Pakistan
Water and Power Development Authority

Lakhra Coal Mine and Power Generation Feasibility Study

Power Plant Feasibility
Volume III

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Gilbert/Commonwealth International, Inc.

LAKHRA COAL MINE AND POWER GENERATION FEASIBILITY STUDY

POWER PLANT FEASIBILITY

VOLUME III

Submitted to

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

and

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

By

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8.0 CAPITAL COSTS OF POWER PLANT

The capital costs developed for this feasiblity study included all material, labor and import duties to design, supply, and construct the 2x350 MW coal-fired thermal power plant as discussed in Chapter 5. Separate capital costs were developed for Units 1 and 2 for each of the proposed sites. Tables 8.1 and 8.6 provide in summary form the cost in U.S. dollars. Tables 8.3, 8.4 and 8.5 provide a lower level summary by account for Lakhra Unit 1, Unit 2, and a Unit 1 cash flow, respectively. Tables 8.8, 8.9 and 8.10 provide a lower level summary by account for Khanot Unit 1, Unit 2, and a Unit 1 cash flow. In addition, estimates for each of the selected SO_2 removal options were developed. Appendix 8.1 provides the cost details for the Lakhra site. The construction costs have been estimated in foreign exchange and local (PAKISTANI) currency components. The foreign exchange component (FEC) includes costs required for purchase of imported materials, equipment and supplies, ocean transportation and foreign engineers. The local currency portion includes the salaries and wages for Pakistani personnel, workers and the costs for the construction materials such as cement, brick masonry, asphalt concrete, reinforcement mild steel, and building steel. The cost information in millions of rupees is listed on Tables 8.2 through 8.7.

8.1 ESTIMATE BASIS

The primary bases for the development of the cost estimates are the plant layouts, system designs and equipment specifications described in Chapter 5.0. In addition, other projects in Gilbert/Commonwealth's data bank provided some bulk quantity and commodity costs for this project. All costs are in July 1985 U.S. dollars.

The following sections describe in more detail the methods and assumptions used in the development of the capital cost estimates.

8.1.1 Quantities

Civil/Structural

Quantities for major foundations and structures were obtained by factoring existing plants based on the plant layout requirements for equipment and personnel for the different sites and site conditions as described in Section 5.3.

The buildings and structures that were developed this way are as follows:

- Turbine/Generator Building
- Turbine/Generator Pedestal
- Boiler Building
- Control Complex
- Administration and Service Building
- P.A., F.D., and I.D. Fan Foundations
- Ductwork Supports
- Precipitator Foundation and Support
- Intake Structure
- Circulating Water Pump House
- Bottom, Fly Ash, Sludge and Waste Evaporation Ponds
- Cooling Tower Basin

Other minor structures and improvements were quantified by either factoring similar projects or surveys from the plant layout drawings. These include:

- Waste and Sewage Treatment Facilities
- Ash Handling System Structures
- Coal Handling System Structures
- Roads and Railroads

Mechanical

Mechanical equipment quantities were established based on design descriptions for the major systems. Quantities for equipment not specifically addressed were established by evaluating the same systems from plants of similar size.

Piping

Piping quantities for the power block (boiler and turbine generator areas) were obtained by analyzing piping data for plants of similar size and capacity. Piping quantities for site sensitive systems were developed by laying out the systems on the plot plan and considering spatial requirements and factors such as number of pumps and heat exchangers. Each piping system was reviewed to determine a predominant pipe diameter based on the piping specifications.

The piping unit of measure is the lineal foot. This unit of measure includes an allowance for other piping system materials such as fittings, valves, hangers and supports, and insulation. These other materials are included based on historical information on the ratio of these items per foot of pipe.

Electrical

Electrical equipment quantities were established based on the main plant one line diagram and the 220V AC and 125V DC one line diagram. Quantities for equipment not specifically addressed were established by evaluating the same equipment from plants of similar size and capacity.

Conduit, tray, and cable quantities for the main plant were obtained by analyzing bulk quantities of similar size power plants. Site sensitive systems, such as grounding, were developed by laying out the system on the site plot plant drawing.

8.1.2 Material Pricing

Equipment and materials were priced from vendor quotes and historical data. The following describes the source of pricing for each discipline.

Civil/Structural

Installed costs of commodities are primarily based on information developed for Gilbert/Commonwealth by Engineering Consultants and analyses of WAPDA Composite Schedule of Rates 1979.

Mechanical

Preliminary vendor quotations (Table 8.19) were obtained for major equipment associated with the power block to arrive at the price level of the following items:

- Boiler & Auxiliaries (fans, air preheaters, ash removal system)
- Turbine Generator
- Feedwater Pump
- Circulating Water Pump
- Condenser
- Feedwater Heaters
- Chimney
- Coal Handling
- Precipitator
- Waste Treatment
- Fly Ash Handling
- Fire Pumps
- Sulfur Dioxide Removal System

Other equipment pricing is based on recent pricing of equipment of similar design for other plants.

Piping

Piping pricing is a composite unit price for the selected predominant pipe size and addresses costs for pipe, fittings, valves, hangers and supports, and insulation. Costs were taken from GCII in-house data and consider fabricated spool pieces. Valves and specialty costs are taken from recent plants and in-house data. GCII's historical cost for prefabricated pipe was adjusted based on the analysis indicated in Table 8.20. The costs of the major piping systems were verified by obtaining the cost of these systems from a foreign supplier based on a recently completed 300 MW power plant and factored up for 350 MW.

Electrical and Instrumentation

Pricing for the electrical and instrumentation equipment and materials came from quotes, G/C in-house data, and supplier pricing sheets.

8.1.3 Labor and Productivity Factor

Using U.S. productivity and G/C in-house data, direct labor manhours were estimated for the mechanical and electrical work activities. These labor manhours were adjusted by information obtained through interviews with persons who are or were involved in construction work with Pakistani labor. These productivity multipliers, using a norm of 1.00 for U.S. labor, are 2.5 for pipefitters, 3.0 for electricians and 4.0 for millwrights. These data agree with the information outlined in a 1984 American Association of Cost Engineer Transaction, "International Composite Cost Location Factors." This productivity factor also agrees with the assumption of 3.3 used in the February 1977 report on this same project as prepared by Montreal Engineering Company, Limited. A composite wage rate of $2.25/hour for the mechanical and electrical trades, based on a skilled worker rate per hour of $.80, was applied against the local manhours to obtain the contractor's installed cost. This composite wage rate is developed on the basis that the contractor would be responsible for all construction activities including the provisions for temporary construction facilities, camp, catering and small construction supplies. The composite wage rate also includes any training cost for the workers, bonuses to maintain skilled workers and the contractor's field office expenses and overheads.

8.1.4 Import Duty

WAPDA currently is using a composite rate of 45 percent of the clearing and forwarding prices of imported materials, equipment

and supplies for import duty. For this feasibility study, the individual commodities custom tariffs have been used. The rates for some of the commodities are: 40 percent for steam and turbine generators, 85 percent for piping and traveling cranes, and 70 percent for steel beams and plates. The resulting composite rate from the study is 46 percent, which generally agrees with the number WAPDA has been using.

8.1.5 Infrastructure

The residential housing colony has been included in the capital cost estimate based on provided housing for the anticipated staffing level of approximately 2,174 people. The total square footage of housing is an aggregate of worker classification times their housing requirements. Included with the cost of the residential buildings are roads, paths, sewerage and electrification. Other buildings such as mosques, hospital, schools and rest home are included and have been modeled after the anticipated building requirements of the Jamshoro Oil-Fired Power Plant. The residential colony is integrated at the Lakhra site with the mining colony in that common facilities were shared where possible. Monies have also been estimated to provide the following items under security and protection: perimeter fence, sentry posts, alarm system and watch towers.

An initial complement of transportation vehicles has been included in the infrastructure category. For the power plant at Lakhra, transportation vehicles required for the colony are shared. The following vehicles have been included:

Vehicles	Quantity
Car	1
Pick-up truck	6
Garbage truck	2
Bus	5
Dump truck	8
Front-end loader	4
Jeep - 4WD	6

8.1.6 Engineering and Consultancy

An amount equal to approximately 7 percent of the estimated cost has been included for engineering and consultancy services. This sum includes a fixed amount of $12 million to accomplish the detailed engineering and design for the preparation of tender documents and provide assistance to WAPDA during the construction of the project. The cost would include personnel expenses, overheads, traveling expenses, and any other expenses. The variable portion of 4 percent represents

the engineering and design portion required by contractors to supplement the engineering design in the tender documents in order to construct the power plant.

8.1.7 WAPDA Administration Costs

As directed by WAPDA, an amount representing 4 percent of the direct cost for each unit has been provided to cover those field and home office expenses necessary for WAPDA to undertake this project.

8.1.8 Contingencies

A contingency factor of 10 percent has been used in developing the overall total cost estimate for the power plant. This figure has been applied based on the confidence level in the direct cost. Approximately 50 percent of the FEC in the estimate is the outcome of the budgetary quotes based on the project specifications. Where several quotes were received for an item, there was not a large deviation between the quotes. This effort provided the assurance that at least for the critical mechanical components accurate pricing has been used in developing the cost estimates. This contingency allowance has been included for those unforeseeable but inevitable design modifications that are anticipated as probable occurrence within the scope of the project.

8.1.9 Clearing, Forwarding, Handling and Inland Transportation

Five percent of the clearing and forwarding cost of plant and equipment has been included in the cost estimate for unloading, storing and moving equipment and material from the Port of Karachi to the job site.

8.1.10 Insurance During Construction

Two percent of the landed cost, which equals the foreign exchange component plus import duty, has been provided for insurance premiums during the construction of the plant.

8.1.11 Escalation

Escalation has been calculated based on the anticipated cash flow developed from the construction schedule and the following payment schedules: civil construction and installation costs - progress payments; equipment costs - 95 percent of

clearing and forwarding value upon shipment, remaining 5 percent upon completion of acceptance tests. The following yearly rates were applied against the local and foreign exchange components:

	FEC %	Local %
1986	5.0	6.5
1987	6.25	6.5
1988	6.50	6.5
1989	7.0	6.5
1990	8.0	6.5
1991	8.0	6.5

The foreign exchange component rates reflect the present soft market in the supply of power plant components and the expected anticipation that this market will pick up towards the latter part of this decade. In addition, the rate indicates the international competition to supply these components. The composite escalation component represents 28.31 percent of the present day costs.

8.1.12 Interest During Construction

The interest during construction (IDC) has been worked out at 13 percent per annum in year of expenditure dollars on the local component and 11 percent per annum on the same basis on the foreign component. See Tables 8.5 and 8.10 for a detailed cash flow of the Khanot and Lakhra sites.

8.2 EXCLUSIONS

Main Step-Up Transformers - The cost of the power plant includes the bus duct from the generator to the main step-up transformers. The main step-up transformers have been excluded from the power plant capital costs. They are included in Section 3.0, System Planning and Cost Analysis. Tables 8.1 and 8.6 summarize the power, substation and transmission capital costs.

8.3 CAPITAL COST ANALYSIS

The capital costs developed for this feasibility study were tested against other costs for power plants to determine if these costs are reasonable. The cost data developed for the United States utilities is the most widely available for individual power stations. The cost data for utilities in other nations is not as easily available to the general public. In addition, the method of constructing, financing, different designs of plants, labor rates, labor productivity, infrastructure and custom tariffs tend to make the comparison

between power plants dependent on the subjectiveness of the analyzer in assigning a value to these items. This analysis is required since the data are not readily identifiable. For example, Turkey's Afsin-Elbistan Thermal Electric Power Station consisting of 4 x 340 MW lignite-fired units is expected to exceed $2 billion for the entire project, which is assumed to include the mining operation. The cost per kilowatt for these units would be over $1470. The first unit went on line in 1983 with the remaining three units planned to be integrated into the power grid over the next four years. A similar size plant of 4 x 350 MW units with similar completion dates being constructed by the Australia Queensland Electricity Generating Board, the Tarong Power Station, was reported to cost $835/KW in 1982 dollars. The Queensland station is 43 percent less costly than the Turkey power station. However, the reported dollars are probably not compatible due to scope differences. This example illustrates the difficulty of comparing cost data from published data without a defined scope.

The test for reasonableness of this cost data is if two independent groups have developed costs within $\pm$ 10 percent. The Stone and Webster Engineering Company (SWEC) estimated cost for a 300 MW first unit in January 1983 dollars is $366.8 million. By factoring up to 350 MW and escalating for 2 years to be comparable with the current Lakhra estimate, the adjusted SWEC estimated cost is $435.7 million (10.5 percent for size and 7.5 percent for time). The Lakhra Unit 1 cost is $444.7 million. The difference between the two cost figures is 2.1 percent. The variance falls within the acceptable range.

A second independent estimate is contained in the recent U.S. Department of Energy publication of their Nuclear Energy Cost Data Base which indicated that a 350 MW coal-fired unit with FGD would cost $586 million. The Lakhra cost is $541.7 million. If the differences due to the import duty and labor are considered as equal, then this check again verified that the costs developed for this feasibility study are reasonable and accurate.

Current international market conditions indicated that the power block portion of a 350 MW oil-fired unit currently costs on a turnkey basis approximately $400/kW. Coal-fired power plants will cost at least 50 percent more than oil-fired units. Therefore, the lowest cost achievable for a coal plant is $600/kW. For Hopewell Power (China) Ltd., it is reported that two 350 MW units in operation by 1988 on a turnkey basis will cost the utility $686/kW. When the Khanot site cost is adjusted for import duty, colony related cost, WAPDA administration cost, and the other indirect costs specific to building a plant

in Pakistan, the cost per kilowatt is approximately $650/kW. When the aspect of burning the lignite type coal is factored into the Lakhra power plant, the estimated cost is within the expected range of costs based on currently reported information.

8.4 COAL WASHING - POWER PLANT COST DIFFERENTIAL

If washed coal is used as the primary fuel supply, the total capital cost savings will be $23,860,000 or Rs 374.5 million. These savings result from a smaller precipitator (5 fields versus 6 fields), a corresponding reduction in the fly ash transport system, and a reduced fly ash storage pond. They account for the major savings, since the boiler size and heat transfer area would not change due to burning the washed coal versus the unwashed coal. These savings would only result if the equipment was sized for the washed coal specifications. If the reliability of the washed plant did not equal or exceed the overall reliability of the power plant and the derate of the plant was unacceptable, then good design practice would require that the equipment be sized for the unwashed coal specifications. See Table 8.11 for a summary of the costs.

8.5 FLUE GAS DESULFURIZATION OPTIONS

The capital costs for three sulfur dioxide emission limits were estimated. Table 8.12 contains costs associated with a 1,000 ton per day site emission limit. This assumes that 50 percent of the Unit 1 flue gas is scrubbed to 90 percent efficiency and none of the Unit 2 flue gas is scrubbed. Table 8.13 contains costs for a 750 ton per day site emission limit with 50 percent of each unit's flue gas being scrubbed to 90 percent efficiency. Table 8.14 contains costs for a 500 ton per day site emission limit with 100 percent of each unit's flue gas being scrubbed with 90 percent efficiency.

The cost impact between the Lakhra and Khanot sites is minimal, with the only differences assumed to be in piping costs to the disposal pond.

The sulfur dioxide equipment package price was based on an estimate furnished by Peabody Process Systems. The foundations and structures cost includes all building and equipment foundations, an enclosure around the sulfur dioxide removal facility, and miscellaneous buildings and structures. The limestone and auxiliary system costs include a limestone processing area with limestone conveyors, crusher, live storage stacking and reclaiming area, and service water and air piping for the sulfur dioxide removal facility. An allowance for spare parts is included based on an initial five year time requirement.

The limestone and auxiliary system costs and the spare parts allowance are reduced for Unit 2 due to shared facilities with Unit 1.

All indirect costs of engineering, WAPDA administration forwarding expenses, insurance, escalation and IDC are similar to the factors used in developing the power plant base case.

Tables 8.15 and 8.16 contain a summary of the total capital costs for each of the emission limits for each site, plus the capital cost credits for using washed coal. As expected the capital costs are lowest for the washed coal option and greatest for the 500 TPD site emission limit.

8.6 OPERATION AND MAINTENANCE

The operation and maintenance costs associated with the power plant have been developed on an annual basis. The maintenance expense for operating years after the first year will be considerably less than the first year due to debugging and warranty validations and inspections. The maintenance expense includes local furnished supplies. Spare parts are estimated separately as foreign exchange components for the first five years of operation, and include import duty. The cycle for the remaining years repeats. The costs also include SO_2 scrubber operations based on scrubbing on both units.

Operating costs include all labor and materials required for the operation of two units. In addition, a preoperational training program and the associated costs are included.

