EXECUTIVE SUMMARY:

LAKHRA COAL MINE AND POWER GENERATION PROJECT ENVIRONMENTAL AND SOCIAL SOUNDNESS ASSESSMENT (INCLUDING ENVIRONMENTAL MITIGATION PLAN)

PAKISTAN WATER AND POWER
DEVELOPMENT AUTHORITY
Lahore, Pakistan

Sponsored by:

OFFICE OF ENERGY AND ENVIRONMENT
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
MISSION TO PAKISTAN
Islamabad, Pakistan

Prepared by:

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
Gainesville, Florida
and
KBN ENGINEERING AND APPLIED SCIENCES, INC.
Gainesville, Florida

85-165-0200-0120

June 1986

EXECUTIVE SUMMARY:

LAKHRA COAL MINE AND POWER GENERATION PROJECT ENVIRONMENTAL AND SOCIAL SOUNDNESS ASSESSMENT (INCLUDING ENVIRONMENTAL MITIGATION PLAN)

PAKISTAN WATER AND POWER
DEVELOPMENT AUTHORITY
Lahore, Pakistan

Sponsored by:

OFFICE OF ENERGY AND ENVIRONMENT
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
MISSION TO PAKISTAN
Islamabad, Pakistan

Prepared by:

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
Gainesville, Florida
and
KBN ENGINEERING AND APPLIED SCIENCES, INC.
Gainesville, Florida

85-165-0200-0120

June 1986

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

AAQS	Ambient Air Quality Standards
ADB	Asian Development Bank
Btu	British thermal units
Btu/kW	British thermal units per kilowatt
CC	combined cycle
CT	combustion turbine
cusec	cubic foot per second
EA	Environmental Assessment
EMP	Environmental Mitigation Plan
ENERPLAN	Ministry of Energy
ESE	Environmental Science and Engineering, Inc.
ESP	Electrostatic precipitation
FBC	Fluidized bed combustion
FGD	Flue gas desulfurization
GCII	Gilbert/Commonwealth International, Inc.
GOP	Government of Pakistan
GSP	Geological Survey of Pakistan
ha	hectare
KBN	KBN Engineering and Applied Sciences, Inc.
km	Kilometer
kV	Kilovolt
lb/10^6 Btu	Pounds per million British thermal units
LIMB	Limestone injection multistage burner
m^3/day	Cubic meters per day
m^3/year	Cubic meters per year
mg/L	Milligrams per liter
MH	Ministry of Health
MI	Ministry of Industry
ML	Ministry of Labor
MPD	Ministry of Planning and Development
MT/day	Metric tons per day

MT/yr	Metric tons per year
MW	Megawatt
NO_x	Nitrogen oxide
NO_2	Nitrogen dioxide
PCSIR	Pakistan Council for Scientific and Industrial Research
PEPA	Pakistan Environmental Protection Agency
PM	Particulate matter
PMDC	Pakistan Mineral Development Corporation
SO_2	Sulfur dioxide
TLV	Threshold Limit Values
ug/m^3	Micrograms per cubic meter
USAID	United States Agency for International Development
WAPDA	Water and Power Development Authority

1.0 INTRODUCTION

This Executive Summary provides an overview of the significant environmental and social effects, as well as proposed mitigations, for a coal mine and power plant project proposed to be located in the Lakhra coal field, Sind Province, Pakistan. The purpose of this document is to summarize the salient features contained in the report titled "Lakhra Coal Mine and Power Generation Project, Environmental and Social Soundness Assessment" so that representatives of the host country and donor organizations have a clear understanding of the significant impacts to the natural and human environment, as well as the project's benefits in developing the coal resources and the necessary electrical energy for Pakistan. Preparation of the Environmental and Social Soundness Assessment followed the procedures of:

1. The Government of Pakistan Environmental Policy and Regulations (Ordinance No. XXVII of 1983 and Environmental Pro forma),
2. The United States Agency for International Development (USAID) Environmental Policy and Regulations (PD-6, 22CFR216), and
3. The environmental policies of the World Bank and Asian Development Bank (ADB).

The Environmental Assessment (EA) was prepared using specific data and information collected for the project through field and site visits by staff from Environmental Science and Engineering, Inc. (ESE) and KBN Engineering and Applied Sciences, Inc. (KBN). Technical and economic information was obtained from J.T. Boyd Company (mining feasibility), Gilbert/Commonwealth International, Inc. (GCII) (power plant feasibility), and ICF Incorporated (economic feasibility). In addition, environmental representatives from J.T. Boyd Company and GCII assisted in the preparation of the mining and social impacts of the project, respectively.

2.0 OBJECTIVES OF THE PROJECT AND THE GOVERNMENT OF PAKISTAN (GOP)

The shortage of electric power is one of the most serious obstacles to the economic and social development of Pakistan. Under the range of current and potential electrical energy demands, new thermal generating capacity will be

required in the early 1990s to assist in alleviating this shortage as well as providing for future energy needs. The Lakhra Coal Mine and Power Generation Project has been proposed as one facet of a comprehensive energy management plan to provide the needed generation. In addition, the project will also assist the Government of Pakistan (GOP) in:

1. Diversifying fuel usage,
2. Increasing energy self-sufficiency and reducing foreign exchange exposure,
3. Developing a coal-fired generation technology base,
4. Mobilizing and developing a modern private sector coal industry, and
5. Providing domestic economic and industrial development.

3.0 DESCRIPTION OF PROPOSED PROJECT AND STUDY AREA

The Lakhra coal project will consist of the following two components: (1) a coal mine with associated facilities (e.g., transportation), and (2) a power generation complex. It is planned that the coal mine and associated facilities will be developed and operated by the private sector, whereas the power plant complex will be operated by the Water and Power Development Authority (WAPDA) of Pakistan's Ministry of Water and Power.

The Lakhra area, including the proposed coal mine and power plant site at Lakhra and the proposed power plant site at Khanot, are located in the Dadu District of the province of Sind (Figure 1). The Indus River runs along the District's eastern boundary in this area. To the east is the Hyderabad District containing the city of Hyderabad. Agriculture is the main economic enterprise in the Dadu District. In the study area, the more suitable agricultural lands occur in the Hyderabad District. Grazing and torrent-watered cropping is the primary agriculture activity within the Lakhra area.

Coal mining is a major source of employment and revenue in the study area. The Lakhra mining area is approximately 15 kilometers (km) west of the Indus Highway and currently includes several privately owned mines. These existing mines occur south of the proposed mining area. Scattered throughout these

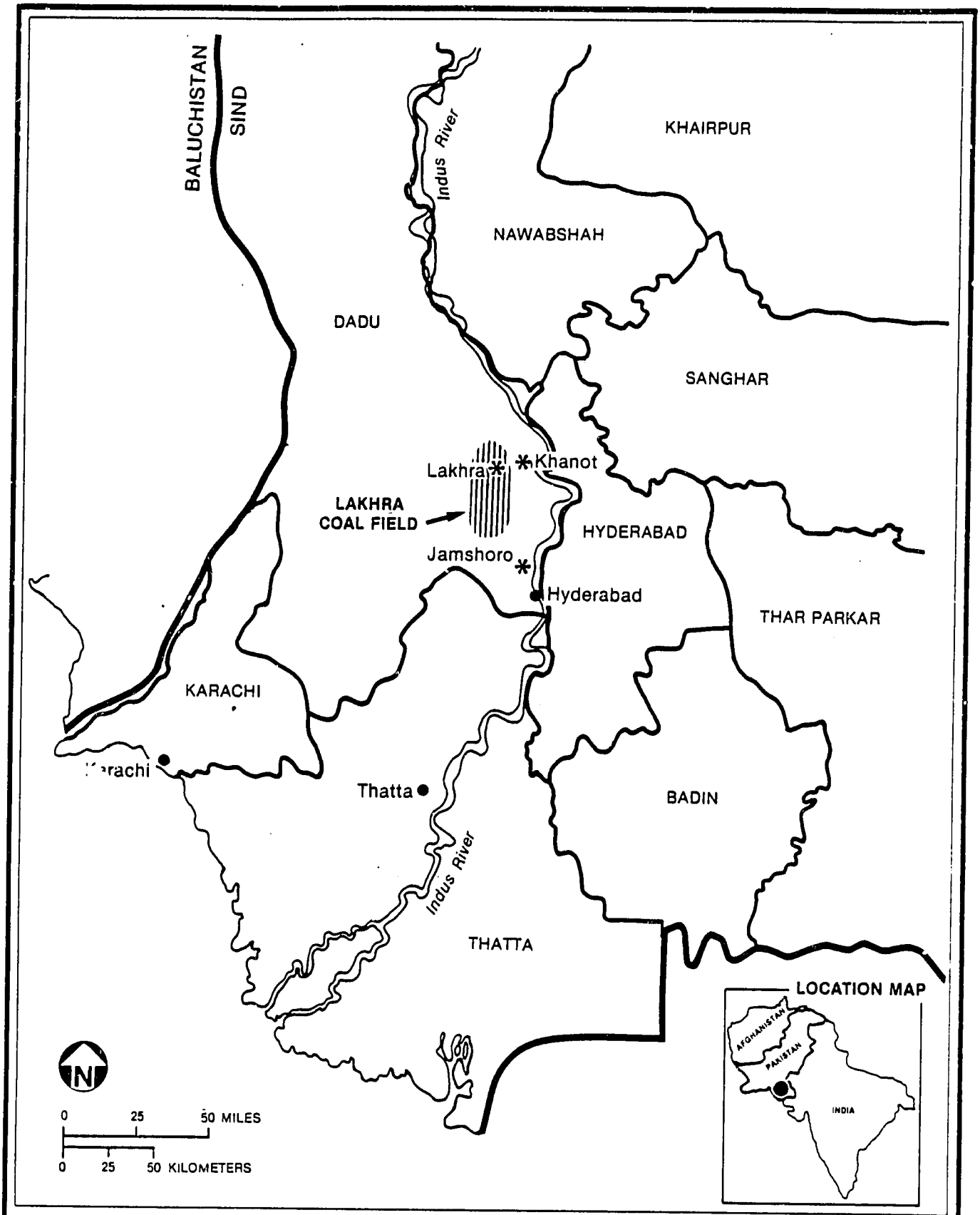


Figure 1
LOCATION OF LAKHRA COAL FIELD
AND PROJECT AREA

SOURCES: GOVERNMENT OF PAKISTAN, 1984; ESE, 1986.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

Lakhra Coal Mine and Power Generation Feasibility Study

mines are several Khosa Baluch villages ranging in size from 20 to 100 people. The main road from the Indus Highway to Lakhra is located approximately 1 km below the village of Khanot. This village is composed of about 2,000 people. A major north/south rail line of the Pakistan Railway runs east of the Indus Highway with a rail station at Khanot. A truck stop with shops and a mosque exists at the intersection. Several other Sindhi villages exist in a 5-km radius to the northeast and southeast of the truck stop. The City of Hyderabad, which is located about 30 km south of the intersection of the Lakhra mine road and the Indus Highway, has a population of approximately 750,000.

