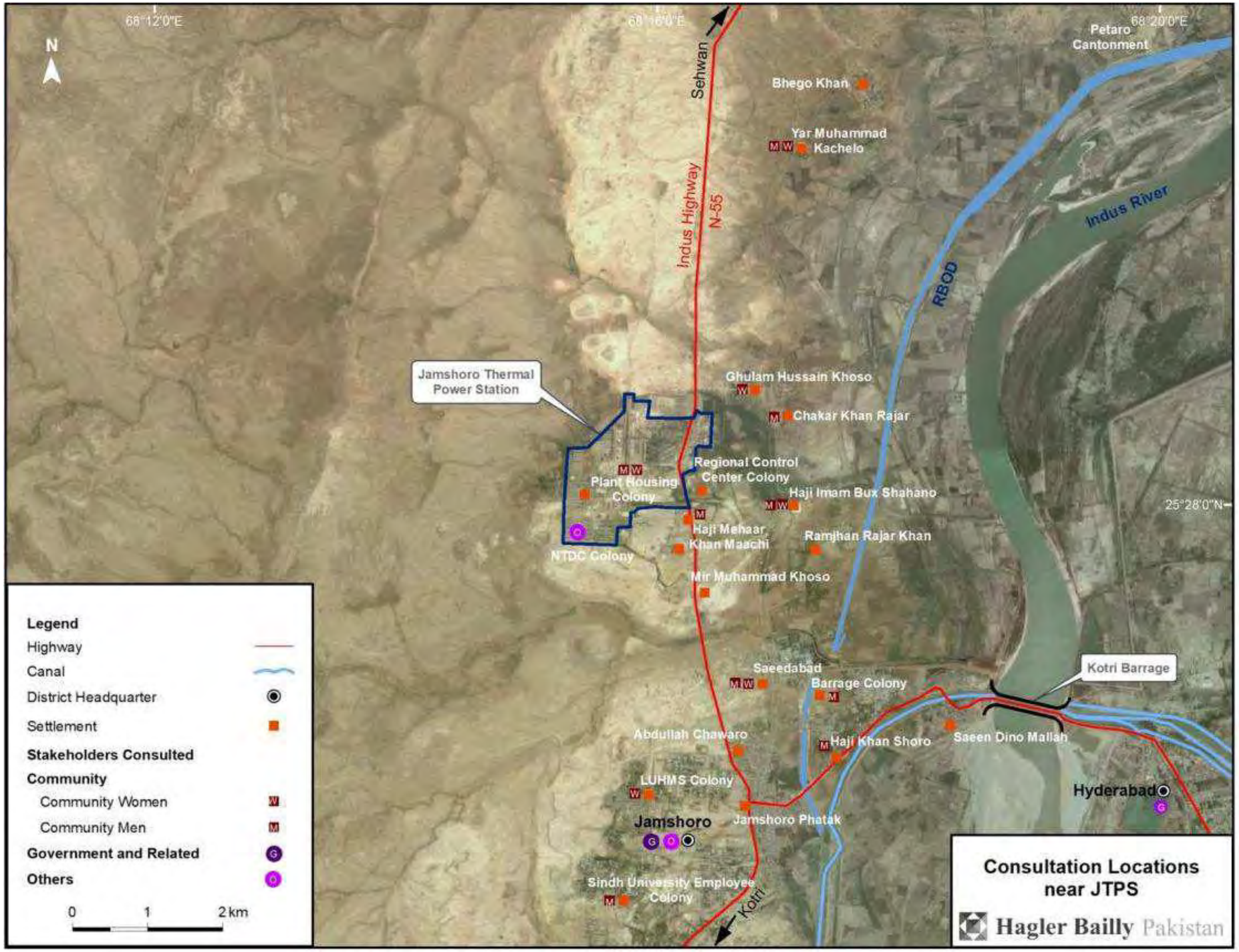
Table 7-1: Stakeholders Consulted

Group	Stakeholders	Scoping	Feedback Consultation
Community: Villages within five kilometers of the Power Station's boundary	Barrage Colony	C	C
	Goth Haji Imam Bux Shahano	C	C
	Sindh University Employee Colony	C	C
	Goth Chakkar Khan Rajar	C	C
	Goth Haji Mehaar Khan Maachi	C	C
	Goth Yar Muhammad Kachelo	C	C
	Goth Haji Khan Shoro	C	
	Plant Housing Colony	C	C
	Saeedabad	C	C
	Goth Ghulam Hussain Khoso	C	C
	Liaqat University of Health and Medical Sciences(LUHMS) Colony	C	C
	Ramzan Rajar		C
	Juma Khan Shoro/WAPDA Colony		C
	Saaen Dino Mallah		C

Group	Stakeholders	Scoping	Feedback Consultation
Government and related	District Coordination Office (DCO), Jamshoro	C	I
	Executive District Office (EDO), Health, Jamshoro	C	C
	National Transmission and Despatch Company (NTDC)	C	C
	Sindh Environmental Protection Agency, Hyderabad	C	I
	Provincial Health and Development Centre	C	
	Sindh Wildlife Department, Jamshoro	C	C
	Thermal Power Plant, Jamshoro	C	C
	Agriculture Engineering and Water Management Department		C
	Sindh Forest Department		C
Others (Power plant, Academia, and NGOs)	International Union for the Conservation of Nature	C	I
	Pakistan Wetlands Programme (PWP), WWF	C	C
	Mehran University, Jamshoro	C	I
	Liaqat University of Health and Medical Sciences (LUHMS) and Nirma Cancer Hospital	C	I
	Thardeep Rural Development Programme (TRDP)	C	I
	Sindh University, Department of Environmental Sciences	C	I
	Fishermen	C	
	Sindh Rural Support Programme		C
	National Highway Authority		C
	Pakistan Fisherfolk Forum		C
	Power Cement Company		C
	Dewan Hattar Cement		C

C – Consulted; I – Invited but did not participate

Figure 7-1: Consultation Locations near JTPS



7.2.2 Consultations Mechanism

Scoping Consultation

520. The Potentially Affected Communities were visited and consultations were conducted with the community members within their settlements to encourage and facilitate their participation. Representatives, notables and other interested groups from the Potentially Affected Communities were invited. A total of 11 settlements were consulted out of 19 settlements located within five kilometers of the Study Area. Separate consultations were conducted with community women of six settlements. Coverage was given to the fishermen and farming community in the consultations.

521. Letters to inform experts/institutional stakeholders about the objective of the consultation process and to arrange meetings with the stakeholders were dispatched in advance. BID was enclosed with the letters for the information of the stakeholders.

522. The key agenda items for the meetings with the communities, experts/institutional stakeholders and, fishermen communities included:

- 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.

Feedback Consultation

523. 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.

524. For institutional consultation JTPS organized two meetings, one for the government departments and agencies and the second for the remaining institutions. Invitations for the meetings were sent a week before the meeting and these were followed up with phone call to ensure maximum participation. A presentation was made to the participants on multimedia projector. This was followed by a question-answer session.

525. Individual meetings with stakeholders based in Karachi were undertaken.

7.2.3 Consultation Team

526. An EIA specialist led the team, which comprised of male and female social assistants that were familiar with the area and the local languages.

7.2.4 Future Consultations

527. Further consultations to be undertaken as part of the Project EIA process include the Project public hearing. The Sindh EPA 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 Sindh EPA will notify the Project proponents that one or more public hearings must be held. The Sindh EPA 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.

Consultation beyond the EIA Process

528. 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 (EIA **Chapter 11**).

7.3 Summary of Consultations

7.3.1 Scoping Consultation

529. **Table 7-2** summarizes the key concerns emerging from consultations and explains how each concern was addressed in the EIA. The detailed log of consultations is provided in **Appendix 8.**

530. The photographs of the consultations are given in **Figure 7-2**.

7.3.2 Feedback Consultation

531. **Table 7-3** summarizes the key concerns emerging from consultations and explains how each concern was addressed in the EIA. The detailed log of consultations is provided in **Appendix 8.**

532. The photographs of the consultations are given in **Figure 7-3**.

Table 7-2: Summary of Concerns Expressed in Scoping Consultation and How They Have Been Addressed in the EIA

Issues raised by Stakeholders	Addressed in the EIA
Resettlement and Related	
The inhabitants of the surrounding communities lost their agricultural land and were given inadequate compensation when the existing power plant was constructed. The new project should provide adequate compensation to the local people in case of any land acquisition	In case of land acquisition, adequate compensation will be provided to the affected people, as is required under the national law and ADB standards. A Land Acquisition and Resettlement Framework (LARF) have been prepared, and data is being collected on the land ownership and prices.
Physical Environment and Related	
The air pollution due to coal burning will have a negative impact on the health of the inhabitants and can cause skin allergies and respiratory diseases	Mitigation measures (ESP and FGD) have been proposed to ensure that national and ADB standards for air quality are met (EIA **Chapter 9**)
The particulate matter emission from coal fired boilers should be quantified and discussed in the EIA report	Included in EIA **Chapter 4**.
Mitigation measures should be taken to prevent all types of pollution (air, noise, water) from the plant	Mitigation measures have been proposed to ensure that national and ADB standards for air and water quality are met (EIA **Chapter 6**).
The existing power plant emissions are deteriorating the air and water quality. It has damaged 2,000 acre of land around a village Goth Chakar Khan Rajar, affected NTDC grid station equipment and is posing health issues for the local population	Mitigation measures (ESP and FGD) have been proposed to ensure that national and ADB standards for air quality are met (EIA **Chapter 5**)
The present air quality and the wind flow patterns of the area should be studied for air modeling. The stack heights should be engineered accordingly.	Air modeling was completed, details given in EIA **Chapter 9**.
The operation of the power plant will result in an increase in the temperature of the surrounding area.	The impact of heat released by power plants on the ambient air temperature is insignificant.
The study plan should address the ecological impacts	The Project will not result in any significant ecological impacts (EIA **Chapter 5**)
The wastewater from the plant should be treated before discharge as it can damage the fertility of surrounding agricultural land.	Mitigation measures have been proposed to ensure that national and ADB standards for water quality are met (EIA **Chapter 5**). See B-Physical Environment
Extensive plantation should be done within and outside the power plant to lessen the effects of air pollution.	Mitigation measures have been proposed to ensure that national and ADB standards for air and water quality are met (EIA **Chapter 5**).

Issues raised by Stakeholders	Addressed in the EIA
Groundwater Issues	
The water quality should not deteriorate.	Mitigation measures have been proposed to ensure that national and ADB standards for water quality are met (EIA **Chapter 5**).
Social and Other issues	
Mitigation measures proposed for the project will not be followed by the power plant authorities.	Implementation of the EMP is a legal and contractual obligation of the project proponent (EIA **Chapter 3**)
Villagers should be given employment opportunities in the project	Recruitment from nearby communities will be given preference provided they meet the requirements for the job (EIA **Chapter 6**)
The project management of the power plant should ensure that the health and livelihoods of the locals are not be affected by the project.	Mitigation measures have been proposed to ensure that national and ADB standards for air and water quality are met (EIA **Chapter 6**). See B-Physical Environment and Related in table
Populations in surroundings of coal power projects face several problems. Therefore, we do not support conversion of Jamshoro power plant to coal.	Conversion is not part of this project. For the new project, mitigation measures have been proposed to ensure that national and ADB standards for air and water quality are met (EIA **Chapter 6**). See B – Physical Environment and Related in table
The villagers do not have enough economic resources to spend on addressing health problems, which they fear, will be created due to the project.	Mitigation measures have been proposed to ensure that national and ADB standards for air and water quality are met (EIA **Chapter 6**). See B – Physical Environment and Related in table
Wildlife/ Biodiversity Issues	
Pollutant contamination from power station may affect fish and aquatic fauna of Indus River.	Other than COD, that was slightly above the NEQS, the concentration of the toxic metals in the effluent from the Project were all found to be within the NEQS limits for liquid effluents as well as those for the drinking water. (EIA **Chapter 6**).
Pollutant contamination of Indus River ends up in the delta region and may affect the sensitive mangrove ecosystem of the region.	Other than COD, that was slightly above the NEQS, the concentration of the toxic metals in the effluent from the Project were all found to be within the NEQS limits for liquid effluents as well as those for the drinking water. (EIA **Chapter 6**).
The project management should compensate the community and set up a fund for conservation of regional biodiversity under the Cooperate Social Responsibility Programme.	While recognizing that the plant is not significantly affecting wildlife, the suggestion has been noted and will be considered by the JTPS management.

Figure 7-2: Photographs of the Scoping Consultations

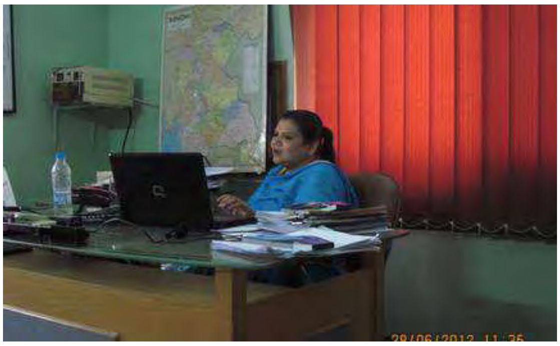
Consultation at Sindh University

Consultation at EDO Office

Consultation with Men at Plant Housing Colony

Consultation at Mehran University

Consultation with Sindh EPA



Consultation with Thar Deep Rural Development Programme

Consultation with Men at Goth Yar Muhammad Kachelo

Consultation with Men at Goth Haji Imam Bux Shahano

Table 7-3: Summary of Feedback Consultation and Comments

Stakeholder	Issues raised	Comments
Communities	**Power supply:** Desire was expressed by some villages that free electricity or at cheaper rate should be provided to them	Power distribution is not in legal mandate of JTPS.
	Development issues: In most of the villages, the stakeholders expressed the problems due to lack of development. The amenities that were demanded included link roads, school, teachers in school, clean drinking water, health facilities, sewerage system, rehabilitation of disabled people, And improvements of housing.	Although these issues are not in the scope of JTPS, the company is proposing to invest for social augmentation of the area.
	Issues with existing plant: Complaints regarding the existing plant were mostly related to the wastewater discharge and a demand to rehabilitate the existing system. Some villagers also complained about smell, health issues related to air quality, and heat.	A corrective action plan has been developed (**Chapter 6**)
	Employment: Provision of jobs was another common demand. In particular, a desire was expressed that special quotas be kept for 'local' community, for widows and off-springs of former employees.	JTPS will develop means of ensuring provision of maximum jobs to the local community (**Chapter 9**)
	New Plant: Villagers expressed support for the new plant provided their grievances are addressed. Some concerns the air quality impacts are addressed.	A grievance redress mechanism has been proposed (**Chapter 11**). Mitigation measures for the new plant has been proposed (Chapter 9 and 10)
	Management Some members suggested an independent government body for the plant including representation from community.	The plant is managed under the requirements of the corporate laws of Pakistan. However, representation of the community is proposed in the grievance redress mechanism.
Institutional at Jamshoro	**Environmental Issues:** The issues that were discussed included ash management, air quality effluent disposal, and tree plantation.	Generally, the participants expressed satisfaction with the proposed measures.
	Social Issues: Social Issues were similar to those discussed in the community meetings.	See above
	Monitoring: The need for detailed environmental monitoring was discussed	Monitoring plan is included in the EMP.

Stakeholder	Issues raised	Comments
Cement Industries	The aspects that were discussed included: • The national standard for Portland Cement (PS232-2008R) has been revised to allow use of fly ash in the manufacture of Portland Cement. It allows for 5% mixing of fly as in ordinary Portland cement and as much as 30% in lower grade composite cement. • At least one plant in Pakistan (located in northern Pakistan) is mixing purchased fly ash on experimental basis. As the use of ash improves the fineness of the cement and hence increases the strength, there is interest among cement manufacturers. • Within a distance of 200km of JTPS, there are several cement plants with which also have expansion plans. The total daily demand of fly ash can reach 1,000-15,000 tons. • Costing of ash would be critical in developing a demand among cement manufacturers. • An Memorandum of Understanding with the JPCL is possible which can then lead to a firm agreement once the ash quality, availability and price is determined.	
National Highway Authority	Expressed full cooperation in facilitating transport of power plant equipment to the JTPS from the port. Some toll plaza may not be wide enough for the large equipment. However, the plazas can be rebuilt.	
WWF	A detailed discussion took place on the EIA. No serious concern was expressed	
Pakistan Fisherfolk Form	PFF expressed serious concern on ADB funded projects. They expressed the view that as they are opposed to a) ADB funding in Pakistan and b) do not have faith in EIA process, they are not ready to engage in discussion on the EIA	

Figure 7-3: Photographs of the Feedback Consultations

Men Consultation at Barrage Colony

Consultation at Chakkar Khan Rajjar

Consultation at Machar Khan Machi

Consultation at Ramzan Rajar

Men Consultation at Saeedabad

Consultation at Saeen Dino Mallah

Women Consultation at Imam Bux Shahno

Women Consultation at Ramzan Rajar

Consultation with Government Institutions

Consultation with NGOs and Academia

8. Analysis of Alternatives

8.1 No Project Option

533. 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 5,000 MW. The proposed Project represents nearly 20% of the current gap. Thus in the absence of this project, the gap in power supply and demand will continue to grow.
- The project can also be considered as a pioneer as this will be first large-size coal-based power project. As such it is likely to 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.
- Environmentally, this project will contribute towards improving the air quality in and around Jamshoro. The installation of FGD at the existing power plant will clean the air and improve the living conditions of the population in the vicinity of the plant. Similarly, a component of the project is the rehabilitation of the cooling water and wastewater discharge systems of the existing units. The depilated state of the existing system is having adverse impact on the land of the surrounding areas.

534. Therefore, unless an economically and environmentally more viable options can be found, which appears unlikely (see **Section 8.2**), the 'no project' option will have a negative impact on the economy as well as on the environment around the existing JTPS.

8.2 Alternatives to the Proposed Project

535. The project alternatives of the proposed Project include power generation from LNG/imported natural gas based combined cycle gas turbines (CCGTs), and fuel oil based diesel engines or steam plants. In addition, green field thermal projects and other options such as nuclear, run-of-the-river hydropower, or wind and solar based renewable energy power plants at other suitable locations could also be considered as the project alternatives. An analysis of the life cycle average cost of generation from the competing technologies was carried out to assess the least cost generation alternative of the project.

536. **Table 8-1** illustrates the calculation of life cycle average cost for the competing alternatives for power generation in Pakistan. The analysis was carried out at the delivered prices of US$ 696 per ton for fuel oil[1] and US$120/ton for imported coal. The price of LNG/imported natural gas was also worked out with reference to the Brent crude oil price. The cost data of alternatives for thermal power generation were taken from recent industry experience in Pakistan.

[1] Corresponding to Brent Crude oil price of US$102/bbl

Table 8-1: Life Cycle Average Cost of Power Generation from the Project Alternatives

Cost Parameters	Cost Units	Existing–Jamshoro (Fuel Oil)	New Imported Coal Fired Steam at Jamshoro	CCGT-LNG/ Imported Gas	Diesel Engine- Fuel Oil	New Steam- Fuel Oil	Hydel RoR	Wind
Project Life	Years	–	30	30	25	30	30	20
WACC/IRR		–	17%	15%	15%	15%	16%	16%
Plant Factor		–	85%	85%	85%	85%	55%	30%
Plant Efficiency		29.9%	39.5%	48%	44%	38%	0%	0%
Fuel Price	$/MMBtu	17.70	4.54	17.03	17.70	17.70	–	–
Power Plant Capital Cost	$/kW	–	1,908	944	1,283	860	1,851	2,424
Annualized Capital Cost	$/kW	–	327	144	199	131	300	409
Capital Cost	Cents/kWh	–	4.40	1.93	2.67	1.76	6.22	15.37
O&M Cost	Cents/kWh	0.78	0.88	0.56	1.43	0.78	0.12	1.69
Fuel Cost	Cents/kWh	20.19	3.92	12.07	13.72	15.89	–	–
Average Cost of Generation	Cents/kWh	20.97	9.19	14.56	17.82	18.43	6.34	17.06

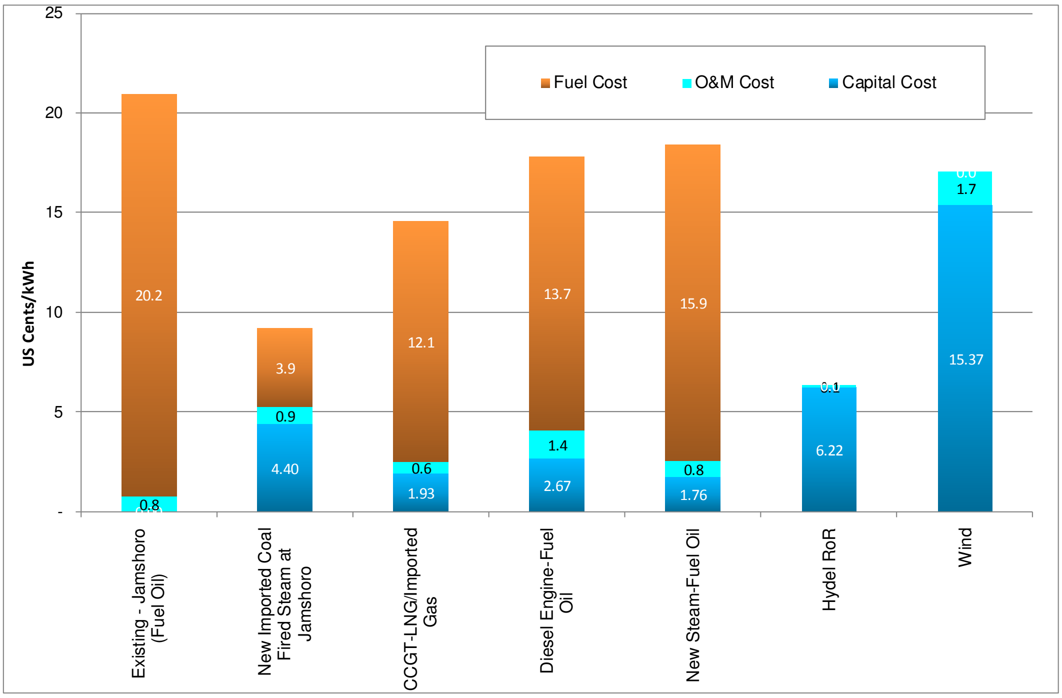
Source: Hagler Bailly Pakistan Estimates

537. **Figure 8-1** shows the comparison of cost of generation from various project alternatives. The column 'New Imported Coal Fired Steam' indicates the economics of the proposed 1,200 MW capacity under the Project.