The operating cost has been developed for both the Lakhra and Khanot sites. The difference between sites is the premium paid for the Lakhra site.

Tables 8.17 and 8.18 contain yearly costs for Lakhra and Khanot, respectively. The total personnel cost represents the fixed portion of the O&M costs. The variable portion comprises: supplies, spare parts, colony operating costs and scheduled outage inspections and disposal ponds. All costs are associated with the power plant and power plant colony only.

TABLE 8.1

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
LAKHRA, PAKISTAN

($ x 1,000)

	Description	Unit 1	Unit 2	Total
1.0	Land Cost	0	0	0
2.0	Site Preparation	1,078	0	1,078
3.1	Coal Handling	14,516	2,057	16,573
3.3	Cooling System	6,332	6,332	12,664
3.4	Ash Handling	30,510	7,549	38,059
4.0	Boiler Plant & Auxiliaries	94,210	93,068	187,278
5.0	Turbine Generator & Auxiliaries	70,304	68,653	138,957
6.0	FGD Plant & Auxiliaries	N/A	N/A	N/A
7.0	Electrical Facilities	16,779	16,779	33,558
8.0	Main Civil Works & Structures	63,537	21,699	85,236
9.0	Colony and Transport. Equipment	35,480	0	35,480
9.6	Construction Equipment	16,656	6,662	23,318
9.8	Spare Parts	10,500	10,500	21,000
	SUBTOTAL	359,902	233,299	593,201
	Engineering & Consultants	21,617	19,754	41,371
	WAPDA Administration	14,396	9,332	23,728
	Contingencies	35,990	23,330	59,320
	Clearing, Handling & Inland Transportation	8,087	6,809	14,896
	Insurance During Construction	4,706	3,922	8,628
	SUBTOTAL - JULY 1985	444,698	296,446	741,144
	Escalation	128,957	110,989	239,946
	Interest During Construction	141,144	79,291	220,435
	CAPITAL COST OF PLANT	714,799	486,726	1,201,525
	Capital Cost Transm. & Substations	31,887	15,254	47,141
	TOTAL CAPITAL COST	746,686	501,980	1,248,666

TABLE 8.2

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
LAKHRA, PAKISTAN

Rupees in Millions
Rs 15.7 = 1.00 Dollar

	Description	Unit 1	Unit 2	Total
1.0	Land Cost	0	0	0
2.0	Site Preparation	16.9	0	16.9
3.1	Coal Handling	227.9	32.3	260.2
3.3	Cooling System	99.4	99.4	198.8
3.4	Ash Handling	497.0	118.5	615.5
4.0	Boiler Plant & Auxiliaries	1,479.1	1,461.2	2,940.3
5.0	Turbine Generator & Auxiliaries	1,103.8	1,077.9	2,181.7
6.0	FGD Plant & Auxiliaries	N/A	N/A	N/A
7.0	Electrical Facilities	263.4	263.4	526.8
8.0	Main Civil Works & Structures	997.5	340.7	1,338.2
9.0	Colony and Transport. Equipment	557.0	0	557.0
9.6	Construction Equipment	261.5	104.6	366.1
9.8	Spare Parts	164.9	164.9	329.8
	SUBTOTAL	5,668.4	3,662.9	9,331.3
	Engineering & Consultants	339.4	310.1	649.5
	WAPDA Administration	226.0	146.5	372.5
	Contingencies	565.0	366.3	931.3
	Clearing, Handling & Inland Transportation	127.0	106.9	233.9
	Insurance During Construction	73.9	61.6	135.5
	SUBTOTAL - JULY 1985	6,999.7	4,654.3	11,654.0
	Escalation	2,024.6	1,742.5	3,767.1
	Interest During Construction	2,216.0	1,244.9	3,460.9
	CAPITAL COST OF PLANT	11,240.3	7,641.7	18,882.0
	Capital Cost Transm. & Substations	500.6	239.5	740.1
	TOTAL CAPITAL COST	11,740.9	7,881.2	19,622.1

TABLE 8.3

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
LAKHRA SITE

UNIT 1

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
1.0	LAND COST	0	0	0	0	0	0	0	0
2.0	SITE PREPARATION	1,078,400	1,078,400	0	0	0	0	1,078,400	1,078,400
3.1.3	TRANSFER HOUSE FOUNDATION	47,802		0		0		47,802	
3.1.3.2	CRUSHER HOUSE FOUNDATION	339,760		0		0		339,760	
3.1.4	EMERGENCY RECLAIM HOPPER	69,930		0		0		69,930	
3.1.5	RECLAIM HOPPER TUNNEL	92,810		0		0		92,810	
3.1.6	CONVEYOR BENT FOUNDATIONS	70,954		0		0		70,954	
SUBTOTAL 3.1			621,256		0		0		621,256
3.2	COAL HANDLING EQUIPMENT	1,327,290	1,327,290	8,850,500	8,850,500	3,717,210	3,717,210	13,895,000	13,895,000
3.3.1	COOLING TOWER BASIN	451,914		0		0		451,914	
3.3.2	CLOSED LOOP CIRC. WATER PIPE	797,117		200,250		170,213		1,167,580	
3.3.3	COOLING TOWER	469,614		2,950,000		1,292,500		4,712,114	
SUBTOTAL 3.3			1,718,645		3,150,250		1,462,713		6,331,608
3.4.1	CONVEYOR EQUIPMENT & PIPING	960,000		2,006,000		902,700		3,868,700	
3.4.2	BTM.FLY ASH & WASTE EVAP. PONDS	20,800,967		1,160,020		1,000,417		22,961,404	
3.4.3	FLY ASH PIPE TO PONDS	205,875		1,878,000		1,596,300		3,680,175	
SUBTOTAL 3.4			21,966,842		5,044,020		3,499,417		30,510,279
TOTAL 3.0			25,634,033		17,044,770		8,679,340		51,358,143
4.1	STEAM GENERATOR	7,625,000	7,625,000	47,297,000	47,297,000	18,445,830	18,445,830	73,367,830	73,367,830
4.2	PRECIPITATOR	1,376,000	1,376,000	7,925,000	7,925,000	3,170,000	3,170,000	12,471,000	12,471,000
4.3	MAIN, HOT & COLD PRESSURE PIPE	328,725	328,725	1,809,768	1,809,768	1,538,303	1,538,303	3,676,796	3,676,796
4.4	MISC. STEAM, WATER, & DRAIN. SYS	261,990	261,990	1,176,680	1,176,680	1,000,178	1,000,178	2,438,848	2,438,848
4.5	BOTTOM ASH PIPING & PUMPS	139,300	139,300	648,900	648,900	324,450	324,450	1,112,650	1,112,650
4.6	FUEL OIL STORAGE & SUPPLY	54,868	54,868	636,230	636,230	451,723	451,723	1,142,821	1,142,821
TOTAL 4.0			9,785,883		59,493,578		24,930,484		94,209,945
5.1	TURBINE - GENERATOR	621,000	621,000	21,870,000	21,870,000	8,748,000	8,748,000	31,239,000	31,239,000
5.2	TURBINE PEDESTAL	815,165	815,165	0	0	0	0	815,165	815,165
5.3	BF,EXTRACTION, COND. PIPING	367,043	367,043	3,636,050	3,636,050	3,090,643	3,090,643	7,093,736	7,093,736
5.4	HEATX, CONDENSER & MAIN PUMPS	191,190	191,190	5,834,928	5,834,928	2,333,971	2,333,971	8,360,089	8,360,089
5.5	CYCLE TREATMENT SYSTEMS	345,020	345,020	3,081,625	3,081,625	1,386,731	1,386,731	4,813,376	4,813,376
5.6	INSTRUMENTATION - MAIN PLANT	538,425	538,425	8,204,100	8,204,100	3,281,640	3,281,640	12,024,165	12,024,165
5.7	SERVICE AIR,GAS,SOOTBLOW SYS.	219,970	219,970	2,819,110	2,819,110	1,268,600	1,268,600	4,307,680	4,307,680
5.8	MISC. MECHANICAL EQUIPMENT	49,700	49,700	920,000	920,000	680,800	680,800	1,650,500	1,650,500
TOTAL 5.0			3,147,513		46,365,813		20,790,385		70,303,711

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TABLE 8.3 (Cont'd.)

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
LAKHRA SITE

UNIT 1

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
7.0	ELECTRICAL FACILITIES	2,684,093	2,684,093	10,067,980	10,067,980	4,027,192	4,027,192	16,779,265	16,779,265
8.01.1	BOILER BUILDING FOUNDATION	2,095,466		0		0		2,095,466	
8.01.1.1	FD FAN FOUNDATIONS	61,919		0		0		61,919	
8.01.1.2	ID FAN FOUNDATIONS	131,076		0		0		131,076	
8.01.1.3	PA FAN FOUNDATIONS	6,136		0		0		6,136	
8.01.1.4	PRECIPITATOR FOUNDATION	173,041		0		0		173,041	
8.01.1.5	BREECHING SUPPORT FOUNDATIONS	112,754		0		0		112,754	
8.01.2	BOILER BUILDING	10,596,394		1,265,133		834,593		12,696,120	
SUBTOTAL 8.01			13,176,786		1,265,133		834,593		15,276,512
8.02.1	TURBINE BUILDING FOUNDATION	1,201,994		0		0		1,201,994	
8.02.2	TURBINE BUILDING	3,996,060		662,945		417,810		5,076,815	
SUBTOTAL 8.02			5,198,054		662,945		417,810		6,278,809
8.03.1	CONTROL BUILDING FOUNDATION	91,297		0		0		91,297	
8.03.2	CONTROL & SHOP BUILDING	612,353		512,909		268,511		1,393,773	
SUBTOTAL 8.03			703,650		512,909		268,511		1,485,070
8.04.1	ADMIN. & SERVICE BLDG. FND.	175,287		0		0		175,287	
8.04.2	ADMIN. & SERVICE BUILDING	3,430,384		332,501		196,895		3,959,780	
SUBTOTAL 8.04			3,605,671		332,501		196,895		4,135,067
8.05.1	CHIMNEY FOUNDATION	404,509		0		0		404,509	
8.05.2	CHIMNEY	1,725,000		1,840,000		1,104,000		4,669,000	
SUBTOTAL 8.05			2,129,509		1,840,000		1,104,000		5,073,509
8.06	MINE ACCESS ROAD FROM KHANOT	6,609,427	6,609,427	0	0	0	0	6,609,427	6,609,427
8.07.1	MAKE-UP WATER INTAKE STRUCTURE	1,820,151		1,245,088		672,496		3,737,735	
8.07.2	MAKE-UP WATER PIPE TO INDUS R.	10,725,099		0		0		10,725,099	
8.07.3	WATER SURGE POND	907,200		0		0		307,200	
SUBTOTAL 8.07			13,452,450		1,245,088		672,496		15,370,034
8.08.1	CIRCULATING WATER PUMPHOUSE	343,888	343,888	13,115	13,115	9,181	9,181	366,184	366,184
8.09	WATER TREATMENT	451,610	451,610	1,463,600	1,463,600	834,252	834,252	2,749,462	2,749,462
8.10	WASTE TREATMENT	200,860	200,860	573,400	573,400	258,030	258,030	1,032,290	1,032,290
8.11	SITE WORK - PAVED ROADWAYS	4,308,142	4,308,142	0	0	0	0	4,308,142	4,308,142
8.12.1	SITE WORK-FIRE PROTECTION LOOP	40,740		116,420		139,704		296,864	
8.12.2	SITE WORK-SERVICE WATER LINES	36,750		105,000		126,000		267,750	
SUBTOTAL 8.12			77,490		221,420		265,704		564,614
8.15	TRANSFORMER WIREWALLS	122,809	122,809	89,000	89,000	75,650	75,650	287,459	287,459
TOTAL 8.0			50,380,346		8,219,111		4,937,122		63,536,579

TABLE 8.3 (Cont'd.)

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
LAKHRA SITE

UNIT 1

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
9.1	COLONY - WATER SUPPLY	669,900	669,900	200,000	200,000	0	0	869,900	869,900
9.2	COLONY - POWER DISTR.& COMMUN.	322,900	322,900	55,000	55,000	0	0	377,900	377,900
9.3	COLONY - RESIDENCES	21,646,900	21,646,900	0	0	0	0	21,646,900	21,646,900
9.4	COLONY - COMMUN. BLDGS.& FACILS.	2,046,600	2,046,600	176,000	176,000	0	0	2,222,600	2,222,600
9.5	COLONY - SERVICE FACILITIES	6,143,550	6,143,550	639,650	639,650	0	0	6,783,200	6,783,200
9.6	LEASE CONSTRUCTION EQUIPMENT	0	0	10,410,000	10,410,000	6,246,000	6,246,000	16,656,000	16,656,000
9.7	COLONY - SECURITY & PROTECTION	985,740	985,740	0	0	0	0	985,740	985,740
9.8	SPARE PARTS & LAB.& SHOP EQUIP.	0	0	7,500,000	7,500,000	3,000,000	3,000,000	10,500,000	10,500,000
9.9	TRANSPORTATION EQUIPMENT	54,000	54,000	1,560,000	1,560,000	979,500	979,500	2,593,500	2,593,500
	TOTAL 9.0		31,869,590		20,540,650		10,225,500		62,635,740
	REPORT TOTAL		124,579,858		161,731,902		73,590,023		359,901,783
	ENGINEERING & CONSULTANTS		2,345,247		19,271,589				21,616,836
	WAPDA ADMINISTRATION		14,396,071						14,396,071
	CONTINGENCIES		12,457,986		16,173,190		7,359,002		35,990,178
	CLEARING, FORWARDING, HANDLING AND INLAND TRANSPORTATION		8,086,595						8,086,595
	INSURANCE DURING CONSTRUCTION		4,706,439						4,706,439
	SUBTOTAL JULY 1985 COST		166,572,196		197,176,682		80,949,025		444,697,903
	ESCALATION		46,573,586		57,062,932		25,320,855		128,957,373
	INTEREST DURING CONSTRUCTION BASED ON COMMERCIAL OPERATION OF JUNE 1991		62,835,376		54,025,918		24,282,668		141,143,962
	CAPITAL COST OF PLANT		275,981,158		308,265,531		130,552,548		714,799,237

TABLE 8.4

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
LAKHRA SITE

UNIT 2

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
3.2	COAL HANDLING EQUIPMENT	580,690	580,690	1,039,500	1,039,500	436,590	436,590	2,056,780	2,056,780
3.3.1	COOLING TOWER BASIN	451,914		0		0		451,914	
3.3.2	CLOSED LOOP CIRC. WATER PIPE	797,117		200,250		170,213		1,167,580	
3.3.3	COOLING TOWER	469,614		2,950,000		1,292,500		4,712,114	
SUBTOTAL 3.3			1,718,645		3,150,250		1,462,713		6,331,608
3.4.1	CONVEYOR EQUIPMENT & PIPING	960,000		2,006,000		902,700		3,868,700	
3.4.3	FLY ASH PIPE TO PONDS	205,875		1,878,000		1,596,300		3,680,175	
SUBTOTAL 3.4			1,165,875		3,884,000		2,499,000		7,548,875
TOTAL 3.0			3,465,210		8,073,750		4,398,303		15,937,263
4.1	STEAM GENERATOR	7,625,000	7,625,000	47,297,000	47,297,000	18,445,830	18,445,830	73,367,830	73,367,830
4.2	PRECIPITATOR	1,376,000	1,376,000	7,925,000	7,925,000	3,170,000	3,170,000	12,471,000	12,471,000
4.3	MAIN, HOT & COLD PRESSURE PIPE	328,725	328,725	1,809,768	1,809,768	1,538,303	1,538,303	3,676,796	3,676,796
4.4	MISC. STEAM, WATER, & DRAIN. SYS	261,990	261,990	1,176,680	1,176,680	1,000,178	1,000,178	2,438,848	2,438,848
4.5	BOTTOM ASH PIPING & PUMPS	139,300	139,300	648,900	648,900	324,450	324,450	1,112,650	1,112,650
TOTAL 4.0			9,731,015		58,857,348		24,478,761		93,067,124
5.1	TURBINE - GENERATOR	621,000	621,000	21,870,000	21,870,000	8,748,000	8,748,000	31,239,000	31,239,000
5.2	TURBINE PEDESTAL	815,165	815,165	0	0	0	0	815,165	815,165
5.3	BF, EXTRACTION, COND. PIPING	367,043	367,043	3,636,050	3,636,050	3,090,643	3,090,643	7,093,736	7,093,736
5.4	HEATX, CONDENSER & MAIN PUMPS	191,190	191,190	5,834,928	5,834,928	2,333,971	2,333,971	8,360,089	8,360,089
5.5	CYCLE TREATMENT SYSTEMS	345,020	345,020	3,081,625	3,081,625	1,386,731	1,386,731	4,813,376	4,813,376
5.6	INSTRUMENTATION - MAIN PLANT	538,425	538,425	8,204,100	8,204,100	3,281,640	3,281,640	12,024,165	12,024,165
5.7	SERVICE AIR, GAS, SOOTBLOW SYS.	219,970	219,970	2,819,110	2,819,110	1,268,600	1,268,600	4,307,680	4,307,680
TOTAL 5.0			3,097,813		45,445,813		20,109,585		68,653,211
7.0	ELECTRICAL FACILITIES	2,684,093	2,684,093	10,067,980	10,067,980	4,027,192	4,027,192	16,779,265	16,779,265
8.01.1	BOILER BUILDING FOUNDATION	2,095,466		0		0		2,095,466	
8.01.1.1	FD FAN FOUNDATIONS	61,919		0		0		61,919	
8.01.1.2	ID FAN FOUNDATIONS	131,076		0		0		131,076	
8.01.1.3	PA FAN FOUNDATIONS	6,136		0		0		6,136	
8.01.1.4	PRECIPITATOR FOUNDATION	173,041		0		0		173,041	
8.01.1.5	BREECHING SUPPORT FOUNDATIONS	112,754		0		0		112,754	
8.01.2	BOILER BUILDING	10,596,396		1,265,133		834,593		12,696,122	
SUBTOTAL 8.01			13,176,788		1,265,133		834,593		15,276,514
8.02.1	TURBINE BUILDING FOUNDATION	1,201,994		0		0		1,201,994	
8.02.2	TURBINE BUILDING	3,320,882		502,745		375,670		4,299,297	

TABLE 8.4 (Cont'd.)