The coal mining facilities, as currently envisaged, will include:

1. One and/or two open pit mines and/or one underground mine in the Lakhra Coal field to produce 1.8 to 4.3 million metric tons per year (10^6 MT/yr);
2. Surface coal handling facilities and transportation; and
3. A colony for miners and mine support personnel, along with necessary access roads, utilities, and other necessary equipment and infrastructure.

The power generation facilities, as currently envisaged, will include:

1. A coal-fired, steam power plant with a capacity ranging from 300 to 700 megawatts (MW) located in the Province of Sind either at Jamshoro, Khanot, or Lakhra;
2. Coal receiving storage and handling facilities;
3. Air pollution control equipment including a space for flue gas desulfurization (FGD);
4. Ash handling and disposal;
5. Electrical connection facilities to WAPDA's existing 500-kilovolt (kV) transmission network;
6. An intake water system located on the Indus River, and a water supply line to the power plant of a size sufficient for all plant and colony requirements (with onsite storage ponds at Lakhra);
7. A colony for plant construction, operation, and maintenance personnel;

8. Provision for disposal or use of cooling tower blowdown and low volume wastes;
9. Rail and road access; and
10. Training facilities and secondary infrastructure support.

4.0 ENVIRONMENTAL ASSESSMENT PURPOSE AND SCOPE

The purpose of the EA is to provide host country and donor decision makers with a full discussion of significant environmental effects of the planned coal-fired power plant and associated mine project. The EA includes an evaluation of alternatives which would avoid or minimize adverse effects or enhance the quality of the environment so that the expected benefits of development objectives can be weighed against any adverse impacts upon the human environment or any irreversible or irretrievable commitment of resources.

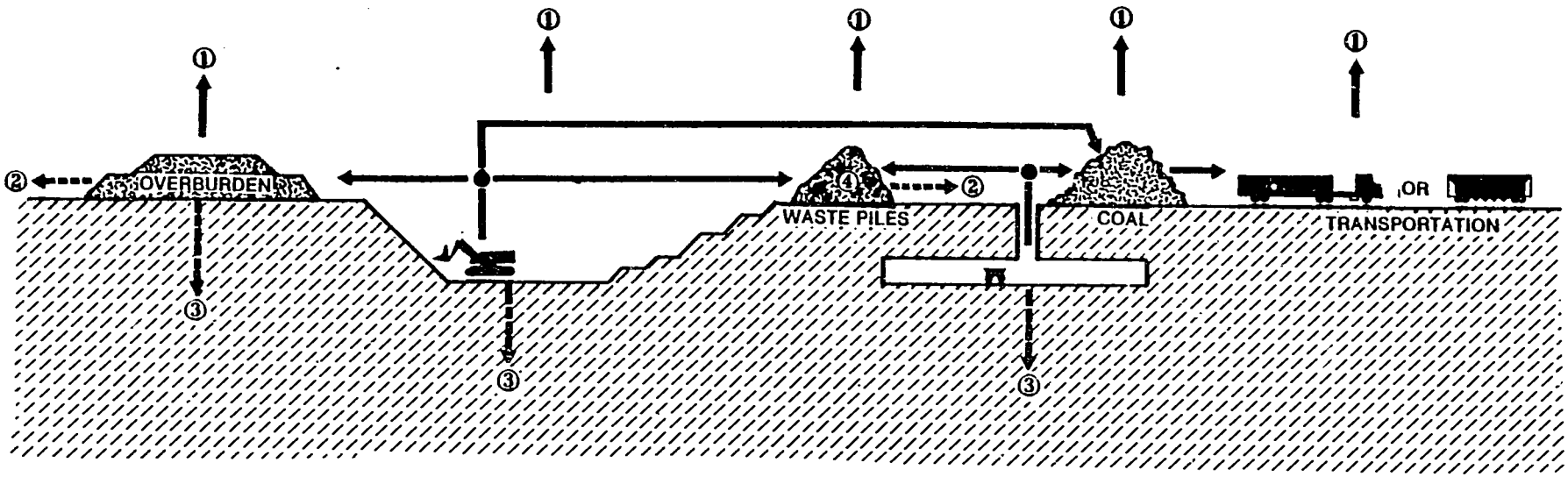
From this evaluation, monitoring programs are developed to assess the project's impacts and to provide a mechanism for managing environmental effects as they occur. These monitoring programs provide the basis for GOP to implement an environmental program for the project.

The scope of the EA is based on the type and magnitude of the project, the existing natural and human environment that may be affected, and the potential for significant impacts. For a coal mine and power generation project, potential environmental impacts may occur to the air, water, and land resources (see Figures 2 and 3) as well as to the existing socioeconomic infrastructure of the region. These potential impacts must be evaluated in the EA to provide the basis for effective decision making.

5.0 ENVIRONMENTAL POLICY AND REGULATIONS

5.1 GOVERNMENT OF PAKISTAN

GOP has initiated through the promulgation of the Pakistan Environmental Ordinance of 1983 the mechanisms for formulating national environmental policy and developing and enforcing national environmental quality standards. Policy and standards approval is the purview of the Pakistan Environmental



KEY
① AIR POLLUTION
② SURFACE WATER DISCHARGE
③ GROUND WATER DISCHARGE
④ SOLID WASTE DISPOSAL

Figure 2
GENERIC FLOW DIAGRAM OF SURFACE AND UNDERGROUND MINE AND MAJOR POTENTIAL ENVIRONMENTAL IMPACTS

SOURCE: ESE, 1986.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

Lakhra Coal Mine and Power Generation Feasibility Study

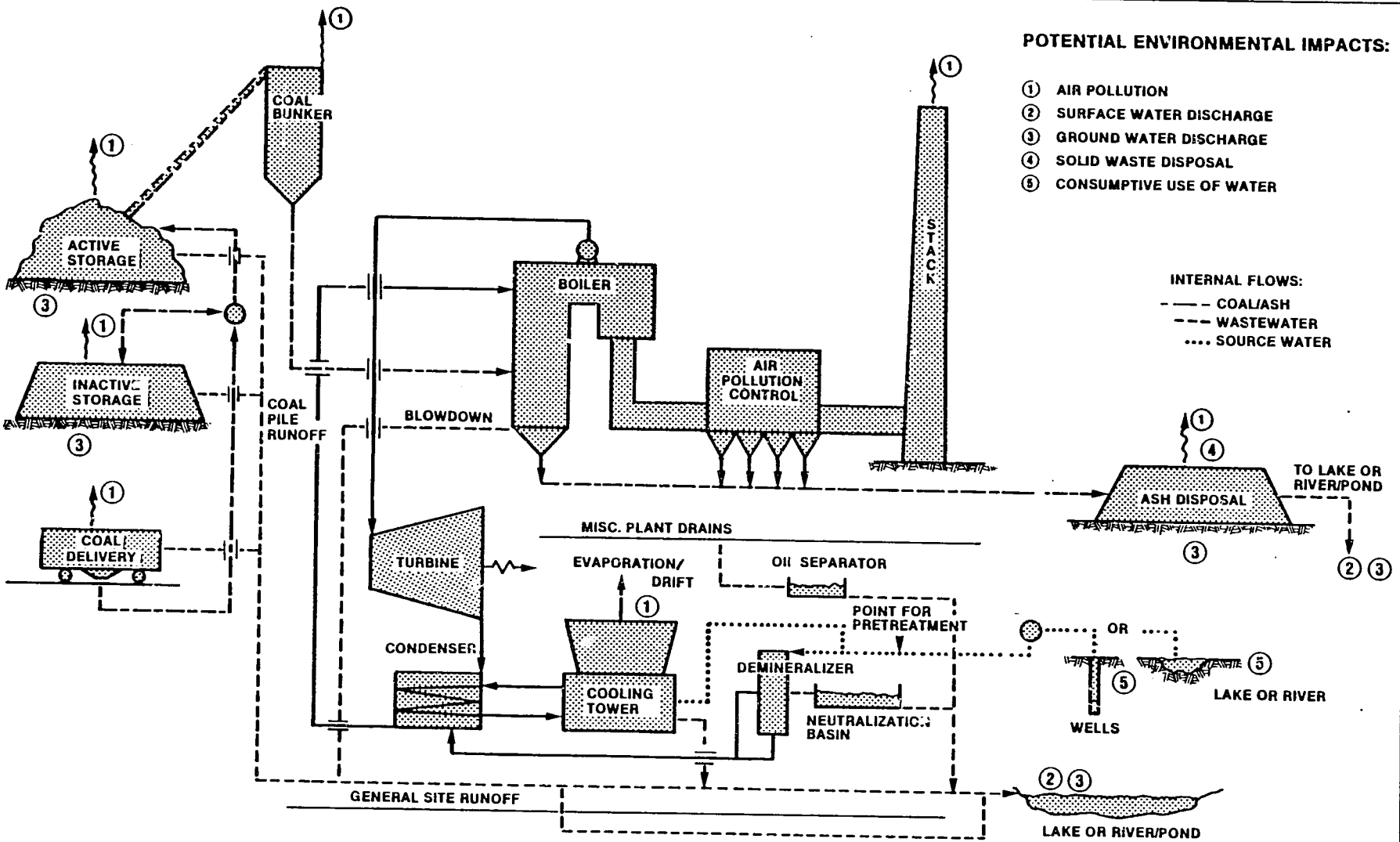


Figure 3
GENERIC FLOW DIAGRAM OF COAL-FIRED POWER PLANT AND MAJOR POTENTIAL ENVIRONMENTAL IMPACTS

SOURCE: ESE, 1986.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

Lakhra Coal Mine and Power Generation Feasibility Study

USAID PAKISTAN 06/89

Council, whereas standards development and enforcement, as well as other environmental programs, are administered by the Environmental and Urban Affairs Division of the Ministry of Housing and Works.