538. The total cost of power generation in terms of US cents/kWh for various blends of imported coal and Thar lignite considered for the Project will not be significantly different as delivered energy price of Thar lignite is estimated to be close to that of imported sub-bituminous coal.

539. The cost of generation from run-of-the-river hydropower (RORH) projects works out to be lower than the proposed Project. However, the cost of RORH must be dealt with caution as it is based on average cost and hydrology data of a basket of RORH projects in Pakistan. The actual capital cost and plant factors of any specific RORH project could vary significantly from project to project. In addition, the RORH potential lies in the northern region of the country and these projects may require additional investment in transmission interconnections to supply the generated power to the Southern and mid-country markets. The power generated by RORH plants also varies seasonally, and is reduced to about 25% of the peak capacity in winters. Given the mix of available power generation capacity in Pakistan, the shortfalls in power supply in winter attributable to RORH plants have to be met by operation of thermal power generation units such as the one proposed under the Project. Given these constraints and considerations, the Project is the least cost option amongst available alternatives.

Figure 8-1: Comparison of Cost of Power Generation from the Project Alternatives



8.3 Alternative Sites for the Power Plant

540. The main selection criteria for the site for coal-based power plant are the following:

a. Proximity to source of coal, in this case the ports and the Thar field—the potential source of indigenous lignite;
b. Availability of cooling water;
c. Proximity to transmission network for evacuation of power;
d. Proximity to road network for transportation of equipment;
e. Connection with the rail network for the transportation of coal;
f. Availability of sufficient land;
g. Sufficient distance from population centers; and
h. Safe distance from ecologically sensitive areas.

541. Reviewing the map of southern Sindh in light of the above criteria, it is evident that there are not many choices and also the advantages proposed site can be appreciated. An evaluation of the potential sites based on these criteria is presented in **Table 8-2**.

542. Jamshoro stands out to be a natural choice. It is well connected with the rail and road network; a year-round source of water is available, the transmission line network is available or planned; it is located at a suitable distance from Thar and ports; there is sufficient land available; it is at a reasonable distance from population center; and it is not close to any ecologically sensitive area. The only disadvantage is the relatively degraded airshed due to the existing power plant. However, by installation of FGD on the existing units, this disadvantage is converted to advantage, as the project will result in improvement of the ambient air quality.

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Table 8-2: Selection of Site for the Power Plant

Criteria	Areas that meet the criteria
Proximity to source of coal, in this case the ports and the Thar field—the potential source of indigenous lignite	Given that the port of import for the coal (Karachi or Bin Qasim) and the possible source of indigenous coal (Thar coal field) are both in southern Sindh, the transportation cost will be minimized by locating the plant in southern Sindh. Further, given that imported coal will be the main source so to optimize transportation cost, the site shall be closer to the port than to the Thar coal field. **Suitable area:** Area in southern Sindh, below 26° N and about 1/3rd of the way between Karachi and Islamkot.
Availability of cooling water	Potential sources of cooling water are the sea, Indus River, irrigation canal, or the groundwater. The groundwater options are limited primarily to the east of Indus. The flow in Indus downstream of Kotri Barrage is not guaranteed. Irrigation canals are a potential source, however, during annual closure period of the canals for maintenance, alternate water sources would be required for continued operation of the power plant. **Suitable areas:** Coastal zone, areas close to Indus River upstream of Kotri Barrage, or irrigated area east of Indus River where groundwater may be available in sufficient quantity.
Proximity to transmission network for evacuation of power	The present circuit of 500kVA transmission line, the backbone of the transmission system, in the southern Sindh consists of grid stations at Hubco (west of Karachi) and Jamshoro and a 500kVA line connecting these that generally follows M-9 (Super Highway). The secondary 220kVA network is found in areas around Hyderabad and along the M-9. **Suitable area:** Areas north of the latitude of 25° N preferable close to Hyderabad.
Proximity to road network for transportation of equipment	The main highways which can be used for the transport of the equipment are the National Highways N-5 and N-55, and the M-9. **Suitable area:** Areas within a short distance (say 10 km) of the N-5, N-55, or M-9.
Connection with the rail network for the transportation of coal	The present main railway line follows Highway N-5. It crosses Indus River near Kotri and then heads north after Hyderabad. The line to Dadu starts from Kotri and after passing through Jamshoro heads north along the right bank of Indus River. **Suitable area:** Areas within a short distance (say 5 km) of the railway lines.
Availability of sufficient land	There is sufficient land available throughout the region and this criterion does not limit the choice. However, east of Indus in the irrigated area, land is both expensive and conversion to industrial purpose is not preferable. **Suitable area:** Mostly areas west of Indus River.
Sufficient distance from population centers; and	The population density in the irrigated area, east of Indus River, is high compared to the non-irrigated areas to west. **Suitable area:** Preferably areas to the west of Indus River.
Away from ecologically sensitive areas.	The ecologically sensitive areas in the region are the Rann of Kutch, Indus Delta, and the mangrove forest along the southern coast of the Sindh and the Kirthar Park Complex, north of M-9.

8.4 Selection of Imported Coal for the Project

543. 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, covering the available sources and supplies, and the cost for the Jamshoro coal fired boiler. Other similar coal is available in South Africa and Australia. **Table 8-3** presented the properties of sub-bituminous coal from Australia, Indonesia, and South Africa. Properties of Thar coal are also provided for reference.

Table 8-3: 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

544. 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.

545. 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 8-4**.

Table 8-4: 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%

546. 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.

8.5 Port Handling and Transportation of Coal

8.5.1 Selection of Port

547. Coal imports in Pakistan in 2010 were 4.3 million tons, mainly for use in cement plants. 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 facilities to handle coal, and are connected to the road and rail network for transportation of goods to the northern markets in the country **Figure 8-2**.

548. Karachi Port was commissioned in 1973 as the capacity at KPT 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. 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. KPT has two container terminals. PQ is located at a distance of 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.

549. 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 Paksitan Bulk International Terminal Ltd. has planned expansion of capacity to handle up to 8 million tons of coal and other bulk products with an investment of US $ 185 million[2].

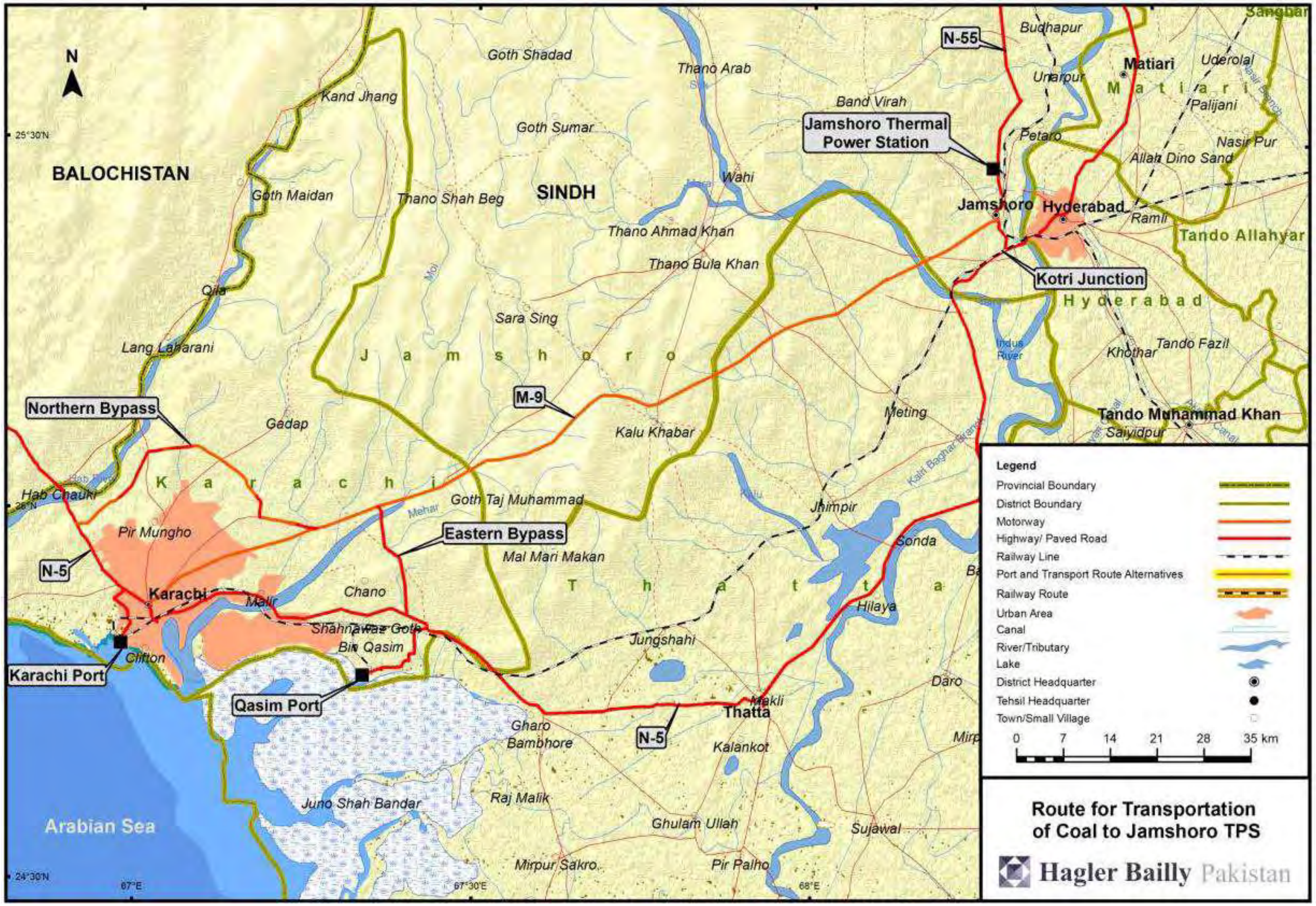
8.5.2 Transportation of Coal to Project Site

550. Imported coal can be transported from Port Qasim to Project site by rail, or by road. Thar lignite can be transported by road, or by rail following extension of the rail network to Thar. Fuel oil was originally transported to the JTPS from Karachi by means of rail, and facilities for decanting of oil located from rail wagons at the plant site were operational until 2003. This practice was discontinued due to limitations in the capacity of Pakistan railways to provide a reliable and dependable service.

551. Transportation requirement for imported coal is estimated at 2.1 to 2.3 million tons per year, and will increase to 4.2 to 4.5 million tons per year after future expansion of the generation capacity to 1,200 MW. The Pakistan Railways can use the existing track from Port Qasim to the JTPS for transportation of coal. Initial discussions with Pakistan railways indicate that the condition of track is dependable, and the bridges on the route are also in satisfactory condition and being rehabilitated under a proposed program to further improve their life and reliability. Pakistan Railways also indicates that it has sufficient rolling stock available to cater for the needs of the project. Facilities for unloading coal at Jamshoro and for loading the coal at Port Qasim will have to be modernized.

[2] www.pibt.com.pk downloaded on September 23 2103.

Figure 8-2: Route for Transportation of Coal to Jamshoro TPS



552. Transportation traffic is estimated at 10-11 trains a day, each train carrying 1,200 tons of coal over a distance of about 150 km from Port Qasim to JTPS. A total of eight to nine locomotives of 3,000 HP each operating on diesel fuel will be required, seven operating and one or two standby. Pakistan Railway is not in a position to finance the purchase of the locomotives required, estimated to cost $ 12.6 million for nine locomotives priced at US$ 1.4 million each. Under the current tariff regime, the cost of transportation of coal is estimated at Rs 800/ton of coal. In case the financing cannot be arranged by the Pakistan railways, the option of the Project financing the purchase of locomotives in return for a negotiated reduction in tariff can be discussed with Pakistan Railways. Given the current financing costs, a reduction in transportation tariff of about 10% is estimated under this arrangement. Annual greenhouse gas emissions are estimated at 5,700-6,070 tons assuming emission factor of 0.0089 kg carbon/ton coal/km for transportation by rail.

553. Cost of transportation of imported coal by road using commercially available trucking services is estimated at Rs 1,200/ton of coal. In addition to the transportation cost in comparison to that for rail, transportation by road will result in additional traffic on the roads and highways, and greenhouse gas emissions estimated at 57,500-61,300 tons assuming emission factor of 0.09 kg carbon/ton coal/km.

554. As both the Karachi and Bin Qasim ports are connected to the national rail system, transportation by rail would be the preferred option in view of lower transportation costs, lower traffic volumes on the roads which are already carrying heavy traffic volumes, lower impacts related to air quality and noise, and lower greenhouse gas emission. Track capacity of the Pakistan Railways network also exists as the trunk north-south track from Karachi up to Kotri Junction located about 20 km south of the Project site is a dual carriageway. Transportation of imported coal by rail from Port Qasim to JTPS is therefore recommended as it is the only viable option for the Project.

555. The reliability of the rail system in Pakistan has reduced to a point where transportation by rail is no longer considered a reliable option. Pakistan Railways system is facing chronic delays on all major routes on account of shortage of engines and rolling stock, and inadequate maintenance of the tracks. The Government of Pakistan has recently approved procurement of locomotives to improve the performance and reliability of the services offered by Pakistan Railway. Recognizing the overwhelming advantage of rail transportation over road transportation, GENCO will work with the Pakistan Railway to ensure availability of transportation capacity for this option. This may include the Project purchasing the engines and rolling stock and then operating the trains either itself or through the Pakistan Railways.

556. Thar lignite can be transported by road or by rail. While the impact of transportation by trucks on the traffic is not expected to be significant[3], there are safety risks associated with storage, handling, and transportation of lignite associated with the tendency of lignite towards spontaneous combustion. Transportation by rail in specially designed rail wagons and storage and handling systems as being done elsewhere in the world is therefore recommended. Further studies will be required to establish the viability of transportation of Thar lignite by road.

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3 Truck traffic is estimated at 5 trucks per hour in one direction on an average basis.

8.6 Management of Oil Contaminated Soils

557. **Figure 6-8** shows the area where soil is contaminated by oil spills from past operations at the JTPS. Based on the industry practices, the following options can be considered for treatment and disposal of this contaminated soil:

- Burning in brick kilns
- Mixing with coal and burning in the coal fired boilers on site
- Disposal in the lined facility being constructed for storage of ash
- Bioremediation

558. Burning in brick kilns will not be feasible for soils with a low level of oil contamination as it will technically not be suitable for use in the brick kilns owing to its low heating value. Available literature suggests that combustion in boilers as a method for treatment of oil contaminated soils is not preferred by the industry.[4] Use of a lined facility for permanent storage will require land, and the cost of storage in a lined facility is also high.

559. Bioremediation techniques are well developed and considered to be cost effective and environmentally acceptable.[5] Tests have to be conducted to develop site specific techniques. This technique has successfully been tested in Pakistan by BHP Billiton on soils contaminated by oil up to a level of 20%. This technique has therefore been recommended for the JTPS and cost estimates have been included in the EMMP for the Project (**Chapter 10**).

8.7 Boiler Combustion Technology

560. Coal based thermal power plants with advanced coal technologies aim to increase the amount of electrical energy extracted from each unit of coal fired boiler. The coal boiler solutions considered are:

- Various advanced pulverized coal (PC) combustion technologies (subcritical, supercritical, ultra supercritical)
- Fluidized bed combustion (FBC) technologies (atmospheric, circulating and pressurized).

561. It is important that the proposed solution for coal fired steam generators is a technologically proven and commercially available. Although a lot of new technological advances in this field has been achieved, it is imperative that only commercially proven systems are considered to reduce risks during implementation and subsequent operation and maintenance.

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4 http://www.pecj.or.jp/japanese/report/e-report/00M313e.pdf

Report Reference 2000M3.1.3, R&D on Oil Contaminated Soil Treatment System Oil Contaminated Soil Treatment Group. Yasuhi Hotta, Masanobu Tomita, Eiichiro Kozuka, Hiroaki Ohtsuka, Nobuya, Miyachi, Takeshi Nomura, Hiroshi Kimura, Yukio Takagi

5 http://www.pecj.or.jp/japanese/report/e-report/00M313e.pdf

Report Reference 2000M3.1.3, R&D on Oil Contaminated Soil Treatment System Oil Contaminated Soil Treatment Group. Yasuhi Hotta, Masanobu Tomita, Eiichiro Kozuka, Hiroaki Ohtsuka, Nobuya, Miyachi, Takeshi Nomura, Hiroshi Kimura, Yukio Takagi

8.7.1 Pulverized Coal-Fired

562. Pulverized Coal (PC) fired stations have been in use more than 60 years and, in terms of overall numbers and generating capacity, they dominate the global market. Pulverized fuel (PF) based plant is in widespread use throughout the world, in both the developed and developing nations. PF firing technology has emerged as an environmentally acceptable technology for burning a wide range of solid fuels to generate steam and electric power. Plants with PF boilers are available up to a current maximum capacity of 1,300MW.

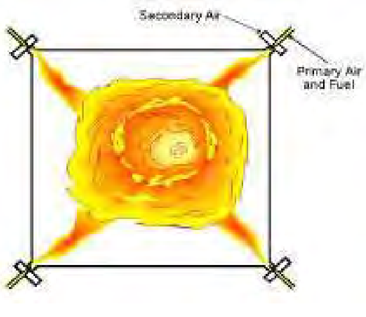
563. Over the years, many advances have been made with pulverized fuel technology, including environmentally focused measures to minimize emissions of SOx, NO_x and particulates, as well as application of advanced steam cycles that allow for greater plant efficiency. Globally, PF plant is characterized by overall thermal efficiencies of up to roughly 36% (Lower Heating Value [LHV] basis), whereas plant with higher steam temperatures and pressures can attain up to some 45%. As further developments take place in the metallurgy of critical components of boiler and turbine that are exposed to high pressure and high temperature steam, it is expected that efficiencies of 50% to 55% will ultimately be achieved.

564. It has to be noted however, that the increase in efficiency of the generating plant is due to the combination of the boiler and steam turbine working at higher pressures and temperatures. As far as the steam generation is concerned, the efficiency of the boiler per say does not vary much as steam pressures and temperatures are increased.

Firing System

565. Controlling parameters in the PF combustion process are time, temperature and turbulence. In a PF boiler, furnace temperature shall be about 1,300 to 1,500°C and fuel residence time is about 2 to 5 seconds. The most popular system for firing pulverized coal is the use of tangential firing and opposing firing shown in **Table 8-5**.

Table 8-5: Type of PF Firing System

Type of Firing	Tangential firing	Wall/Opposing firing
Description	Four burners corner to corner to create a fire ball at the center of the furnace.	Typically the combustion is staged, with the first stage combustion taking place from the burners to the centre of the furnace. The partially combusted material mixes in the flow upwards; there overfire air ports encourage complete combustion by supply air for the second stage of combustion.
Schematic diagram		

Advantages of PF Combustion

566. The following are the advantages of the PF combustion technology:

- *Fuel Flexibility* - PF boiler has the ability to burn varying quality of coals and all ranks of coal from anthracitic to lignite, and it permits combination of firing (i.e., can use coal, oil and gas). Because of these advantages, there is widespread use of pulverized coal furnaces.
- *High Combustion Efficiency* - Since the coal is being burnt in pulverized form, the rate of burning the amount of excess air required are optimized resulting in better combustion efficiency than the other types of boilers.
- *Sustainability to load variations* - Boiler is known to have high thermal inertia than any equipment in a power station. In such case, the rate of reaction with respect to load variation is the most essential. A PF boiler has the flexibility to sustain load variations in very short periods than any other type of boiler. This will increase the operational flexibility for the plant operator.
- *Maintenance problems* - Pulverized fuel boilers are less outage prone when compared with other types of boilers such as Fluidized bed combustion. Erosion of economizer and pressure parts are less, and hence the outages are less. However, there is a need to be vigilant and maintain the grinding elements of the pulverizers.
- *Provenness and Reliability* - Pulverized fuel fired boilers are reliable and proven worldwide since 1918, when Milwaukee Electric Railway and Light company, later Wisconsin Electric, conducted tests in the use of pulverized coal in 1918. Plants with PF boilers are available up to a maximum capacity of 1,300MW. PF technology with tangential firing

Classification of PF Coal Power Plants

567. Pulverized coal power plants are broken down into three categories; subcritical pulverized coal plants, supercritical pulverized coal plants, and ultra-supercritical pulverized coal plants. The classifications are mainly based on the live steam parameters and reheat steam temperature. Some of the well-known classifications are presented in **Table 8-6**.

Table 8-6: Classification of Pulverized Coal Plants

Category	Unit	Subcritical	Supercritical	Ultra supercritical
Year		<1990	1990	2000-
Live steam pressure	Bar	165	>221	>300
Live steam temperature	°C	540	540-560	>600
Reheat steam temperature	°C	540	560	>600
Single Reheat		Yes	Yes	No
Double Reheat		No	No	Yes
Power Plant Generating Efficiency	%	~38	~41	~46+

Source: Henderson, 2003; Smeers et al., 2001.

8.7.2 Fluidized Bed Combustion

568. Fluidized bed combustion (FBC) power plants use the same steam cycle as conventional PF plant. They raise steam via a different combustion technology. The possibility of applying fluidized bed combustion technology for the generation of electricity from coal first attracted worldwide interest in the 1960´s. This was especially because it promised to be a cost effective alternative to PF plants, while at the same time allowing sulfur capture without use of add-on scrubbers. Moreover, the technology is suitable for high ash, variable quality, high moisture and high sulfur fuels.