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
LAKHRA SITE

UNIT 2

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
SUBTOTAL 8.02			4,522,876		602,745		375,670		5,501,291
8.08.1	CIRCULATING WATER PUMPHOUSE	343,888	343,888	13,115	13,115	9,181	9,181	366,184	366,184
8.12.2	SITE WORK-SERVICE WATER LINES	36,900	36,900	105,000	105,000	126,000	126,000	267,900	267,900
8.15	TRANSFORMER WIREWALLS	122,809	122,809	89,000	89,000	75,650	75,650	287,459	287,459
TOTAL 8.0			18,203,261		2,074,993		1,421,094		21,699,348
9.6	LEASE CONSTRUCTION EQUIPMENT	0	0	4,164,000	4,164,000	2,498,400	2,498,400	6,662,400	6,662,400
9.8	SPARE PARTS & LAB.& SHOP EQUIP.	0	0	7,500,000	7,500,000	3,000,000	3,000,000	10,500,000	10,500,000
TOTAL 9.0			0		11,664,000		5,498,400		17,162,400
REPORT TOTAL			37,181,392		136,183,884		59,933,335		233,298,611
	ENGINEERING & CONSULTANTS		693,461		19,060,220				19,753,681
	WAPDA ADMINISTRATION		9,331,944						9,331,944
	CONTINGENCIES		3,718,139		13,618,388		5,993,334		23,329,861
	CLEARING, FORWARDING, HANDLING AND INLAND TRANSPORTATION		6,809,194						6,809,194
	INSURANCE DURING CONSTRUCTION		3,922,344						3,922,344
SUBTOTAL JULY 1985 COST			61,656,475		168,862,492		65,926,669		296,445,636
	ESCALATION		20,365,134		68,321,764		22,302,992		110,989,890
	INTEREST DURING CONSTRUCTION BASED ON COMMERCIAL OPERATION OF JUNE 1992		12,959,414		46,559,270		19,772,267		79,290,951
CAPITAL COST OF PLANT			94,981,023		283,743,526		108,001,927		486,726,477

TABLE 8.5

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
ANNUAL EXPENDITURE REQUIREMENTS
LAKHRA SITE
UNIT 1

(Thousands of Dollars)

	TOTAL				1986			1987			1988			1989			1990			1991		
	LOCAL	FEC	IMPORT DUTY	TOTAL	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY
Land	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Site Preparation	1,078	-	-	1,078	-	-	-	500	-	-	578	-	-	-	-	-	-	-	-	-	-	-
Coal Handling	1,948	8,851	3,717	14,516	-	-	-	-	-	-	740	3,452	1,450	740	5,399	2,267	468	-	-	-	-	-
Cooling System	1,719	3,150	1,463	6,332	-	-	-	-	-	-	619	-	-	361	3,150	1,463	739	-	-	-	-	-
Ash Handling	21,967	5,044	3,499	30,510	-	-	-	-	-	-	20,561	-	-	1,406	5,044	3,499	-	-	-	-	-	-
Boiler Plant & Auxiliaries	9,786	59,494	24,930	94,210	-	-	-	-	-	-	-	-	-	2,251	35,101	15,955	5,872	18,443	7,728	1,663	5,950	1,247
Turbine Generator Plant & Auxiliaries	3,148	46,366	20,790	70,304	-	-	-	-	-	-	-	4,637	-	567	31,993	14,345	2,015	9,736	4,366	566	-	2,079
Electrical Facilities	2,684	10,068	4,027	16,779	-	-	-	-	-	-	-	2,500	1,000	1,900	7,568	3,027	784	-	-	-	-	-
Civil & Structural Works	50,381	8,219	4,937	63,537	-	-	-	-	-	-	13,683	-	-	34,259	4,685	2,814	1,511	3,534	2,123	1,008	-	-
Colony & Transport. Equip.	31,870	2,631	979	35,480	-	-	-	1,912	-	-	3,824	-	-	17,847	-	-	8,287	2,631	979	-	-	-
Construction Equipment	-	10,410	6,246	16,656	-	-	-	-	-	-	-	2,700	1,600	-	4,410	2,646	-	3,300	2,000	-	-	-
Spare Parts	-	7,500	3,000	10,500	-	-	-	-	-	-	-	-	-	-	-	-	-	3,267	-	-	4,233	3,000
Subtotal	124,581	161,733	73,588	359,902	-	-	-	2,412	-	-	39,925	13,289	4,850	59,331	97,350	46,016	19,676	40,911	17,196	3,237	10,183	6,326
SUBTOTAL BY YEAR				359,902		-			2,412			57,264			202,697			77,783			19,746	
Engineering & Consultants	2,345	19,272	-	21,617	-	1,831	-	1,126	5,512	-	1,219	6,437	-	-	2,139	-	-	2,139	-	-	1,214	-
WAPDA Administration	14,396	-	-	14,396	230	-	-	1,943	-	-	3,873	-	-	3,873	-	-	2,534	-	-	1,943	-	-
Contingencies	12,458	16,163	7,359	35,980	-	-	-	-	-	-	3,289	1,407	434	5,855	10,011	4,563	1,732	2,384	1,685	1,582	2,361	677
Clearing, Forwarding & Inland Transportation	8,887	-	-	8,887	-	-	-	-	-	-	1,181	-	-	4,545	-	-	2,361	-	-	-	-	-
Insurance During Construction	4,706	-	-	4,706	-	-	-	1,177	-	-	1,177	-	-	1,764	-	-	588	-	-	-	-	-
Subtotal	41,992	35,435	7,359	84,786	230	1,831	-	4,246	5,512	-	10,739	7,844	434	16,037	12,150	4,563	7,215	4,523	1,685	3,525	3,575	677
SUBTOTAL BY YEAR				84,786		2,061			9,758			19,017			32,750			13,423			7,777	
SUBTOTAL-JULY 1985 COSTS	166,573	197,168	88,947	444,688	230	1,831	-	6,658	5,512	-	50,664	21,133	4,484	75,368	109,500	50,579	26,891	45,434	18,881	6,762	13,758	7,083
Escalation	45,793	57,245	25,315	128,353	15	92	-	894	637	-	10,536	3,975	932	21,593	29,707	14,491	9,952	16,947	6,988	2,884	5,887	2,983
Interest During Construction	64,506	53,710	24,315	142,531	16	106	-	525	207	-	5,062	2,383	352	16,000	11,593	4,979	26,778	23,956	11,538	16,126	15,551	7,445
SUBTOTAL BY YEAR					261	2,028	-	8,076	6,351	-	65,261	27,411	5,769	112,961	150,801	70,049	63,621	86,337	37,407	25,691	35,196	17,352
CAPITAL COST OF PLANT	276,872	308,123	138,576	715,571		2,289			14,427			99,441			333,811			187,364			78,239	

TABLE 8.6

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
KHANOT, PAKISTAN

($ x 1,000)

	Description	Unit 1	Unit 2	Total
1.0	Land Cost	527	0	527
2.0	Site Preparation	1,680	0	1,680
3.1	Coal Handling	16,729	2,057	18,786
3.3	Cooling System	6,332	6,332	12,664
3.4	Ash Handling	31,015	8,655	39,670
4.0	Boiler Plant & Auxiliaries	92,745	93,067	185,812
5.0	Turbine Generator & Auxiliaries	70,304	68,653	138,957
6.0	FGD Plant & Auxiliaries	N/A	N/A	N/A
7.0	Electrical Facilities	16,779	16,779	33,558
8.0	Main Civil Works & Structures	44,732	21,699	66,431
9.0	Colony and Transport. Equipment	35,226	0	35,226
9.6	Construction Equipment	16,656	6,662	23,318
9.8	Spare Parts	10,500	10,500	21,000
	SUBTOTAL	343,225	234,404	577,629
	Engineering & Consultants	21,819	19,790	41,609
	WAPDA Administration	13,729	9,376	23,105
	Contingencies	34,322	23,441	57,763
	Clearing, Handling & Inland Transportation	8,324	6,835	15,159
	Insurance During Construction	4,863	3,941	8,804
	SUBTOTAL - JULY 1985	426,282	297,787	724,069
	Escalation	123,974	111,481	235,455
	Interest During Construction	133,369	79,654	213,023
	CAPITAL COST OF PLANT	683,625	488,922	1,172,547
	Capital Cost Transm. & Substations	25,043	15,254	40,297
	TOTAL CAPITAL COST	708,668	504,176	1,212,844

TABLE 8.7

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY
KHANOT, PAKISTAN

Rupees in Millions
Rs 15.7 = 1.00 Dollar

	Description	Unit 1	Unit 2	Total
1.0	Land Cost	8.3	0	8.3
2.0	Site Preparation	26.4	0	26.4
3.1	Coal Handling	262.6	32.3	294.9
3.3	Cooling System	99.4	99.4	198.8
3.4	Ash Handling	486.9	135.9	622.8
4.0	Boiler Plant & Auxiliaries	1,456.1	1,461.2	2,917.3
5.0	Turbine Generator & Auxiliaries	1,103.8	1,077.9	2,181.7
6.0	FGD Plant & Auxiliaries	N/A	N/A	N/A
7.0	Electrical Facilities	263.4	263.4	526.8
8.0	Main Civil Works & Structures	702.3	340.7	1,043.0
9.0	Colony and Transport. Equipment	553.0	0	553.0
9.6	Construction Equipment	261.5	104.6	366.1
9.8	Spare Parts	164.9	164.9	329.8
	SUBTOTAL	5,388.6	3,680.3	9,068.9
	Engineering & Consultants	342.6	310.7	653.3
	WAPDA Administration	215.5	147.2	362.7
	Contingencies	538.9	368.0	906.9
	Clearing, Handling & Inland Transportation	130.9	107.3	238.2
	Insurance During Construction	76.3	61.9	138.2
	SUBTOTAL - JULY 1985	6,692.8	4,675.4	11,368.2
	Escalation	1,946.4	1,750.3	3,696.7
	Interest During Construction	2,093.9	1,250.6	3,344.5
	CAPITAL COST OF PLANT	10,733.1	7,676.3	18,409.4
	Capital Cost Transm. & Substations	393.2	239.5	632.7
	TOTAL CAPITAL COST	11,126.3	7,915.8	19,042.1

TABLE 8.8

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
KHANOT SITE

UNIT 1

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
1.0	LAND COST	527,000	527,000	0	0	0	0	527,000	527,000
2.0	SITE PREPARATION	1,679,900	1,679,900	0	0	0	0	1,679,900	1,679,900
3.1.1	COAL UNLOADING STRUCTURE	410,253		0		0		410,253	
3.1.2	UNLOADER STRUCT. CONVEYOR TNL.	114,427		0		0		114,427	
3.1.3	TRANSFER HOUSE FOUNDATION	47,802		0		0		47,802	
3.1.3.2	CRUSHER HOUSE FOUNDATION	339,760		0		0		339,760	
3.1.4	EMERGENCY RECLAIM HOPPER	69,930		0		0		69,930	
3.1.5	RECLAIM HOPPER TUNNEL	92,810		0		0		92,810	
3.1.6	CONVEYOR BENT FOUNDATIONS	70,954		0		0		70,954	
SUBTOTAL 3.1			1,145,936		0		0		1,145,936
3.2	COAL HANDLING EQUIPMENT	1,447,110	1,447,110	9,954,700	9,954,700	4,180,974	4,180,974	15,582,784	15,582,784
3.3.1	COOLING TOWER BASIN	451,914		0		0		451,914	
3.3.2	CLOSED LOOP CIRC. WATER PIPE	797,117		200,250		170,213		1,167,580	
3.3.3	COOLING TOWER	469,614		2,950,000		1,292,500		4,712,114	
SUBTOTAL 3.3			1,718,645		3,150,250		1,462,713		6,331,608
3.4.1	CONVEYOR EQUIPMENT & PIPING	960,000		2,006,000		902,700		3,868,700	
3.4.2	BOTTOM ASH & WASTE EVAP. PONDS	10,427,186		1,549,960		1,331,866		13,309,012	
3.4.3	FLY ASH DISPOSAL POND	4,654,558		5,596,416		3,585,994		13,836,968	
SUBTOTAL 3.4			16,041,744		9,152,376		5,820,560		31,014,680
TOTAL 3.0			20,353,435		22,257,326		11,464,247		54,075,008
4.1	STEAM GENERATOR	6,161,000	6,161,000	47,297,000	47,297,000	18,445,830	18,445,830	71,903,830	71,903,830
4.2	PRECIPITATOR	1,376,000	1,376,000	7,925,000	7,925,000	3,170,000	3,170,000	12,471,000	12,471,000
4.3	MAIN, HOT & COLD PRESSURE PIPE	328,743	328,743	1,809,768	1,809,768	1,538,303	1,538,303	3,676,814	3,676,814
4.4	MISC. STEAM, WATER, & DRAIN. SYS	262,008	262,008	1,176,680	1,176,680	1,000,178	1,000,178	2,438,866	2,438,866
4.5	BOTTOM ASH PIPING & PUMPS	139,300	139,300	648,900	648,900	324,450	324,450	1,112,650	1,112,650
4.6	FUEL OIL STORAGE & SUPPLY	54,868	54,868	636,230	636,230	451,723	451,723	1,142,821	1,142,821
TOTAL 4.0			8,321,919		59,493,578		24,930,484		92,745,981
5.1	TURBINE - GENERATOR	621,000	621,000	21,870,000	21,870,000	8,748,000	8,748,000	31,239,000	31,239,000
5.2	TURBINE PEDESTAL	815,165	815,165	0	0	0	0	815,165	815,165
5.3	BF, EXTRACTION, COND. PIPING	367,043	367,043	3,636,050	3,636,050	3,090,643	3,090,643	7,093,736	7,093,736
5.4	HEATX, CONDENSER & MAIN PUMPS	191,190	191,190	5,834,928	5,834,928	2,333,971	2,333,971	8,360,089	8,360,089
5.5	CYCLE TREATMENT SYSTEMS	345,020	345,020	3,081,625	3,081,625	1,386,731	1,386,731	4,813,376	4,813,376
5.6	INSTRUMENTATION - MAIN PLANT	538,425	538,425	8,204,100	8,204,100	3,281,640	3,281,640	12,024,165	12,024,165
5.7	SERVICE AIR, GAS, SOOTBLOW SYS.	219,970	219,970	2,819,110	2,819,110	1,268,600	1,268,600	4,307,680	4,307,680
5.8	MISC. MECHANICAL EQUIPMENT	49,700	49,700	920,000	920,000	680,800	680,800	1,650,500	1,650,500
TOTAL 5.0			3,147,513		46,365,813		20,790,385		70,303,711

TABLE 8.8 (Cont'd.)