For the Lakhra project, GOP has requested the preparation of an EA via the requirement for an Environmental Pro forma. The details of the Pro forma are contained as an appendix to the EA. Currently, no environmental standards have been adopted by GOP; however, draft standards have been proposed that would restrict the discharge of pollutants into the atmosphere and water.

Additionally, GOP and the Sind Government have established legislation governing antiquities, endangered species, national parks, wildlife sanctuaries, game reserves, forestry, and water management. These requirements are presented in Table 1.

5.2 DONOR ORGANIZATIONS

Multilateral development organizations, such as the World Bank and ADB, have established procedures for the evaluation of potential environmental impacts and the adequacy of pollution control measures of financed projects. These evaluations are concerned with both the natural and human environment as well as the health and safety of workers. Specifically, the Lakhra coal project will be required to consider and evaluate, based on project-specific needs, Environmental Guidelines established by the World Bank. The preparation of the EA for the Lakhra Coal Project involved direct coordination with, and involvement of, the World Bank Office of Environmental Affairs. This coordination assisted in the decision process orientation of the EA and provided a set of environmental criteria for the mine and power plant (Tables 2 and 3).

Bilateral funding organizations, such as USAID, have established policies for evaluating the environmental consequences of funded projects. For USAID, environmental policies have been included as part of promulgated environmental

Table 1. Major Environmental Legislation and Regulations for Pakistan

Type	Authority	Administering Agency	Requirements
Comprehensive Environmental Protection	Ordinance No. XXVII of 1983	Environmental and Urban Affairs Div. Ministry of Housing and Works	Environmental Pro forma
Protection of Antiquities	Act No. VI of 1977	Ministry of Culture, Archaeology, Sports, and Tourism; Dept. of Archaeology	Provides protection and preservation of historically and archaeologically important sites
Water Resources	West Pakistan Act of 1958	WAPDA	Management of water resources
	Sind Irrigation Act of 1879	Government of Sind, Irrigation and Power Department	Granting of water use from Indus River
Wildlife	West Pakistan Wildlife Protection Ordinance of 1959	Zoological Survey; National Council for Conservation of Wildlife; Ministry of Food, Agriculture, and Cooperatives	Promote conservation and establish limits on hunting
Wildlife	Sind Wildlife Protection Ordinance	Government of Sind, Ministry of Forest, Wildlife, and Forestry	Promote conservation and limit hunting

Table 1. Major Environmental Legislation and Regulations for Pakistan (Continued, Page 2 of 2)

Type	Authority	Administering Agency	Requirements
Forests	Forest Act of 1927 No. XVI	Ministry of Food, Agriculture, and Cooperatives; Pakistan Forest Institute; Government of Sind, Ministry of Forest, Wildlife, and Forestry	Protection; regulation of exploitation of forests

Sources: ESE, 1986.
KBN, 1986.

Table 2. Applicable Environmental Criteria for Lakhra Coal Mine

Environmental Resource	Criteria
Air	Ambient Quality for Particulate: 100 µg/m^3 annual geometric mean 500 µg/m^3 maximum 24-hour average.
Land	Surface mine reclamation shall be performed to return lands to conditions capable of supporting prior uses or uses that are equal to or better than prior land use. Develop a sedimentation and erosion control plan. Cover waste piles.
Water	Runoff and drainage limitations: Total Suspended Solids: 30-100 mg/L Total Iron: 4-7 mg/L pH: 6-9 Soluble Toxicants: None Apply best practicable commercially available technology to minimize, control, or prevent disturbances to surface or underground water quality and quantity.
Social and Cultural	Secondary growth effects to general population and tribal people shall be addressed.
Occupational	Threshold Limit Values (TLV) by American Conference of Governmental Industrial Hygienists; World Bank Health and Safety Guidelines for Mining.

Notes µg/m^3 = Micrograms per cubic meter.
mg/L = Milligrams per liter.
TLV = Threshold Limit Values.

Sources: ESE, 1986.
KBN, 1986.

Table 3. Applicable Environmental Criteria for Lakhra Coal-Fired Power Plant

Environmental Resource	Criteria
Air	Emissions: 1. SO_2--908 MT/day (1,000 tons/day) at 85 percent capacity factor 2. Particulate--100 $\mu g/m^3$ 3. NO_x--260 mg/source (0.6 $lb/10^6$ Btu). Ambient Quality: 1. SO_2--100 $\mu g/m^3$ annual average 500 $\mu g/m^3$ maximum 24-hour average 2. Particulate--100 $\mu g/m^3$ annual geometric mean 500 $\mu g/m^3$ maximum 24-hour average 3. NO_2--100 $\mu g/m^3$ annual average
Water, Land, and Noise	No specific limitation but general restrictions on affecting human health and welfare.
Social and Cultural	Secondary growth effects to general population and tribal people shall be addressed.
Occupational	TLVs by American Conference of Governmental Industrial Hygienists.

Notes: SO_2 = Sulfur dioxide.
MT/day = Metric tons per day.
$\mu g/m^3$ = Micrograms per cubic meter.
NO_x = Nitrogen oxide.
$lb/10^6$ Btu = Pounds per million British thermal units.
NO_2 = Nitrogen dioxide.
TLV = Threshold Limit Values.

Sources: ESE, 1986.
KBN, 1986.

procedures [see 22 CFR Part 216; § 216.1(b)] and in an official USAID policy determination on Environmental and Natural Resource Aspects of Development Assistance (see PD-6, April 26, 1983). As part of USAID-funded projects, an EA which is a detailed study of potentially significant environmental impacts must be prepared. The purpose of the EA is to:

1. Ensure that environmental impacts are identified and considered prior to a final decision and that appropriate safeguards are adopted,
2. Assist the host government in developing effective environmental programs,
3. Identify impacts to the natural and human environment, and
4. Define environmental limiting factors for the project.

The Lakhra coal project EA was prepared to address the USAID environmental requirements as well as those of GOP and other bi- and multi-lateral funding organizations. The EA includes:

1. Identification of the potentially affected environment,
2. Identification of environmental issues through a scoping process,
3. Evaluation of project alternatives,
4. Assessment of environmental and social soundness impacts, and
5. Recommendations for mitigation and monitoring programs.

6.0 ALTERNATIVES EVALUATED

6.1 MANAGEMENT ALTERNATIVES

Although Pakistan has an installed capacity of about 2,550-MW hydro-power generation and over 2,000-MW thermal-power generation, load shedding has occurred because of the inability of the electric system to meet energy demands. To meet its existing and projected energy needs and alleviate load shedding and associated socioeconomic impacts, Pakistan is projected to need approximately 1,000 MW of new capacity each year until the turn of the century. Therefore, the "no-project" alternative would worsen the current shortage of electrical energy and result in significant social/economic impacts. Energy conservation would produce benefits; however, in itself energy conservation would not lower demand sufficiently to eliminate the need for

additional generation. Postponing unit retirements would also not substantially increase electrical supply. Rehabilitation of older plants is currently a part of WAPDA's expansion program. Nine units from seven existing generating stations (Multon, Faisalabad, Guddu, Sukkur, Quetta, Shahdara, and Kotri) are scheduled for upgrades with an in-service rehabilitation date of about June 1989; however, an increase of only about 126 MW is anticipated. Management alternatives do not provide a means to meet Pakistan's energy demands.

6.2 ALTERNATIVE PROJECTS

The current electrical generation plan for Pakistan (WAPDA, 1986) includes provisions for a variety of generation projects including hydro, steam, and combustion turbine combined-cycle generation (see Table 4). A number of these projects have been committed to (and in some cases initiated or already completed), whereas others on the list, including the Lakhra project, are in a proposed or conceptual stage. Generation studies sponsored by USAID and coordinated with WAPDA have identified the need for additional baseload capacity to meet 1991-1993 demand. Viable alternatives for increased power generation include plants fired with domestic (Lakhra) coal, imported coal, or imported oil; nevertheless, all three types of plants are included in the generation plan. An environmental/social soundness analysis (see Table 5) of these alternatives suggests that a domestic coal-fired power plant is part of an overall generation program.

6.3 PLANT-SPECIFIC ALTERNATIVES

The project-specific alternatives include three basic plant configurations: one 300-MW unit; two 250-MW units; and two 350-MW units. The basic design specifications of these alternatives are listed in Table 6.