569. FBC is a method of burning coal in bed of heated particles suspended in a gas flow. An evenly distributed air or gas is passed upward through a finely divided bed of solid particles such as sand supported on a fine mesh; the particles are undisturbed at low velocity. As air velocity is gradually increased, a stage is reached when the individual particles are suspended in the air stream and the bed is called "fluidized".

Classification of FBC

570. FBC falls into three main categories which is atmospheric fluidized bed combustion (AFBC), pressurized fluidized bed combustion (PFBC), and advanced pressurized fluidized bed combustion (APFBC).

571. Atmospheric fluidized-bed combustion (AFBC) technology is commercially available in subcritical pressure with a size limit of about 350 MW. FBC is commercially available as bubbling fluidized bed combustion (BFBC) or circulating fluidized bed combustion (CFBC) version. CFBC technology has emerged as an environmentally acceptable technology for burning a wide range of solid fuels to generate steam and electric power.

572. In PFBC type, a compressor supplies the forced draft (FD) air and the combustor is a pressure vessel. In PFB plant, the boiler combustion occurs under pressure. The pressure is typically 6 to 16 times higher than atmosphere pressure. The heat release rate in the bed is proportional to the bed pressure and hence a deep bed is used to extract large amounts of heat. This improves the combustion efficiency and sulfur dioxide absorption in the bed.

573. APFBC, a technology that will not be commercially available for at least 10 years, will utilize high temperature gas turbines and have cycle efficiency of above 50% by fuel gasification. The bed also operates at a higher temperature which improves efficiency at expense of higher NO_x emission.

Advantages of FBC

574. The following are few of the advantages of FBC:

- *Fuel Flexibility* - The relatively low furnace temperatures are below the ash softening temperature for nearly all fuels. As a result, the furnace design is independent of ash characteristics which allow a given furnace to handle a wide range of fuels.
- *Low SO_2 Emissions* - Limestone is effective sulfur sorbent in the temperature range of (815 – 925°C). SO_2 removal efficiency of 95% and higher has been demonstrated along with good sorbent utilization.
- *Low NO_x Emissions* - Low furnace temperature plus staging of air feed to the furnace produce very low NO_X emissions.

- *Combustion Efficiency* - The long solids residence time in the furnace resulting from the collection/ recirculation of solids via the cyclone, plus the vigorous solids/gas contact in the furnace caused by the fluidization airflow, result in better combustion efficiency, even with difficult-to-burn fuels.

8.7.3 The Proposed Technology for Boiler Combustion

575. **Table 8-7** presents a comparison of various types of pulverized coal combustion and fluidized bed combustion technologies. The selected coal combustion technology for the proposed Plant is the PF fired supercritical boiler. The main reason for selecting PF boiler was low complexity of the firing system. The supercritical boiler was selected for its high efficiency.

Table 8-7: Technical and Economic Status for Coal Combustion Technologies

Criteria	Pulverised Coal-Fired Combustion		Fluidized Bed Combustion	
	Subcritical	Supercritical	CFBC	PFBC
Status	Commercial	Commercial	Commercial	Demonstrated
Complexity	Low	Medium	Medium	Medium
Usage	Base/medium load	Base/medium load	Base/medium load	Base/medium load
Fuel range	All coals, Co-firing with selected biomass	All coals, Co-firing with selected biomass	All coals, residuals, biomass	All coals
Operational flexibility	Medium – performance limited at low load	Medium – performance limited at low load	Medium – potentially similar to PF but not yet proven.	Medium – potentially similar to PF but not yet proven.
Unit size	< 1000 MW	400 – 1,000 MW	≤460 MW	≤360 MW
Environmental performance	Requires ESP for Particulate Matter Control, FGD for SOx Emission Control. NO_x reduction mainly achievable via burner design and configuration	Requires ESP for Particulate Matter Control, FGD for SOx Emission Control. NO_x reduction mainly achievable via burner design and configuration	Requires ESP for Particulate Matter Control. SOx Emission controlled by in furnace limestone injection. NO_x reduction mainly achievable via low temperature combustion	Requires ESP for Particulate Matter Control. SOx Emission controlled by in furnace limestone injection. NO_x reduction mainly achievable via low temperature combustion
Availability	Proven to be excellent	Proven to be good	Proven to be good	Limited experience

8.8 Environmental Control Technology

8.8.1 Particulate Matter Treatment Options

576. Particulate matter treatment technologies are electrostatic precipitators (ESP), fabric filters, cyclones and wet scrubbers. **Table 8-8** presents a comparison among the technologies in terms of efficiencies, advantages and disadvantages.

Table 8-8: 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 %	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 m3/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	ESP is 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 Relatively simple operation	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
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 multi-cyclone	A cyclone is a cylindrical vessel which can be installed singly, in series or groups as in a multi-cyclone 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 (PM_{10}). Inability to handle sticky materials.

577. For the proposed supercritical PF boiler, 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 chimney. 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.

8.8.2 SO_2 Treatment Options

578. 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).

a. 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.

b. Dry FGD/ Spray Drying: Dry scrubbers are an alternative application for SO_2 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 SO_2 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 SO_2 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.

c. 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 750-1,250^{0}C. 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.

d. Duct Injection: In duct injection, the sorbent is evenly distributed in the flue gas duct after the pre-heater where the temperature is about 150^0C. 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.

8.8.3 Post Combustion SOx Control

579. **Table 8-9** 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 8-9: 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 MMBTU/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 product.
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.

580. 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 by-product Gypsum.

8.8.4 NO_x Treatment Options

581. NO_x control technologies are mainly two categories: primary control technologies and secondary control technologies. Primary control technologies reduce the amount of

NO_x produced in the primary combustion zone. In contrast, secondary control technologies reduce the NO_x present in the flue gas away from the primary combustion zone. Some of the secondary control technologies actually use a second stage of combustion, such as reburning. **Table 8-10** summarizes available NO_x control technologies.

582. The standard practice of modern PF Boilers is to have both Low NO_x burners with Overfire air ports. This is by far the easiest solution, which also has one of the highest NO_x reduction rates. However, in order to achieve the emission standards for NO_x, an SCR will be installed.

8.9 Ash Disposal Options

583. 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.

8.9.1 Ash Recycling Options

584. *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

Table 8-10: NO_x Control Options for Coal-Fired Boilers

Control Technique	Description of technique	Applicable boiler designs	NO_x reduction potential	Commercial availability R&D status	Comments
Combustion Modifications					
Load reduction	Reduction of coal and air.	Stokers	Minimal	Available	Applicable to stokers that can reduce load without increasing excess air; may cause reduction in boiler efficiency; NO_x reduction varies with percent load reduction.
Operational modifications (BOOS, LEA, BF, or combination)	Rearrangement of air or fuel in the main combustion zone.	Pulverized coal boilers (some designs); Stokers (LEA only)	10-20	Available	Must have sufficient operational flexibility to achieve NO_x reduction potential without sacrificing boiler performance.
Overfire Air	Injection of air above main combustion zone	Pulverized coal boilers and stokers	20-30	Available	Must have sufficient furnace height above top row of burners.
Low NO_x Burners (LNB)	New burner designs controlling airfuel mixing	Pulverized coal boilers	35-55	Available	Available in new boiler designs.
LNB with OFA	Combination of new burner designs and injection of air above main combustion zone	Pulverized coal boilers	40-60	Available	Available in new boiler designs.
Reburn	Injection of reburn fuel and completion air above main combustion zone	Pulverized coal boilers, cyclone furnaces	50-60	Commercially available but not widely demonstrated	Reburn fuel can be natural gas, fuel oil, or pulverized coal.

Control Technique	Description of technique	Applicable boiler designs	NO_x reduction potential	Commercial availability R&D status	Comments
Post-Combustion Modifications					
SNCR	Injection of NH3 or urea in the convective pass	Pulverized coal boilers, cyclone furnaces, stokers, and fluidized bed boilers	30-60	Commercially available but not widely demonstrated	Applicable to new boilers or as a retrofit technology; must have sufficient residence time at correct temperature (1,750E±90 EF); elaborate reagent injection system; possible load restrictions on boiler; and possible air preheater fouling by ammonium bisulfate
Selective Catalytic reduction (SCR)	Injection of NH3 in combination with catalyst material	Pulverized coal boilers, cyclone furnaces	75-85	Commercially offered, but not yet demonstrated	Applicable to new boilers or as a retrofit technology provided there is sufficient space; hot-side SCR best on low-sulfur fuel and low fly ash applications; cold-side SCR can be used on high-sulfur/high-ash applications if equipped with an upstream FGD system.
LNB with SNCR	Combination of new burner designs and injection of NH3 or urea	Pulverized coal boilers	50-80	Commercially offered, but not widely demonstrated as a combined technology	Same as LNB and SNCR alone.
LNB with OFA and SCR	Combination of new burner design, injection of air above combustion zone, and injection of NH3 or urea	Pulverized coal boilers	85-95	Commercially offered, but not widely demonstrated as a combined technology	Same as LNB, OFA, and SCR alone.

585. A review of the utilization of fly ash produced in the coal powered plants in India[6] 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[7] 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 JTPS. These include cement plants are located at a distance of 100-150 km from the plant mainly on the main highway M-9 linking Hyderabad to Karachi (**Figure 8-3**), which is also the route through which coal will be transported to JTPS. One of the manufacturers, the Power Cement Limited (Formerly Al-Abbas Cement Limited) located about 60km from the JTPS 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 (letter from the manufacturer included in **Appendix 9**). Production of cement concrete blocks where bottom ash can be used as an aggregate is also common and widespread in the Karachi-Hyderabad area.

586. *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 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

8.9.2 Preferred Ash Disposal Approach for the Project

587. Recycling of ash will be the preferred option for ash disposal. JTPS 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, JTPS 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**.

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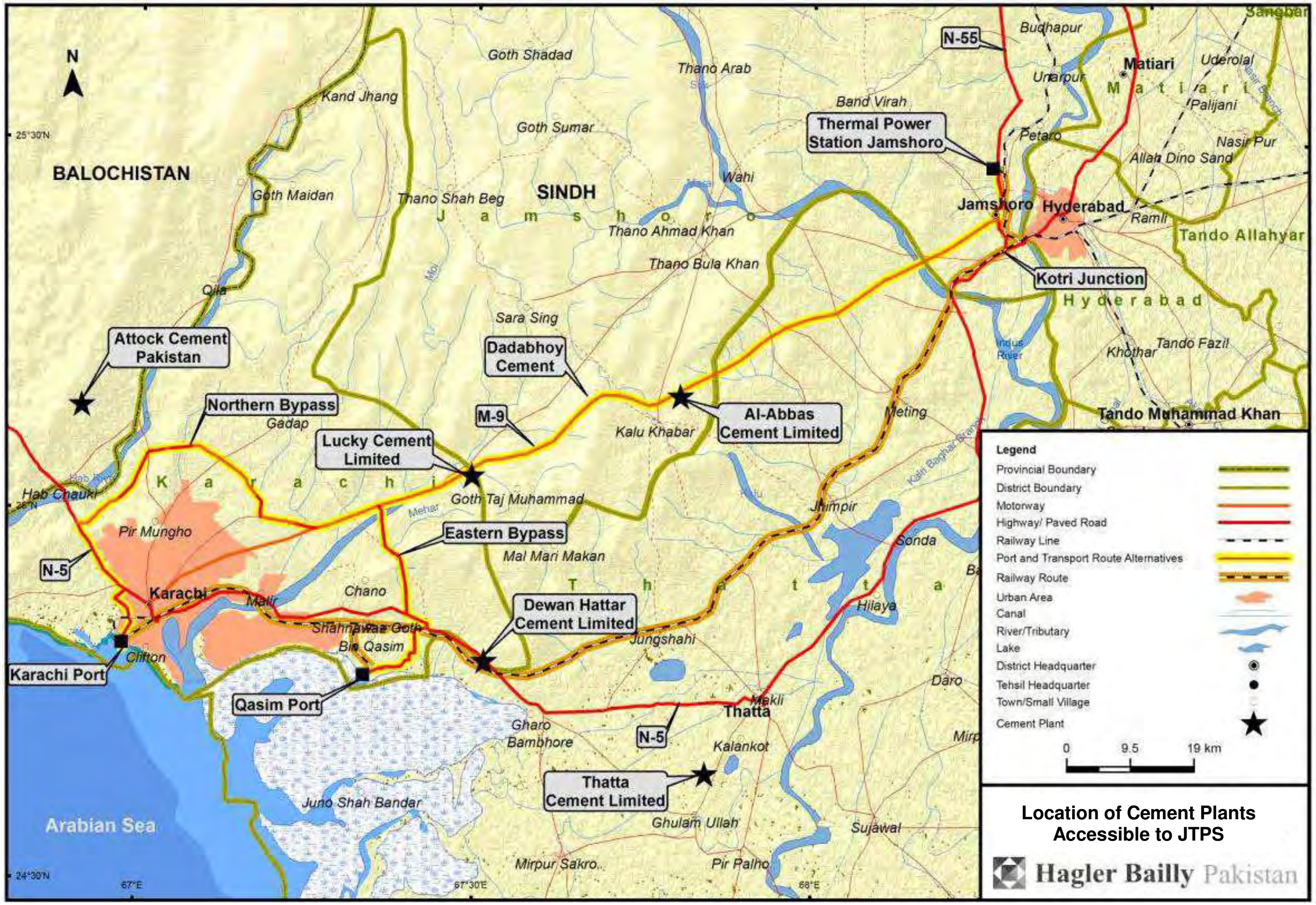
6 Report on Fly Ash Generation at Coal/Lignite Based Thermal Power Stations and its Utilization in the Country for the Year 2010-11, Central Electricity Authority, New Delhi, December 2011

7 PS 232-2008 (R), Pakistan Standard: Ordinary Portland Cement (OPC) (33, 43 & 53 Grades), Pakistan Standards and Quality Control Authority

Figure 8-3: Location of Cement Plants Accessible to JTPS



8.10 Location Alternatives of the Ash Pond Facility

588. As described in **Chapter 3** 'Description of the Project', ash will be transferred to the ash pond through a slurry pipeline. Land requirement for the ash pond is estimated at 40.5 hectares or 100 acres. Alternative locations considered for the ash disposal pond are indicated in **Figure 8-4**. The following factors were considered in selection of the location for the ash pond.

a. 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.
b. The economic value of the land should be low in terms of both the current and potential uses.
c. The location should not be subject to flooding.

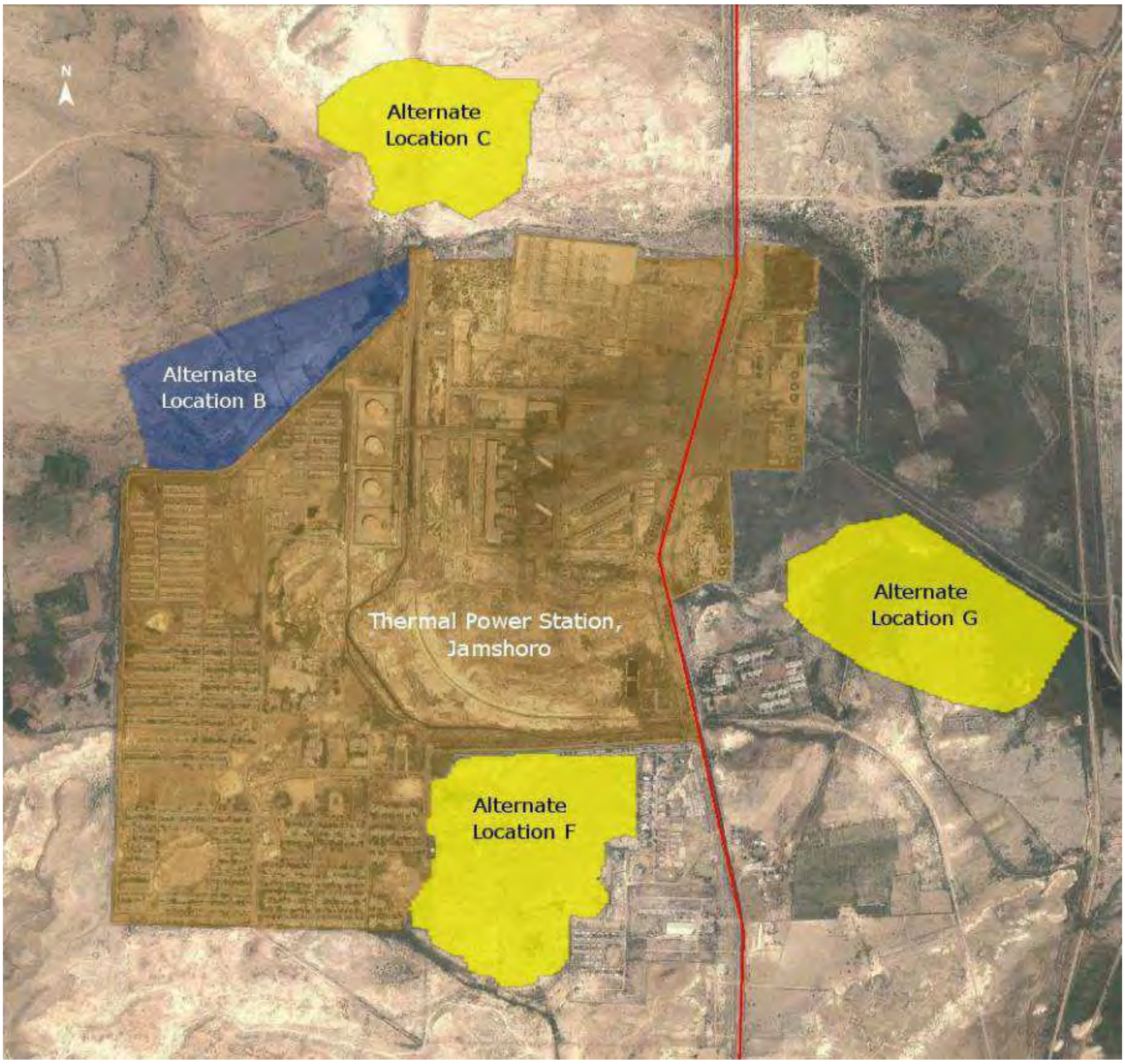
589. Location F is situated in between JTPS and the NTDC housing colonies. This location has good access to the Indus Highway, and is suitable for residential purposes in future either for expansion of the existing housing colonies or for construction of a residential area. This location is therefore not considered appropriate for the ash pond.

590. Location G is a low lying area. This site has been partially inundated by uncontrolled release of cooling water effluent from the plant. Construction cost at this location would be comparatively lower as the soil appears to mostly silt. This land would be suitable for agriculture if the cooling water effluent is transported to the Indus River through a pipeline to avoid uncontrolled inundation, and making water for irrigation available from the pipeline. Access to Indus Highway from this location is also good which will mean comparatively higher land prices as the land could be used for industrial and commercial purposes in future. This location is therefore not considered appropriate.

591. Location C is close to the plant and is about 0.5 km from the Indus Highway. The land is currently not being utilized and is not prone to flooding due to its elevation. Housing projects are currently being planned along the Indus Highway immediately east of this area, and in the long term the residential areas located on the Indus Highway will spread to this location.

592. Location B situated northwest of the plant is at a distance of less than a kilometer from the plant avoiding the low lying area adjacent to the plant which is prone to flooding, and where agriculture lands exist. This location is about 2 km from the Indus Highway, and the land is barren as water is not available for agriculture. This location is being investigated to find ownership and price range and is now the preferred site for the construction of ash pond.

Figure 8-4: Alternative Locations for JTPS Ash Disposal Site



8.11 Hazardous Waste Storage Facility

593. Plant generates various types of waste. Some of these are potentially hazardous. As described in **Section 5.1.3**, potential hazardous waste includes:

- Asbestos in the scrap piles located in the plant. Additional asbestos may be discarded during rehabilitation work
- Soot removed from the boilers, which at present is dumped in the open area.

594. Options for management of hazardous waste include storage at certified facility outside the plant, or construction of a facility for storage of hazardous waste at the plant. Currently certified facilities for storage of hazardous waste are not available in the country. Construction of a hazardous waste storage facility (HWSF) at the plant site is therefore proposed.

9. Environmental Impacts and Mitigation Measures for the Proposed Project

9.1 Identification of Significant Environmental Aspects

595. **Chapter 6** includes a discussion on the Impacts of existing plant on the environment, and measures to mitigate the impacts. This section covers the assessment of potential environmental impact of the proposed activities. Each potential impact is then categorized based on **Table 9-1**, 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:

- **H**—Definite impact, major deterioration and/or long-term impact and/or large footprint
- **M**—Possible impact, moderate deterioration and/or medium-term impact and/or intermediate footprint
- **L**—Unlikely (or low likelihood) impact, minor deterioration and/or short-term impact and/or small footprint

596. The significant issues are then further discussed in the following sections.

9.2 Construction Impact

597. 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
- Cultural impact related to presence of non-local workers

Table 9-1: Potential Environmental and Socioeconomic Impacts of the Proposed Activities

Project Activity	Description	Impacts	Risk[1]	Discussion
Construction Phase				
Transportation of equipment	The equipment for the power plant will be imported via Karachi Port or Port Qasim. It will then be moved to JTPS 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.	During the main phase of equipment transportation, the additional traffic generated on the road can potentially result in the following types of impact: road congestion and inconvenience to existing road users, additional noise and emissions and impact on the nearby community, and community safety issues. For the over-sized consignments, it may be necessary to remove obstructions, such as toll plaza, and low level power and telephone lines, to allow the equipment to pass through. Further, the heavy load may also damage the road surface particularly the shoulders.	L	All the roads that will be used for the transportation of plant equipment are national highways, dual carriage and have at least 4 lanes. The current volume of traffic on any of the highways ranges from 8,000 to 21,000 vehicles per day (see **Table 9-3**). In comparison the volume of traffic generated by the movement of plant equipment is likely to be less than 500 trucks, spread over several weeks. The incremental traffic and consequently the impact will therefore be insignificant. Environmental management measures have been included in the EMP.
Construction impact	Construction activities include construction and operation of staff camp, storage of equipment, civil works, installation of equipment, and disposal of waste.	Potential environmental impacts of construction activities include: Camp waste disposal; disposal of camp wastewater; spills and leakages of oil and contamination of soil and potentially surface water; and noise and vibration	L	As the plant is not located in any congested areas and most of the activities will be within the existing JTPS, the risk is low. A construction management is included in the EMP.
		Industrial construction activities pose an occupational health and safety risk to the workers. Improper management of this aspect can lead to fatalities and health issues.	M	Requirements for occupational health and safety management plan are included in **Chapter 10** to address this concern

[1] H = High; M = Moderate; L = Low. See Section 9.1 for discussion on the categories.