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
KHANOT SITE

UNIT 1

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
7.0	ELECTRICAL FACILITIES	2,684,093	2,684,093	10,067,980	10,067,980	4,027,192	4,027,192	16,779,265	16,779,265
8.01.1	BOILER BUILDING FOUNDATION	2,095,466		0		0		2,095,466	
8.01.1.1	FD FAN FOUNDATIONS	61,919		0		0		61,919	
8.01.1.2	ID FAN FOUNDATIONS	131,076		0		0		131,076	
8.01.1.3	PA FAN FOUNDATIONS	6,136		0		0		6,136	
8.01.1.4	PRECIPITATOR FOUNDATION	173,041		0		0		173,041	
8.01.1.5	BREECHING SUPPORT FOUNDATIONS	112,754		0		0		112,754	
8.01.2	BOILER BUILDING	10,596,394		1,265,133		834,593		12,696,120	
SUBTOTAL 8.01			13,176,786		1,265,133		834,593		15,276,512
8.02.1	TURBINE BUILDING FOUNDATION	1,201,994		0		0		1,201,994	
8.02.2	TURBINE BUILDING	3,996,060		662,945		417,810		5,076,815	
SUBTOTAL 8.02			5,198,054		662,945		417,810		6,278,809
8.03.1	CONTROL BUILDING FOUNDATION	91,297		0		0		91,297	
8.03.2	CONTROL & SHOP BUILDING	612,353		512,909		268,511		1,393,773	
SUBTOTAL 8.03			703,650		512,909		268,511		1,485,070
8.04.1	ADMIN. & SERVICE BLDG. FDN.	175,287		0		0		175,287	
8.04.2	ADMIN. & SERVICE BUILDING	3,430,385		332,501		196,895		3,959,781	
SUBTOTAL 8.04			3,605,672		332,501		196,895		4,135,068
8.05.1	CHIMNEY FOUNDATION	404,509		0		0		404,509	
8.05.2	CHIMNEY	1,725,000		1,840,000		1,104,000		4,669,000	
SUBTOTAL 8.05			2,129,509		1,840,000		1,104,000		5,073,509
8.06	RAILROAD SIDING	1,117,500	1,117,500	0	0	0	0	1,117,500	1,117,500
8.07.1	MAKE-UP WATER INTAKE STRUCTURE	1,670,951		805,088		478,896		2,954,935	
8.07.2	MAKE-UP WATER PIPE TO INDUS R.	1,269,851		0		0		1,269,851	
8.07.3	WATER SURGE POND	907,200		0		0		907,200	
SUBTOTAL 8.07			3,848,002		805,088		478,896		5,131,986
8.08.1	CIRCULATING WATER PUMPHOUSE	343,888	343,888	13,115	13,115	9,181	9,181	366,184	366,184
8.09	WATER TREATMENT	451,610	451,610	1,463,600	1,463,600	834,252	834,252	2,749,462	2,749,462
8.10	WASTE TREATMENT	200,860	200,860	573,400	573,400	258,030	258,030	1,032,290	1,032,290
8.11	SITE WORK - PAVED ROADWAYS	1,233,722	1,233,722	0	0	0	0	1,233,722	1,233,722
8.12.1	SITE WORK-FIRE PROTECT. LOOP	40,740	40,740	116,420	116,420	139,704	139,704	296,864	296,864
8.12.2	SITE WORK-SERVICE WATER LINES	36,750	36,750	105,000	105,000	126,000	126,000	267,750	267,750
8.15	TRANSFORMER FIREWALLS	122,885	122,885	89,000	89,000	75,650	75,650	287,535	287,535
TOTAL 8.0			32,209,628		7,779,111		4,743,522		44,732,261

TABLE 8.8 (Cont'd.)

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
KHANOT SITE

UNIT 1

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
9.1	COLONY - WATER SUPPLY	878,000	878,000	28,000	28,000	11,200	11,200	917,200	917,200
9.2	COLONY - PWR. DISTRIB. & COMMUN.	341,300	341,300	0	0	0	0	341,300	341,300
9.3	COLONY - RESIDENCES	20,000,200	20,000,200	0	0	0	0	20,000,200	20,000,200
9.4	COLONY - COMM. BLDGS. & FACILS.	2,210,000	2,210,000	320,000	320,000	144,000	144,000	2,674,000	2,674,000
9.5	COLONY - SERVICE FACILITIES	6,702,000	6,702,000	697,800	697,800	314,010	314,010	7,713,810	7,713,810
9.6	LEASE CONSTRUCTION EQUIPMENT	0	0	10,410,000	10,410,000	6,246,000	6,246,000	16,656,000	16,656,000
9.7	COLONY - SECURITY & PROTECTION	985,740	985,740	0	0	0	0	985,740	985,740
9.8	SPARE PARTS & LAB. & SHOP EQUIP.	0	0	7,500,000	7,500,000	3,000,000	3,000,000	10,500,000	10,500,000
9.9	TRANSPORTATION EQUIPMENT	54,000	54,000	1,560,000	1,560,000	979,500	979,500	2,593,500	2,593,500
	TOTAL 9.0		31,171,240		20,515,800		10,694,710		62,381,750
	REPORT TOTAL		100,094,728		166,479,608		76,650,540		343,224,876
	ENGINEERING & CONSULTANTS		2,266,297		19,552,685				21,818,983
	WAPDA ADMINISTRATION		13,728,995						13,728,995
	CONTINGENCIES		10,009,473		16,647,961		7,665,054		34,322,488
	CLEARING, FORWARDING, HANDLING AND INLAND TRANSPORTATION		8,323,980						8,323,980
	INSURANCE DURING CONSTRUCTION		4,862,603						4,862,603
	SUBTOTAL JULY 1985 COST		139,286,077		202,680,254		84,315,594		426,281,925
	ESCALATION		38,944,387		58,655,666		26,373,918		123,973,970
	INTEREST DURING CONSTRUCTION BASED ON COMMERCIAL OPERATION OF JUNE 1991		52,542,341		55,533,883		25,292,553		133,368,777
	CAPITAL COST OF PLANT		230,772,804		316,869,803		135,982,065		683,624,672

TABLE 8.9

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
KHANOT SITE

UNIT 2

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
3.2	COAL HANDLING EQUIPMENT	580,690	580,690	1,039,500	1,039,500	436,590	436,590	2,056,780	2,056,780
3.3.1	COOLING TOWER BASIN	451,914		0		0		451,914	
3.3.2	CLOSED LOOP CIRC. WATER PIPE	797,117		200,250		170,213		1,167,580	
3.3.3	COOLING TOWER	469,614		2,950,000		1,292,500		4,712,114	
SUBTOTAL 3.3			1,718,645		3,150,250		1,462,713		6,331,608
3.4.1	CONVEYOR EQUIPMENT & PIPING	960,000		2,006,000		902,700		3,868,700	
3.4.3	FLY ASH PIPE TO PONDS	372,600		2,385,630		2,027,786		4,786,016	
SUBTOTAL 3.4			1,332,600		4,391,630		2,930,486		8,654,716
TOTAL 3.0			3,631,935		8,581,380		4,829,789		17,043,104
4.1	STEAM GENERATOR	7,625,000	7,625,000	47,297,000	47,297,000	18,445,830	18,445,830	73,367,830	73,367,830
4.2	PRECIPITATOR	1,376,000	1,376,000	7,925,000	7,925,000	3,170,000	3,170,000	12,471,000	12,471,000
4.3	MAIN, HOT & COLD PRESSURE PIPE	328,725	328,725	1,809,768	1,809,768	1,538,303	1,538,303	3,676,796	3,676,796
4.4	MISC. STEAM, WATER, & DRAIN. SYS	261,990	261,990	1,176,680	1,176,680	1,000,178	1,000,178	2,438,848	2,438,848
4.5	BOTTOM ASH PIPING & PUMPS	139,300	139,300	648,900	648,900	324,450	324,450	1,112,650	1,112,650
TOTAL 4.0			9,731,015		58,857,348		24,478,761		93,067,124
5.1	TURBINE - GENERATOR	621,000	621,000	21,870,000	21,870,000	8,748,000	8,748,000	31,239,000	31,239,000
5.2	TURBINE PEDESTAL	815,165	815,165	0	0	0	0	815,165	815,165
5.3	BF, EXTRACTION, COND. PIPING	367,043	367,043	3,636,050	3,636,050	3,090,643	3,090,643	7,093,736	7,093,736
5.4	HEATX, CONDENSER & MAIN PUMPS	191,190	191,190	5,834,928	5,834,928	2,333,971	2,333,971	8,360,089	8,360,089
5.5	CYCLE TREATMENT SYSTEMS	345,020	345,020	3,081,625	3,081,625	1,386,731	1,386,731	4,813,376	4,813,376
5.6	INSTRUMENTATION - MAIN PLANT	538,425	538,425	8,204,100	8,204,100	3,281,640	3,281,640	12,024,165	12,024,165
5.7	SERVICE AIR, GAS, SOOTBLOW SYS.	219,970	219,970	2,819,110	2,819,110	1,268,600	1,268,600	4,307,680	4,307,680
TOTAL 5.0			3,097,813		45,445,813		20,109,585		68,653,211
7.0	ELECTRICAL FACILITIES	2,684,093	2,684,093	10,067,980	10,067,980	4,027,192	4,027,192	16,779,265	16,779,265
8.01.1	BOILER BUILDING FOUNDATION	2,095,466		0		0		2,095,466	
8.01.1.1	FD FAN FOUNDATIONS	61,919		0		0		61,919	
8.01.1.2	ID FAN FOUNDATIONS	131,076		0		0		131,076	
8.01.1.3	PA FAN FOUNDATIONS	6,136		0		0		6,136	
8.01.1.4	PRECIPITATOR FOUNDATION	173,041		0		0		173,041	
8.01.1.5	BREECHING SUPPORT FOUNDATIONS	112,754		0		0		112,754	
8.01.2	BOILER BUILDING	10,596,396		1,265,133		834,593		12,696,122	
SUBTOTAL 8.01			13,176,788		1,265,133		834,593		15,276,514
8.02.1	TURBINE BUILDING FOUNDATION	1,201,994		0		0		1,201,994	
8.02.2	TURBINE BUILDING	3,320,882		602,745		375,670		4,299,297	

TABLE 8.9 (Cont'd.)

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
KHANOT SITE

UNIT 2

CODE	DESCRIPTION	LOCAL		FEC		IMPORT DUTY		TOTAL	
SUBTOTAL 8.02			4,522,876		602,745		375,670		5,501,291
8.08.1	CIRCULATING WATER PUMPHOUSE	343,888	343,888	13,115	13,115	9,181	9,181	366,184	366,184
8.12.2	SITE WORK-SERVICE WATER LINES	36,900	36,900	105,000	105,000	126,000	126,000	267,900	267,900
8.15	TRANSFORMER WIREWALLS	122,809	122,809	89,000	89,000	75,650	75,650	287,459	287,459
TOTAL 8.0			18,203,261		2,074,993		1,421,094		21,699,348
9.6	LEASE CONSTRUCTION EQUIPMENT	0	0	4,164,000	4,164,000	2,498,400	2,498,400	6,662,400	6,662,400
9.8	SPARE PARTS & LAB.& SHOP EQUIP.	0	0	7,500,000	7,500,000	3,000,000	3,000,000	10,500,000	10,500,000
TOTAL 9.0			0		11,664,000		5,498,400		17,162,400
REPORT TOTAL			37,348,117		136,691,514		60,364,821		234,404,452
	ENGINEERING & CONSULTANTS		696,159		19,094,028				19,790,187
	WAPDA ADMINISTRATION		9,376,178						9,376,178
	CONTINGENCIES		3,734,812		13,669,151		6,036,482		23,440,445
	CLEARING, FORWARDING, HANDLING AND INLAND TRANSPORTATION		6,834,576						6,834,576
	INSURANCE DURING CONSTRUCTION		3,941,127						3,941,127
	SUBTOTAL JULY 1985 COST		61,930,968		169,454,693		66,401,303		297,786,964
	ESCALATION		20,455,799		68,561,369		22,463,561		111,480,728
	INTEREST DURING CONSTRUCTION BASED ON COMMERCIAL OPERATION OF JUNE 1992		13,017,109		46,722,553		19,914,616		79,654,278
	CAPITAL COST OF PLANT		95,403,875		284,738,615		108,779,480		488,921,971

TABLE 8.10

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
ANNUAL EXPENDITURE REQUIREMENTS
KHANOT SITE
UNIT 1

(Thousands of Dollars)

	TOTAL				1986			1987			1988			1989			1990			1991		
	LOCAL	FEC	IMPORT DUTY	TOTAL	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY	LOCAL	FEC	IMPORT DUTY
Land	527	-	-	527	-	-	-	527	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Site Preparation	1,680	-	-	1,680	-	-	-	780	-	-	900	-	-	-	-	-	-	-	-	-	-	-
Coal Handling	2,593	9,955	4,181	16,729	-	-	-	-	-	-	1,001	3,972	1,668	991	5,983	2,513	601	-	-	-	-	-
Cooling System	1,718	3,151	1,463	6,332	-	-	-	-	-	-	632	-	-	373	3,151	1,463	713	-	-	-	-	-
Ash Handling	16,042	9,152	5,821	31,015	-	-	-	-	-	-	15,015	-	-	1,027	9,152	5,821	-	-	-	-	-	-
Boiler Plant & Auxiliaries	8,322	59,493	24,930	92,745	-	-	-	-	-	-	-	-	-	1,947	34,803	16,030	5,035	18,383	7,703	1,340	6,307	1,197
Turbine Generator Plant & Auxiliaries	3,148	46,366	20,790	70,304	-	-	-	-	-	-	-	4,822	-	563	31,900	14,262	2,025	9,644	4,407	560	-	2,121
Electrical Facilities	2,684	10,068	4,027	16,779	-	-	-	-	-	-	-	2,500	1,000	1,900	7,568	3,027	784	-	-	-	-	-
Civil & Structural Works	32,209	7,779	4,744	44,732	-	-	-	-	-	-	8,696	-	-	21,967	4,434	2,704	982	3,345	2,040	644	-	-
Colony & Transport. Equip.	31,171	2,686	1,449	35,226	-	-	-	1,839	-	-	3,741	-	-	17,456	-	-	8,135	2,686	1,449	-	-	-
Construction Equipment	-	10,410	6,246	16,656	-	-	-	-	-	-	-	2,700	1,600	-	4,410	2,646	-	3,300	2,000	-	-	-
Spare Parts	-	7,500	3,000	10,500	-	-	-	-	-	-	-	-	-	-	-	-	-	3,267	-	-	4,233	3,000
Subtotal	100,094	166,480	76,651	343,225	-	-	-	3,146	-	-	29,985	13,994	4,268	46,224	101,401	48,466	18,195	40,545	17,599	2,544	10,540	6,318
SUBTOTAL BY YEAR				343,225		-			3,146			48,247			196,091			76,339			19,402	
Engineering & Consultants	2,266	19,553	-	21,819	-	1,857	-	1,099	5,573	-	1,167	6,551	-	-	2,170	-	-	2,170	-	-	1,232	-
WAPDA Administration	13,729	-	-	13,729	220	-	-	1,853	-	-	3,693	-	-	3,693	-	-	2,417	-	-	1,853	-	-
Contingencies	10,009	16,648	7,665	34,322	-	-	-	-	-	-	2,642	1,448	452	4,705	10,385	4,753	1,391	2,464	1,755	1,271	2,431	705
Clearing, Forwarding & Inland Transportation	8,324	-	-	8,324	-	-	-	-	-	-	1,215	-	-	4,678	-	-	2,431	-	-	-	-	-
Insurance During Construction	4,863	-	-	4,863	-	-	-	1,216	-	-	1,216	-	-	1,823	-	-	608	-	-	-	-	-
Subtotal	39,191	36,201	7,665	83,057	220	1,857	-	4,168	5,573	-	9,933	7,999	452	14,899	12,475	4,753	6,847	4,634	1,755	3,124	3,663	705
SUBTOTAL BY YEAR				83,057		2,077			9,741			18,384			32,127			13,236			7,492	
SUBTOTAL-JULY 1985 COSTS	139,285	202,681	84,316	426,282	220	1,857	-	7,314	5,573	-	39,918	21,993	4,720	61,123	113,876	53,219	25,042	45,179	19,354	5,668	14,203	7,023
Escalation	38,427	58,698	26,303	123,428	14	93	-	982	644	-	8,301	4,137	982	17,512	38,895	15,247	9,268	16,852	7,163	2,350	6,877	2,912
Interest During Construction	53,683	55,426	25,477	134,586	15	107	-	572	284	-	4,319	2,370	371	13,126	12,030	5,240	22,174	24,727	12,095	13,476	15,987	7,771
SUBTOTAL BY YEAR					250	2,057	-	8,867	6,422	-	52,538	28,500	6,072	91,761	156,801	73,706	56,484	86,758	38,612	21,494	36,268	17,706
CAPITAL COST OF PLANT	231,395	316,805	136,096	684,295		2,307			15,289			87,110			322,268			181,854			75,468	

TABLE 8.11

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

OPTION 2 - WASHED COAL
(Thousands of U.S. Dollars)