These alternatives were evaluated on the basis of economic and environmental criteria. Because of the low heating value of the Lakhra coal and the advantages of using open pit mining to effectively utilize the coal resources, a 300-MW plant may not be as economically viable as a larger plant. Projected costs for supplying coal for a 300-MW plant were estimated to be about

Table 4. Summary of Pakistan's Power Generation Program (After April 1986)

Station/Project Designation*	Unit Number(s)	Total Capacity (MW)	In-Service Dates
Kot Addu CT	1-8	800	From Nov 86 to Feb 89
CC	9-10	200	Jun 89
Guddu CC	5,6	200	Dec 87 and Jun 88
Jamshoro Imported Oil	1-6	1,570	From Dec 88 to Dec 93
KESC Steam	D-3,D-4,D-5	630	From Feb 89 to Dec 89
Mangla	9 and 10	200	Sept 89
Undesignated CT	1,2	200	Dec 89
Tarbela	11-17	2,928	From Jun 90 to Dec 95
Faisalabad CC	9 and 10	80	Feb 90
Kotri CC	7 and 8	40	Feb 90
Multan	1-3	630	From Oct 90 to Oct 91
Lowhead Hydro	†	420	From Dec 90 to Dec 92
Lakhra Coal	1 and 2	600	From Mar 92 to Dec 92
Undesignated Imported Coal	1-3	1,200	From Dec 93 to Dec 95
Kalabagh	1-5	1,500	From Sep 94 to Sep 95

*CT = combustion turbine; CC = combined cycle.
†Chashma, Taunsa, and Jinnah.

Source: WAPDA, 1986.

Table 5. Summary of Alternative Project Evaluation

Alternative Project	Environmental Score	Environmental Rank
Domestic Coal (Lakhra)	35	First
Imported Coal	33	Second
Imported Oil	33	Second

NOTE: The environmental evaluation of alternative projects was performed by calculating rating coefficients with respect to four environmental criteria (air, land, socioeconomics, and water resources). To develop rating coefficients, sites were compared two at a time against each environmental criterion. The environmental analysis is summarized below.

	Environmental Resource Rating*				
Site	Air	Land	Socio-economic	Water	Sum
Lakhra-Coal	0	0	23	12	35
Imported-Coal	10	5	6	12	33
Imported-Oil	5	10	6	12	33

*Higher ratings denote a more environmentally favorable alternative.

Sources: ESE, 1986.
KBN, 1986.

Table 6. General Design Specifications and Environmental Discharges for Power Plant Alternatives (at 100 Percent Capacity Factor)

Design Specification/ Environmental Discharges	Plant Size (MW)		
	300	Two 250	Two 350
Heat Rate (Btu/kW)	11,120	11,016	11,200
Heat Input (10^6 Btu/hr)	3,336	5,508	7,834
Average Annual Coal Consumption (10^6 MT)	1.6	2.7	3.8
Air			
Sulfur Dioxide Emissions			
Maximum (MT/day)	585	967	1,373
Annual Average (1,000 MT)	149	247	351
Particulate Matter			
Maximum (MT/day)	5.8	9.8	13.9
Annual Average (1,000 MT)	1.5	2.5	3.5
Nitrogen Oxides			
Maximum (MT/day)	21.8	36.0	51.2
Annual Average (1,000 MT)	5.6	9.2	13.1
Water			
Consumptive Use ($1,000 m^3$/day)	33	55	77
Cooling Tower Blowdown ($1,000 m^3$/day)	1.8	2.9	4.1
Filter Backwash ($1,000 m^3$/day)	2.0	3.3	4.6
Fly Ash Transport ($1,000 m^3$/day)	14	24	33
Bottom Ash Sluice ($1,000 m^3$/day)	1.2	2.0	2.8
Solid Waste			
Bottom Ash (1,000 MT/yr)	135	224	318
Fly Ash (1,000 MT/yr)	203	336	478
Water Treatment Sludge ($1,000 m^3$/yr)	218	363	508

Notes: MT = Metric tons.
Btu/kW = British thermal units per kilowatt.
10^6 Btu/hr = Million British thermal units per hour.
m^3/day = Cubic meters per day.
m^3/yr = Cubic meters per year.

Sources: GCII, 1986.
ESE, 1986.
KBN, 1986.

18 percent higher than for a 700-MW plant using comparable mining techniques. In addition, a 300-MW plant would provide only a portion of the needed generation; however, if underground reserves were sufficient to supply the entire needs for a 300-MW plant, overall generation costs may be economically viable.

The principal environmental design criterion for the plant will allow each unit an SO_2 emission limit of 450 MT (500 tons) per day when operating at 85 percent of rated capacity. Based on the above design criterion, a plant consisting of two 250-MW units would achieve this criterion and on an annual average basis have the SO_2 emissions of approximately 340 MT (370 tons) per day per unit at the projected annual average operating capacity factor of 70 percent. This environmental design criterion has been found acceptable to the World Bank, provided emissions at this level are demonstrated not to cause significant impacts to local, regional, and global environments.

A plant consisting of two 350-MW units would be required to install FGD equipment to reduce SO_2 emissions to levels acceptable to the World Bank. The addition of FGD equipment would result in significant economic penalties as well as environmental effects (see Air Emission Control Alternatives section) that would make a two 350-MW project economically unattractive. Therefore, based upon a balance of economic and environmental criteria, a two 250-MW plant is the preferred alternative.

6.4 POWER PLANT SITE ALTERNATIVES

Three potential sites were evaluated for the power plant complex: Jamshoro, Khanot, and Lakhra (Figure 4). An evaluation of these sites was performed by evaluating the air, land, socioeconomic, and water resource effects pertaining to each site. The results (see Table 7) indicate that the Lakhra site is environmentally superior to either the Jamshoro or Khanot sites. Although the Jamshoro site was ranked second environmentally, potential air quality impacts

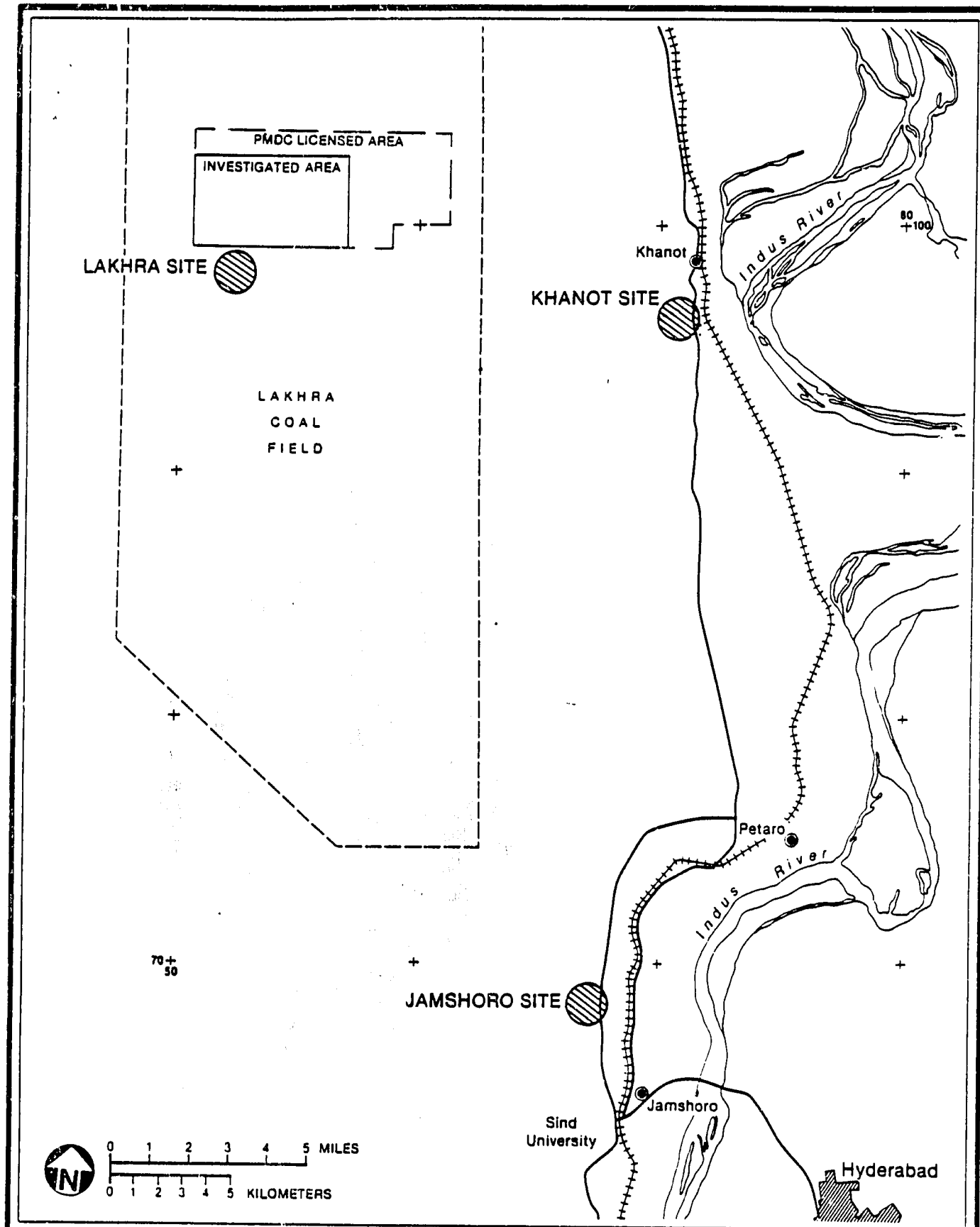


Figure 4
LOCATION OF ALTERNATIVE SITES

SOURCE: ESE, 1986.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

Lakhra Coal Mine and Power Generation Feasibility Study

Table 7. Summary of Power Plant Site Alternatives Analysis

Site	Environmental Score	Rank
Lakhra	48	First
Khanot	22	Third
Jamshoro	29	Second*

*Fatal flaw in environmental impacts determined due to air impacts to local hospital.

NOTE: The environmental evaluation of alternative projects was performed by calculating rating coefficients with respect to four environmental criteria (air, land, socioeconomics, and water resources). To develop rating coefficients, sites were compared two at a time against each environmental criterion. The environmental analysis is summarized below:

Site	Environmental Resource Rating*				
	Air	Land	Socio-economic	Water	Sum
Lakhra-Coal	17	3	5	23	48
Imported-Coal	0	3	20	6	29
Imported-Oil	8	3	5	6	22

*Higher ratings denote a more environmentally favorable alternative.