Project Activity	Description	Impacts	Risk[1]	Discussion
Socioeconomic impact of the Project	Contribution of the project to the local livelihoods in the construction phase.	Additional employment opportunities, resulting in increased prosperity and wellbeing due to additional employment for local people.	M (Benefit)	The project will employ about 3,000 persons during the construction phase.
Grievances of stakeholders due to construction activities	Unaddressed grievances of Project stakeholders due to absence of grievance redress mechanism	Ill will of local people and other stakeholders towards the Project	M	Grievances are addressed on occasional basis in the existing plant operation. A formal system for addressing the grievances to ensure that achieve closure on the issues are achieved expeditiously is of priority as construction related activities are likely to generate concerns and issues among the stakeholders. A Grievance Redress Mechanism to be followed in Project implementation is included in **Chapter 11**.
Operations Phase				
Emission from Power Plant	Emission of SO_2, NOx, PM_{10}, and other pollutants	Health issues due to Project related pollution, resulting in increased health expenses and affecting deprived segments of the local populace.	H	Mitigation measures such as installation of FGDs on boilers in the existing plant have been incorporated in the EIA and design.
	GHG Emissions	Global warming	L	As described in **Section 9.7**, ash from the Project will recycled in the cement industry to partially offset the GHG emission.
Socioeconomic impact of the Project	Contribution of the project to the local livelihoods and economy of the country.	Increased power generation due to the Project, reducing energy shortfall and reviving associated economy.	H (Benefit)	The project will fill critical gaps and provide significant support to the local economy as well as that of the country. As indicated in **Chapter 2**, in addition to reducing power outages which are affecting growth of the economy, the project will lower the average cost of power generation in the country by shifting the fuel mix in power generation from fuel oil to coal.

Project Activity	Description	Impacts	Risk[1]	Discussion
				Grievances are addressed on occasional basis in the existing plant operation. A formal system for addressing the grievances to ensure that achieve closure on the issues are achieved expeditiously is of priority as construction related activities are likely to generate concerns and issues among the stakeholders. A Grievance Redress Mechanism to be followed in Project implementation is included in **Chapter 11**.

598. 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:

- To the extent possible, the camp of the construction contractor(s) will be located within the premises of JTPS.
- 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 JTPS and CSC 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

9.3 Disposal of Waste from Construction Works

599. The plant construction and installation of equipment will generate considerable amount of 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

600. A comprehensive Waste Management Plan will be instituted at JTPS and re-use opportunities for waste generated during construction will be investigated. Hazardous waste identified, if any, will be stored in the proposed Hazardous Waste Storage Facility as described in **Chapter 4**.

601. 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 JTPS or other companies owned by GENCO Holding Company.

9.4 Air Quality Impacts During Operation

9.4.1 Modeling Approach

602. Emissions from the power plant are estimated for four scenarios. The scenarios and the rationale for selecting them is as follows:

(i) *Without JTPS scenario*—the conditions that would exist if there was no JTPS (neither the existing units nor the proposed power plant)

(ii) *Baseline scenario*—the existing conditions where all the units with existing efficiency operate on HSFO, and there are no controls on emission. This is the worst-case present day condition. It is important to establish the baseline condition and determine whether the present airshed shall be considered degraded or non-degraded (this is discussed further in later in this section).

(iii) *Baseline scenario with Offset*—All the units with existing efficiency operate on HSFO, and FGDs are installed on stacks. Installation of FGD will reduce the emission of SO_2 to a fraction (5% or less) of its present value will also, therefore, reduce the concentration of SO_2 in ambient air. To a lesser degree it will also reduce the particulate matter in the ambient air. This will be the virtual baseline for the proposed project as discussed later.

(iv) *Post 600 MW Scenario*—This is the predicted ambient quality once First Stage 1 of the project commissioned. It includes incremental impact due to the project but also takes into account the offset on the existing units.

(v) *Post 1,200 MW Scenario*—This is the predicted ambient quality once the project is installed. It includes incremental impact due to the project but also takes into account the offset on the existing units.

603. A sixth possible scenario is a variation of third scenario where the offset is provided on only one stack of the existing plant. This is also discussed separately.

604. The 1,200 MW is modeled with the following assumption:

- Blended coal (Sub-bituminous 80%, Thar 20%)
- Efficiency on LHV 43.4%
- ESP (99.9%), FGD (95%), and SCR (80%) installed
- Plant factor 85%

9.4.2 Background Concentration of Pollutant

605. The existing JTPS has dual-fuel fired boilers, however currently the plant operates mainly on HSFO. As shown in **Table 4-2**, the SO_2 emission from the existing stacks exceeds the IFC emission guidelines. This is also likely to result in exceeding the ambient air quality standards. This is, however, not reflected in the baseline data shown **Table 5-7** as the data was collected over three days only and under conditions in which the plant was not operating at full load.

606. For this reason, the SO_2 and NO_X background levels were modeled on the basis of known point sources in the area and the road traffic. As the sources of PM_{10} and $PM_{2.5}$ are both natural and anthropogenic, the background level calculated in **Table 5-9**

which is assumed to be primarily from natural sources was used as background and were added to the modeled results for PM_{10} and $PM_{2.5}$.

9.4.3 Emissions Sources and Modeling Parameters

607. The emission sources that are included in each scenario are described in **Table 9-2**.

608. The existing traffic data used to model highways is shown in **Table 9-3**. The existing major point sources include the power plants in various locations. These are characterized in **Table 9-4**. Modeling parameters including stack height, gas temperature, flow rate, and pollutant emission rates are also summarized in **Table 9-4.**

Table 9-2: Emission Sources in the Modeled Scenarios

Source	Type	Scenario 1: Without JTPS	Scenario 2: Current Baseline	Scenario 3: Current Baseline Mitigated	Scenario 4: Proposed Project (1,200 MW Mitigation on Existing)
Existing traffic on road (N-55, M-9, and N-5)	Line source	✓	✓	✓	✓
Lakhra power plant	Point Source	✓	✓	✓	✓
Kotri power plant	Point Source	✓	✓	✓	✓
JTPS HSFO Units unmitigated	Point Sources		✓		
JTPS HSFO Units mitigated	Point Sources			✓	✓
1200 MW	Point sources				✓

Table 9-3: Traffic Data used for Air Quality Modeling

	Car	Wagon/Pickup	Mini Bus	Bus	2 Axle Truck	3 Axle Truck	>3 Axle Truck	Tractor	Motor Cycles	Total
Karachi – Hyderabad (M-9)	9,327	1,197	732	1,476	2,309	2,272	3,243	12	486	21,115
Hyderabad – Hala (N-5)	4,370	1,621	344	402	1,275	1,176	229	42	822	10,510
Karachi-Dadu (N-55)	3171	1703	-	819	1183		1,186		-	8,062

Source: National Highway Authority (NHA), 2010;.

Table 9-4: Modeling Parameters and Major Point Sources of Emissions in the Model Area

	JTPS Existing Status [1]		JTPS (after FGD Installation)		Lakhra TPS (Coal fired)	Kotri TPS (Combined Cycle)	New 1,200 MW Power Plant at JTPS	
Stack Number	Stack 1	Stack 2	Stack 1	Stack 2			Stack 1	Stack 2
Capacity, MW	450	400	450	400	150	174	660	660
Units Connected	1 and 2	3 and 4	1 and 2	3 and 4			1	2
Stack Height, m	150	150	150	150	100	15	210	210
Inner Dia, m	4.5	4.5	4.5	4.5	4.5	4.5	8	8
Flue Gas Temperature, K	410	413	335	337	433	413	333	333
Exit Velocity, m/s	20	20	20	20	23	20	38.3	38.3
SO_2, g/s	1,187.67	1,035.82	59.38[2]	51.79[2]	43.33	1.80	100.2	100.2
PM_{10}, g/s	54.45	47.49	54.45[3]	47.49[3]	19	4.1	11.8	11.8
$PM_{2.5}$ g/s	24.50	21.37	24.50[3]	21.37[3]	-	-	5.31	5.31
NO_2, g/s	237.8	233.0	237.8[4]	233.0[4]	150	104	29.7	29.7

Notes: [1] Existing JTPS was modelled assuming 90% of existing capacity available and 85% plant factor. Emission factors are based on production data for 2011, wherever available. All other emissions are design emissions. [2] The total SO2 emission (both stack) equals 9.61 Tons per day (TPD) compared to NEQS limit of 500 TPD. [3] Total PM emission (PM_{10} + $PM_{2.5}$) from Stack 1 and 2 is 305 and 267 mg/Nm^3, respectively compared to NEQS limit of 500 Mg/Nm^3. [4] NO2 emissions from Stacks 1 and 2 are 126 ng/J and 123.4 ng/J compared to the NEQS limit of 130 ng/J of heat input.

9.4.4 Fugitive Emissions

609. 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 modelling.

610. By proper utilization of the following measures, dust generation and dispersions will be reduced.

- Dust extraction/suppression system will be provided at transfer points of conveyor system;
- 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.

611. Two methods of dust control will be implemented: dust extraction and dust suppression. A Coal Dust Management Plan is included in **Chapter 10**, EMP.

612. Coal 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 at the stockyard will include a facility to introduce a surfactant or "wetting agent" to the water supply to minimize the amount of water required. The contaminated water resulting from dust suppression will be collected and directed to the coal stockyard waste water management system.

613. Coal dust extraction system will extract dust 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 will come in contact with water; the slurry will be collected in the hopper and disposed of in the settling pond. Settled 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.

614. The volatility of the coal of this project is expected to be high, and can easily cause spontaneous combustion; therefore, the coal in the coal yard will be stored in different piles and compacted. The earlier it comes, the earlier it will be used, with regular rearrangement of the coal piles. The bucket wheel machine will be used and will be equipped with water tank to spray water over the fly dust points 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, alerting presence of hot spots. Based on the temperature and the risks, the coal will be either immediately sent to the boiler for utilization, or the portion of coal will be isolated and allowed to burn off. Coal fires cannot be extinguished by water. Rubber belt of the belt conveyer will use flame retardant material.

615. Following emission controls will be installed to reduce the emission from the plant:

- High efficiency (>99.9%) electrostatic precipitators (ESP) will be installed to limit the total PM emissions to 30 mg/Nm^3.
- Flue Gas Desulphurisation (FGD) units (efficiency > 95%) using lime slurry will be installed to limit SO_2 emissions on the existing as well as the proposed plant.
- Selective catalytic reduction (SCR) unit (efficiency > 80%), low NO_x burners with Overfire air ports will be designed and procured to limit the NO_x generation to 75.2 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.

9.4.5 Model Description

616. USEPA regulatory model AERMOD 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 $PM_{2.5}$.

Model Area

617. A 50 km by 50 km area with the JTPS in the center was selected as the model area. Given that the area is nearly flat and hills west of the plant are uninhabited, the modeling was done assuming flat terrain.

Meteorological Data

618. A pre-processed hourly meteorological data for the Hyderabad Station for 2009, 2010, and 2011 were purchased and used in the model. A monthly summary of the meteorological data is given in **Table** 9-5.

Table 9-5: Summary of 2009, 2010 and 2011 Meteorological Data Input to AERMOD

Month	Wind		Temperature (°C)		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

619. The model area was divided into a 1,000 m grid and receptors were allocated on the corner of each grid for plotting of air quality data within all the model area. A finer grid of 250m interval was defined within 5 km of the JTPS to accurately estimate the air quality data near the probable high concentration areas. Further, 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 9-6**. These are also shown in **Figure 9-1**.

Figure 9-1: Location of Sensitive Receptors

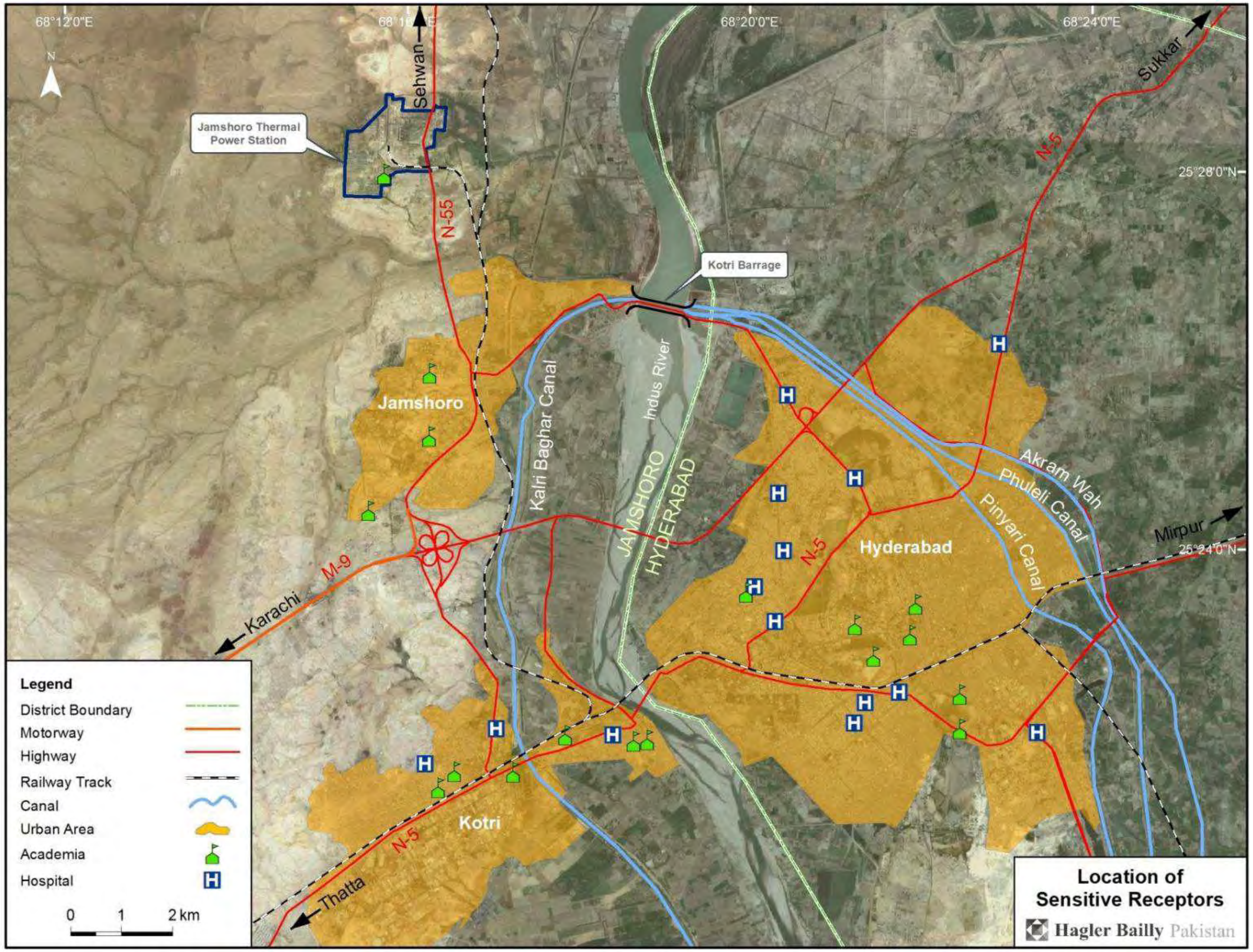


Table 9-6: Details of Sensitive Receptors

Name of Sensitive Receptors	Location	
	Latitude	Longitude
Hyderabad		
Maa Jee Hospital	25.374507	68.363028
Hospital	25.367445	68.389935
Allah Bachayo Memon Hospital	25.426842	68.340969
Quaid Public School	25.368129	68.374772
Hyderabad Public School	25.374247	68.374772
Girls College	25.368129	68.374772
Noor Muhammad High School	25.386448	68.354317
City School	25.380856	68.357906
Govt. Boys Degree College Qasimabad	25.390098	68.366062
Old Campus Sindh University	25.384631	68.365014
The Aga Khan Maternal and Child Care Centre	25.412229	68.354273
Qasimabad Government Hospital	25.409516	68.339295
Jijal Maa Hospital	25.39934	68.340411
Red Crescent Hospital	25.392968	68.334859
Government School for Boys	25.392061	68.333099
Ghani Hospital	25.3869	68.338813
City Care Hospital	25.369011	68.354316
St Elizabeth Hospital	25.372636	68.356451
Isra University Hospital	25.436066	68.382168
Jamshoro		
Plant Colony (Iqra Public School)	25.465558	68.262302
Sindh University	25.419255	68.271317
Mehran University of Engineering & Technology	25.406085	68.259634
LUMHS university	25.430443	68.271340
Kotri		
Taluka Hospital	25.366694	68.307366
T. B. Sanotorium Hospital	25.361439	68.270974
Government Girls High School	25.357232	68.273442
Kulsoom Ghulam Hussain Memorial School	25.360111	68.276585
T&T Hospital	25.367653	68.284729
Government Degree Boys College	25.360072	68.287958
Govt. Girls High School	25.365656	68.311347
Govt. Boys High School	25.365908	68.31404
Govt. Muslim Primary School	25.36664	68.298086

9.4.6 Air Quality Modeling Results

620. In this section, the maximum concentration levels in ambient air are presented for SO_2, NO_2, PM_{10}, $PM_{2.5}$ and CO for the four scenarios specified earlier. For SO_2, NO_2, PM_{10}, $PM_{2.5}$ the maximum concentration levels were modeled for 24-hour averaging period and annual averaging period to correspond with the NEQS requirements. For CO the maximum concentration levels were modeled for 1-hour and 8-hour averaging periods to correspond to the NEQS requirements. The 24-hour and annual isopleth for the 1,200 MW scenario for SO_2, NO_2, and PM_{10}, are included in **Appendix 10**. Similarly for CO the diagrams show the highest 8-hour and 1-hour concentration corresponding to the standards. The NEQS permit the 24-hour and 8-hour standard value (for CO) to be exceeded 2% of the time in a year, but not on two consecutive days. Therefore, to assess whether a particular pollutant meets the NEQS standards, the number of exceedances per year were assessed. **Table 9-7** summarize the air quality modeling results for the five scenarios. The maximum value gives the extreme high, 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.

621. In case an FGD is installed on one stack only in the existing plant, SO_2 concentration will be 142-145 µg/m^3 and the 24–hr (98th percentile) limit for SO_2 for NEQS of 120µg/m^3 will not be met. Similarly, the Maximum 24 hour concentration with FGD installed on one stack only is estimated at 147-150 µg/m^3, and the limit of 125 µg/m^3 under IFC Guidelines will also not be met. Installation of FGD on one stack only in the existing plant is therefore not an option.

622. At full load, the contribution of the new plant in the SO_2 concentration will be about 50% of the total concentration. About 25% will come from the existing plant (with FGD installed) and the remaining from other sources. The contribution of SO_2 from the new plant will be about 18% of the IFC Guidelines limit.

Table 9-7: Air Quality Modeling-Results

Pollutant	Averaging Time	Criteria		Ambient Air Quality Under Various Scenarios									
		NEQS (µg/m³)	IFC Guide-lines (µg/m³)	No JTPS		Current Baseline		Current Baseline with Offset		Post 600 MW		Post 1200 MW	
				Concen-tration (µg/m³)	Days Exceeding Per year	Concen-tration (µg/m³)	Days Exceeding Per year	Concen-tration (µg/m³)	Days Exceeding Per year	Concen-tration (µg/m³)	Days Exceeding Per year	Concen-tration (µg/m³)	Days Exceeding Per year
SO_2	Maximum 24–hr	–	125	10.3	–	223.0		22.3	–	34.8	–	47.2	–
	24–hr (98th %le)	120		9.2	–	184.5	50	21.0	–	32.6	0	44.1	0
	Annual	80		3	–	55.5	–	5.7	0	8.5	–	11.2	–
NO_2	Maximum 24–hr	–	200	9	–	56.1	–	56.1	–	59.2	–	62.3	–
	24–hr (98th %le)	80		7.2	–	37.6	–	37.6	–	47.4	0	57.2	0
	Annual	40	40	1.2	–	12.0	–	12.0	0	17.2	–	22.3	–
PM_{10}	Maximum 24–hr	–	150	108.4	–	126.1	–	126.1	–	129.2	–	132.2	–
	24–hr (98th %le)	150		100.8	–	117.2	–	117.2	–	118.9	0	120.5	0
	Annual	120	70	69.1	–	73.2	–	73.2	0	76.2	–	79.2	–
$PM_{2.5}$	Maximum 24–hr		75	60.8	–	68.8	–	68.8	–	70.2	–	71.5	–
	24–hr (98th %le)	35		57.7	–	66.3	–	65.5	0	66.3	0	67.1	0
	Annual	15	35	43.1	–	44.9	–	44.9	–	46.3	–	47.6	–
CO	1–hr	10,000		–	–	8,846	–	8,846	–	9,352	–	9,858	–
	Maximum 8–hr	–		–	–	4,083	–	4,083	–	4,347	–	4,611	–
	8–hr (98th %le)	5,000		–	–	1,541	0	1,541	0	1,610	0	1,678	0

Notes:

1. According to NEQS 24-hr Average standard values may be exceeded 2% of the year but not on two consecutive days
2. A '–' indicates that either the information is not available of not applicable.
3. As the two stacks are identical and close to each other, the 600 MW results are estimated from the 1,200 MW modeling results assuming linier increment .
4 The PM_{10} and $PM_{2.5}$ baseline (No JTPS) is set equal to the values calculated from baseline (**Chapter 5**).