	Lakhra/Khanot				
	Unit 1				Unit 2
Description	Local	FEC	Import	Total	Total
Precipitator	(229.3)	(1,320.8)	(528.3)	(2,078.4)	(2,078.4)
Ash Handling System	(326.4)	(670.0)	(301.5)	(1,297.9)	(1,297.9)
Electrical & Instruments	(225.5)	(1,279.1)	(511.8)	(2,016.4)	(2,016.4)
Piping	(68.8)	(627.3)	(533.2)	(1,229.3)	(1,229.3)
Disposal Pond	(5,080.5)	(290.0)	(250.1)	(5,620.6)	N/A
Total Direct Cost	(5,930.5)	(4,187.2)	(2,124.9)	(12,242.6)	(6,622.0)
Engineering	(237.2)	(167.5)		(404.7)	(190.0)
WAPDA	(489.7)			(489.7)	(264.9)
Clearing	(209.4)			(209.4)	(194.9)
Insurance	(126.2)			(126.2)	(115.4)
Contingency	(593.1)	(418.7)	(212.5)	(1,224.3)	(662.2)
Subtotal	(7,586.1)	(4,773.4)	(2,337.4)	(14,696.9)	(8,049.4)
Escalation	(2,067.2)	(1,385.7)	< 730.9>	< 4,183.8>	< 3,055.0>
IDC	(2,977.1)	(1,300.2)	< 702.0>	< 4,979.3>	< 2,327.2>
TOTAL CAPITAL COST (CREDIT)	(12,630.4)	(7,459.3)	<3,770.3>	<23,860.0>	<13,431.6>

TABLE 8.12

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

OPTION 3 - 1,000 TPD SITE EMISSION LIMIT
(Thousands of U.S. Dollars)

	Lakhra/Khanot				
	Scrub 50% - Unit 1				No SO_2 Removal Unit 2
Description	Local	FEC	Import	Total	Total
Equipment Package	1,406.3	25,000.0	10,000.0	36,406.3	0
Foundations & Structures	2,110.9	2,500.0	1,000.0	5,610.9	0
Electrical & Instruments	528.8	2,161.8	864.7	3,555.3	0
Limestone & Auxiliary Sys.	675.0	3,820.0	1,528.0	6,023.0	0
Spare Parts		2,500.0	1,000.0	3,500.0	0
Total Direct Cost	4,721.0	35,981.8	14,392.7	55,095.5	0
Engineering	188.8	1,439.3		1,628.1	0
WAPDA	2,203.8			2,203.8	0
Clearing	1,799.1			1,799.1	0
Insurance	1,007.5			1,007.5	0
Contingency	472.1	3,598.2	1,439.3	5,509.6	0
Subtotal	10,392.3	41,019.3	15,832.0	67,243.6	0
Escalation	2,831.9	11,907.9	4,950.7	19,690.5	0
IDC	4,078.3	11,172.9	4,755.1	20,006.3	0
TOTAL CAPITAL COST	17,302.5	64,100.1	25,537.8	106,940.4	0

TABLE 8.13

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

OPTION 4 - 750 TPD SITE EMISSION LIMIT
(Thousands of U.S. Dollars)

	Lakhra/Khanot							
	Scrub 50% - Unit 1				Scrub 50% - Unit 2			
Description	Local	FEC	Import	Total	Local	FEC	Import	Total
Equipment Package	1,406.3	25,000.0	10,000.0	36,406.3	1,406.3	25,000.0	10,000.0	36,406.3
Foundations & Structures	2,110.9	2,500.0	1,000.0	5,610.9	2,110.9	2,500.0	1,000.0	5,610.9
Electrical & Instruments	528.8	2,161.8	864.7	3,555.3	528.8	2,161.8	864.7	3,555.3
Limestone & Auxiliary Sys.	675.0	3,820.0	1,528.0	6,023.0	360.0	2,021.0	808.4	3,189.4
Spare Parts		2,500.0	1,000.0	3,500.0		1,250.0	500.0	1,750.0
Total Direct Cost	4,721.0	35,981.8	14,392.7	55,095.5	4,406.0	32,932.8	13,173.1	50,511.9
Engineering	188.8	1,439.3		1,628.1	176.2	1,317.3		1,493.5
WAPDA	2,203.8			2,203.8	2,020.5			2,020.5
Clearing	1,799.1			1,799.1	1,646.6			1,646.6
Insurance	1,007.5			1,007.5	922.1			922.1
Contingency	472.1	3,598.2	1,439.3	5,509.6	440.6	3,293.3	1,317.3	5,051.2
Subtotal	10,392.3	41,019.3	15,832.0	67,243.6	9,612.0	37,543.4	14,490.4	61,645.8
Escalation	2,831.9	11,907.9	4,950.7	19,690.5	3,174.8	15,193.8	4,902.1	23,270.7
IDC	4,078.3	11,172.9	4,755.1	20,006.3	3,273.4	10,336.5	4,343.9	17,953.8
TOTAL CAPITAL COST	17,302.5	64,100.1	25,537.8	106,940.4	16,060.2	63,073.7	23,736.4	102,870.3

TABLE 8.14

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

OPTION 5 - 500 TPD SITE EMISSION LIMIT
(Thousands of U.S. Dollars)

Description	Lakhra/Khanot							
	Scrub 100% - Unit 1				Scrub 100% - Unit 2			
	Local	FEC	Import	Total	Local	FEC	Import	Total
Equipment Package	2,025.0	36,450.0	14,580.0	53,055.0	2,025.0	36,450.0	14,580.0	53,055.0
Foundations & Structures	2,940.0	3,645.0	1,458.0	8,043.0	2,940.0	3,645.0	1,458.0	8,043.0
Electrical & Instruments	793.1	3,242.7	1,297.1	5,332.9	793.1	3,242.7	1,297.1	5,332.9
Limestone & Auxiliary Sys.	1,012.5	5,677.5	2,271.0	8,961.0	540.0	2,979.0	1,191.6	4,710.6
Spare Parts		2,916.0	1,166.4	4,082.4		1,822.5	729.0	2,551.5
Total Direct Cost	6,770.6	51,931.2	20,772.5	79,474.3	6,298.1	48,139.2	19,255.7	73,693.0
Engineering	270.8	2,077.2		2,348.0	251.9	1,925.6		2,177.5
WAPDA	3,179.0			3,179.0	2,947.7			2,947.7
Clearing	2,596.6			2,596.6	2,407.0			2,407.0
Insurance	1,454.1			1,454.1	1,347.9			1,347.9
Contingency	677.1	5,193.1	2,077.3	7,947.5	629.8	4,813.9	1,925.6	7,369.3
Subtotal	14,948.2	59,201.5	22,849.8	96,999.5	13,882.4	54,878.7	21,181.3	89,942.4
Escalation	4,073.4	17,186.2	7,145.1	28,404.7	4,585.4	22,209.4	7,165.6	33,960.4
IDC	5,866.3	16,125.4	6,862.8	28,854.5	4,727.8	15,109.3	6,349.7	26,186.8
TOTAL CAPITAL COST	24,887.9	92,513.1	36,857.7	154,258.7	23,195.6	92,197.4	34,696.6	150,089.6

TABLE 8.15

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

COMPARISON OF SO_2 EMISSION OPTIONS
TOTAL CAPITAL COSTS
($ x 1,000)

Description	Lakhra					
	Unit 1			Unit 2		
	Local & FEC	Import Duty	Total	Local & FEC	Import Duty	Total
1. Base - Without Scrubbing, 1985 $	381,939	85,215	467,154	238,982	67,912	306,894
Escalation and IDC	228,231	51,301	279,532	151,954	43,132	195,086
Total Capital Cost	610,170	136,516	746,686	390,936	111,044	501,980
2. Washed Coal, 1985 $	369,579	82,878	452,457	233,270	65,575	298,845
Escalation and IDC	220,501	49,868	270,369	147,836	41,868	189,704
Total Capital Cost	590,080	132,746	722,826	381,106	107,443	488,549
3. 1,000 TPD Site Emission Limit, 1985 $	433,351	101,047	534,398	238,982	67,912	306,894
Escalation and IDC	258,222	61,007	319,229	151,954	43,132	195,086
Total Capital Cost	691,573	162,054	853,627	390,936	111,044	501,980
4. 750 TPD Site Emission Limit, 1985 $	433,351	101,047	534,398	286,138	82,402	368,540
Escalation and IDC	258,222	61,007	319,229	183,933	52,378	236,311
Total Capital Cost	691,573	162,054	853,627	470,071	134,780	604,851
5. 500 TPD Site Emission Limit, 1985 $	456,089	108,065	564,154	307,743	89,093	396,836
Escalation and IDC	271,482	65,309	336,791	198,585	56,648	255,233
Total Capital Cost	727,571	173,374	900,945	506,328	145,741	652,069

NOTE: Capital Costs include Transmission and Substation Costs.

LPS2/B6404-Tbl.8.15/D10

TABLE 8.16

LAKHRA POWER FEASIBILITY STUDY
PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

COMPARISON OF SO_2 EMISSION OPTIONS
TOTAL CAPITAL COSTS
($ x 1,000)

Description	Khanot					
	Unit 1			Unit 2		
	Local & FEC	Import Duty	Total	Local & FEC	Import Duty	Total
1. Base - Without Scrubbing, 1985 $	356,252	87,666	443,918	239,849	68,386	308,235
Escalation and IDC	211,750	53,000	264,750	152,505	43,436	195,941
Total Capital Cost	568,002	140,666	708,668	392,354	111,822	504,176
2. Washed Coal, 1985 $	343,932	85,289	429,221	233,862	66,324	300,186
Escalation and IDC	204,020	51,567	255,587	148,387	42,172	190,559
Total Capital Cost	547,952	136,856	684,808	382,249	108,496	490,745
3. 1,000 TPD Site Emission Limit, 1985 $	407,664	103,498	511,162	239,849	68,386	308,235
Escalation and IDC	241,741	62,706	304,447	152,505	43,436	195,941
Total Capital Cost	649,405	166,204	815,609	392,354	111,822	504,176
4. 750 TPD Site Emission Limit, 1985 $	407,664	103,498	511,162	287,005	82,876	369,881
Escalation and IDC	241,741	62,706	304,447	187,483	49,682	237,165
Total Capital Cost	649,405	166,240	815,609	474,488	132,558	607,046
5. 500 TPD Site Emission Limit, 1985 $	430,402	110,516	540,918	308,611	89,567	398,178
Escalation and IDC	255,001	67,008	322,009	199,137	56,951	256,088
Total Capital Cost	685,403	177,524	862,927	507,748	146,518	654,266

NOTE: Capital Costs include Transmission and Substation Costs.

TABLE 8.17

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

LAKHRA SITE
TWO-UNIT 2 X 350MW
STAFFING PLAN

YEARLY COSTS ($ X 1,000)

POSITION	NUMBER	$/MONTH	1	2	3	4	5	6	7	8	9	10	11-15	16-20	21-25	26-30
Resident Engineer's Office																
Resident Engineer	1	489	6	6	6	6	6	6	6	6	6	6	30	30	30	30
Steno	2	134	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Naib Qasid	2	83	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Total	5	706	11	11	11	11	11	11	11	11	11	11	55	55	55	55
Operation Department (excl. scrubber)																
Assistant Resident Engr. (Operation)	1	401	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Senior Engineer	10	401	48	48	48	48	48	48	48	48	48	48	240	240	240	240
Junior Engineer	46	356	197	197	197	197	197	197	197	197	197	197	985	985	985	985
Fire Officer	1	125	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Head Fireman	4	101	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Fireman	30	89	32	32	32	32	32	32	32	32	32	32	160	160	160	160
Chowkidar	8	83	8	8	8	8	8	8	8	8	8	8	40	40	40	40
Foreman	30	236	85	85	85	85	85	85	85	85	85	85	425	425	425	425
Assistant Foreman	20	172	41	41	41	41	41	41	41	41	41	41	205	205	205	205
Operator	164	146	287	287	287	287	287	287	287	287	287	287	1,435	1,435	1,435	1,435
Attendant	236	134	379	379	379	379	379	379	379	379	379	379	1,895	1,895	1,895	1,895
Helper	208	125	312	312	312	312	312	312	312	312	312	312	1,560	1,560	1,560	1,560
Senior Chemist	1	401	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Junior Chemist	5	356	21	21	21	21	21	21	21	21	21	21	105	105	105	105
Assistant Chemist	12	236	34	34	34	34	34	34	34	34	34	34	170	170	170	170
Steno	3	134	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Clerk	1	116	1	1	1	1	1	1	1	1	1	1	5	5	5	5
Coolies	12	69	10	10	10	10	10	10	10	10	10	10	50	50	50	50
Naib Qasid	3	83	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Fitter	20	101	24	24	24	24	24	24	24	24	24	24	120	120	120	120
Electrician	20	116	28	28	28	28	28	28	28	28	28	28	140	140	140	140
Instrument Mechanic	8	116	11	11	11	11	11	11	11	11	11	11	55	55	55	55
Total	843	4,097	1,543	1,543	1,543	1,543	1,543	1,543	1,543	1,543	1,543	1,543	7,715	7,715	7,715	7,715
Scrubber Operation																
Junior Engineer	8	356	34	34	34	34	34	34	34	34	34	34	170	170	170	170
Foreman	8	236	23	23	23	23	23	23	23	23	23	23	115	115	115	115
Assistant Foreman	8	172	17	17	17	17	17	17	17	17	17	17	85	85	85	85
Operator	32	146	56	56	56	56	56	56	56	56	56	56	280	280	280	280
Attendant	48	134	77	77	77	77	77	77	77	77	77	77	385	385	385	385
Helper	48	125	72	72	72	72	72	72	72	72	72	72	360	360	360	360
Fitter	8	101	10	10	10	10	10	10	10	10	10	10	50	50	50	50
Coolies .	24	69	20	20	20	20	20	20	20	20	20	20	100	100	100	100
Electrician	8	116	11	11	11	11	11	11	11	11	11	11	55	55	55	55
Total	192	1,455	319	319	319	319	319	319	319	319	319	319	1,600	1,600	1,600	1,600

TABLE 8.17 (Cont'd.)

Maintenance Department																
Assistant Resident Engr. (Maintenance)	1	401	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Senior Engineer	6	401	29	29	29	29	29	29	29	29	29	29	145	145	145	145
Junior Engineer	10	356	43	43	43	43	43	43	43	43	43	43	215	215	215	215
Head Draftsman	1	172	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Draftsman	1	146	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Traces	2	79	2	2	2	2	2	2	2	2	2	2	10	10	10	10
F.A. Operator	1	74	1	1	1	1	1	1	1	1	1	1	5	5	5	5
Foreman	14	236	40	40	40	40	40	40	40	40	40	40	200	200	200	200
Assistant Foreman	24	172	50	50	50	50	50	50	50	50	50	50	250	250	250	250
Fitter	87	101	105	105	105	105	105	105	105	105	105	105	525	525	525	525
Welder	8	172	17	17	17	17	17	17	17	17	17	17	85	85	85	85
Attendant	18	134	29	29	29	29	29	29	29	29	29	29	145	145	145	145
Helper	85	125	128	128	128	128	128	128	128	128	128	128	640	640	640	640
Steno	3	134	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Naib Qasid	3	83	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Clerk	2	116	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Miscellaneous Support	260	108	337	337	337	337	337	337	337	337	337	337	1,685	1,685	1,685	1,685
Total	526	3,010	798	798	798	798	798	798	798	798	798	798	4,005	4,005	4,005	4,005
Quality Control Department																
Senior Engineer	1	401	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Junior Engineer	2	356	9	9	9	9	9	9	9	9	9	9	45	45	45	45
Operator	4	146	7	7	7	7	7	7	7	7	7	7	35	35	35	35
Steno	1	134	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Clerk	1	116	1	1	1	1	1	1	1	1	1	1	5	5	5	5
Attendant	3	134	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Helper	3	125	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Total	15	1,412	33	33	33	33	33	33	33	33	33	33	170	170	170	170
Training Department																
Training Coordinator	1	356	4	4	4	4	4	4	4	4	4	4	20	20	20	20
Steno	2	134	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Clerk	2	116	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Naib Qasid	1	83	1	1	1	1	1	1	1	1	1	1	5	5	5	5
Total	6	689	11	11	11	11	11	11	11	11	11	11	55	55	55	55
Other Departments Per Guddu (Reporting to Resident Engr.)																
Civil Engineer	1	401	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Staff	161	108	209	209	209	209	209	209	209	209	209	209	1,045	1,045	1,045	1,045
Total	162	509	213	213	213	213	213	213	213	213	213	213	1,070	1,070	1,070	1,070
Senior Budget & Accounts Officer	1	401	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Staff	17	108	22	22	22	22	22	22	22	22	22	22	110	110	110	110
Total	18	509	27	27	27	27	27	27	27	27	27	27	135	135	135	135
Assistant Director Administration	1	356	4	4	4	4	4	4	4	4	4	4	20	20	20	20
Staff	25	108	32	32	32	32	32	32	32	32	32	32	160	160	160	160
Total	26	464	37	37	37	37	37	37	37	37	37	37	180	180	180	180
Other Departments Per Guddu (Reporting to Chief Engr.)																
Chief Security Officer	1	401	5	5	5	5	5	5	5	5	5	5	25	25	25	25
Staff	212	108	275	275	275	275	275	275	275	275	275	275	1,375	1,375	1,375	1,375
Total	213	509	280	280	280	280	280	280	280	280	280	280	1,400	1,400	1,400	1,400
Medical Superintendent	1	356	4	4	4	4	4	4	4	4	4	4	20	20	20	20
Staff	11	108	14	14	14	14	14	14	14	14	14	14	70	70	70	70
Tot	12	464	19	19	19	[illegible]9	19	19	19	19	19	19	90	90	[illegible]90	90

TABLE 8.17 (Cont'd.)