Sources: ESE, 1986.
KBN, 1986.

to sensitive receptors such as the Liaquat Medical College and Hospital make this site unacceptable.

Further analysis of specific environmental impacts of two 250-MW units located at Lakhra or Khanot was performed. The results of this analysis indicated the potential for significant air pollution impacts to the population and agriculture of the Indus Valley from a plant located at the Khanot site (see Figure 5). Conversely, at the Lakhra site the potential for significant air quality impacts is small because the site is located over 20 km from the Indus Valley agricultural areas and is very sparsely populated, with only minor agricultural activities.

The remoteness of the Lakhra site, which is an advantage in relation to affecting existing human populations, agriculture, and the natural environment, makes this site much less suitable as a site for a power plant workers colony. As a result, the placement of a power plant workers colony near Khanot, where living conditions are more customary and acceptable, would be a viable alternative (see Infrastructure Alternatives section). Worker transportation, if provided by buses and traveling on an improved road, will not extend the workday by more than approximately one hour.

6.5 MINING TECHNOLOGY ALTERNATIVES

To supply from 1.6 to 3.8 x 10^6 MT/year of Lakhra coal, various mining alternatives have been proposed, including an underground mine, a surface mine, or a combination of an underground and surface mine (see Table 8). In addition, the existing private sector mines may provide some supplementary coal. The preferred mining alternative is a combination of a surface and underground mine which considers the following factors:

1. The economy of a large surface mine,
2. The use of an underground mine that utilizes existing technology with improved modern techniques,
3. Maximizing the recoverable resources, and
4. Providing fuel supply reliability.

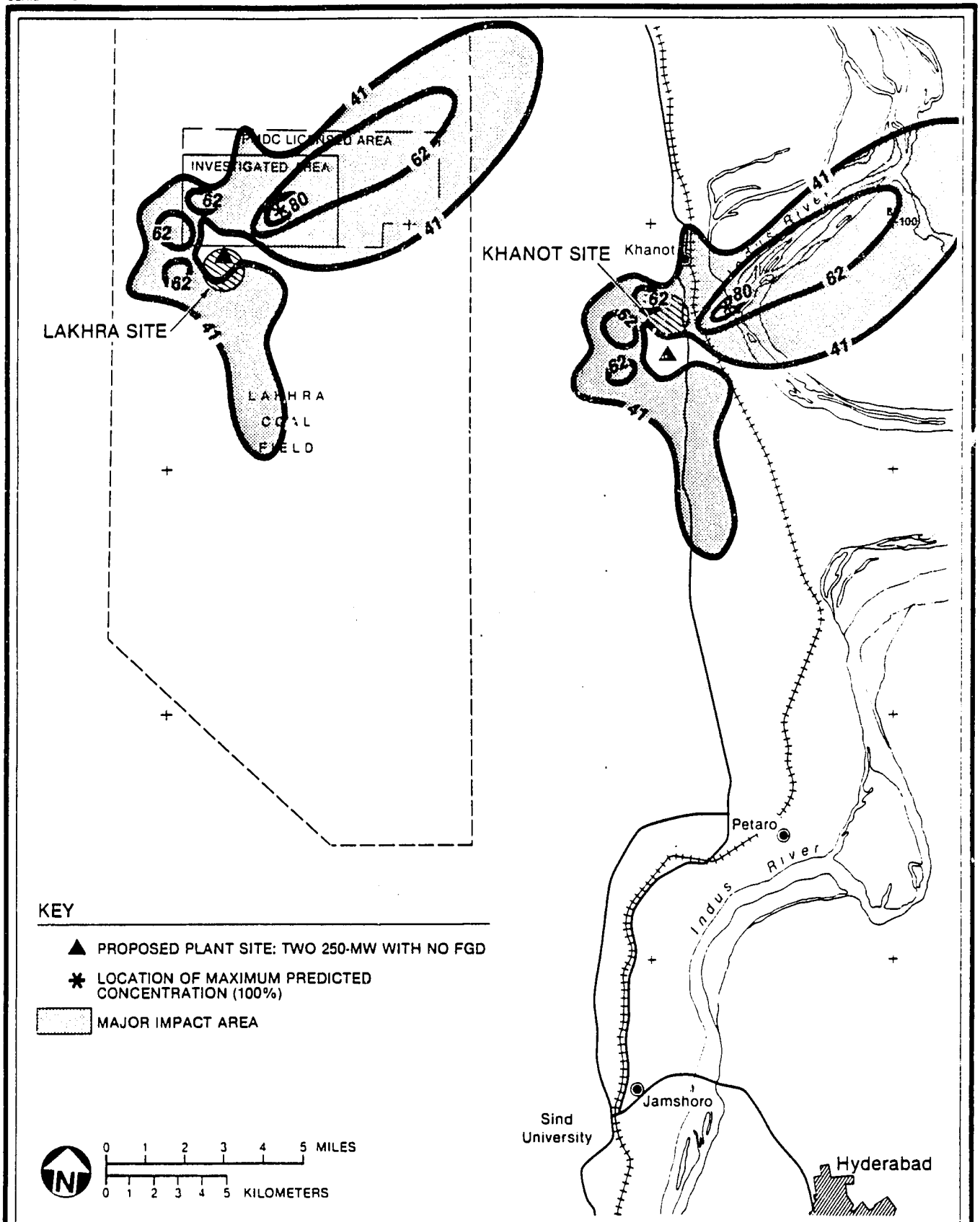


Figure 5
SPATIAL DISTRIBUTION OF MAXIMUM PREDICTED 24-HOUR AVERAGE SO_2 CONCENTRATIONS (% OF MAXIMUM CONCENTRATION)

SOURCE: ESE, 1986.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

Lakhra Coal Mine and Power Generation Feasibility Study

Table 8. Mining Alternatives

Output (10^6 MT/yr)	Plant Size	Underground (10^6 MT/yr)	Surface (10^6 MT/yr)	No. of Surface Mines	Over-burden Removed (10^6 MT)	Surface Area Impacted (ha)
1.6	300	0.9	0.7	1	12	390
1.6	300	0.0	1.6	1	28	910
1.6	300	1.6	0.0	0	0	<100
2.7	500	0.3	2.4	2	42	1,360
3.8	700	0.3	3.5	2	61	1,990

Notes: 10^6 MT/yr = Million metric tons per year.
ha = hectares.

Sources: J.T. Boyd, 1986.
ESE, 1986.
KBN, 1986.

The areas affected by the surface and underground mines are presented in Figure 6. The mines will comply with the World Bank environmental and occupational health and safety guidelines for surface and underground mining. In addition, they will conform to internationally recognized standards for environmental protection, mining technology, occupational health and safety, and resource recovery. The mines will also be required to have properly designed programs for emergency prevention, planning, and management. The power plant will be authorized to obtain indigenous coal only from other sources which have been found by an inspector qualified in modern mining practices, to comply with guidelines used for project-supported surface and underground mines for environmental protection, mining technology, occupational health and safety, and resource recovery.

6.6 COAL TREATMENT ALTERNATIVES

The process of physically cleaning coal has been practiced for many years to reduce ash-forming impurities and improve British thermal units (Btu) content. More recently, coal washing has been used to reduce the sulfur content of coals. Sulfur occurs in coal in three forms: organic, sulfate, and pyritic sulfur. Organic sulfur, in which the sulfur is chemically bound to the coal, cannot be removed by mechanical means. Sulfate and pyritic sulfur, which are not chemically bound, may be removed from the coal in varying degrees. Processes are available for chemically removing organic sulfur (solvent-refined coal), but these processes have not been demonstrated commercially.

Coal washability tests, sponsored by USAID and performed under the direction of GCII and J.T. Boyd Company, indicated that SO_2 and particulate matter (PM) emissions could be reduced by about 40 and 50 percent, respectively. In addition, the Btu content would be improved by approximately 20 percent; however, there is a concomitant loss of about 22 percent in net energy by coal washing, which would result in a significant increase in coal costs. Therefore, this alternative was found not to be economically viable and was rejected from further consideration.