Sensitive Receptors

623. LUMHS in Jamshoro and Iqra Public School in WAPDA colony were identified as the two closest sensitive receptor locations to JTPS and chosen for further analysis. The baseline and post project modeling results for the two receptors are given in **Table** 9-8 below.

Table 9-8: Post 1200 MW Concentration at Sensitive Receptors

Sr	Pollutant	Averaging Time	Iqra Public School		LUMHS	
			Average (µg/m³)	Exceedances[4] (days)	Average (µg/m³)	Exceedances (days)
1	SO_2	Maximum 24-hr	41		32	0
		24-hr (98th Percentile)	37	–	19.1	–
		Annual	6.2	–	3.7	–
2	NO_2	Maximum 24-hr	37.0	0	25.1	0
		24-hr (98th Percentile)	25.3	–	14.2	–
		Annual	4.3	–	3	–
3	PM_{10}	Maximum 24-hr	95.8	0	31.8	0
		24-hr (98th Percentile)	78.2	–	3.7	–
		Annual	71.2	–	0.9	–

Maximum Ground Level Concentration

624. For the post 1,200 MW Project scenario, the maximum ground level concentration will occur near the coordinates 25.4240N, 68.2792 E (located east of LUMHS near the Indus River). It is recommended that a fixed station monitoring station be established at this point.

9.4.7 Compliance with Guidelines and Standards

Ambient Air Quality

625. The compliance status of the 600 MW and 1,200 MW power plant against the applicable standards and guidelines is summarized in **Table 9-9**. The 1,200 MW plant meets all the limits under the NEQS and IFC Guidelines except:

- PM_{10} with respect to IFC Guidelines, where the estimated Annual Average concentration of 79.2 µg/m³ exceeds the limit of 70 µg/m³.
- $PM_{2.5}$ with respect to IFC Guidelines, where the estimated Annual Average concentration of 47.6 µg/m³ exceeds the limit of 35 µg/m³.

Table 9-9: Compliance with Ambient Guidelines and Standards

		NEQS (µg/m³)	IFC Guidelines (µg/m³)	Concentrations for 600 MW (µg/m³)	Concentrations for 1200 MW (µg/m³)
SO_2	Maximum 24–hr	–	125	34.8	47.2
	24–hr (98th %le)	120	-	32.6	44.1
	Annual	80		8.5	11.2
NO_2	Maximum 24–hr	–	200	59.2	62.3
	24–hr (98th %le)	80		47.4	57.2
	Annual	40	40	17.2	22.3
PM_{10}	Maximum 24–hr	–	150	129.2	132.2
	24–hr (98th %le)	150		118.9	120.5
	Annual	120	70	76.2	79.2
$PM_{2.5}$	Maximum 24–hr		75	70.2	71.5
	24–hr (98th %le)	35		66.3	67.1
	Annual	15	35	46.3	47.6
CO	1–hr	10,000		9,352	9,858
	Maximum 8–hr	–		4,347	4,611
	8–hr (98th %le)	5,000		1,610	1,678

- $PM_{2.5}$ with respect to NEQS, where the estimated Annual Average concentration of 47.6 µg/m³ exceeds the limit of 15 µg/m³.
- $PM_{2.5}$ with respect to NEQS, where the estimated concentration of 67.1 µg/m³ exceeds the 24–hour (98th percentile) limit of 35 µg/m³.

626. The predicted concentrations for 600 MW are lower however, the same limits are exceeded.

627. The estimated Annual Average concentration of PM_{10} for 1,200 MW at 79.2 µg/m³ exceeds the IFC Guideline for PM_{10} by 9 µg/m³, and the baseline level by 6 µg/m³. The background concentration of PM_{10} is estimated at 69 (No JTPS case in **Table 9-7**), while the baseline is estimated at 73 µg/m³ (Current Baseline in **Table 9-7**). An increase of 13% over the background concentration of PM_{10} can be considered as acceptable under the ADB Guidelines[2], as the background concentration associated with natural sources in the area is already close to the limit in the IFC Guideline. Similarly, the background concentration of $PM_{2.5}$ associated mainly with natural sources at 58 µg/m³ for 24–hour (98th percentile) and 43 µg/m³ for Annual Average basis which are already above the limits set in NEQS and IFC Guidelines. The increase in $PM_{2.5}$

[2] According to ADB Safeguards Policy Statement 2009 Appendix 1 para 34, 'The borrower/client will avoid, or where avoidance is impossible, will minimize or control the intensity or load of pollutant emission and discharge.' The Project includes best available technology for removal of particulate matter in the form of ESP units with efficiency of 99.5%.

concentrations due to Project will be of the order of 3 µg/m³. Under these conditions, an increase of about 6% over the current baseline concentration of $PM_{2.5}$ can also be considered as acceptable under the ADB Guidelines.

628. As pointed in **Section 5.2.6**, the ambient air quality NEQS for $PM_{2.5}$ requires rationalization. The project proponent has approached the Sindh Environmental Protection Agency in Government of Sindh for review of the $PM_{2.5}$ standards. The Department has indicated its willingness to review the standards (**Appendix 12**). 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 for at least two years before commissioning of the Project and included in the Environmental Management Plan (**Chapter 10**).

Degraded vs Non-degraded Airshed

629. 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*.[3]

630. 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 5.6**. 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 9-7**, it is argued that the airshed after the application of offset to the existing power plant shall be considered as non-degraded as all ambient air quality standards (with the possible exception of $PM_{2.5}$ which is currently under review) will be met.

631. 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 …"

632. The airshed of the JTPS 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 introduction of FGD on the existing stacks will result in reducing the emission of SO_2 by 95%. This will result in cleaning the air to the extent that the concentration of SO_2 will be well within the ambient air quality standards. This would result in re-classifying the airshed as non-degraded.

$PM_{2.5}$ Offset

633. IFC also recommends that for facilities in degraded airsheds where even after minimizing the emissions, compliance with IFC guidelines cannot be achieved, the "project should explore and implement site-specific offsets that result in no net increase in the total emissions of those pollutants (e.g., particulate matter, sulfur dioxide, or

3 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.

nitrogen dioxide) that are responsible for the degradation of the airshed". The proposed 1,200 MW power plant will replace power production from small to medium sized backup generators used by electricity consumers during forced outages or load shedding. The $PM_{2.5}$ emission factor for backup power generators is about 0.5 g per MJ of power output[4], while that for the proposed power plant is 0.004 g per MJ of power output. A unit of electric power generated from the power plant will thus result in less than 1% $PM_{2.5}$ emission compared to that produced by backup generators. The total annual power generation in the country in 2011-12 was 95,365 GWh.[5] The estimated shortfall in power supply in the country is about 25% of the demand on an annual average basis[6]. Thus about 31,800 GWh of power demand is unmet by the generating companies, of which about one-third is replaced by back-up generators primarily running on diesel and gasoline. These generators thus generate about 10,600 GWh of electricity annually. Based on this the current total annual emission of $PM_{2.5}$ from backup power generators in the country during forced outages is estimated to be 19,000 tons. Assuming a 90% plant factor, the 600 MW power plant will produce about 4,730 GWh annually, corresponding to 15% of the unmet demand of 31,800 GWh. Assuming a proportionate reduction in power generation from back-up generators, the 600 MW plant will result in a country-wide reduction of $PM_{2.5}$ emission by 2,800 tons. The corresponding reduction for 1,200 MW power plant will be 5,600 tons. The power consumption in Hyderabad area is about 5.5% of the country-wide demand. Thus, the reduction of $PM_{2.5}$ emission in the Hyderabad Area will be about 300 tons annually due to the 1,200 MW power plant. A detailed ambient air monitoring program including that of the $PM_{2.5}$ will be instituted. The program will be initiated before the commissioning of the Project with the objective of developing a good understanding of the $PM_{2.5}$ issue in Jamshoro area and possibly designing future mitigation programs. The objectives and approach of the program are described in **Section 10.19**.

Stack Emission

634. The compliance status of the 1,200 MW project is shown in **Table 9–10**. It shows that:

- The PM_{10} emission will meet the NEQS as well as the IFC Guidelines for DA.
- SO_2 emission will comply with IFC Guidelines for NDA and will be marginally above the DA limits. As it is argues that the airshed shall be re-categorized as non-degraded subsequent to installation of FGD on the existing power plant, the SO_2 emission shall be considered as compliant to the IFC Guidelines.
- Nitrogen oxides emission will comply with the IFC Guidelines for DA and the NEQS.

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4 USEPA Emission factor for large gasoline engines, small gasoline engines and diesel engines is 0.12, 0.37, 2.64 g/MJ. A mix of 40%, 10%, and 50% is assumed for these types of engines respectively. Emission factors are derived from *USEPA Emissions Factors & AP 42, Compilation of Air Pollutant Emission Factors* (http://www.epa.gov/ttn/chief/ap42/index.html#toc), Chapters 3.3 and 3.4 and *USEPA: Exhaust Emission Factors for Nonroad Engine Modeling,* July 2010 (http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2010/420r10019.pdf). In Ap-42, USEPA assumes that all PM emission is less than 1 micron. In the second document, 92% of the emission is assumed to be less than 92%.

5 Government of Pakistan, Ministry of Petroleum and Natural Resources, *Pakistan Energy Yearbook*, 2012. March 2013.

6 Shortage at peak demand level is about a third of the demand (Section 2.5)

Table 9-10: Compliance of Plant Emission with NEQS and IFC Guidelines

Parameter	Emission from Each Stack	Standards	IFC Guidelines
Particulate matter	30 mg/Nm^3	500 mg/Nm^3	For NDA: 50 mg/Nm^3 For DA: 30 mg/Nm^3
Sulfur oxides	254 mg/Nm^3 (20% blending of Thar with maximum 2.7% S) 200 mg/Nm^3 (20% blending of Thar with maximum 1.4% S)		For NDA: 200-850 mg/Nm^3 For DA: 200 mg/Nm^3
	17.3 TPD (Both Units)	100-500 Tons per day	
Oxides of nitrogen	75.2 mg/Nm^3		For NDA: 510 mg/Nm^3 For DA: 200 mg/Nm^3
	19.0 ng/J of heat input	260 ng/J of heat input	

9.5 GHG Emissions

635. The estimated greenhouse gas emission from the power plant is provided in **Table 9-11**. Estimate has been developed using two different methodologies: The IPCC Tier 1 methodology that assumes a 96,100 kg of CO_2 emission per terajoule of heat input from sub-bituminous and 101,000 kg of CO_2 emission per terajoule of heat input from lignite. Calculation is also made using the carbon content of design coals. The GHG emission based on the IPCC Tier 1 method for Coal G is being used as the benchmark.

Table 9-11: Carbon Dioxide Emission Estimates

	Sub-bituminous (Million Tons per year)	Lignite (Million Tons per year)	Total (Million Tons per year)
IPCC Tier 1			
Coal E	7.577	0.413	7.990
Coal F	7.372	0.638	8.010
Coal G	7.192	0.882	8.074
From Carbon Content			
Coal E	6.069	0.429	6.498
Coal F	5.905	0.663	6.568
Coal G	5.761	0.916	6.677

Note: All figures for both units and assume 85% plant factor. For 600 MW the quantities will be half of the numbers in the table.

636. The ADB Guidelines for GHG emission require the project proponents to consider available options for offset of the GHG emissions. In the case of this Project, options for offset that can be considered include tree plantations, carbon capture, 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. ADB is considering provision of $ 1 million from its Carbon Capture and Storage (CCS) to conduct a study on determining potential for CCS in Pakistan. Subject to determination of financial viability, ADB will consider a CCS demonstration project to offset carbon in Pakistan.

637. 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 8** fly ash can be used as a cement replacement and consultations with cement manufacturers located in the vicinity of JPCL indicate that the industry is keenly interested in pursuing this option. A letter confirming the interest of a cement plant located about 60 km from the Project in utilization of fly ash from the Project is included in **Appendix 9**. 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 0.87.[7] On this basis, 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.[8]

638. Offset potential of tree plantations will be limited in view of limited availability of land and water in the JTPS 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. The study will also consider working with the UN-REDD Programme.[9]

639. As shown in **Section 9.4.7**, the proposed 1,200 MW power plant will replace power production from small to medium sized backup generators used by electricity consumers during load shedding. The capacity of these backup generators installed by the residential, commercial, and industrial consumers is estimated at 2,500 MW[10]. These generators operate mainly on diesel and gasoline, and generate about 9,745 GWh of electricity annually[11]. Average efficiency of these generators is estimated at 19.0%[12]. With 1,200 MW power available from the new coal fired power plant, 7,596 GWh will be available for consumption after accounting for 15% T&D losses, which will result in 31% reduction in load shedding. The plant will displace 3,038 GWh of energy

7 United States Environmental Protection Agency. *Solid Waste Management and Greenhouse Gases*. http://epa.gov/climatechange/wycd/waste/downloads/fly-ash-chapter10-28-10.pdf. Accessed October 2013.

8 Corresponding to fly ash production of 349,600 t/year.

9 The UN-REDD Programme (http://www.un-redd.org/Home/tabid/565/Default.aspx) is the United Nations collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries.

10 Survey conducted by Hagler Bailly Pakistan in 2009 by interviewing sellers and service providers of backup generators.

11 Of the 2,500 MW installed capacity of backup generators, 50% operates on diesel mainly in commercial and residential segments, 35% on gasoline mainly in residential segment, and 15% on natural gas mainly in industry.

12 Corresponding efficiencies taking into account operation at part loads, inadequate maintenance, and deterioration in performance over the life of the equipment are estimated at 20% for diesel, 15% for gasoline, and 25% for natural gas fired generators.

from backup generators, while the remaining 4,557 GWh will be used by the consumers that previously could not access power either from the grid or from the backup generators. Allowing for new coal fired plant operating at 42.8% efficiency, 15% technical losses in the transmission and distribution system and assuming the IPCC emission factors for the fuels, reduced operation of backup generators will result in an offset of an estimated 1.06 million tons of GHG annually.

9.6 Traffic Impact

640. Aspects resulting from transportation of construction equipment and plant machinery to the JTPS 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

641. Traffic baseline has been provided in **Chapter 5**. Currently HSFO is transported through Karachi using M-9 and N55 and N5. In **Table** 9-12, the comparison of existing traffic and the projected traffic with the demand of the plant is presented.

Table 9-12: Daily Road and Fuel Truck Traffic

Current Traffic (2012)	
Light vehicles	11,300
Heavy vehicles	9,300
Total	20,600
Projected Traffic (2015)	
Light vehicles	13,700
Heavy vehicles	12,400
Total	26,100
Plant Fuel Trucks	
Oil tankers – current	55

642. Currently the JTPS traffic associated with transportation of HSFO constitutes about 0.6% of the heavy traffic on the M-9. Both imported coal and Thar lignite for the 1,200 MW power plant will be transported by railway. GHCL will work with the Pakistan Railways, GoS, and coal mining companies in Thar to develop the rail link to Thar as soon as possible.

643. During construction additional road traffic carrying equipment will be generated. These shall not be more than 10-drucks daily during peak construction period.

644. A comprehensive transportation management plan will be prepared for transportation of material during construction and operation of the Project.

9.7 Ash Disposal and Handling

645. The annual ash produced from the Project will be in excess of 400,000 tons. Options for disposal of fly ash and prospects for sale to the cement industry are discussed in **Chapter 8.** Taking into account the potential for recycling of fly ash in the cement and construction industry, the land requirement for the ash disposal for ten years is about 100 acres (**Section 4.10**). The depth of the ash pond will be around 3.5 m to avoid ash dust formation from 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
- Of-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

9.8 Disposal of FGD Gypsum

646. Options for disposal of FGD gypsum and prospects for sale to the cement industry are discussed in **Chapter 8**. 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.

9.9 Noise

647. 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.

648. 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.

649. 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,

650. There are no communities in the vicinity of the power plant and the existing plant noise is well within the limits. A preliminary assessment of noise levels from the power plant under unmitigated conditions (**Chapter 5**) indicate that the noise level at the nearest community (1,800 m from the noise source) will be about 60 dBA which with mitigation and due to the presence of a high hill between the proposed site and the residential area will be reduced by another 5-10 dBA. This noise is therefore not a major concern.

651. However, 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.

9.10 Port Impacts

652. Port Qasim currently has a capacity to handle 4 million tons of coal annually. The project will require about 3.74 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 1,200 MW coal fired capacity at JTPS.

9.11 Waste Management

653. The main environmental and social concerns relate to waste disposal. Other issues mainly relate to occupational health and safety. In **Table** 9-13, the mitigation measures related to different activities are described.

Table 9-13: 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.
Construction activities–General	• Appropriate 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[13] 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

9.12 Water Resource Impacts

9.12.1 Extraction of Water from the River

654. Water is extracted from the Indus River and used for cooling in the JTPS. As described in **Chapter 4**, the existing power plant requires 1.13 m^3/s water from the River Indus when operating at full capacity. This requirement will increase to 2.06 m^3/s with commissioning of the Project. Of this, an estimated quantity of 0.47 m^3/s will be returned to the river. The net extraction of water by the existing and the proposed power plant is therefore estimated at 1.59 m^3/s at full capacity. As detailed in **Chapter 6**, river flow upstream of Kotri barrage[14] varies from a monthly average level of 7,517 m^3/s in August, to a monthly average level of 213 m^3/s in December. Water extracted by the power plant

[13] 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.

[14] Data provided by Sindh Irrigation and Drainage Authority (SIDA) for the period 1986-2004.

will therefore be 0.75% (0.2% for the existing plant) 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 5.3% (1.7% for the existing plant). 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.

9.12.2 Quality and Temperature of the Effluent Discharged into the River

655. As discussed in **Chapter 6**, level of key pollutants observed in the plant effluents presently being returned to the river were <5 mg/l and <4 mg/l (below minimum detection limit) for BOD and COD respectively, while the toxic metals, nitrates, and phosphates were well below the NEQS limits. The concentrations of toxic metals in the plant effluents were also observed to be below the National Standards for Drinking Water. As described in **Chapter 4**, the proposed 1,200 MW power plant will only discharge cooling tower effluent/blowdown into the river, and all other waste water generated will either be recycled or channeled to the evaporation ponds. Effluent flow with the proposed 1,200 MW power plant will increase only slightly from 0.428 m^3/s to 0.470 m^3/s. The additional effluent from the Project with TDS in the range of 1,000 to 1,500 mg/l will meet the NEQS (**Chapter 4, Table 4-4**, concentrations for circulating water).

656. As discussed in **Chapter 6,** the existing plant effluent meets the NEQS[15] limits for temperature in the river. Modeling of thermal plume assuming a worst case temperature difference of 2^oC between the river water temperature and that of the effluent water and low flow conditions during a drought period in winter was conducted to assess the extent of penetration of the plume relative to the available habitat in the river. Results of thermal plume modeling for the existing plant following proposed rehabilitation indicate that a temperature of 0.5^oC above that of the river water temperature is reached within a distance of 31 m downstream from the point of discharge, at a point which is 12 m from the river bank. Considering the width of the river of the order of 500 m in the dry season, the plume modeling confirmed that the fish fauna of the river will not be subjected to stress on account of the temperature of the effluent discharged into the river. Interviews with local fishermen also confirm that there is no significant difference in the fish catch upstream or downstream of where this water is discharged.

657. **Table 9-15** lists thermal plume modeling inputs with the Project. Effluent flow with the proposed 1,200 MW power plant will increase only slightly, from 0.428 m^3/s to 0.470 m^3/s. The temperature of effluent will increase from 20.0°C to 20.5°C. This will increase the assumed worst case temperature difference between the river water temperature and that of the effluent water for the existing plant at low flow conditions during a drought period in winter from of 2^oC to 2.5^oC. All other operating parameters listed in **Table 6-9** will remain unchanged. Results of thermal plume modeling for the proposed Project plant inclusive of rehabilitation of the existing plant are illustrated in **Figure 6-9**. The results show that a temperature of 0.5^oC above that of the river water temperature will be reached within a distance of 40m (31m for the existing plant) downstream from the point of discharge, at a point which is 14m (12m for existing plant) from the river bank. The plant effluent will therefore comply with the NEQS standard for temperature of water in the river.

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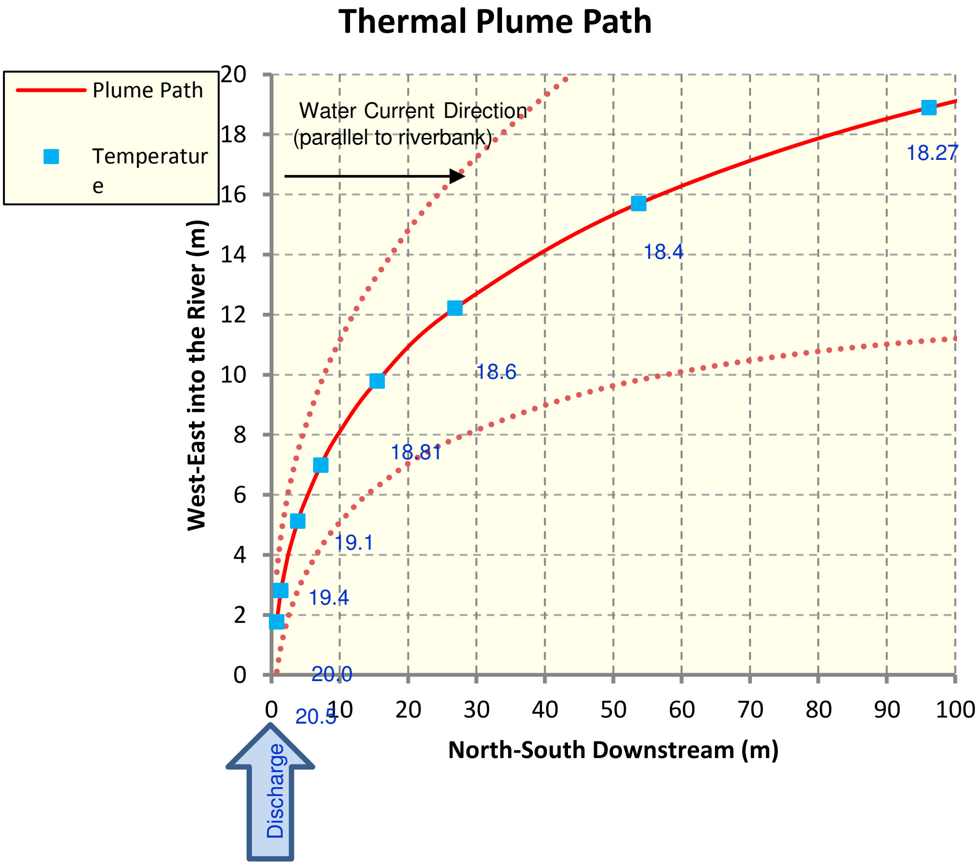
[15] The NEQS specify a drop of temperature to within 3°C at a distance of 100 m of the ambient from the point of discharge.