School Principal/Headmaster	2	356	9	9	9	9	9	9	9	9	9	9	45	45	45	45
Staff	60	108	78	78	78	78	78	78	78	78	78	78	390	390	390	390
Total	62	464	86	86	86	86	86	86	86	86	86	86	435	435	435	435
Arbo Superintendent	1	172	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Staff	93	89	99	99	99	99	99	99	99	99	99	99	495	495	495	495
Total	94	261	101	101	101	101	101	101	101	101	101	101	505	505	505	505
Total Reporting to & Including Resident Engineer	1,793	12,851	2,993	2,993	2,993	2,993	2,993	2,993	2,993	2,993	2,993	2,993	14,985	14,985	14,985	14,985
Total Other Reporting to & Including Resident Engineer	381	1,698	486	486	486	486	486	486	486	486	486	486	2,430	2,430	2,430	2,430
Subtotal - Personnel Cost	2,174	14,549	3,479	3,479	3,479	3,479	3,479	3,479	3,479	3,479	3,479	3,479	17,415	17,415	17,415	17,415
Supplies			348	348	348	348	348	348	348	348	348	348	1,742	1,742	1,742	1,742
Spare Parts			9,000	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	36,820	36,820	36,820	36,820
Colony Operating Cost			1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	5,602	5,602	5,602	5,602
Scheduled Outage Inspections & Disposal Ponds Beyond Initial Investment					4,000			3,000		1,500		3,000	4,500	4,500	4,500	4,500
Subtotal			10,468	8,832	12,832	8,832	8,832	11,832	8,832	10,332	8,832	11,832	48,664	48,664	48,664	48,664
Total Station	2,174	14,549	13,947	12,311	16,311	12,311	12,311	15,311	12,311	13,811	12,311	15,311	66,079	66,079	66,079	66,079
Fixed Cost - $/Kilowatt Month			0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Variable Cost - $/Megawatt Hour			2.44	2.06	2.99	2.06	2.06	2.76	2.06	2.41	2.06	2.76	11.34	10.03	10.03	10.03

17-Dec-85

TABLE 8.18

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

KHANOT SITE
TWO-UNIT 2 X 350MW
STAFFING PLAN

YEARLY COSTS ($ X 1,000)

POSITION	NUMBER	$/MONTH	1	2	3	4	5	6	7	8	9	10	11-15	16-20	21-25	26-30
Resident Engineer's Office																
Resident Engineer	1	428	5	5	5	5	5	5	5	5	5	5	30	30	30	30
Steno	2	117	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Naib Qasid	2	72	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Total	5	617	10	10	10	10	10	10	10	10	10	10	55	55	55	55
Operation Department (excl. scrubber)																
Assistant Resident Engr. (Operation)	1	351	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Senior Engineer	10	351	42	42	42	42	42	42	42	42	42	42	240	240	240	240
Junior Engineer	46	312	172	172	172	172	172	172	172	172	172	172	985	985	985	985
Fire Officer	1	109	1	1	1	1	1	1	1	1	1	1	10	10	10	10
Head Fireman	4	88	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Fireman	30	78	28	28	28	28	28	28	28	28	28	28	160	160	160	160
Chowkidar	8	72	7	7	7	7	7	7	7	7	7	7	40	40	40	40
Foreman	30	206	74	74	74	74	74	74	74	74	74	74	425	425	425	425
Assistant Foreman	20	150	36	36	36	36	36	36	36	36	36	36	205	205	205	205
Operator	164	128	252	252	252	252	252	252	252	252	252	252	1,435	1,435	1,435	1,435
Attendant	236	117	331	331	331	331	331	331	331	331	331	331	1,895	1,895	1,895	1,895
Helper	208	109	272	272	272	272	272	272	272	272	272	272	1,560	1,560	1,560	1,560
Senior Chemist	1	351	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Junior Chemist	5	312	19	19	19	19	19	19	19	19	19	19	105	105	105	105
Assistant Chemist	12	206	30	30	30	30	30	30	30	30	30	30	170	170	170	170
Steno	3	117	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Clerk	1	101	1	1	1	1	1	1	1	1	1	1	5	5	5	5
Coolies	12	60	9	9	9	9	9	9	9	9	9	9	50	50	50	50
Naib Qasid	3	72	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Fitter	20	88	21	21	21	21	21	21	21	21	21	21	120	120	120	120
Electrician	20	101	24	24	24	24	24	24	24	24	24	24	140	140	140	140
Instrument Mechanic	8	101	10	10	10	10	10	10	10	10	10	10	55	55	55	55
Total	843	3,580	1,349	1,349	1,349	1,349	1,349	1,349	1,349	1,349	1,349	1,349	7,715	7,715	7,715	7,715
Scrubber Operation																
Junior Engineer	8	312	30	30	30	30	30	30	30	30	30	30	170	170	170	170
Foreman	8	206	20	20	20	20	20	20	20	20	20	20	115	115	115	115
Assistant Foreman	8	150	14	14	14	14	14	14	14	14	14	14	85	85	85	85
Operator	32	128	49	49	49	49	49	49	49	49	49	49	280	280	280	280
Attendant	48	117	67	67	67	67	67	67	67	67	67	67	385	385	385	385
Helper	48	109	63	63	63	63	63	63	63	63	63	63	360	360	360	360
Fitter	8	88	8	8	8	8	8	8	8	8	8	8	50	50	50	50
Coolies	24	60	17	17	17	17	17	17	17	17	17	17	100	100	100	100
Electrician	8	101	10	10	10	10	10	10	10	10	10	10	55	55	55	55
Total	192	1,271	279	279	279	279	279	279	279	279	279	279	1,600	1,600	1,600	1,600

TABLE 8.18 (Cont'd.)

Maintenance Department																
Assistant Resident Engr.(Maintenance)	1	351	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Senior Engineer	6	351	25	25	25	25	25	25	25	25	25	25	145	145	145	145
Junior Engineer	10	312	37	37	37	37	37	37	37	37	37	37	215	215	215	215
Head Draftsman	1	150	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Draftsman	1	128	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Tracer	2	69	2	2	2	2	2	2	2	2	2	2	10	10	10	10
F.A. Operator	1	65	1	1	1	1	1	1	1	1	1	1	5	5	5	5
Foreman	14	206	35	35	35	35	35	35	35	35	35	35	200	200	200	200
Assistant Foreman	24	150	43	43	43	43	43	43	43	43	43	43	250	250	250	250
Fitter	87	88	92	92	92	92	92	92	92	92	92	92	525	525	525	525
Welder	8	150	14	14	14	14	14	14	14	14	14	14	85	85	85	85
Attendant	18	117	25	25	25	25	25	25	25	25	25	25	145	145	145	145
Helper	85	109	111	111	111	111	111	111	111	111	111	111	640	640	640	640
Steno	3	117	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Naib Qasid	3	72	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Clerk	2	101	2	2	2	2	2	2	2	2	2	2	15	15	15	15
Miscellaneous Support	260	95	296	296	296	296	296	296	296	296	296	296	1,685	1,685	1,685	1,685
Total	526	2,631	699	699	699	699	699	699	699	699	699	699	4,005	4,005	4,005	4,005
Quality Control Department																
Senior Engineer	1	351	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Junior Engineer	2	312	7	7	7	7	7	7	7	7	7	7	45	45	45	45
Operator	4	128	6	6	6	6	6	6	6	6	6	6	35	35	35	35
Steno	1	117	1	1	1	1	1	1	1	1	1	1	10	10	10	10
Clerk	1	101	1	1	1	1	1	1	1	1	1	1	5	5	5	5
Attendant	3	117	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Helper	3	109	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Total	15	1,235	29	29	29	29	29	29	29	29	29	29	170	170	170	170
Training Department																
Training Coordinator	1	312	4	4	4	4	4	4	4	4	4	4	20	20	20	20
Steno	2	117	3	3	3	3	3	3	3	3	3	3	15	15	15	15
Clerk	2	101	2	2	2	2	2	2	2	2	2	2	15	15	15	15
Naib Qasid	1	72	1	1	1	1	1	1	1	1	1	1	5	5	5	5
Total	6	602	10	10	10	10	10	10	10	10	10	10	55	55	55	55
Other Departments Per Guddu (Reporting to Resident Engr.)																
Civil Engineer	1	351	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Staff	161	95	184	184	184	184	184	184	184	184	184	184	1,045	1,045	1,045	1,045
Total	162	446	188	188	188	188	188	188	188	188	188	188	1,070	1,070	1,070	1,070
Senior Budget & Accounts Officer	1	351	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Staff	17	95	19	19	19	19	19	19	19	19	19	19	110	110	110	110
Total	18	446	24	24	24	24	24	24	24	24	24	24	135	135	135	135
Assistant Director Administration	1	312	4	4	4	4	4	4	4	4	4	4	20	20	20	20
Staff	25	95	29	29	29	29	29	29	29	29	29	29	160	160	160	160
Total	26	407	32	32	32	32	32	32	32	32	32	32	180	180	180	180
Other Departments Per Guddu (Reporting to Chief Engr.)																
Chief Security Officer	1	351	4	4	4	4	4	4	4	4	4	4	25	25	25	25
Staff	212	95	242	242	242	242	242	242	242	242	242	242	1,375	1,375	1,375	1,375
Total	213	446	246	246	246	246	246	246	246	246	246	246	1,400	1,400	1,400	1,400
Medical Superintendent	1	312	4	4	4	4	4	4	4	4	4	4	20	20	20	20
Staff	11	95	13	13	13	13	13	13	13	13	13	13	70	70	70	70
Total	12	407	16	16	16	16	16	16	16	16	16	16	90	90	90	90

TABLE 8.18 (Cont'd.)

School Principal/Headmaster	2	206	5	5	5	5	5	5	5	5	5	5	45	45	45	45
Staff	60	95	68	68	68	68	68	68	68	68	68	68	390	390	390	390
Total	62	301	73	73	73	73	73	73	73	73	73	73	435	435	435	435
Arbo Superintendent	1	150	2	2	2	2	2	2	2	2	2	2	10	10	10	10
Staff	93	78	87	87	87	87	87	87	87	87	87	87	495	495	495	495
Total	94	228	89	89	89	89	89	89	89	89	89	89	505	505	505	505
Total Reporting to & Including Resident Engineer	1,793	11,235	2,618	2,618	2,618	2,618	2,618	2,618	2,618	2,618	2,618	2,618	14,985	14,985	14,985	14,985
Total Other Reporting to & Including Resident Engineer	381	1,382	424	424	424	424	424	424	424	424	424	424	2,430	2,430	2,430	2,430
Subtotal - Personnel Cost	2,174	12,617	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043	17,415	17,415	17,415	17,415
Supplies			348	348	348	348	348	348	348	348	348	348	1,742	1,742	1,742	1,742
Spare Parts			9,000	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	7,364	36,820	36,820	36,820	36,820
Colony Operating Cost			1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	5,602	5,602	5,602	5,602
Scheduled Outage Inspections & Disposal Ponds Beyond Initial Investment					4,000			3,000		1,500		3,000	4,500	4,500	4,500	4,500
Subtotal			10,468	8,832	12,832	8,832	8,832	11,832	8,832	10,332	8,832	11,832	48,664	48,664	48,664	48,664
Total Station	2,174	12,617	13,511	11,875	15,875	11,875	11,875	14,875	11,875	13,375	11,875	14,875	66,079	66,079	66,079	66,079
Fixed Cost - $/Kilowatt Month			0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Variable Cost - $/Megawatt Hour			2.44	2.06	2.99	2.06	2.06	2.76	2.06	2.41	2.06	2.76	11.34	10.03	10.03	10.03

TABLE 8.19

LAHKRA POWER FEASIBILITY STUDY

VENDORS SOLICITED FOR BUDGETARY QUOTES

Steam Generator
Combustion Engineering Inc.
Babcock & Wilcox International Inc.
Foster-Wheeler

Condenser
Marley Heat Transfer
Hamon-Sobelco

Boiler Feed Pump
Ingersoll Rand
EBARA
Weir

Mechanical Draft Cooling Tower
Marley Cooling Tower Company

Sanitary Wastewater Treatment
Klaeranlagen Winter & Co. GMBH

Electrostatic Precipitator
Flakt, Inc.
Lodge-Cottrell-England
Combustion Engineering Inc.
Babcock & Wilcox

Coal Handling
Roberts & Schaefer
Italimpianti of America Inc.

Fly Ash Handling
United Conveyor Corporation

Fire Pump
Peerless Pump

SO_2 Removal System
Peabody Process Systems
Combustion Engineering Inc.

Turbine Generator
General Electric
Westinghouse
Mitsubishi Heavy Industries, Ltd.

Feedwater Heaters
Marley Heat Transfer
Hamon-Sobelco

Circulating and Condensate Pumps
Ingersoll Rand
EBARA

Wastewater Treatment Plant
Belco Pollution Control Company

Traveling Water Screens
ENVIREX

Fabricated Pipe
Dravo
Mitsubishi
Officine Meccaniche Fochi

Chimney
Pullman Power Products
Peabody Continental-Heine

Closed Circuit Cooling Water Heat Exchanger
Sihi-Halberg

Cycle Make-up Demineralizer
Permutit

TABLE 8.20

LAHKRA POWER FEASIBILITY STUDY
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY

PREFABRICATED PROCESS PIPING
C.S. GR. 106

INTERNATIONAL PRICING COMPARISON
($ Per Linear Foot)

	Size (inches)	U.S. (a)	Japan (b)	Var. (a-b)	Var. (a-b/a) %
Std.	2-1/2	21.00	8.90	12.10	57.62
	3	22.00	10.61	11.39	51.79
	4	27.00	14.14	12.86	47.62
	5	33.00	18.53	14.47	43.85
	6	39.00	23.53	15.47	39.67
	8	53.00	34.62	18.38	34.67
	10	71.00	48.64	22.36	31.49
	12	87.00	65.10	21.90	25.17
	14	107.00	80.46	26.54	24.80
	16	127.00	89.00	38.00	29.92
	18	163.00	99.97	63.03	38.67
	20	193.00	111.43	81.57	42.26
	24	257.00	134.11	122.89	47.82
XS	2-1/2	24.00	11.46	12.54	52.25
	3	26.00	13.41	12.59	48.42
	4	33.00	19.14	13.86	42.00
	5	42.00	25.60	16.40	39.04
	6	51.00	34.87	16.13	31.63
	8	72.00	51.69	20.31	28.21
	10	92.00	76.32	15.68	17.05
	12	114.00	106.07	7.93	6.96
	14	138.00	132.89	5.11	3.71

APPENDIX 8.1

COST DETAILS

FOR THE

KHANOT SITE

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
LAKHRA SITE

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
				REPORT TOTALS			124580008	161731902	73590023	359901933