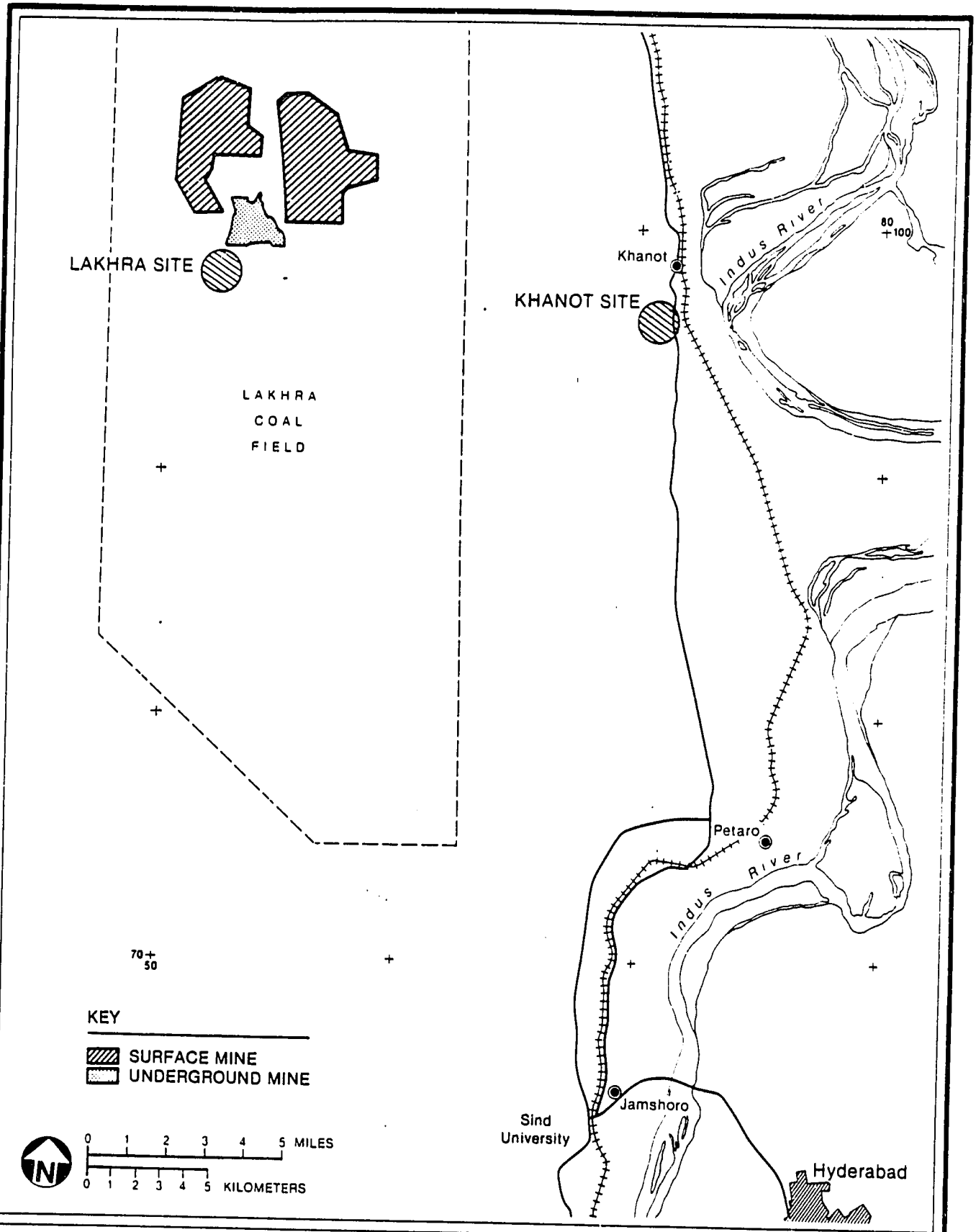


Figure 6
GENERAL AREA FOR SURFACE AND UNDERGROUND MINES

SOURCE: ESE, 1986.

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

Lakhra Coal Mine and Power Generation Feasibility Study

6.7 AIR EMISSIONS CONTROL ALTERNATIVES

An evaluation of air pollution emissions control alternatives included FGD for SO_2 removal, electrostatic precipitation (ESP) or fabric filters for particulate removal, and combustion controls for NO_x reduction. A summary of the evaluation is presented in Table 9.

An evaluation of FGD systems based on consideration of uncontrolled emissions, SO_2 removal efficiency required, availability of reagents, availability and quality of raw water make up, by-product disposal, and potential for salable FGD by-products determined that a wet limestone slurry FGD system producing a throwaway gypsum by-product would be a preferred alternative for the project if SO_2 removal is required. The wet FGD system would be more economical than a dry or regenerable system and would achieve the same desired efficiency.

As previously discussed, in order to meet the project's environmental criteria, the application of an FGD system would be required for two 350-MW units, and this requirement makes this alternative economically unattractive. For two 250-MW units, an FGD system would not be necessary to meet project criteria. Although an FGD system could be installed to reduce SO_2 emissions from a 500-MW plant, the economic impacts would still be significant and make this alternative economically unattractive. Furthermore, the net air quality benefit would not be as great as the emission reduction for any FGD systems evaluated. For example, a 45 percent reduction in emissions using partial FGD would reduce maximum air quality concentrations by only 27 percent; a 90 percent emission reduction would reduce maximum air quality concentrations by only 78 percent. In addition, an FGD system would also increase water consumption by about 30 percent. Therefore, because of the economic penalty, water usage, and the relatively lower air quality benefit associated with FGD systems, the preferred alternative for two 250-MW units would not include the construction and operation of an FGD system; however, space for an FGD system would be provided.

Table 9. Air Pollution Control Alternatives Comparison for SO_2 Removal

	Emissions*	Air Quality Impact†		Annualized Cost**
		24-Hour	Annual Average	
Base--No SO_2 Reduction	2.0	0.41	0.20	-0-
22.5% Removal	1.5	0.46††	0.22††	0.25-0.46
45% Removal	1.3	0.54	0.27	0.44-0.74
67.5% Removal	0.6	0.70††	0.41††	0.52-0.88††
90% Removal	0.2	0.91	0.59	0.60-1.01

*Normalized to MT/day/MW.
†Normalized to $\mu g/m^3$/MT emission for 24-hour and $\mu g/m^3$/1,000 MT emission for annual average.
**Normalized to $/kWh for 5 and 10 percent discount rates.
††Estimated from data.

Sources: ESE, 1986.
KBN, 1986.
ICF, 1986.

Fluidized bed combustion (FBC) boilers and limestone injection multistage burners (LIMB) were considered as alternative technologies for reducing SO_2 emissions. Because of the developmental nature of these technologies, the specific requirements for burning Lakhra coal, and the need to construct new generation by the mid-1990s, conventional steam generator technology was considered most appropriate for the Lakhra project.

For particulate control, ESPs are the preferred alternative over fabric filters. The abrasive nature of fly ash generated by burning Lakhra lignite, as determined from combustion tests, would make fabric filters unsuitable for particulate control.

NO_x emissions will be controlled through combustion techniques that may include low excess air burners and staged combustion. Final design will depend upon the boiler vendor selected.

The alternative for controlling fugitive dust emissions from mining and lignite handling include paving (for roads only), chemical stabilization, and watering. Watering is the preferred alternative because low quality water (cooling tower and boiler blowdown) will be readily available and lower in cost than paving and chemical stabilization. Also, the latter two alternatives cannot be easily adapted to the evolving nature of the surface mine.

6.8 INFRASTRUCTURE ALTERNATIVES

The mine and power plant workers colony will include provisions for:

1. Housing;
2. Utilities, including potable water, electricity, sewage disposal, and municipal refuse;
3. Primary and secondary education facilities;
4. Mosque;
5. Recreational facilities;
6. Fire and police protection;
7. Stores;

8. Training facilities;
9. Transportation;
10. Medical facilities; and
11. Telecommunications.

These facilities will be available for both the mine and power plant colonies; however, the specific site for each colony was evaluated under two alternative scenarios: Khanot or Lakhra.

The construction and operational activities of the mine and power plant will cause a number of potential direct impacts to cultural resources of the area and require consideration for secondary infrastructure development. These impacts include:

1. Increased demand upon existing facilities and services,
2. Induced development in the surrounding area associated with construction of the mine and power plant,
3. Disruption of existing transportation and communication systems,
4. Change in employment and economic patterns, and
5. Disruption of existing cultural patterns and values.

The areas most affected by these impacts include the village of Khanot and the general Lakhra area.

The results of the infrastructure evaluation are as follows:

Site	Relative Score	Rank
Khanot	67	First
Lakhra	34	Second

For the workers colony, the results suggest that the preferred location for both mine and power plant worker's colonies is the Khanot area. The major reasons for this ranking are:

1. Significant air quality impacts in the Lakhra area,
2. Proximity of Khanot to urban areas,
3. Ability of the Khanot area to support cottage industries, and
4. Employee acceptance.

The power plant worker's colony will be designed and built by WAPDA, based on WAPDA's standard practices and procedures for layout and construction of such colonies. The mine worker's colony will be built by the private company or companies responsible for supply of coal to the power plant. No details on the design of the miner's colony will be available until the coal supplier is identified and the specific plans are available. Because of the different working patterns and requirements of the mining and plant workers, the residential and mosque facilities for the two groups should be separate, whereas common facilities should include schools, clinics, market areas, and utility systems (water, sewer, electric) as well as public services (police and fire protection).

Secondary infrastructure development should consist of a series of community and infrastructure improvements brought about by the project. In addition, certain services provided to the workers also should be made available on a limited basis to the local inhabitants. The suggested alternatives are

1. Improvement/upgrading of Indus Highway from Kotri to Khanot,
2. Public availability of potable water at selected stations,
3. Public availability of medical facilities on an emergency basis and 1 to 2 days per week (as scheduled), and
4. Coordination with local governments (Sind Province and Dadu District) for areawide improvements in police and medical facilities.

6.9 EMPLOYMENT ALTERNATIVES

The construction and operation of the mine and power plant complex will require skilled and unskilled workers. The surface and underground mine activities will require about 1,000 employees with about 150 employees needed directly for the colony. Operation of the power plant will also require about

1,000 employees with a similar number of colony personnel. These workers will include both permanent and transient workers from the mine operator, WAPDA, and contractors. During the initial stages of the project, the mine operator, WAPDA, and contractor's staff will be increasing to form the construction employment base (greater than 1,500 construction-related employees) that will extend over several years. After construction is complete, employment will decline to operational levels with a majority of the decrease occurring in contractor employees. This variation in labor force will require the development of the mine and power plant infrastructure early in the project schedule. To ensure adequate facilities are available, an implementation plan for infrastructure development for construction workers, many of whom will arrive in the Lakhra/Khanot area prior to operational workers, is needed. Alternatives for obtaining the necessary employees are listed in Table 10.

During the construction and initial phases of operation, management and technical advisors will be expatriate; however, the actual number of expatriate employees is expected to be small. Skilled construction workers will likely come from the Hyderabad area, whereas unskilled workers will come from the rural Dadu District population as well as the Khosa Baluch (nomadic villagers of the Lakhra area). Mine workers, particularly underground miners, will likely come from the existing mines. These miners are generally Swati immigrants who work existing mines for 4 to 6 months out of the year. Providing improved working and living conditions for these miners as a result of the Lakhra project would produce a more stable employment base.