Table 9-14: Plume Model Input Parameter

Parameter	Input Value
Discharge Channel Width	2 meters
Discharge Channel Depth	0.3 meters
Angle of Discharge[a]	90 degrees
Region of Interest	1000 meters
Port Depth[b]	0 meters
Effluent Flow	0.470 m^3/s
Effluent Salinity	997 kg/m^3
Effluent Temperature	20.5°C
Water Current Speed (m/s)	0.3 m/s
Current Direction	Parallel to shore, towards north
Ambient water density	997 kg/m^3

Figure 9-2: Results of the Thermal Plume Modeling



9.13 Ecological Impacts

658. Following the implementation of mitigation measures listed for the existing plant as detailed in **Chapter 6**, there will be no impacts associated with the quantity or quality of the water discharged to the river and ponds created by return of cooling water effluent to the river, and seepage of effluent from the evaporation ponds. Other potential impacts due to the Project are discussed below.

659. As described in **Chapter 4**, 80,000 t/day (0.93 m^3/s) of fresh water will be required for the 1,200 MW power plant. The Project will therefore increase the water intake from the river from 1.13 m^3/s to 2.06 m^3/s. As discussed in **Section 9.12** above, there will be minor impact on the hydraulic parameters and consequentially the aquatic fauna due to change in the quantity of water extracted.

660. As discussed in **Section 9.12** above, the temperature of the effluent discharged into the river will be 2.5 ^oC above that of the river in the worst case in winter when the river flow is at minimum. A temperature of 0.5^oC above that of the river water temperature will be reached within a distance of 40m downstream from the point of discharge, at a point which is 14m from the river bank. Comparing with the width of the river of the order of 500 m in the dry season, the magnitude of the impact of the quality and temperature of the plant effluents discharged into the River Indus on the aquatic ecology will remain minor and the significance will be low. Slightly warmer water at the plant effluent outlet in the river in winter will not stress the aquatic species as they will not be exposed to a temperature outside their tolerance range.

661. As discussed in **Section 9.12.3** above, the level of key pollutants in the effluent returned to the river from the plant will remain well below the NEQS limits. The conclusion reached in **Chapter 6** for the existing plant following rehabilitation that the river ecology is not at risk on account of higher point concentrations of pollutants discharged by the existing power plant into the river will therefore remain unchanged.

662. Birds and mammals are not expected to be attracted to the ash pond or the evaporation 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.

663. Following the implementation of mitigation measures listed for the existing plant as detailed in **Chapter 6**, there will be no additional impacts on the quantity or quality of the water discharged to the river and ponds created by return of cooling water effluent to the river, and seepage of effluent from the evaporation ponds. Other potential impacts are discussed below.

9.14 Socioeconomic Impacts

664. 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:

- Increased power generation reducing energy shortfall and reviving associated economy,

- Additional employment opportunities, resulting in increased prosperity and wellbeing due to higher and stable incomes of employed people,

665. The potential adverse impacts include:

- Land acquisition resulting in physical or economic displacement of people

666. Each of these is discussed below.

Reduction in Power Outages

667. 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.

668. Due to the Project, 1,200 MW 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.

Employment Impact

669. The Project will create additional job opportunities. It is expected that more than 200 staff positions will be created under the Project. Most of these positions will be skilled, having expertise in handling the new equipment and processes. During construction period about 3,000 people will be hired.

670. The education levels of the rural population are low at 38% and the rural economy less diversified, mostly specializing in labor work and agriculture. Given this, it is less likely that they will benefit from the Project employment opportunities. However, due to the presence of the Sindh, Mehran and LUHMS universities, the local urban and colony populations have a pool of skilled labor, which are likely to have the skills required for the Project. The Project will:

- Preferentially recruit local candidates provided they have the required skills and qualifications for the announced positions;
- Coordinate efforts to recruit unskilled labor, if any are required under the Project, from the adjacent rural areas;

671. The long-term stable incomes of people employed by the Project during operational phase of the Project are likely to lead to improved nutritional status, better housing, access to education and improvement in overall well-being of their families.

Physical or Economic Resettlement

672. Additional land will be required for the ash pond proposed under the Project (see **Chapter 3**, Project Description). The potential sites for the ash pond have been identified and shown in **Figure 6.2** in **Chapter 6**. None of the identified sites is used for residential purposes. However, some land with marginal agriculture falls within the proposed sites.

673. The land will be acquired through the principles and standards laid out under Pakistan Land Acquisition Act 1894 and the ADB standards spelled out under SPS

2009. Both require that the affected people be compensated adequately for their loss due to resettlement. The framework under which land will be acquired under the Project is given in **Appendix 11** of the report.

9.15 Occupational Health and Safety

674. 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. Although risk is characterized in a similar way to impacts (consequence and probability), generally the probability of such risks occurring is much lower than the impacts discussed in the previous sections. This will be achieved through instituting an occupation health and safety management system. Although JPCL has a safety policy and a management system, it needs to be up-graded to bring it at par with the international standards. The requirements are described in **Chapter 11**.

675. 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.

9.16 Cumulative Impacts

676. The following are the special aspects of the location of JTPS that are of relevance to the cumulative impacts of the project:

- JTPS is 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 has access to river water for operation of cooling towers and general plant use.
- The plant is connected to both the national rail and highway networks.
- With proximity to Jamshoro town and city of Hyderabad, the plant has access to a pool of skilled and unskilled labor.

677. While the area in which JTPS is located is attractive for installation of additional power capacity, there are no firm plans available at present for installation of additional power plants in the area. GENCO has been considering conversion of the existing 850 MW fuel oil fired capacity to coal firing. If 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, JPCL 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.

678. Capacity expansion at JTPS can trigger further industrial and housing development in the vicinity of the plant. As the transportation of coal to the plant will be by rail, the road transportation network in the vicinity of the plant is not likely to be impacted by the plant operations in future. Air quality in the new residential areas that may develop in close proximity of the plant could be a potential concern. JPCL will coordinate the planning and zoning of the area in the vicinity of the plant with the local authorities and explore the option of buffer zones around the plant where residential developments are restricted.

9.16.1 Port Facility

679. As discussed earlier the port capacity and existing usage has sufficient capacity to handle JTPS 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

680. 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 millions tons in future.

9.16.2 Road and Railway Transport

681. Imported coal for the Project will be transported to JTPS by rail. In the long term, upgrading of the railway facilities for inland transportation of coal will contribute substantially to lowering the pressure on road networks. As shown earlier, the 1,200 MW project will generate lignite transportation requirement from Thar. It may be possible to use road trucks in the early years but railway transportation needs to be developed in the long term. Extension of railway system to Thar will be essential to meet future demands of the new plant at Jamshoro.

10. Environmental Management Plan

682. The main objective of the Environmental Management Plan (EMP) is to identify mechanisms to implement the environmental mitigation measures discussed in Chapter 9. It is the fundamental tool that ensures that all mitigation measures are consolidated, their implementation responsibilities identified and the resources required to implement the measures are provided. Further, the EMP includes monitoring measures as a feedback mechanism on implementation and effectiveness of the mitigation measures.

683. Environmental Management Plan (EMP) is prepared for all the identified environmental impacts during design, construction, and O&M stages due to implementation of various Project activities. The methodology followed for preparing the EMP consists of the following steps:

- Deriving mitigation/protection measures for identified impacts,
- Recommend mitigation, compensation and enhancement measures for each identified impacts and risks,
- 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.

10.1 Institutional Framework for Implementation of EMP

684. **Figure 10-1** presents the structure of the project organization. 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 JPCL.

685. Project Management Unit (PMU) and, Project Implementation Unit (PIU) will ensure that the mitigation and management measures proposed in the EIA are properly implemented. The top management of JPCL and GHCL will ultimately head the PIU and PMU. For this purpose, JPCL and GHCL will develop internal institutional capacity for environmental management (**Section 10.4**)

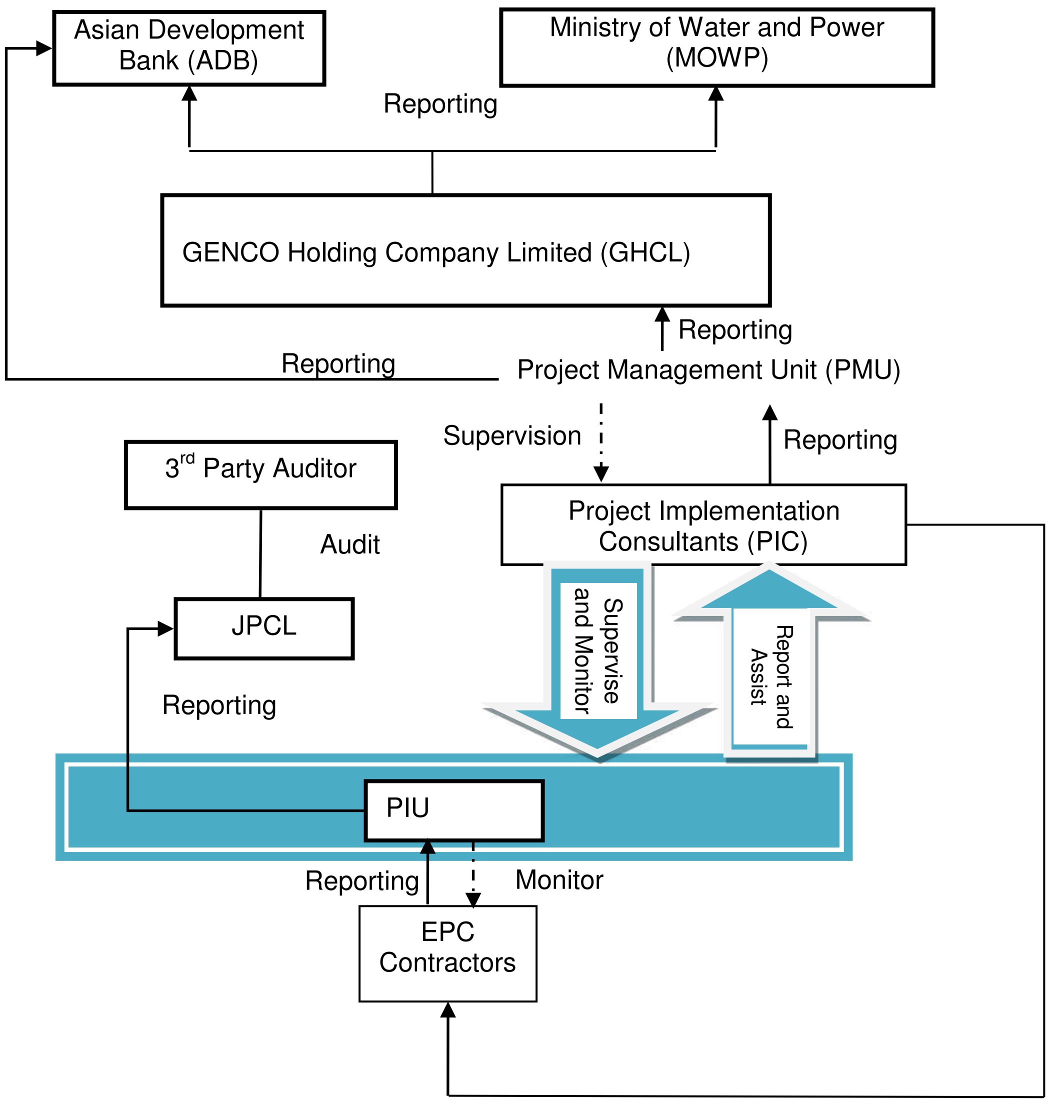
686. Project Implementation Consultant (PIC) will be primarily responsible for the implementation of the EMP and the corrective action plan for the existing plant, and will report to the PMU. The PIC will be engaged in early 2014 at the start of the Project and will remain engaged through the construction and commissioning of the Project ending in 2018. The PIU will supervise, while PMU will monitor the implementation of the EMP. Two EPC contractors will come on board in 2016, one responsible for project construction and the other for bioremediation. The PIC will ensure that all activities of both the EPC contractors carried out under the Project comply with the ADB guidelines and 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 ensure 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.

687. 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 JPCL. The terms of reference of the environmental specialists required to monitor, implement and supervise of the EMP are included as **Appendix 13.**

688. A Recycling Marketing Expert will work under the PIC in order to market the ash, liaise between GENCO and cement manufacturers and facilitate the signing of ash purchase agreement between GENCO and cement manufacturers.

Figure 10-1: Project Organization



10.2 Institutional Strengthening and Capacity Building

689. Currently, the plant laboratory at JTPS is responsible for monitoring of environmental conditions at the plant. A full-fledged Health, Safety and Environment (HSE) Department will be established under JPCL as part of this 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.

690. The department will be headed by an EHS Manager. The person will have qualification in environmental sciences, management or engineering. The person will have at least 5 years of experience in environmental management in industrial units.

10.3 Mitigation Plan

691. The mitigation plan prepared in accordance with the above framework is given in **Table 10-1**. 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

692. Principal mitigation measures for improvement of environmental performance of the existing facilities (see Chapter 6) are the following:

- Installation of FGD on the existing stacks
- Rehabilitation of effluent pipeline
- Development of a hazardous waste storage facility
- Development of a landfill site for colony waste
- Treatment plant for colony wastewater
- Rehabilitation of evaporation pond
- Bio-remediation facility for oily waste

693. In addition to the above, specific management plans have been developed for areas of concern. The plans that have been developed include:

- Coal Dust Management Plan
- Construction Management Plan
- Ash Management Plan
- Asbestos Management Plan
- Social Augmentation Plan
- Soil Bioremediation Plan

694. EMP will be included in all the bid documents of the Project and will become a 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.

Table 10-1: Environmental Mitigation and Management Plan

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
A. Design Phase					
Project disclosure	Ensure statutory compliance with PEPA 1997.	Submit EIA to Sindh EPA and obtain approval.	Before start of construction	GENCO	GENCO
Land Acquisition	Effects on livelihood	The land acquisition and resettlement plan (LARP) will be implemented. In case of any change in the area of the land, the LARP will be updated before any acquisition of land.	As and when required	JPCL	PIC
Stack Emissions	SO_2, NOx 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 99.9%) to limit the total PM emissions to 30 mg/Nm^3 • FGD (High efficiency 95%) using lime slurry to limit SO_2 emissions • SCR 9 High efficiency 80%) and dry low NOx burners to minimize the NOx 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 ADB.	During detailed designing	Design Consultant	GENCO

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
Ash pond	Dust and leachate are the potential sources of contamination	**Minimum Area:** A minimum of 100 acres of land will be purchased for the ash pond disposal. **Additional Land:** The ash recycling agreement with the cement plant will be put in place within two years of loan becoming effective. At the end of the two year period, the land requirement for the power plant for 20-year operation will be reassessed as follows: Land Requirement = (Estimated volume of ash – volume of ash for which recycling agreement is in place) / designed depth of ash pond In case the land requirement is more than 100 acres, fresh land acquisition process will be initiated such that the land is available by the time of the commissioning of the project. Prior to initiating the process, the EMP will be updated to reflect the change. The revised EMP will be approved by ADB and will also be shared with the SEPA.. **Design:** A High Concentration Slurry Disposal (HCSD) is proposed for ash disposal, in which the slurry is highly viscous and non–Newtonian fluid requiring less water compared to conventional low concentration slurry disposal. 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 for 20 years of plant operation.	During detailed designing	Design Consultant	GENCO
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 (see **Table 10-4**), national standards and international best practices: • Cooling tower blow down will be extracted from the	During detailed designing	JPCL	PIC

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
		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 • Provision is made for continuous monitoring of the temperature of the river water and the temperature of the waste water returned to the river through the effluent discharge pipeline, and the ΔT between the two, complete with alarms on ΔT. • The evaporation pond is reconstructed to allow discharge of untreated waste from demin plant and other non-compliant waste			
Colony effluent	Effluent is discharged to the surrounding area where the population is exposed	Ensure the facility is designed after proper survey of effluent quality and quantity	During detailed designing	JPCL	PIC
Colony solid waste	Colony solid waste is not properly disposed creating a health hazard	Ensure the facility is designed after proper survey of colony waste characteristics and quantity	During detailed designing	JPCL	PIC
Hazardous waste	Hazardous waste from the existing plant is not properly disposed	Ensure that accurate estimated are developed and characterization undertaken of the hazardous waste in order to design the hazardous waste facility	During detailed designing	JPCL	PIC
GHG Offset	GHG Emission from the Project	A comprehensive study to assess the potential of tree plantation to offset the GHG emission will be undertaken. The study will also consider working with the UN-REDD Programme	Prior to Commission of the First Stage of the Project	Consultant	PIC
B. Construction and Implementation Phase					

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
Disposal of replaced spare parts	Generates wastes such as Iron, cooper, electronics and oil	Ensure that the waste is disposed as per the waste management plan.	During construction	Contractor	JPCL, PEPCO
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 10-7** is developed	Before construction	Contractor	PIC, JPCL, External Monitor
		Ensure that the CMP is implemented	During Construction	Contractor	PIC
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 10.19**).	For a period of at least two years prior to commission-ing and three years during operations	JPCL	PIC
C. Operation and Maintenance Phase					
Water and Effluent Waste					
Waste water from plant	Pollution of receiving water bodies.	Compliance with the World Bank Group EHS Guidelines, 2008 (see **Table 10-4**), national standards and international best practices ; Complete segregation of wastewater streams to ensure that all streams other than the cooling tower blow down and the silt from the water treatment plant are routed to the evaporation pond; Recycling of wastewater in coal–fired plants for use as FGD makeup. This practice conserves water and reduces the number of wastewater streams requiring treatment and;	During operation	JPCL	Sindh EPA

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
		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; 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; Elimination of metals such as chromium and zinc from chemical additives used to control scaling and corrosion in cooling towers.			

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
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 settling basin for retention and settling of suspended solids, and the clear water from there may be used for dust suppression system. 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 refuelling 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	JPCL	
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	JPCL	EPA
Fugitive Emissions					
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. Conveyor belt will be enclosed to prevent dust generation; Provision of water sprinkling system at material handling	During operation	JPCL	

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
		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	JPCL	
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	JPCL	
Ash Disposal					
Fly ash	Dust	The following strategies will be adopted to ensure maximum fly ash utilization in brick and cement block manufacturing: JPCL will make ash available for at least 10 years without any payment or any other consideration, for the purpose of manufacturing ash–based products. Fly ash will be supplied to the users free of charge at the user silos initially for few years. Basic technology, as well as initial expert advice for using fly ash in making bricks and cement blocks, will be provided to local brick and cement block makers free of charge. JPCL will use fly ash building materials in the construction of its various facilities to instill confidence in local people regarding fly ash building materials.	During operation	JPCL	

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
Disposal of FDG Sludge					
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 could not be marketed, will be disposed in the ash pond.			
Air and Noise pollution					
Air Pollution	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 (CEM) equipment on the new stack for coal-fired boilers	During operation	JPCL	
Noise pollution	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 protection equipment will be provided to the workers.	During operation	JPCL	
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 exposure, limiting access to properly trained workers; Implementation of action plans to address potential or	During operation	JPCL	

Aspect or Concern	Potential Environmental Impact	Environmental Mitigation and Management Measures	When	Institutional Responsibilities	
				Implementation	Supervision
		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).28 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	JPCL	

10.4 Monitoring Mechanism

695. 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:

- 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)
- Frequency of monitoring (daily, weekly, monthly, seasonally, annually or during implementation of a particular activity)

696. 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.

697. 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 waste water quality monitoring and greenbelt development around the plant will be important parameter of the monitoring program.