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
9.6	LEASE CONSTRUCTION EQUIPMENT									
	LEASE CONSTRUCTION EQUIP.	100.0	PC	.0	.0	.00	0	10410000	6246000	16656000
				CODE TOTALS			0	10410000	6246000	16656000
9.7	COLONY - SECURITY & PROTECTION									
	ANTI-TERROIST EQUIPMENT	100.0	PC	9857.4	.0	.00	985740	0	0	985740
				CODE TOTALS			985740	0	0	985740
9.8	SPARE PARTS & LAB.& SHOP EQUIP									
	STEAM GENERATOR	100.0	PC	.0	.0	.00	0	2500000	1000000	3500000
	TURBINE GENERATOR	100.0	PC	.0	.0	.00	0	1500000	600000	2100000
	OTHER EQUIPMENT	100.0	PC	.0	.0	.00	0	2000000	800000	2800000
	LAB & SHOP EQUIPMENT	100.0	PC	.0	.0	.00	0	1500000	600000	2100000
				CODE TOTALS			0	7500000	3000000	10500000
9.9	TRANSPORTATION EQUIPMENT									
	JEEP - 4WD	6.0	EA	.0	.0	.00	0	60000	36000	96000
	CAR	1.0	EA	.0	.0	.00	0	15000	52500	67500
	GARBAGE TRUCK	2.0	EA	.0	.0	.00	0	40000	24000	64000
	SPARE PARTS	100.0	PC	.0	.0	.00	0	100000	60000	160000
	PICK-UP TRUCK	6.0	EA	9000.0	.0	.00	54000	0	0	54000
	FRONT END LOADER	4.0	EA	.0	.0	.00	0	840000	504000	1344000
	DUMP TRUCK	8.0	EA	.0	.0	.00	0	280000	168000	448000
	BUSES	5.0	EA	.0	.0	.00	0	225000	135000	360000
				CODE TOTALS			54000	1560000	979500	2593500

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
9.2	COLONY-PWR.DISTRIB.& COMMUN.									
	POWER DISTRIB.& COMMUN.	100.0	PC	3229.0	.0	.00	322900	55000	0	377900
				CODE TOTALS			322900	55000	0	377900
9.3	COLONY - RESIDENCES									
	RESIDENCES - ALL TYPES	100.0	PC	216469.0	.0	.00	21646900	0	0	21646900
				CODE TOTALS			21646900	0	0	21646900
9.4	COLONY - COMM.BLDGS & FACILS.									
	COMMUNITY BUILDING	100.0	PC	20466.0	.0	.00	2046600	176000	0	2222600
				CODE TOTALS			2046600	176000	0	2222600
9.5	COLONY SERVICE FACILITIES									
	SERVICE FACILITIES	100.0	PC	61435.5	.0	.00	6143550	639650	0	6783200
				CODE TOTALS			6143550	639650	0	6783200

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.12.2	SITE WORK-SERVICE WATER LINES									
	SERV. WATER LINES COMPL.	3000.0	M	12.3	.0	.00	36900	105000	126000	267900
				CODE TOTALS			36900	105000	126000	267900
8.15	TRANSFORMER FIREWALLS									
	EXCAVATION, HAND & MACHINE	778.0	CM	7.5	.0	.00	5835	0	0	5835
	STRUCTURAL STEEL	22.6	TNE	1214.0	.0	.00	27436	0	0	27436
	FIRE PROTECTION	100.0	PC	.0	6000.0	2.25	13500	89000	75650	178150
	REBAR	45.4	TNE	751.0	.0	.00	34095	0	0	34095
	CONCRETE BLOCK FIRE WALL	316.0	SM	5.0	.0	.00	1580	0	0	1580
	BACKFILL	317.0	CM	2.5	.0	.00	793	0	0	793
	EMBEDDED IRON	1.4	TNE	2.0	.0	.00	3	0	0	3
	CONCRETE	363.0	CM	109.0	.0	.00	39567	0	0	39567
				CODE TOTALS			122809	89000	75650	287459
9.1	COLONY - WATER SUPPLY									
	WATER SUPPLY COMPLETE	100.0	PC	6699.0	.0	.00	669900	200000	0	869900
				CODE TOTALS			669900	200000	0	869900

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.09	WATER TREATMENT									
	WATER TREATMENT COMPLETE	100.0	PC	4516.1	.0	.00	451610	1463600	834252	2749462
				CODE TOTALS			451610	1463600	834252	2749462
8.10	WASTE TREATMENT									
	WASTE TREATMENT COMPLETE	100.0	PC	2008.6	.0	.00	200860	573400	258030	1032290
				CODE TOTALS			200860	573400	258030	1032290
8.11	SITE WORK - PAVED ROADWAYS									
	ROAD-SITE FROM MINE AREA	4.0	KM	768605.0	.0	.00	3074420	0	0	3074420
	PAVED ROADWAYS COMPLETE	4.9	KM	251780.0	.0	.00	1233722	0	0	1233722
				CODE TOTALS			4308142	0	0	4308142
8.12.1	SITE WORK-FIRE PROTECT. LOOP									
	FIRE PROTECT.LOOP COMPL.	100.0	PC	407.4	.0	.00	40740	116420	139704	296864
				CODE TOTALS			40740	116420	139704	296864

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.07.2	MK-UP WATER PIPE TO INDUS R.									
	STEEL PIPE 2 @ .726M DIA.	50000.0	M	164.2	.0	.00	8210000	0	0	8210000
	EXCAVATION	288000.0	CM	6.4	.0	.00	1843200	0	0	1843200
	BACKFILL	237673.0	CM	1.9	.0	.00	451579	0	0	451579
	BEDDING	21600.0	CM	10.2	.0	.00	220320	0	0	220320
				CODE TOTALS			10725099	0	0	10725099
8.07.3	WATER SURGE POND									
	WATER SURGE POND COMPLETE	100.0	PC	9072.0	.0	.00	907200	0	0	907200
				CODE TOTALS			907200	0	0	907200
8.08.1	CIRCULATING WATER PUMPHOUSE									
	CONCRETE	1303.0	CM	109.0	.0	.00	142027	0	0	142027
	EXCAVATION	7520.0	CM	4.5	.0	.00	33840	0	0	33840
	BACKFILL	2278.0	CM	2.0	.0	.00	4556	0	0	4556
	STRUCTURAL STEEL	34.3	TNE	1214.0	.0	.00	41640	0	0	41640
	EXTERIOR WALLS (METAL)	305.0	SM	3.0	.0	.00	915	13115	9181	23211
	ROOFING W/DECK	187.5	SM	4.0	.0	.00	750	0	0	750
	REBAR	160.0	TNE	751.0	.0	.00	120160	0	0	120160
				CODE TOTALS			343888	13115	9181	366184

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.05.1	CHIMNEY FOUNDATION									
	EXCAVATION	2294.0	CM	7.5	.0	.00	17205	0	0	17205
	CONCRETE	2224.0	CM	85.0	.0	.00	189040	0	0	189040
	REBAR	264.0	TNE	751.0	.0	.00	198264	0	0	198264
				CODE TOTALS			404509	0	0	404509
8.05.2	CHIMNEY									
	CONC. SHELL & BRICK LINERS	100.0	PC	17250.0	.0	.00	1725000	1840000	1104000	4669000
				CODE TOTALS			1725000	1840000	1104000	4669000
8.06	MINE ACCESS ROAD FROM KHANOT									
	ACCESS ROAD COMPLETE	22.0	KM	300428.5	.0	.00	6609427	0	0	6609427
				CODE TOTALS			6609427	0	0	6609427
8.07.1	MAKE-UP WATER INTAKE STRUCTURE									
	CONCRETE	3234.0	CM	110.0	.0	.00	355740	0	0	355740
	ELEC. TRANSM. & SUPPLY	100.0	PC	1500.0	.0	.00	150000	440000	193600	783600
	MECH. EQUIPMENT & PIPE	100.0	PC	617.3	.0	.00	61730	564440	310442	936612
	EXTERIOR WALLS (METAL)	1749.3	SM	3.0	.0	.00	5248	75220	52654	133122
	REBAR	652.4	TNE	751.0	.0	.00	489952	0	0	489952
	EMBEDS	96.0	TNE	4500.0	.0	.00	432000	0	0	432000
	STRUCTURAL STEEL	263.7	TNE	1214.0	.0	.00	320132	0	0	320132
	ROOFING W/DECK	628.2	SM	4.0	.0	.00	2513	0	0	2513
	SHEETPILE	945.3	SM	3.0	.0	.00	2836	165428	115800	284064
				CODE TOTALS			1820151	1245088	672496	3737735

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.04.1	ADMIN. & SERVICE BLDG. FND.									
	REBAR	55.5	TNE	751.0	.0	.00	41681	0	0	41681
	CONCRETE	1145.5	CM	110.0	.0	.00	126005	0	0	126005
	EXCAVATION	1689.0	CM	4.5	.0	.00	7601	0	0	7601
				CODE TOTALS			175287	0	0	175287
8.04.2	ADMIN. & SERVICE BUILDING									
	HVAC	100.0	PC	244.6	.0	.00	24460	195719	88074	308253
	FIRE PROTECTION	100.0	PC	206.0	.0	.00	20600	87156	74083	181839
	ROOFING	2250.0	SM	2.0	.0	.00	4500	0	0	4500
	CONCRETE FLOORS	8425.0	SM	92.5	.0	.00	779313	0	0	779313
	SPECIAL FLOORS	5074.7	SM	14.0	.0	.00	71046	0	0	71046
	EXTERIOR WALLS (MASONRY)	5197.5	SM	12.0	.0	.00	62370	0	0	62370
	STRUCTURAL STEEL	1858.7	TNE	1214.0	.0	.00	2256462	0	0	2256462
	INTERIOR WALLS (MASONRY)	6656.4	SM	5.0	.0	.00	33282	0	0	33282
	GRATING FLOORS	919.0	SM	2.7	.0	.00	2481	49626	34738	86845
	ARCHITECTURAL FINISHES	100.0	PC	1300.0	.0	.00	130000	0	0	130000
	PLUMBING	100.0	PC	458.7	.0	.00	45870	0	0	45870
				CODE TOTALS			3430384	332501	196895	3959780

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.03.1	CONTROL BUILDING FOUNDATION									
	EXCAVATION	787.5	CM	4.5	.0	.00	3544	0	0	3544
	CONCRETE	610.0	CM	110.0	.0	.00	67100	0	0	67100
	REBAR	27.5	TNE	751.0	.0	.00	20653	0	0	20653
				CODE TOTALS			91297	0	0	91297
8.03.2	CONTROL & SHOP BUILDING									
	HVAC	100.0	PC	290.0	.0	.00	29000	195300	87885	312185
	PASSENGER ELEVATOR	1.0	EA	19800.0	.0	.00	19800	99000	39600	158400
	ARCHITECTURAL FINISHES	100.0	PC	50.0	.0	.00	5000	40000	16000	61000
	INTERIOR WALLS (MASONRY)	900.0	SM	5.0	.0	.00	4500	0	0	4500
	ROOFING	1014.1	SM	2.0	.0	.00	2028	0	0	2028
	CONCRETE FLOORS	1014.1	SM	92.5	.0	.00	93804	0	0	93804
	GRATING FLOORS	2028.2	SM	2.7	.0	.00	5476	68959	48271	122706
	STRUCTURAL STEEL	292.5	TNE	1214.0	.0	.00	355095	0	0	355095
	SPECIAL FLOORS (CMPTR.RM)	500.0	SM	180.0	.0	.00	90000	0	0	90000
	EXTERIOR WALLS (METAL)	2550.0	SM	3.0	.0	.00	7650	109650	76755	194055
				CODE TOTALS			612353	512909	268511	1393773

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.02.1	TURBINE BUILDING FOUNDATION									
	FINISH GR.SLAB CONCRETE	2025.0	CM	85.0	.0	.00	172125	0	0	172125
	EXCAVATION	9712.5	CM	7.5	.0	.00	72844	0	0	72844
	CONCRETE	6300.0	CM	110.0	.0	.00	693000	0	0	693000
	EMBED	4.5	TNE	4500.0	.0	.00	20250	0	0	20250
	REBAR	324.6	TNE	751.0	.0	.00	243775	0	0	243775
				CODE TOTALS			1201994	0	0	1201994
8.02.2	TURBINE BUILDING									
	HVAC	100.0	PC	217.4	.0	.00	21740	113043	79130	213913
	ARCHITECTURAL FINISHES	100.0	PC	108.7	.0	.00	10870	54350	24458	89678
	INTERIOR WALLS (MASONRY)	3876.0	SM	5.0	.0	.00	19380	0	0	19380
	STRUCTURAL STEEL	2398.7	TNE	1214.0	.0	.00	2912022	0	0	2912022
	ROOFING	4500.0	SM	2.0	.0	.00	9000	0	0	9000
	CONCRETE FLOORS	8807.0	SM	92.5	.0	.00	814648	0	0	814648
	FINISH GR.SLAB CONCRETE	2025.0	SM	85.0	.0	.00	172125	0	0	172125
	GRATING FLOORS	2250.0	SM	2.7	.0	.00	6075	76500	53550	136125
	EXTERIOR WALLS (METAL)	6080.0	SM	3.0	.0	.00	18240	261440	183008	462688
	PLUMBING - MAIN PLANT	100.0	PC	108.7	.0	.00	10870	81522	69294	161686
	HOISTS & MONORAILS	100.0	PC	10.9	.0	.00	1090	76090	8370	85550
				CODE TOTALS			3996060	662945	417810	5076815

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.01.1.4	PRECIPITATOR FOUNDATION									
	EXCAVATION	958.8	CM	7.5	.0	.00	7191	0	0	7191
	ELEVATED CONCRETE SLAB	107.7	SM	55.0	.0	.00	5924	0	0	5924
	CONCRETE	864.0	CM	110.0	.0	.00	95040	0	0	95040
	REBAR	86.4	TNE	751.0	.0	.00	64886	0	0	64886
				CODE TOTALS			173041	0	0	173041
8.01.1.5	BREECHING SUPPORT FOUNDATIONS									
	CONCRETE	550.6	CM	110.0	.0	.00	60566	0	0	60566
	REBAR	62.5	TNE	751.0	.0	.00	46938	0	0	46938
	EXCAVATION	700.0	CM	7.5	.0	.00	5250	0	0	5250
				CODE TOTALS			112754	0	0	112754
8.01.2	BOILER BUILDING									
	EXTERIOR WALLS (METAL)	4249.5	SM	3.0	.0	.00	12749	182729	127910	323388
	HOISTS & MONORAILS	100.0	PC	50.0	.0	.00	5000	30000	12000	47000
	STRUCTURAL STEEL	7892.1	TNE	1214.0	.0	.00	9581009	0	0	9581009
	CONCRETE FLOORS	7503.0	SM	92.5	.0	.00	694028	0	0	694028
	ROOFING	4140.0	SM	2.0	.0	.00	8280	0	0	8280
	GRATING FLOORS	16494.0	SM	2.7	.0	.00	44534	560796	392557	997887
	INTERIOR WALLS (MASONRY)	1424.0	SM	5.0	.0	.00	7120	0	0	7120
	SPECIAL FLOORS	183.5	SM	14.0	.0	.00	2569	0	0	2569
	FINISH GR.SLAB CONCRETE	1890.0	CM	85.0	.0	.00	160650	0	0	160650
	COAL BUNKER STEEL (7)	182.3	TNE	202.0	.0	.00	36825	273450	191415	501690
	FREIGHT ELEVATOR	1.0	EA	28000.0	.0	.00	28000	140000	56000	224000
	HVAC	100.0	PC	156.3	.0	.00	15630	78158	54711	148499
				CODE TOTALS			10596394	1265133	834593	12696120

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
8.01.1.1	FD FAN FOUNDATIONS									
	REBAR	25.4	TNE	751.0	.0	.00	19075	0	0	19075
	EMBED	2.0	TNE	4500.0	.0	.00	9000	0	0	9000
	EXCAVATION	386.8	CM	7.5	.0	.00	2901	0	0	2901
	CONCRETE	281.3	CM	110.0	.0	.00	30943	0	0	30943
				CODE TOTALS			61919	0	0	61919
8.01.1.2	ID FAN FOUNDATIONS									
	REBAR	35.4	TNE	751.0	.0	.00	26585	0	0	26585
	EXCAVATION	397.5	CM	7.5	.0	.00	2981	0	0	2981
	EMBED	2.0	TNE	4500.0	.0	.00	9000	0	0	9000
	CONCRETE	841.0	CM	110.0	.0	.00	92510	0	0	92510
				CODE TOTALS			131076	0	0	131076
8.01.1.3	PA FAN FOUNDATIONS									
	REBAR	1.8	TNE	751.0	.0	.00	1352	0	0	1352
	CONCRETE	41.3	CM	110.0	.0	.00	4543	0	0	4543
	EXCAVATION	32.1	CM	7.5	.0	.00	241	0	0	241
				CODE TOTALS			6136	0	0	6136

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
5.8	MISC. MECHANICAL EQUIPMENT									
	MISC. MECHANICAL EQUIP.	100.0	PC	497.0	.0	.00	49700	920000	680800	1650500
				CODE TOTALS			49700	920000	680800	1650500
7.0	ELECTRICAL FACILITIES									
	LTG,COMM,GROUNDING, ETC.	100.0	PC	.0	19720.0	22.50	443700	1906950	762780	3113430
	ELECTRICAL EQUIPMENT	100.0	PC	.0	21750.0	22.50	489375	4384690	1753876	6627941
	CABLE & CONDUIT	100.0	PC	.0	77823.0	22.50	1751018	3776340	1510536	7037894
				CODE TOTALS			2684093	10067980	4027192	16779265
8.01.1	BOILER BUILDING FOUNDATION									
	CONCRETE	5880.0	CM	110.0	.0	.00	646800	0	0	646800
	REBAR	1625.0	TNE	751.0	.0	.00	1220375	0	0	1220375
	FINISH GR. SLAB CONCRETE	1890.0	CM	85.0	.0	.00	160650	0	0	160650
	EXCAVATION	9018.8	CM	7.5	.0	.00	67641	0	0	67641
				CODE TOTALS			2095466	0	0	2095466