7.0 PROPOSED ACTION AND IMPACTS

The preferred project alternative consists of a collocated power plant (two 250-MW units) and associated surface/underground mine. The potential effects associated with the construction and operation of the project are presented in Table 11. Impacts to the physical, biological, and social environments are presented in Tables 12, 13, and 14. A majority of these impacts, however,

Table 10. Employment Alternatives

General Job Classifications	Existing Employment Sources					
	Dadu District	Khosa Baluch	Hyderabad Urban	Hyderabad Rural	Other Pakistani	Ex-Patriate
Construction/ Development						
Management			SS*		SS	PS†
Technical			SS		SS	PS
Skilled Craft			PS		SS	
Laborers	PS	SS	SS	SS	SS	
Operation**						
Advisors-- Tech/Mgt						PS
Management			PS		SS	
Technical			PS		PS	
Skilled Craft			PS		SS	
Laborers	PS	SS	SS	SS	SS	

*SS = Secondary source of employees.
†PS = Primary source of employees.
**After training of Pakistani staff.

Sources: ESE, 1986.
KBN, 1986.

Table 11. Potential Environmental Effects Evaluated for the Construction and Operation of Lakhra Coal-Fired Plant and Coal Mine

CONSTRUCTION
Change of Land Use
Vegetation Removal and Loss of Habitat
Increased Soil Erosion and Runoff
Change in Drainage
Change in Surface Water Quality
Spills and Chemical Usage
Road Traffic and Road Kills
Noise and Vibration
Air Emissions--Fugitive Dust from Construction and Overburden Removal
OPERATION
Thermal Discharge
Discharge of Blowdown Chemicals
Change in Surface Water Flow and Quality
Change in Ground Water Table Quality
Maintenance Dredging
Entrainment
Fog Formation
Formation of Biological Barriers and Corridors
Loss of Future Biological Productivity
Chemical Spills and Nonpoint Source
Domestic Wastes Discharge
Air Emissions-includes emissions from stacks, fugitive dust from coal handling, and reclamation
Noise and Vibration
Avian Hazards--from stacks, transmission, etc.
Increased Access--i.e., opening up otherwise less accessible natural areas
Consumptive Water Use
Induced Development--associated with power plant in the surrounding area
Disruption of Cultural Values and Patterns
Loss of Cultural, Historical, and Archaeological Resources

Sources: Argonne National Laboratory, 1978.
ESE, 1985.
KBN, 1986.

Table 12. Environmental Impacts for Construction and Operation of Lakhra Coal Mine and Power Plant--Physical Impacts

Impacts	Extent/Duration/Significance* of Impacts
Construction	
Change of Land Use	Site specific/long-term/not significant.
Increased Soil Erosion and Runoff	Site specific/long-term/not significant.
Change in Drainage	Site specific/long-term/not significant.
Change in Surface Water Quality	Site specific/long-term/not significant.†
Spills and Chemical Usage	Site specific/short-term/easily mitigated by prevention.
Air Emissions	Regional/short-term/moderately significant near source, not significant after about 5 km.
Operation	
Thermal Discharge	Site specific/long-term/not significant.
Change in Surface Water Flow and Quality	Site specific/long-term/not significant.**
Change in Ground Water Quality	Site specific/long-term/minor effects; pond leachate may degrade ground water quality; acid mine waste may further degrade ground water quality; low impacts due to limited quantity and low quality of existing ground water.††

Table 12. Environmental Impacts for Construction and Operation of Lakhra Coal Mine and Power Plant--Physical Impacts (Continued, Page 2 of 2)

Impacts	Extent/Duration/Significance* of Impacts
Maintenance Dredging of Ponds and Land or Mine Disposal of Solid Wastes	Site specific/long-term/not significant; will likely improve quality of leachate from settling/evaporation ponds.***
Chemical Spills and Nonpoint Sources	Site specific/short-term/not significant; little or no impact due to low rainfall and high evaporation rates in region.
Domestic Wastes Discharges	Site specific/long-term/minor impacts.
Consumptive Water Use	Site specific/long term/minor impacts; downstream water availability reduced by about 25 cubic feet per second (cusecs), which is a small amount compared to available supplies from the Indus River.
Air Emissions	Regional/long-term/moderately significant near source, minor after 20 km.

*In terms of impacts, the following definitions are used:
1. Extent refers to the areal effect of the impact, e.g., whether the impact is confined to the site only or extends some distance from the site;
2. Duration refers to the length of time the impact will last, e.g., whether the impact is short-term, lasts for several years, or for much longer periods; and
3. Significance refers to the magnitude of the impact in relation to the type of resource being impacted.

†Indus River is only perennial surface water in region.
**No perennial surface water bodies on or adjacent to the Lakhra site.
††If local wells are degraded, impacts can be mitigated by supplying treated water from power plant. Lakhra site is about 20 km in distance to the Indus River and a limited number of wells currently exist in the area.
***Mine disposal of all solid wastes (ash) at Lakhra is preferred.

Source: ESE, 1986.

Table 13. Environmental Impacts for Construction and Operation of Lakhra Coal Mine and Power Plant--Biological Resources

Impacts	Extent/Duration/Significance* of Impacts
Construction	
Vegetation Removal and Loss of Habitat	Site-specific/long-term/moderately significant; loss of some acreage of tropical scrub forest vegetation and tropical plain thorn forest habitat, including desert monitor habitat; no significant loss given the small amount lost versus amount available.
Spills and Chemical Usage	Site-specific/short-term/not significant: no aquatic habitat; no effects.
Road Traffic and Road Kills	Regional/short-term/not significant: increased probability of wildlife road kills.
Air Emissions--Fugitive Dust from Overburden Removal Effects on Vegetation	Regional/short-term/minor effects: vegetation will adapt to conditions.
Operation	
Entrainment	Site-specific/long-term/minor impacts: minimal larval and fish populations expected to be impacted.
Formation of Biological Barriers and Corridors	Site-specific/long-term/not significant.
Loss of Future Biological Productivity	Site-specific/long-term/not significant: small area.
Air Emissions--includes emissions from stacks, fugitive dust from coal handling, and reclamation	Regional/long-term/minor impacts: no major effects to natural vegetation.

Table 13. Environmental Impacts for Construction and Operation of Lakhra Coal Mine and Power Plant--Biological Resources (Continued, Page 2 of 2)

Impacts	Extent/Duration/Significance* of Impacts
Avian Hazards--from stacks, transmission, etc.	Site-specific/long-term/minor impacts.
Increased Access--i.e., opening up otherwise less accessible natural areas	Site-specific/long-term/minor impacts: no special biological resources in vicinity.

*In terms of impacts, the following definitions are used:

1. Extent refers to the areal effect of the impact, e.g., whether the impact is confined to the site only or extends some distance from the site;
2. Duration refers to the length of time the impact will last, e.g., whether the impact is short-term, lasts only several years, or for much longer periods; and
3. Significance refers to the magnitude of the impact in relation to the type of resource being impacted.

Sources: ESE, 1986.
KBN, 1986.

Table 14. Environmental Impacts for Construction and Operation of Lakhra Coal Mine and Power Plant--Social Impacts

Impacts	Extent/Duration/Significance* of Impacts
Construction and Operation	
Loss of Land Use	Site-specific/long-term/minor impacts.
Loss of Future Agricultural Productivity	Site-specific/long-term/not significant.
Road Traffic	Regional/short-term/moderately significant traffic increase.
Change in Ground Water Table and Aquifer Quality	Site-specific/long-term/not significant: lower quality but not extensively used for potable supplies.
Air Emissions--includes emisssions from stacks, fugitive dust from coal handling, and reclamation	Regional/long-term/moderately significant to existing mining population; however, no major agricultural areas nearby.
Noise and Vibration	Site-specific/long-term/not significant.
Induced Development--associated with mine and power plant in surrounding area including facilities and services demand	Regional/long-term/significant: workers colony will require significant development of infrastructure facilities and services.
Disruption of Cultural Values and Patterns	Site-specific/long-term/ significant effects to some local Khosa Baluch: major changes to rural life will occur in the vicinity of the site, both positive and negative. Regional impacts are likely to be minor.

Table 14. Environmental Impacts for Construction and Operation of Lakhra Coal Mine and Power Plant--Social Impacts (Continued, Page 2 of 2)

Impacts	Extent/Duration/Significance* of Impacts
Loss of Cultural, Historical, and archaeological resources	Site-specific/long-term/not significant based on current data.

*In terms of impacts, the following definitions are used:
1. Extent refers to the areal effect of the impact, e.g., whether the impact is confined to the site only or extends some distance from the site;
2. Duration refers to the length of time the impact will last, e.g., whether the impact is short-term, lasts only several years, or for much longer periods; and
3. Significance refers to the magnitude of the impact in relation to the type of resource being impacted.

†Requires road improvement of Indus Highway.

Sources: ESE, 1986.
KBN, 1986.

will not be significant. Potentially significant impacts are discussed in the following sections.

7.1 PHYSICAL IMPACTS

The establishment of a large surface mine and the air emissions and concomitant degradation in air quality are potentially the most significant impacts to the physical environment.

The mining impacts will have two major components: (1) the physical disruption of mining activities, and (2) utilization of non-renewable resources (i.e., lignite). The physical disruption of the surface, which involves up to approximately 2,000 ha, will change the land use, drainage, surface water, and limited ground water resources. The magnitude of these effects will primarily be confined directly to the mining area provided that appropriate management of spoil piles, highwalls, acid-producing materials, and runoff impoundments is practiced. Land within the mining area will be temporarily disrupted; however, through reclamation practices the land will be returned to conditions similar to those which occurred prior to mining. Use of the non-renewable resources will be irretrievable; however, this use is offset by the country's need to supply the required electrical power. For recovering a major portion of the lignite resources, surface mining is preferred; with a surface mine, about 80 to 90 percent of the available lignite resource is recovered, whereas for an underground mine, only about 50 percent is recovered.

The impacts to air quality, resulting from the use of the high-sulfur, low-Btu Lakhra lignite and mining activities, are potentially significant; however, dispersion modeling techniques have shown that the combination of site location coupled with atmospheric dispersion will confine potentially significant air quality impacts to the immediate Lakhra area. In addition, offsite air quality impacts are projected to meet the World Bank and World Health Organization's guidelines for air quality.