698. Environmental monitoring program is presented in **Table 10-2**.

Table 10-2: Environmental Monitoring Plan 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	Contractor	PIC, JPCL
Top Soil	Construction areas	Top soil of 0.5 m depth will be excavated and stored properly	Beginning of earth filling works	Contractor	PIC, JPCL
Erosion	Construction areas and material storage sites	Visual inspection of erosion prevention measures and occurrence of erosion	Monthly	Contractor	PIC, JPCL
Hydrocarbon and chemical storage	Construction camps	Visual Inspection of storage facilities	Monthly	Contractor	PIC
Local Roads	Approach Roads	Visual inspection to ensure local roads are not damaged	Monthly	Contractor	PIC
Traffic Safety	Haul Roads	Visual inspection to see whether proper traffic signs are placed and flagmen for traffic management are engaged	Monthly	Contractor	PIC
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	Contractor	PIC
	Material storage sites	Visual inspection to ensure dust suppression work plan is being implemented	Monthly	Contractor	PIC

Parameter	Location	Means of Monitoring	Frequency	Responsible Agency	
Air Quality (PM, NO_2, SO_2, CO) See **Section 10.19** for details.	Suggested locations are: a) locations where the impact of power plants, road traffic, and other sources are minimal; b) locations near the N-5; c) locations near maximum GLC; d) sensitive receptors (e.g, LUMHS); e) locations on the East (say near Kotri Barrage) to capture the effects of Hyderabad city.	Air quality monitoring station (two) and mobile monitoring station (one)	Suggested frequency is: Continuously at two locations and once every fortnight at other locations for one day Data to be collected for at least two years before operations and to continue for at least three years after the commissioning of the project.	External contractor or arrangements with educational or government agencies	PIC
Noise	Construction sites	Visual inspection to ensure good standard equipment are in use	Weekly	Contractor	PIC
		Hourly, day and night time noise levels (dB) monitoring using noise meters	Quarterly	Contractor through a nationally recognized laboratory	PIC External Monitor
Waste management	Construction camps and construction sites	Visual inspection that solid waste is disposed at designated site	Monthly	Contractor	PIC, JPCL, External Monitor
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	Contractor	PIC, JPCL
Cultural and archeological sites	At all work sties	Visual observation for chance finding	Daily	Contractor	PIC, External Monitor
Reinstatement of work sites	All Work Sites	Visual Inspection	After completion of all works	Contractor	PIC, JPCL, External Monitor

Parameter	Location	Means of Monitoring	Frequency	Responsible Agency	
Safety of workers	At work sites	Usage of Personal Protective equipment	Monthly	Contractor	PIC, External Monitor
During Operation and Maintenance					
Wastewater Drained into the River	At the point where effluent leaves the plant boundary	SMART parameters (flow, temperature, pH, TSS, and oil & grease) and TDS for a 24 hour composite sample 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	Month*h*ly Quarterly	JPCL	EPA
	At point of discharge for effluent and 100 m downstream in the river for river	Continuous monitoring of ΔT between the river water temperature and that of the waste water returned to the river through the pipeline draining the effluent to the river. The maximum temperature difference should be 3ºC as per the legal requirement.	Continuous	JPCL	EPA
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, NOx, CO, PM_{10} and $PM_{2.5}$) and exit gas temperature and velocity. For Units 1 and 2, monthly monitoring as per the SMART rules through third-party contractor	Continuous monitoring	JPCL	EPA

Parameter	Location	Means of Monitoring	Frequency	Responsible Agency	
Ambient air quality	Near the sensitive sites and settlements particularly the GLS sites	24 hours air quality monitoring of PM_{10}, $PM_{2.5}$, , SO_2, NO_2 and CO	Quarterly	JPCL through nationally recognized laboratory	External Monitor
Groundwater	At the Baseline Monitoring Sites and from piezometers around the ash pond	Sampling and laboratory analysis for heavy metals (Zn, Pb, Ni, Fe, Hg, Cu, Co)	Bi–annually	JPCL through nationally recognized laboratory	External Monitor
Noise	At the work areas, control rooms and nearest residential areas	Hourly, day and night time noise levels (dB) monitoring using noise meters	Quarterly	JPCL through nationally recognized laboratory	External Monitor
Treated waste water from housing colony	Outlet of water treatment plant	24 hour composite sample	Quarterly	JPCL through recognized laboratory	External Monitor
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 Thar coal	JPCL through recognized laboratory	External Monitor
GHG emission	Stacks	Monitoring of flue gases flow and carbon content	Once in 6 months	JPCL through recognized laboratory	External Monitor

10.5 Resettlement Specialist

699. A Resettlement Specialist will be hired for the duration land acquisition and resettlement period. The details are included in **Appendix 11**.

10.6 Reporting and Feedback Mechanism

700. 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

701. 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, JPCL.

702. PIC will prepare monthly reports on the status of EMP implementation and environmental performance of the contractor. These reports will be based on the contractor's reports and their supervision. PIC will assess how accurate is the 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.

703. The JPCL will report annually to the ADB on the status of environmental compliance of construction works. Such reporting will contain information on all violations identified and the actions taken for fixing of such cases. JPCL will inform the ADB on any major environmental issues at any time, independently from the schedule of regular reporting.

704. After project completion, JPCL will be in charge of the operation and maintenance of the Project. HSE Department of JPCL will be responsible for compliance with the monitoring plan during O&M.

705. Feedback and adjustment will be carried out in two tiers. Upon request for EMP modification by the Contractor and JPCL 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. JPCL will consider comments and suggestions from PIC and ADB. Appropriate responses and revisions in the EMP will be implemented, if necessary. The contractor and JPCL will then implement the modifications.

706. JPCL 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, PEPCO 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.

10.7 Budget Estimates

707. 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 10-3**. 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.

708. 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.

709. The total budget for EMP implementation is estimated to be about US$ 3.85 million.

Table 10-3: Summary of Costs for Environmental Management and Monitoring

	Item	Unit	Unit Cost US$	Qty	Total Cost US$
A	**Environmental Monitoring 6 years (Design, Construction, and Operation Periods)**				
1	Air quality monitoring Fixed Station	LS			80,000
2	Air quality monitoring Mobile Station	LS			50,000
3	Air quality monitoring recurring cost	LS			428,000
4	Monitoring of SMART parameters in effluent water @ monthly 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 6years)	Site	500	30	15,000
7	Noise monitoring (5 sites@ 3 yearly over 6 years)	Site	25	30	3,000
	Sub Total (A)				**581,280**
B	**Social Augmentation Plan**				
	Social Augmentation Plan	LS	1	1	328,000
	Sub Total (B)				**328,000**
C	**Mitigation Plans**				
	Hazardous Waste Storage Facility (HWSF)	**LS**			47,000
	Soil Bioremediation	**LS**			1,310,000
	Effluent Pipeline	**LS**			1,137,000
	Evaporation Ponds	**LS**			211,000
	Colony Wastewater Treatment	**LS**			155,000
	Colony Landfill	**LS**			10,000
	Sub Total (C)				**2,870,000**
D	**FGD on Existing Stacks**				Included in project budget
E	**Training Cost**				**75,000**
	Grand Total (A+B)				**3,854,280**

10.8 Performance Indicators

710. 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 10-4**.

Table 10-4: Performance Indicators

Aspect	Indicator
Stack emissions (SO_2, NO_X, PM_{10})	**Existing Stacks** SO_2 9.6 TPD NO_2 NEQS PM_{10} NEQS **New Stacks** SO_2 254 mg/Nm^3 NO_2 75.2 mg/Nm^3 PM_{10} 30 mg/Nm^3
Ambient Air quality (PM_{10}, $PM_{2.5}$, SO_2, and NO_2)	Requirement of World Bank EHS Guidelines, that is, the NEQS for Ambient Air, **Table 1-6** of **Appendix 1**
Noise levels	Requirement of World Bank EHS Guidelines, that is, the NEQS for Ambient Noise, **Table 1-7** of **Appendix 1**
Wastewater Quality	Requirement of World Bank EHS Guidelines, that is, 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 and any community within one kilometer of the ash pond.
Greenhouse Gas	Emission per unit of energy produced

10.9 Emergency Response Plan

711. Firefighting system is in place in JTPS with a standard operating procedure, which will be strengthened considering the potential fire from the sparks in coal storage and handling.

10.10 Training Program

712. The planned training program is shown in Table 10-5.

Table 10-5: Training Program

Sr	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. Plant manager will be instructed 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 Sources	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 ADB	External sources	EHS staff Plant managers and supervisors	Environmental standards and their compliance ADB and Govt. regulations	Before starting the project activities	Full day (8 hour session)
6	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)
7	Asbestos Management	External Sources	EHS staff Responsible supervisory staff Management	As per Asbestos Management Plan	Before starting of project activities	Two full day (8 hour session)

10.11 Waste Management Plan

713. In **Table 10-6**, the waste inventory and disposal plan is presented.

10.12 Contaminated Soil Bio-remediation Plan

714. The contaminated soil will be managed in accordance with the IFC General EHS Guidelines (Section 1.8 Contaminated Land).

715. The volume of contaminated soil is estimated at 38,900 m^3. The contamination level is estimated at 23,000 mg/kg. In addition, about 30,000 m^3 of low contamination (about 2,000 mg/kg) was also identified.

716. Bioremediation allows natural processes to clean up harmful chemicals such as oil. Microbes that live in soil like to eat certain harmful chemicals, such as those found in oil. When microbes completely digest these chemicals, they change them into water and harmless gases such as carbon dioxide. In order for the microbes to work, the optimum temperature, nutrients, oxygen, and moisture is required. If conditions are not right, nutrients, enhancers (microbes) and air must be added. Bio-remediation will take place on concrete pads. Leachate collection channels will be constructed around the pads. A concrete sump will be constructed for collection of leachate. A sprinkler system will be installed to sprinkle water on the soil. The facility will also include a washing pad for washing tyres of trucks and equipment to prevent spread of contaminated soil outside of the facility.

717. Contaminated soil will be brought in truck and spread on the concrete native soil in about the same quantity is spread on top of the contaminated soil. Using a tractor, the contaminated soil and the native soil are mixed and will be left on the pad. Periodically (typically once in a fortnight), water will be sprinkled and the mixture will be turned over using a tractor. As and when required nutrients and enhancers may be added to speed up remediation. One batch is estimated to take 2-3 months to complete. Water from the sump may require occasional removal.

718. Total cost for bioremediation is estimated to US$ 1.31 million considering the fact that 1 m^2 of land (includes land for pad, surrounding path, and other facilities) can treat 0.26 m^3 of contaminated soil annually.

Table 10-6: EMP for Waste Management

Sr	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 contractor disposes insulation properly at landfill site.
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

10.13 Construction Management Plan

719. The construction contractor will develop a specific construction management plan (CMP) based on the CMP included in the **Table 10-7**. The CMP will be submitted to the JPCL and ADB for approval.

720. 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

Table 10-7: Construction Management Plan

Aspect	Objective	Mitigation and Management Measure
Vegetation clearance	Minimize vegetation clearance and felling of trees	• Removal of trees will be restricted to the development footprint. • Construction activities shall minimize the loss or disturbance of vegetation • Use clear areas to avoid felling of trees • A procedure shall be prepared to manage vegetation removal, clearance and reuse • Inform the plant management before clearing trees • Cleared areas will be revegetated
Poaching	Avoid illegal poaching	• Contractual obligation to avoid illegal poaching • Provide adequate knowledge to the workers relevant government regulations and punishments for illegal poaching
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

Aspect	Objective	Mitigation and Management Measure
		remove the mud from the wheels. This will be done in every 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 on an as required basis 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	• Do not allow ponding of water especially near the waste storage areas and construction camps • Discard all the storage containers that are capable of storing of water, after use or store them in inverted position • Reinstate relief and landscape.
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 • Remediate the contaminated land using the most appropriate available method to achieve required commercial/industrial guideline validation results

Aspect	Objective	Mitigation and Management Measure
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 2m 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 • Topsoil stockpiles will be monitored and should any adverse conditions be identified corrective actions will include: o Anaerobic conditions – turning the stockpile or creating ventilation holes through the stockpile; o Erosion – temporary protective silt fencing will be erected;
	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 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.

Aspect	Objective	Mitigation and Management Measure
	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	• Water the material stockpiles, access roads and bare soils on an as required basis to minimize dust. • Increase the watering frequency during periods of high risk (e.g. high winds). • Stored materials such as gravel and sand will be covered and confined • Locate stockpiles away from sensitive receptors
	• 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 500m from residences.
	Minimizing impact on water quality	• Stockpiles of potential water pollutants (i.e. bitumen, oils, construction materials, fuel, etc.) shall be locate 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 shall be prepared.
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.

Aspect	Objective	Mitigation and Management Measure
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 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

Aspect	Objective	Mitigation and Management Measure
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.

10.14 Coal Dust Management Plan

721. Coal dusts from coal stockpile and coal conveyor belt area are the major source of fugitive emissions. Dust suppression using a sprinkler system will be primarily employed to control the coal dust from these areas. Recycled water from the waste water treatment plants and cooling water blow down will be the primary source of water to the sprinkler system. Two methods of dust control will be implemented: dust extraction and dust suppression.

722. Coal 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 swivelling 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.

723. 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.

724. 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 settling basin for retention and settling of suspended solids, and the clear water from there may be used for the dust suppression system.

725. The volatility of the coal of this project is high, easy to cause spontaneous combustion; therefore, the coal to the coal yard must be stored in different piles and compacted, the earlier it comes, the earlier it is to be used, with regular rearrangement of the coal piles. The bucket wheel machine itself will be equipped with 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, alerting of the presence of hot spots. Based on the temperature and the risks, the coal will be either immediately sent to the boiler for utilization, or the portion of coal will be isolated and allowed to burn off. Coal fires cannot be extinguished by water. Rubber belt of the belt conveyer shall use flame retardant material.

10.15 Ash Management

726. The ash pond will be 3.5 m deep, and have a raised bund of 1 m. For ease of operation, the ash pond plot will be divided into smaller plots of 20m X 20m. This enables 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.

727. 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 Waste–land 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.

728. 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 JPCL 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.

729. 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.

10.16 Asbestos Management Plan

730. Asbestos is recognized internationally as a hazardous material because it can present a risk to human health. In many jurisdictions asbestos is classified as hazardous and is a controlled chemical waste or a hazardous waste because if it is mishandled it can release airborne fibers that are known to cause asbestosis and have also associated with other lung diseases and cancer. All forms of the asbestos mineral will release asbestos fibers if broken up and all types of asbestos containing material (ACM) will release asbestos fibers to some degree if damaged or abraded.

731. Asbestos has been widely used in numerous types of materials, usually because of its good qualities as a thermal insulation material. Asbestos has also been used extensively in numerous types of cement materials, pipe insulation plaster and in refractory brick work. Asbestos is often used because of its good qualities as a thermal insulation material but it is also useful as a binder to form complicated cement shapes and durable pipes. The amounts of asbestos used vary from product to product but certain types of asbestos cement can contain more than 50% asbestos. When bound in the cement matrix the asbestos is generally considered safe. However over time the cement surface can become corroded or abraded leading to the release of asbestos fibers. The surface of the ACM, such as pipe and corrugated sheets can gradually become more friable and release asbestos fibers. Exposure to chemicals and moisture also affects the rate of deterioration of ACM as they gradually wear out or become more fragile. The removal and replacement of ACM also give rise to some release of fiber as it is almost impossible to remove more fragile old material without breaking them. Therefore in addition to giving rise to a controlled waste the removal of the ACM can also easily lead to the release of asbestos fibers if the removal is not conducted under controlled conditions.

732. This plan has been prepared because the ACM is present in the power plants which may be broken or cracked during the rehabilitation work. The procedures to be adopted are outlined in this framework by reference to known asbestos in ACM. This framework will be applied whenever any ACM is identified. Prior to any removal work asbestos investigation will be carried out to check if there is any likelihood of ACM being present.

10.16.1 Requirement for Asbestos Management

733. Best practice asbestos management usually entails several stages. Survey and investigation are the first steps in which all structural elements, fixtures and fittings are checked for fibrous materials that are potentially asbestos. Samples are taken under controlled conditions and an accredited laboratory analyses the samples using polarized light microscopy. The type, location and condition of asbestos is assessed to undertaken a hazard assessment. If asbestos needs to be removed an asbestos abatement plan is usually prepared to cover removal with detailed work specifications for specialist contractors. In all cases the asbestos will be labeled and safety procedures instigated to prevent disturbance, until such time as it can be removed safely.

734. There are as yet no statutory controls on hazardous waste in Pakistan. The *Hazardous Substances Rules* were drafted in 2003 but were never brought into force. Asbestos waste is listed in the draft *Hazardous Substances Rules 2003*. If enacted the HSR would require an entity licensed under the Pakistan Environmental Protection Act 1997 to have a waste management plan for any listed hazardous substance.

735. Therefore as there are as yet no local standards for asbestos control in Pakistan, any known asbestos waste requiring removal will be disposed of following best international practice.

10.16.2 Responsibilities/Authorities of Various Agencies

736. Potential environmental liabilities with respect to asbestos associated with subprojects will be minimized by implementing the requirements of the AMF and by prescribing the selection of alternative non-asbestos materials. All measures shall be in line with ADB's SPS 2009, the GOP's regulations and guidelines, the Environmental Assessment Review Framework and the *Guidance on Environmentally Responsible Procurement*[1]*.*The subprojects shall only involve asbestos activities that follow the AMF.

737. JPCL will:

- Prepare an asbestos investigation report (AIR) before undertaking any work on a equipment or work area.
- Ensure that adequate sampling and analysis has been carried out to ensure all environmental liabilities with respect to asbestos have been identified, review the asbestos assessments AIR and submit the AIR to ADB.
- Ensure that the contracts have specified the asbestos management procedure (AMP) to be used in the construction of the subproject to control environmental liabilities to acceptable levels.
- Ensure that the asbestos abatement procedures, including all proposed mitigation measures and monitoring are properly implemented.
- Monitor the implementation of AMPs and present its monitoring report.

10.16.3 Minimizing Asbestos Liabilities

738. Potential environmental liabilities with respect to asbestos associated with subprojects will be minimized by taking the following measures:

- Implementing the requirements of the AMF and by prescribing the selection of alternative non-asbestos materials.
- Where ACM must be disturbed in a equipment the ACM shall only be removed under controlled conditions for disposal in line with the provisions of the AMF or any rules subsequently promulgated by the Sindh EPA.
- All Contractors shall agree through their agreement to carry out the asbestos abatement procedures in line with the procedures included in the AMF.
- Conducting sampling of potential asbestos containing materials (ACM) and compiling an asbestos investigation report (AIR) with adequate implementation.

10.16.4 Monitoring During the Construction Period

739. Monitoring during construction will be the responsibility of the PIC. The PIC may acquire the services of an Asbestos Specialist. The monitoring will relate to compliance with construction contracts. The Asbestos Specialist will inspect the ongoing works regularly and systematically; checking that the above-mentioned the asbestos abatement mitigation measures specified in the AMP have been implemented effectively during the design and construction stages of the project and ensure the implementation and effectiveness of mitigation measures. Reporting will be to the JPCL on a regular basis and to ADB semi-annually.

740. The PIC will also be responsible for coordinating and supervising monitoring of asbestos abatement, quality control, and writing the periodic progress reports on implementation of the AMF.

10.16.5 Asbestos Abatement Procedures

Removal of ACM

741. The principle will be that asbestos cement pipes shall be carefully excavated, lifted on to plastic sheets for wrapping, wrapped in polythene and sealed with duct tape and then lifted and lowered on to the transport lorry for transport to the designated storage area or landfill.

742. The procedure shall follow the measures indicated below:

Preparation

- The Contractor shall make available the materials required for the work.
- The Contractor shall be prepared and agree to remove and transport, on lorries covered with tarpaulins, all the ACM, from the site to the designated facility or secure temporary store to await disposal.
- The Contractor shall provide approved protective clothing to all workers. Protective clothing shall consist of an approved disposable full body coverall, with head cover. Hard hats and boots shall also be made available to all workers by the Contractor.

- Workers handling the ACM shall wear approved half face dust masks protective coverall and goggles. The Contractor shall ensure all workers wear the protective clothing provided.

Abatement Method

- The ACM shall be removed in sections carefully using manual labor and hand tools to expose the old ACM so that it can be lifted carefully to avoid cracking as far as possible. Any accidentally fractured loose pieces of asbestos picked up and stored in plastic bags or barrels and sealed.
- The drums / barrels to contain the fractured pieces of ACM shall be made of plastic or metal. If made of some other material the drums / barrels shall be lined with two layers of 0.15mm polythene sheeting. When the drums are full the plastic lining shall be folded over the pipe segments and secured in place with duct tape and the lid placed on the drum and secured in place with duct tape.
- Before commencing with the removal of the ACM the surface of the asbestos shall be wet. Any dry areas of exposed existing ACM shall be sprayed with water (preferably containing a wetting agent) to reduce fiber release. The wetting agent shall be of a correct mix and concentration in accordance with the manufacturer's instructions as specified under materials (**Section 9.6.6**).
- The wetting solution (amended water) shall be sprayed using equipment capable of providing a 'mist' application to reduce the release of fibers. The existing asbestos material shall be sufficiently saturated to wet it thoroughly. The existing asbestos material shall be sprayed repeatedly during the removal processes to maintain a wet condition and to minimize asbestos fiber dispersion.
- The fixed asbestos cement pipes shall be carefully separated and prized off any supporting brackets and separated from any attached asbestos cement pipes or cement screed base and taken up in manageable sections taking care not to drop, crack, break or damage the asbestos cement pipes. Powered mechanical equipment (such as backhoe) shall not be used to remove the asbestos pipes because this will increase the risk of cracking and fiber release.
- The asbestos cement pipes shall then immediately be wrapped in two layers of polythene or smaller pieces can be double bagged and goose neck tied with duct tape and the polythene shall be wet wiped clean.
- The bottom 10cm of soil below the old ACP shall be assumed to be contaminated with asbestos fragments or fibers and shall be loosened and shoveled or picked up and stored in plastic bags or barrels and sealed as ACM.
- The bottom 5cm of soil below the old ACM pipe, loose debris and rubble will be removed to create a level floor to the trench and to designate the completion of the removal work
- The exposed surfaces of the partially wrapped pipes and the surface of the trench to be sprayed with adhesives (PVA) to be used as "lock down" on surfaces during the final cleanup of the area. This is to bind any traces of asbestos fiber which may remain on exposed surfaces.

- All wrapped asbestos cement packs shall be transferred to the lorries for immediate transportation to the temporary buffer store to await disposal. All wrapped asbestos cement packs shall remain at the temporary buffer store and not be removed
- The workers shall immediately wet wipe down the overalls and mask and wash hands and face and any accidentally exposed areas of skin to decontaminate. The dust masks and overalls, gloves, wet wipes and any other litter shall then immediately be double bagged and goose neck tied for disposal as asbestos waste.
- The PIC will then carry out a visual inspection to certify that all visible asbestos cement pipe and fragments have been removed to a satisfactory standard. If the visual inspection indicates a satisfactory standard all the asbestos cement packs shall be counted and picked up and transferred to the lorries for transportation to the temporary buffer store to await disposal.
- The PIC will then carry out a reassurance visual inspection to certify that all remaining polythene packs and equipment and visible asbestos has been removed to a satisfactory standard and proper decontamination of tools and equipment has taken place.
- The PIC will then check and record the number of packs of waste transferred to the lorries are the same as those that arrive at the temporary buffer or landfill using a trip ticket system.
- The PIC will monitor and periodically audit the buffer store and landfill security to ensure no pilfering or theft of the stockpiled waste.