7.2 BIOLOGICAL IMPACTS

The adverse impacts associated with construction of the power plant include the loss of up to approximately 2,000 ha of scrub forest vegetation and associated tropical plain forest wildlife habitat. There is the potential for the desert monitor lizard, classified as endangered, to be affected onsite by these activities; however, the status of the population in the region will not be significantly affected. In addition, in cooperation with GOP, the U.S. Fish and Wildlife Service is sponsoring specific studies on the desert monitor (see mitigation plan).

Adverse operational impacts on ecological resources include potential effects on vegetation and wildlife from air emissions, including atmospheric deposition, entrainment of aquatic organisms during cooling water intake, and increased mortality of wildlife due to highway traffic. The impacts from air emissions are not likely to affect local and regional wildlife and native vegetation. These impacts would be considered significant only if acute effects from air emissions occur. The desert monitor will likely be affected by the operational activities of the mine, but no effect to the regional population is expected. Impacts to other endangered species occurring in the Lakhra area are not projected. Avian mortality due to collisions with stacks is not likely to be significant at the Lakhra site. Impacts to agricultural crops are not considered significant because of the distance of a power plant located at Lakhra and the concomitant lower air pollutant concentrations.

7.3 SOCIAL IMPACTS

Although the unavoidable cultural resource impacts of construction and operation will occur, the magnitude differs in a number of instances. The loss of existing land use is not considered significant. The change in employment and economic patterns is considered a positive impact, while the disruption of cultural patterns and values, increased demand for facilities and services, and the disruption of transportation systems are considered significant adverse impacts which cannot be avoided. Development of secondary infrastructure alternatives will, however, mitigate a majority of these impacts. Impacts to

local inhabitants will be significant on a site-specific basis; however, the number of local inhabitants affected is small (<about 50) and their residence is seasonal. Regional impacts are considered minor. Impacts to historical and archaeological resources are not expected, based on a survey performed by the Pakistan Department of Archeology.

The major operational adverse impacts include a drop in employment and the local economy at the end of construction; potential labor productivity problems between local inhabitants and workers, between construction and operation workers, and between power plant workers and the coal miners; and disruption of existing transportation systems. Adverse effects to man and agriculture in the vicinity of the Indus Valley from air emissions are not considered significant because of the distance of human settlements and sensitive agricultural crops from the Lakhra area.

8.0 ENVIRONMENTAL MITIGATION PLAN

Based on the evaluations and analyses performed through the EA process, an environmental mitigation plan (EMP) has been developed by USAID in conjunction with the World Bank environmental representatives and feasibility consultants (i.e., ESE, KBN, GCII, and Boyd). When finalized, the EMP will be colloboratively adopted by GOP and the international development organizations (i.e., World Bank and ADB) prior to project implementation. The purpose of the EMP is to promulgate those activities that will be taken to avoid, reduce, or otherwise mitigate adverse environmental impacts associated with the Lakhra project. The mitigation activities proposed in the EMP are consistent with GOP, USAID, World Bank, and ADB environmental policies. A summary of the EMP is provided in Table 15 and includes mitigation activities that are national, regional, and site-specific in scope (refer to Draft Environmental Mitigation Plan, May 1986, USAID for more details).

Table 15. Summary of Environmental Mitigation Plan (Draft)

Mitigation Description	Need or Impact	Proposed Mitigation Activity	Implementation Organization*
I. National Coal Development A. Environmentally Sound Coal Development Strategy	GOP policy needed to evaluate/ mitigate environmental impacts of coal development in Pakistan	Develop plan and associated regulations for modern mining and utilization practices	GOP organizations: PEPA, GSP, PMDC, ENERPLAN, MH, MPD, MI and WAPDA. Assistance from international consultant
B. Ambient Air Quality Standards (AAQS)	Use of coal and associated air emissions from its use requires development and implementation of AAQS	Develop AAQS and institutional structure to implement standards	GOP organizations: PEPA, PCSIR, PMDC, ENERPLAN, MH, MPD, MI and WAPDA. Assistance from international consultant
II. Lakhra Coal Mine A. Environmental, Safety, and Health Management Staff	Mine staff needed to manage potentially significant impacts	Development including training of professional staff	Coal mine operator. Oversight by PEPA and ML
B. Environmental Monitoring Program	Detection of potentially significant environmental impacts	Develop long-term monitoring program including monitoring of environment (air, water, etc.), reclamation program, and waste materials (see Table 16)	Coal mine operator with oversight by PEPA and Sind Mine Inspectorate
C. Mine Reclamation	Disruption of land causing air, water, safety, and social impacts	Develop and implement mitigation plan	Coal mine operator with oversight from PEPA and Sind Mine Inspectorate
D. Occupational Safety and Health	Potential serious injuries and fatalities from mining activities	Preparation and implementation of health and safety plan that conforms to World Bank guidelines and Boyd recommendations	Coal mine operator as well as existing private sector mines if coal is received from these sources. Oversight by ML, Sind Mine Inspectorate, and donor organizations

Table 15. Summary of Environmental Mitigation Plan (Draft) (Continued, Page 2 of 3)

Mitigation Description	Need or Impact	Proposed Mitigation Activity	Implementation Organization*
E. Emergency Prevention Planning and Management	Potential emergency situations caused by mining activities; the need to respond in a timely manner to ameliorate emergency condition	Preparation and implementation of plan	Coal mine operator with assistance from GOP and Sind organizations, as necessary. Oversight by ML, Sind Mine Inspectorate, and donor organizations
III. Lakhra Power Plant A. Construction Safety Program	Construction accidents causing serious injuries or fatalities	Preparation and implementation of plan	Power plant contractors. Oversight by ML, WAPDA, and donor organizations
B. Environmental, Safety, and Health Management Staff	Potentially adverse impacts of power plant operation	Development of professional staff including training	WAPDA with oversight by PEPA and ML
C. Environmental Monitoring Program	Detection of potentially adverse environmental impacts	Obtain equipment and develop operation measures to implement program (see Table 16)	WAPDA with oversight from PEPA and donor organizations
D. Occupational Safety and Health Plan	Potential serious injuries and fatalities from power plant operation	Preparation and implementation of plan that conforms with World Bank guidelines and GCII recommendations	WAPDA with oversight from ML and donor organizations
E. Emergency Prevention, Planning, and Management	The need to ameliorate potentially serious injuries during emergencies	Preparation and implementation of plan	WAPDA with assistance from GOP and Sind organizations
IV. Solid Waste Master Plan	Potentially adverse environmental impacts from power plant and mine solid wastes	Develop and implement plan. Plan to comply with PEPA and project criteria	International consultant with input from coal mine operator and WAPDA. Oversight provided by PEPA, MH, MH and Sind Mine Inspectorate

Table 15. Summary of Environmental Mitigation Plan (Draft) (Continued, Page 3 of 3)

Mitigation Description	Need or Impact	Proposed Mitigation Activity	Implementation Organization*
V. Waste Product Utilization	Potentially beneficial and economic uses of waste products (e.g., power plant fly ash)	Perform feasibility study and research into waste product utilization	PCSIR and universities with assistance of WAPDA and coal mine operator
VI. Infrastructure and Public Services	Potentially significant impacts to primary and secondary infrastructures and existing public services	Perform the following activities: A. Upgrading and improvement of Lakhra Highway B. Planning and management of primary infrastructure development C. Planning and management of secondary infrastructure development D. Potable water stations in Khanot E. Local official coordination for increasing public services F. Local official coordination for development of secondary infrastructure	All potentially affected parties: Coal mine operator WAPDA GOP Sind Dadu District Local governments
VII. Grazing and Runoff Cropping	Removal of areas currently used for seasonal grazing and crops using runoff	Develop alternate areas	Coal mine operator
VIII. Endangered Animal Species	Loss of habitat for desert monitor (Varanus griseus)	Study of the ecology of the species in Sind/Lakhra area	GOP Zoological Survey; Sind Ministry of Forest, Wildlife, and Forestry; US FWS
IX. Archeological and Historical Sites	Potential loss of significant archeological and historical sites not found in initial survey	Implementation of "Chance Find" Procedures	Coal mine operator with oversight from the GOP Department of Archeology

ENERPLAN = Ministry of Energy.
GSP = Geological Survey of Pakistan.
MI = Ministry of Industry.
MH = Ministry of Health.
ML = Ministry of Labor.
MPD = Ministry of Planning and Development.
PCSIR = Pakistan Council for Scientific and Industrial Research.
PEPA = Pakistan Environmental Protection Agency.
PMDC = Pakistan Mineral Development Corporation.
AAQS = Ambient Air Quality Standards.

Source: USAID, 1986.

Table 16. Suggested Environmental Monitoring Programs

Type of Monitoring	Parameters	Frequency	Number of Monitoring Stations and Location
Physical			
Air Quality	SO_2/Particulate	Continuous	Two stations located northeast near Indus agricultural areas and south of site.
Air Emissions	SO_2/Particulate/ NO_x	Performance--annual	Testing of emissions at flue of each unit.
	Meteorology	Continuous--wind speed and direction, stability (indirect methods)	One station at or near plant site.
Ground Water Quality	Total suspended solids, pH, temp., iron, arsenic, chromium, and selenium	Quarterly	Six to eight stations near ash/wastewater disposal areas; samples could also be obtained from existing underground mines.

Table 16. Suggested Environmental Monitoring Programs
(Continued, Page 2 of 2)

Type of Monitoring	Parameters	Frequency	Number of Monitoring Stations and Location
Biological	Vegetation	Semi-annual	Survey of Indus agricultural areas northeast of plant for possible air pollution impacts.
	Monitor Lizard	Single 6-month study	Determine status of endangered species and ecology. Note: A project is currently funded by US Fish and Wildlife Service with cooperation of GOP to investigate the habitat of the monitor lizard.
Social	Infrastructure Development	Annually	Discussions with local/community leaders for planning and implementation of secondary infrastructure development.

Sources: ESE, 1986.
KBN, 1986.