10.16.6 Materials and Equipment

Containment Materials

- At least two layers of transparent plastic (0.15mm thickness low density polythene (B.S.4932:1973) shall be used for wrapping the ACM in sizes which minimize the need for jointing. Polythene transparent bags and containers used for packing of asbestos waste should be able to resist puncturing by the sharp edges of the asbestos cement.
- The wrappings shall be carefully joined and sealed with wide duct tape, spray adhesive capable of sealing adjacent sheets of polythene and facilitating attachment of polythene to the asbestos cement. The adhesive agents should be capable of adhering and maintaining the wrapping in place under both wet and dry conditions.
- Pipe sections and fragments of 2m or less shall be completely wrapped in polythene or collected in polythene bags. Pipe sections and fragments of greater than 2m shall have the end up to 1m and any cracked or broken areas completely wrapped in polythene. Intact pipe sections greater than 2m shall have the ends end up to 1m and any cracked or broken areas completely wrapped in polythene.
- The access to the asbestos waste shall be guarded at all times by security personnel.

Wetting Agent and Lock Down

- It is strongly recommended to apply amended water containing a wetting agent on the asbestos materials prior to removal so as to minimize the release of asbestos fibers during the removal process. Electrical equipment is not likely to be present in the excavated trenches but if electrical cables are present these should be de-energized and isolated prior to the application of wetting agents.
- The recommended wetting agent for the amended water to enhance penetration should be 50% polyoxyethylene ester and 50% polyoxyethylene ether or equivalent. The wetting agent shall be diluted in accordance with the manufacturers' instructions. As a fall back option household washing up detergent mixed at 10% to amend wetting water can be substituted Water based polyvinyl acetate adhesives (PVA) to be used as "lock down" for spraying on to surfaces during the final clean up of the area shall be able to bind traces of asbestos fibre which may remain on exposed surfaces. The adhesive shall be dyed to indicate where it has been sprayed and facilitate a check as to whether they have been applied or not and to facilitate cross-checking at a later stage.

Lifting Gear & Ladders

- All lifting appliances, i.e. wire slings, ropes and chain blocks, must comply with the local construction sites safety regulations. Valid test certificates must be kept on site for checking at all times.
- Ladders shall be used in line with general safety procedures. Joints and ends of ladders, scaffolds and parts of lifting gear where appropriate shall be sealed with tape to prevent the incursion of asbestos fibers and finished to create a smooth surface to facilitate cleaning.

Respirators (dust mask)

- The respirators to be provided by the Contractor shall be of an approved type contained appropriate for protection against the level of asbestos fibers reasonably expected in the particular stage and environment of work. In this case half face dust mask shall be required.
- The Contractor shall provide disposable paper respirators to all workers with a protection factor of 4 (*e.g. recommended 3M8812 or equivalent*).
- The respirators shall be removed when wet and be treated as contaminated waste. A new half face dust mask shall be provided to each worker prior to each shift, and the Contractor shall hold sufficient spare masks on site at all times for replacement purposes.

Protective Clothing

- The Contractor shall provide approved protective clothing to all workers. Protective clothing shall consist of an approved disposable full body coverall, with head cover. Hard hats and boots shall also be made available by the Contractor. Coveralls will be of a disposable type:
  - made from material which does not readily retain asbestos dust and
  - prevents, so far as is reasonably practicable, dust penetration;

- o is close fitting at the neck, wrists and ankles; and
- o without external pockets or unnecessary pleating or accessories.

Preferred disposable coveralls, mask and sprayer ***Workers handling drummed high risk friable asbestos***

Laboratories in Pakistan with Capability to Identify Asbestos

1. Pakistan Council of Scientific & Industrial Research
PCSIR Labs Complex
Off University Road, Karachi
Tel#: +92-21-8141841
Fax#: +92-21-8141847
2. National Physical and Standards Laboratory (NPSL), Islamabad
Plot No.16, Sector H-9, Islamabad
Tel#: +92-51-9257459, 9257462-7
Fax#: +92-51-9258162
3. Pakistan Council of Scientific & Industrial Research
PCSIR Labs Complex
Ferozepur Road, Lahore
Tel#: +92-42-9230688-95, 9230704
Fax#: +92-42-9230705

10.17 Social Augmentation Plan

Scope of Accruing Social Benefits

743. There have been impacts in the natural as well as social environment due to the operation of the power plant within the project influence area. The people living within the vicinity of JTPS are mostly poor. Taking this point into consideration some social benefits in terms of environmental enhancement are proposed in the EMP. The proposed social augmentation/enhancement measures are explained below:

Providing water supply facility

744. The people living in Jamshoro town and the villages within the project influence area suffer from severe shortage of water for safe drinking and washing purposes. In Jamshoro town, piped water supply by the town management is often insufficient for the residents. As a consequence, most of the people have to spend considerable amounts of money to install their own pumps and/or to buy drinking water from the water carriers. The poorer residents and villagers in the project influence area have to collect untreated water from the Indus River. Most of the water collection activity is done by the women and children on–top of their day–to–day domestic responsibilities.

745. As a result, the women and children suffer from over–work and a variety of water borne diseases. The EMP under this project proposes to provide potable water by constructing small–scale drinking water supply systems or installing hand–pumps at certain convenient points in the urban and rural communities. Provision of drinking water to communities would contribute to the general health of the women and children and save the families from extra fatigue and water buying costs.

Educational Facilities

746. Apart from the Government universities located in the south of Jamshoro town, there are government high schools for both boys and girls in the town and a number of primary schools in the villages within the Project influence area. Besides, there are some private primary schools where only financially solvent families can afford their children for better quality education. Poor families have to send their children to the government schools where the classrooms are overcrowded because the numbers and sizes of the rooms are insufficient.

747. As a result, educational standards are generally low and overall performances of the children are often poor. The EMP proposes financial assistance to the Education department for constructing additional few classrooms to the nearest schools and providing them with necessary furniture and equipment. The same schools can also be used in the afternoons for adult education, community training, and other collective activities.

Agricultural Training

748. Agriculture is not a major economic activity in the Jamshoro, as most lands are barren and there are no irrigation canals in the vicinity. However, some people grow small–scale irrigated crops on river side where the subsurface water table is high. Most of the people are serving either as a sharecropper or working as land labor. The people reported that they had mainly inherited rather than acquired knowledge on farming, and any attempt to pursue that would be appreciated by them. Therefore, it is proposed that farmers will be provided relevant training on modern agriculture.

749. A need assessment will be carried out by the Project Management Consultant before imparting such training by an NGO(s) with the support of provincial agricultural department. The nature of training would largely depend on the ecological setting, availability of water, technology, interest and ability to produce different crops, etc. The training will be imparted by a professional organization or an experienced NGO in agricultural promotion, and previously worked with the farmers in Sindh province.

Skills Training and Capacity Building Activities

750. Having poor land water resources and nominal agricultural activity, the people in the JTPS area depend mostly on employment in both public and private sectors, industrial and construction labor work, and small scale business activities for earning their living. Women prepare some traditional embroidery items to sell in the local markets to supplement their family incomes. The Project will contribute in economic activities by supporting skills training and capacity building activities for these poor communities, especially for the women and youth. By doing this, the project would be enabling the poor families to enhance their earnings and living standards. Training programs will focus in skill development in construction and power industries.

Health Care Facilities

751. People living in the area are devoid of good quality health care system. In case of suburban and rural communities in the villages around Jamshoro, communities during consultation indicated that the government health facilities are insufficient and inefficient, mainly because of lack of qualified doctors and quality medicines. The people requested for creating an opportunity for their health care under the proposed project. It is proposed to establish basic clinic and paramedic to check condition of the health of the people three times a week, so that their needs for primary health care is taken care of. In addition, the project will attempt to provide financial and technical assistance on health issues of Jamshoro town and rural communities in the project influence area to impart training through an experienced NGO and, especially to traditional birth attendants and in preventive measures against water–borne diseases, mother–and–child care, and the like.

Tentative budget for social benefits

752. 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$ 0.328 million, as presented in **Table 10-8**.

Table 10-8: SAP Implementation Cost Estimates

Activity	Social Augmentation and Monitoring Costs			
	Unit	Quantity	Cost in US Dollars	
			Rate	Amount
Social Augmentation Costs – Civil Works				
Construction of Drinking Water Supply Scheme	No.	4	3,238	12,952
Construction of additional Rooms in Schools	No.	6	3,860	23,160
Fixture/Furniture for Classrooms	No.	6	2,150	12,900
Clinic of Primary Health Care (with Fixture & Furniture)	No.	3	3,800	11,400
Sub–total (a):	–	–	–	60,412
Operational Costs of Project Provided Facilities				
NGO Implementation	Years	3	30,000	90,000
Education Material for adult Education	Years	3	800	2,400
Operational Costs of 3 Primary Health Clinics	Years	3	4,800	14,400
NGO Training Services (3 Trainers)	Years	3	2,100	6,300
Primary Health Training Equipment & Material	Sites	2	2,100	4,200
Skills Training for Women and Youth	Sites	2	2,100	4,200
Farmers' training in modern agriculture	Sites	2	800	1,600
Gender Development & HIV/AIDS training (Basic)	Sites	2	800	1,600
Sub–total (b):	–	–	–	124,700
Social Monitoring During and After Project's Construction				
International Social Development Specialist	MM	3	2,100	6,300
Domestic Social Development Specialist	MM	12	6,000	72,000
Field Vehicle for Social Development Unit (SDU)	No.	1	16,800	16,800
Operational Cost of Field Vehicle	Years	3	3,800	11,400
Furniture & Computers for Database/Monitoring	Site	1	3,000	3,000
Social Monitoring Reports (5 bi–annual, 1 final)	Reports	6	600	3,600
Sub–total (c):	–	–	–	113,100
Total Itemized Costs (a+b+c):	–	–	–	298,212
Admin. Costs & Contingency (10% of Total Itemized Cost):	–	–	–	29,821
Total Estimated Cost:	**–**	**–**	**–**	**328,033**

Implementation and Operation

753. Proposed facilities under the social augmentation program require proper operation and maintenance. The following section discusses the operational procedure and maintenance of the facilities.

Setting up the Facilities

754. All facilities proposed under social augmentation program will be created and implemented by the JPCL in association with local NGOs or local government in close collaboration of the beneficiary. Involvement of beneficiary community from the beginning of the augmentation work is critical as without their active involvement the design and implementation will not be as per the requirement of the targeted people. Participatory Rural Appraisal (PRA) method may be used while designing the facilities to identify the possible locations and scope of operation and maintenance as well as management.

Selection of NGOs

755. Selection of NGOs will be done based on their capacity, experience, and interest. Organizations that have experience of carrying out similar assignment will be given priority as operation and management of such types of jobs require capacity and tenacity. There are some good NGOs operating in both Badin and Hyderabad areas as reported by the stakeholders. A short list of those NGOs can be made first and then proposal may be sought from them for the work. Consultant will prepare a TOR containing the descriptions of all works that will be carried out by the selected NGO(s). The TOR will be included as part of Initial Poverty and Social Assessment Report.

Operation of the Adult Learning School

756. Experienced NGO or NGOs will be recruited for the first three years to operate the adult learning school and then hand over the operation to the Local Government Organization such as Union Council or other suitable public or private organization. Selected NGO will identify a teacher from the nearby area or to engage someone, such as the wife of a JPCL staff, who would be interested in the job.

Imparting Training

757. The targeted people will be trained in modern agricultural practices, health care, sanitation, gender and development, and HIV/AIDS. They will be given training on the modern techniques and methods of agricultural production including marketing to make them aware of the market prices of different agro produce. On the other hand, since the rural people often suffer from various health hazards because of lack of basic health care knowledge, it would be beneficial for them to receive training on those issues. The training will be a part of preventive rather than curative measures. All the trainings including good agricultural practices, health care, gender and development, and HIV/AIDS related issues will be conducted by the selected NGO(s). The training will be provided by both male and female trainers, as some of the issues are more suited for female trainers compared to the male trainers.

758. Before conducting the training, the NGO will perform a needs–assessment to prepare the training modules. Based on the module, a manual will be prepared in local languages covering the scope, needs of the training, and the training techniques.

10.18 Spill Management

759. Liquid waste spills that are not appropriately managed have the potential to harm the environment. By taking certain actions JPCL can ensure that the likelihood of spills occurring is reduced and that the effect of spills is minimized.

10.18.1 Avoiding spills

760. By actively working to prevent spills, JPCL 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.

761. 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.

762. 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.

10.18.2 Spill Management

763. 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.

10.18.3 Spill Kits

764. 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.

765. Spill kits are used to contain and clean up spills in an efficient manner. JPCL 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.

766. 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.

767. 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.

10.18.4 Responding to Spills

768. 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.

769. 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.

770. 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.

771. 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.

10.19 Ambient Air Quality Monitoring Program

772. An ambient air quality monitoring program will be initiated in the Jamshoro Area and an air quality assessment undertaken to help improve the baseline and design and implement offset measurement. The information will be used to document the magnitude of $PM_{2.5}$ offset discussed in **Section 9.4.7**. The outline of the program is as follows:

- *Objective:* To determine the $PM_{2.5}$ and PM_{10} levels in Jamshoro area, understand its seasonal variation, and undertake source apportionment of $PM_{2.5}$ and PM_{10} in the area.
- *Spatial Coverage:* Jamshoro Town including the residential area, commercial areas, educational institutions, rural area, colonies, and JTPS. The area is roughly bounded by the Indus River on the East, the M-9 on the South, and the hills on the West and extends to Petaro area on the North.
- *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 (See studies referred in Footnote 12 and 13 of **Chapter 5** for details)
- *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-5; c) locations near maximum GLC; d) sensitive receptors (e.g, LUMHS); e) locations on the East (say near Kotri Barrage) to capture the effects of Hyderabad city.

- *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.

10.20 Transportation Management Plan

773. 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 bulk transportation and to protect the workers of JPCL 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 project feasibility study, this EIA of the Project, and the Coal Logistics Report commissioned by ADB.[1]
- *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 First Stage of the Project.
- *Executing arrangement:* The PIC will be responsible to commission the study and implement its recommendations.

[1] The report will primarily cover coal handling system at port and Jamshoro and the rail transportation.

11. Grievance Redress Mechanism

774. 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.

775. 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 9.

11.1 Framework for Grievance Redress Mechanism

776. 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 SPS 2009.

11.1.1 ADB Safeguard Policy Statement

777. Developing a grievance redress mechanism is mandated under SPS 2009.[1] The requirements for the grievance redress mechanism under the SPS 2009 are laid out below.

SPS 2009 on Grievance Redress Mechanism

ADB requires that the borrower/client establish and maintain a grievance redress mechanism to receive and facilitate resolution of affected peoples' concerns and grievances about the borrower's/client's social and environmental performance at project level. The grievance redress mechanism should be scaled to the risks and impacts of the project. It should address affected people's concerns and complaints promptly, using an understandable and transparent process that is gender responsive, culturally appropriate, and readily accessible to all segments of the affected people.

11.1.2 Pakistan Environmental Protection Act 1997

778. The Federal Agency, under Regulation 6 of the IEE-EIA Regulations 2000 (see **Chapter 3** for more details), has issued a set of guidelines of general applicability and sectoral guidelines indicating specific assessment requirements. Under the regulations and guidelines, no specific requirements are laid out for developing a grievance redress mechanism for projects. However, under its 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.

[1] Safeguard Policy Statement, Asian Development Bank, June 2009

11.2 Existing Practice for Grievance Redress

779. Currently, the grievances of stakeholders against the activities undertaken at JTPS are redressed on an ad hoc basis, where any concern that reaches the management's notice is given attention. A complaints clerk maintains record of complaints in a daily complaints register and coordinates complaint resolution with the plant management. The complaints clerk is also required to keep the complainant informed of the progress. The current mechanism is not sufficient for the purpose of grievance redress. Under the consultations, the local communities voiced their concern that their issues were not addressed (**Chapter 7**).

11.3 Proposed Mechanism for Grievance Redress

780. Under the Project the following will be established or appointed to ensure timely and effective handling of grievances:

- A Public Complaints Unit (PCU), which will be responsible to receive, log, and resolve complaints; and,
- A Grievance Redress Committee (GRC), responsible to oversee the functioning of the PCU as well as the final non-judicial authority on resolving grievances that cannot be resolved by PCU;
- Grievance Focal Points (GFPs), which will be educated people from each community that can 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.

781. Details of the proposed mechanism are given below.

11.3.1 Function and Structure of PCU

782. PCU will be set up as part of the environment, health and safety department[2] of the Project. A senior official with experience in community and public liaison will lead the unit. Two assistants, one male and one female will be responsible for coordinating correspondence and preparing documentation work and will assist the senior official. The senior official will be responsible to review all documentation.

783. The PCU will be responsible to receive, log, and resolve grievances. Given that 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.

11.3.2 Function and Structure of GRC

784. 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, JTPS;
- Senior engineer that is responsible to oversee the contractors, JTPS;

[2] An Environment, Health and Safety Department is not yet in place and is proposed to be set up under the Project (see Chapter 10).

- Two literate representatives from the communities residing near the plant site;
- 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 with experience in community relations.

785. 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.

11.3.3 Grievance Focal Points

786. The GFPs will be literate people from each community that 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.

11.3.4 Procedure of Filing and Resolving Grievances

787. Grievances will be logged and resolved in the following steps:

Step 1: Receive and Acknowledge Complaint

788. 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

789. 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

790. 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.

791. In case the grievance remains unresolved it will be reassessed and GRC will have further dialogue with the complainant to discuss if there are any further steps, which may be taken to reach a mutually agreed resolution to the problem.

792. For minor or less complex grievances, Steps 1, 2 and 3 or Steps 2 and 3 can be merged.

Step 4: Resolution through GRC

793. In case the PCU is unable to resolve the issue, the matter will be referred to GRC. All complaints that could not be resolved within four weeks will by default be referred to GRC. However, the complainant or the PCU can convene the GRC at any point in time, depending on the nature and urgency of the issue.

11.3.5 Operating Principles for PCU

794. 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;
- Employ female staff, preferably from the nearby communities, to oversee complaints and issues of the female community members.
- 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.

11.3.6 Stages of Grievances

795. Once a grievance is logged with the PCU, it could acquire the following stages:

- **Stage 1:** it is resolved by the PCU or if not PCU, by the GRC;
- **Stage 2:** If the GRC cannot resolve the issue, it will inform ADB accordingly, and the ADB project team will organize a special mission to address the problem and identify a solution; and
- **Stage 3:** If the stakeholders are still not satisfied with the reply in Stage 4, they can go through local judicial proceedings.

11.4 Stakeholder Awareness

796. 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.

797. Additional awareness campaigns may be organized, if necessary.

12. Conclusions

798. The proposed power plant, 600 MW in the First Stage and 1,200 MW after the completion of the Second Stage will be installed within the premises of the JTPS. However, it will be an independent power plant, with its own fuel source, storage, utilities and operations.

799. As the existing plant is not fully compliant with the national environmental regulations and is also below the international best environmental practices as signified by ADB's SPS 2009 and IFC's HSE Guidelines, a corrective action plan has been developed. The plan is an essential part of the project as the improvement it will bring to the environmental practices of JPCL and to the physical environment in the vicinity of the JTPS, will enable the installation of the 1,200 MW power plant. The key areas in which the project is likely to bring a positive environmental changes are:

- Installation of FGD on the existing stacks and thereby reducing the emission of sulfur dioxide;
- Rehabilitation of effluent pipeline and therefore preventing of spread of plant waste in the vicinity of the plant;
- Development of a waste storage facility for hazardous waste;
- Development of a landfill site for colony waste;
- Installation of a treatment plant for colony wastewater;
- Rehabilitation of existing evaporation pond and this prevention of release of untreated wastewater to the river; and
- Clean-up and remediation (or containment) of oily waste.

800. 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.

801. The Project will contribute to improved health of the local community by improving air quality through installation of FGDs on the existing boilers to lower SO_2 concentrations in ambient air associated with utilization of HSFO.

802. The project will contribute to improvement in environmental management practices and capacities in the JPCL through institution of a range of environmental management systems and provision of training to the staff of the plant.

803. The new 1,200 MW power project will comply with all the Pakistan regulatory requirements and that of the ADB safeguard policies, with the exception of ambient air quality standards of PM_{10} and $PM_{2.5}$. It has been shown in this document that the background concentration levels of PM_{10} and $PM_{2.5}$ (without JTPS) reflecting the emissions from natural sources either already exceed or are close to the limits specified by the IFC Guidelines. This is a phenomenon that is prevalent all across Pakistan where due dry conditions the dust levels are very high. The annual average background

concentration of PM_{10} is about the same as the limit specified under the IFC Guidelines, while that of $PM_{2.5}$ exceeds both the limits in both the NEQS and IFC Guidelines. The Project includes installation of electrostatic precipitators with 99.9% efficiency on the boilers for the 1,200 MW capacity. The ESP will limit the PM_{10} and $PM_{2.5}$ emission to level that is recommended for degraded airshed. The incremental contribution of the 1,200 MW plant in the ambient air will be about 13% in PM_{10} concentration and 6% in $PM_{2.5}$. The Project will utilize technology to achieve the maximum control possible, will have small incremental impact, and the background concentrations are mainly due to natural sources which cannot be reduced. The Project is therefore considered acceptable under ADB guidelines which require avoidance, or where avoidance is impossible, minimization or control of the intensity or load of pollutant emission and discharge. The proposed 1,200 MW power plant will replace power production from small to medium sized backup generators used by electricity consumers during load shedding. The proposed project will result in a country-wide reduction of $PM_{2.5}$ emission by 5,600 tons. The power consumption in Hyderabad area is about 5.5% of the country-wide demand. Thus, the reduction of $PM_{2.5}$ emission in the Hyderabad Area will be about 300 tons annually due to the 1,200 MW power plant. A detailed ambient air monitoring program including that of the $PM_{2.5}$ will be instituted. The program will be initiated before the commissioning of the Project with the objective of developing a good understanding of the $PM_{2.5}$ issue in Jamshoro area and possibly designing future mitigation programs.

804. It has been recognized that national standards for ambient air quality will require revision. This issue has been discussed with the Sindh Environmental Protection Agency and they have expressed willingness to review the standards.