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
5.4	HEATX, CONDENSER & MAIN PUMPS									
	HEATX,COND.& MAIN PUMPS	100.0	PC	1911.9	.0	.00	191190	5834928	2333971	8360089
				CODE TOTALS			191190	5834928	2333971	8360089
5.5	CYCLE TREATMENT SYSTEMS									
	CYCLE TREATMENT SYSTEMS	100.0	PC	3450.2	.0	.00	345020	3081625	1386731	4813376
				CODE TOTALS			345020	3081625	1386731	4813376
5.6	INSTRUMENTATION - MAIN PLANT									
	INSTRUMENTATION COMPLETE	100.0	PC	.0	23930.0	22.50	538425	8204100	3281640	12024165
				CODE TOTALS			538425	8204100	3281640	12024165
5.7	SERVICE AIR, GAS, STEAM SYSTEM									
	SERV.AIR,GAS,SOOTBLW.SYS.	100.0	PC	2199.7	.0	.00	219970	2819110	1268600	4307680
				CODE TOTALS			219970	2819110	1268600	4307680

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
4.6	FUEL OIL STORAGE & SUPPLY									
	FUEL STORAGE & SPLY.COMP.	100.0	PC	.0	24385.8	2.25	54868	636230	451723	1142821
				CODE TOTALS			54868	636230	451723	1142821
5.1	TURBINE - GENERATOR									
	TURBINE - GENERATOR COMP.	100.0	PC	.0	27600.0	22.50	621000	21870000	8748000	31239000
				CODE TOTALS			621000	21870000	8748000	31239000
5.2	TURBINE PEDESTAL									
	CONCRETE	2148.2	CM	190.0	.0	.00	408158	0	0	408158
	REBAR	357.4	TNE	751.0	.0	.00	268407	0	0	268407
	EMBEDS	30.8	TNE	4500.0	.0	.00	138600	0	0	138600
				CODE TOTALS			815165	0	0	815165
5.3	BF, EXTRACTION, COND. PIPING									
	BF,EXTRACT,COND.PPG.COMP.	100.0	PC	.0	16313.0	22.50	367043	3636050	3090643	7093736
				CODE TOTALS			367043	3636050	3090643	7093736

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
4.2	PRECIPITATOR									
	PRECIPITATOR COMPLETE	1.0	EA	1376000.	.0	.00	1376000	7925000	3170000	12471000
				CODE TOTALS			1376000	7925000	3170000	12471000
4.3	MAIN, HOT & COLD PRESSURE PIPE									
	PRESSURE PIPE - COMPLETE	100.0	PC	.0	14610.0	22.50	328725	1809768	1538303	3676796
				CODE TOTALS			328725	1809768	1538303	3676796
4.4	MISC. STEAM, WATER, & DRAIN. SYS.									
	MISC. STM, WTR & DRN. COMPL.	100.0	PC	.0	11644.0	22.50	261990	1176680	1000178	2438848
				CODE TOTALS			261990	1176680	1000178	2438848
4.5	BOTTOM ASH PIPING & PUMPS									
	IN-PLANT PPG. & PMPS COMP.	100.0	PC	.0	61911.1	2.25	139300	648900	324450	1112650
				CODE TOTALS			139300	648900	324450	1112650

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
3.4.2	BOTTOM ASH & WASTE EVAP. PONDS									
	RECIRC. PUMP HOUSE	800.0	SM	300.0	.0	.00	240000	0	0	240000
	CUT AND FILL MATERIAL	1048544.	CM	6.0	.0	.00	6291264	0	0	6291264
	ASH SLUICE PMP.HSE & EQP.	100.0	PC	1200.0	.0	.00	120000	160000	150400	430400
	IMPORTED FILL MATERIAL	1707332.	CM	7.0	.0	.00	11951324	0	0	11951324
	PIPE LINE FDNS. REBAR	24.0	TNE	751.0	.0	.00	18024	0	0	18024
	EARTHWORK	1338.0	CM	7.5	.0	.00	10035	0	0	10035
	ASH LINE TRESTLE	1339.0	TNE	1500.0	.0	.00	2008500	0	0	2008500
	ASH SLUICE PIPE TO PONDS	6000.0	M	.0	53000.0	2.25	119250	1000020	850017	1969287
	PIPE LINE FDNS. CONCRETE	387.0	CM	110.0	.0	.00	42570	0	0	42570
				CODE TOTALS			20800967	1160020	1000417	22961404
3.4.3	FLY ASH DISPOSAL POND									
	FLY ASH PIPE LINE	9000.0	M	.0	58500.0	2.25	131625	738000	627300	1496925
	RECIRC.PIPELINES & EQUIP.	3000.0	M	.0	33000.0	2.25	74250	1140000	969000	2183250
				CODE TOTALS			205875	1878000	1596300	3680175
4.1	STEAM GENERATOR									
	STEAM GENERATOR COMPLETE	100.0	PC	76250.0	.0	.00	7625000	47297000	18445830	73367830
				CODE TOTALS			7625000	47297000	18445830	73367830

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
3.3.2	CLOSED LOOP CIRC. WATER PIPE									
	BEDDING	805.0	CM	11.0	.0	.00	8855	0	0	8855
	ADDITIONAL PIPE & VALVES	100.0	PC	253.1	.0	.00	25310	200250	170213	395773
	CONCRETE PIPE 2.74M DIA.	600.0	M	1070.0	.0	.00	642000	0	0	642000
	EXCAVATION	19188.0	CM	4.5	.0	.00	86346	0	0	86346
	BACKFILL	17303.0	CM	2.0	.0	.00	34606	0	0	34606
				CODE TOTALS			797117	200250	170213	1167580
3.3.3	COOLING TOWER									
	CONCRETE	1529.0	CM	110.0	.0	.00	168190	0	0	168190
	EQUIPMENT & ENGINEERING	100.0	PC	.0	55200.0	2.25	124200	2250000	1012500	3386700
	CIRC. WATER PUMPS	2.0	EA	4500.0	.0	.00	9000	700000	280000	989000
	REBAR	224.0	TNE	751.0	.0	.00	168224	0	0	168224
				CODE TOTALS			469614	2950000	1292500	4712114
3.4.1	CONVEYOR EQUIPMENT & PIPING									
	FLY ASH CONV.EQUIP.& PPG.	100.0	PC	9600.0	.0	.00	960000	2006000	902700	3868700
				CODE TOTALS			960000	2006000	902700	3868700

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
3.1.6	CONVEYOR BENT FOUNDATIONS									
	REBAR	34.0	TNE	751.0	.0	.00	25534	0	0	25534
	EXCAVATION	1148.0	CM	4.5	.0	.00	5166	0	0	5166
	CONCRETE	369.3	CM	109.0	.0	.00	40254	0	0	40254
				CODE TOTALS			70954	0	0	70954
3.2	COAL HANDLING EQUIPMENT									
	EQUIP. & MECH. UTILITIES	100.0	PC	13272.9	.0	.00	1327290	8850500	3717210	13895000
				CODE TOTALS			1327290	8850500	3717210	13895000
3.3.1	COOLING TOWER BASIN									
	BACKFILL	714.0	CM	1.5	.0	.00	1071	0	0	1071
	CONCRETE	1093.0	CM	110.0	.0	.00	120230	0	0	120230
	REBAR	400.0	TNE	751.0	.0	.00	300400	0	0	300400
	EXCAVATION	6714.0	CM	4.5	.0	.00	30213	0	0	30213
				CODE TOTALS			451914	0	0	451914

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
3.1.3.2	CRUSHER HOUSE FOUNDATION									
	REBAR	125.0	TNE	751.0	.0	.00	93875	0	0	93875
	ELEV. CONCRETE REBAR	30.2	TNE	751.0	.0	.00	22680	0	0	22680
	ELEV. CONRETE FLOORS	407.0	CM	151.0	.0	.00	61457	0	0	61457
	CONCRETE	1405.0	CM	109.0	.0	.00	153145	0	0	153145
	EXCAVATION	1147.0	CM	7.5	.0	.00	8603	0	0	8603
				CODE TOTALS			339760	0	0	339760
3.1.4	EMERGENCY RECLAIM HOPPER									
	REBAR	34.0	TNE	751.0	.0	.00	25534	0	0	25534
	EXCAVATION	1167.0	CM	7.5	.0	.00	8753	0	0	8753
	CONCRETE	327.0	CM	109.0	.0	.00	35643	0	0	35643
				CODE TOTALS			69930	0	0	69930
3.1.5	RECLAIM HOPPER TUNNEL									
	REBAR	53.4	TNE	751.0	.0	.00	40103	0	0	40103
	CONCRETE	440.4	CM	109.0	.0	.00	48004	0	0	48004
	EXCAVATION	627.0	CM	7.5	.0	.00	4703	0	0	4703
				CODE TOTALS			92810	0	0	92810

GILBERT/COMMONWEALTH
COST ESTIMATING DEPT.

LAKHRA POWER FEASIBILITY PROJECT
PAKISTAN WATER & POWER DEVELOPMENT AUTHORITY
LAKHRA SITE

UNIT 1 - 350 MW

CODE	DESCRIPTION	QUANTITY	U/M	UNIT COST	MANHOURS	WAGE RATE	LOCAL	FEC	IMPORT DUTY	TOTAL
1.0	LAND COST									
	LEASE-NO PURCH. REQUIRED	100.0	PC	.0	.0	.00	0	0	0	0
				CODE TOTALS			0	0	0	0
2.0	SITE PREPARATION									
	SITEWORK & TEMP. FAC.	100.0	PC	10784.0	.0	.00	1078400	0	0	1078400
				CODE TOTALS			1078400	0	0	1078400
3.1.3	TRANSFER HOUSE FOUNDATION									
	CONCRETE	82.0	CM	109.0	.0	.00	8938	0	0	8938
	EXCAVATION	248.0	CM	4.5	.0	.00	1116	0	0	1116
	ELEV. CONCRETE FLOOR	148.6	SM	205.0	.0	.00	30463	0	0	30463
	REBAR	9.7	TNE	751.0	.0	.00	7285	0	0	7285
				CODE TOTALS			47802	0	0	47802

9.0 CONCLUSIONS

9.1 INTRODUCTION

This discussion has been organized to present a summary of conclusions as encountered in the feasibility study from Chapters 3 to 8 and from the work plan. The conclusions are summarized by subject area. Where possible, two or more related conclusions were combined into a single statement. The text and discussion that led to or that supports the conclusion are noted in parentheses.

9.2 SYSTEM PLANNING STUDIES

In March and August, 1985, WAPDA and GCII performed generation and transmission system planning studies. Based on the results of these studies, GCII is of the opinion that:

- The first 350 MW domestic coal-fired unit should be placed in service by mid-1992. A second 350 MW domestic coal-fired unit should be placed in service by mid-1993 (Section 3.6.1).

- Construction of the above noted units at either the Lakhra site or the Khanot site requires that this generation be connected to the existing WAPDA transmission system at the 500 kV voltage level (Section 3.6.2).

9.3 LAKHRA COAL CHARACTERISTICS

The feasibility studies by GCII, John T. Boyd Company, Combustion Engineering Inc. and Roberts & Schaefer Company have drawn the following conclusions:

- Lakhra coals provide a good intense stable flame; are easy to pulverize; are classified as severe slagging and medium to high fouling; have a low gross calorific value due to high ash and high moisture content and can be effectively utilized in a power generation boiler with the application of specific design parameters tailored to the unique characteristics of Lakhra coals (Section 4.1).

- Washing of Lakhra coal indicated that the gross calorific value of the fuel can be improved by nearly 20 percent, 2.7 mJ/kg (1160 Btu/lb), and the ash and sulfur burden can be reduced by up to 40 percent and 20 percent, respectively (Section 4.2.1).

- The mineral characteristics of the ash do not materially change when baseline Lakhra coal is washed (Table 4.5-6, Table 4.5-10, Section 4.5).

9.4 COMBUSTION TEST BURNS

The preliminary September 1985 results of the combustion test burns of baseline Lakhra coal from PMDC No. 2, washed Lakhra coal from PMDC No. 2, and run of mine Lakhra coal from the BT-11 test shaft are:

- Combustion testing of unwashed and washed Lakhra coal has shown no differences in the severe slagging and medium to high fouling potentials which results in no physical differences in design parameters for a boiler sized for unwashed or washed Lakhra coal (Section 4.5).

- Combustion testing of Lakhra coal from the test shaft at bore hole BT-11 has resulted in no differences of design parameter considerations for any of the three coals used in the test burns, BT-11 Seams 1 and 2, baseline PMDC No. 2 or washed PMDC No. 2 (Section 4.6).

9.5 SIMILAR COAL TO LAKHRA COAL

The investigation by GCII has determined there are two power plants in Spain and one in the USA that are burning a coal that is similar to Lakhra, they are:

- The Babcock & Wilcox Steam Generators at San Miguel power station which are operated by Brazos Electric Power Cooperative (Section 4.7, Figures 4.7-1, 4.7-2 and 4.7-3).

- The Combustion Engineering Steam Generator at the Alcudia II power station of Gas y Eletricdad, SA (Section 4.7, Figures 4.7-4 and 4.7-5).

- The Foster-Wheeler Steam Generators at the Teruel power station of Empresa Nacional de Eletricidad, SA (Section 4.7, Figures 4.7-6, 4.7-7, 4.7-8 and 4.7-9).

9.6 BOILER DESIGN PARAMETERS FOR LAKHRA COAL

The conclusions drawn by GCII from various study work and discussions with others such as Babcock & Wilcox, J. T. Boyd, Combustion Engineering, Foster-Wheeler and Roberts & Schaefer are:

- The severe slagging potential requires a net heat input per unit of furnace plan area of not greater than

14,750 mJ/h·m^2 (1.3 million Btu/h·ft^2), a furnace exit gas temperature not greater than 1093°C (2000°F) and excess air leaving the furnace not less than 30 percent (Section 4.8).

- The medium to high fouling potential requires wide tube spacing with clear spaces between tubes ranging from 75 to 1524 mm (3 to 60 inches) depending on gas temperature and the abrasiveness of the ash requires a gas velocity not exceeding 13.7 m/s (45.0 fps) (Section 4.8).

- The air heater exit flue gas temperature shall be not less than 150°C (300°F) over the load range of the boiler (Section 4.8).

- Other furnace design parameters for Lakhra coal are net heat input rates not to exceed 625 megajoules/h·m^2 (55,000 Btu/h·ft^2) for EPRS, nor 2570 megajoules/h·m^2 (225,000 Btu/h·ft^2) for the burner zone (Section 4.8).

9.7 ENVIRONMENTAL CONTROL TECHNOLOGIES

The environmental control technologies that should be applied to the Lakhra Power Plant are:

- The steam generator should be specified to be furnished with low NO_x burners. Other technologies, such as off-stoichiometric firing and flue gas injection at the burners should be specified as not acceptable (Section 5.5.6.1).

- An electrostatic precipitator of the rigid discharge electrode and collecting electrode type should be specified for Lakhra Power Plant. There should be a spare electrical field so that emission guarantees can be met with one electrical field out of service (Sections 4.8 and 5.5.6.2).

- Any required gas desulfurization system for the Lakhra two x 350 MW power plant should be a wet limestone slurry system that produces a throwaway calcium sulfate product (Section 5.5.6.3).

- The mean uncontrolled SO_2 emissions for two 350 MW Lakhra lignite fired units is 1,148 tons per day, calculated in accordance with World Bank Standards.

- An applied SO_2 emission limit of 1,000 TPD for the two Lakhra units requires a very minimal resolution. Partial

stream scrubbing at a low efficiency can be used to control SO_2 to this level; however, this step must be weighed against potential variation (reduction?) potential of SO_2 emission calculation variables such as capacity factor (assumed at 70 percent) and mill rejection of sulfur (assumed at 10 percent).

- An applied SO_2 emissions limit of 500 TPD for the two 350 MW units will require a full stream SO_2 scrubbing system.

- Wherever possible, effluent waste water should be reused, treated and reused, or treated and evaporated on site. No discharges should be made to the Indus River (Section 5.5.6.4).

9.8 AVAILABILITY

- The Lakhra Power Plant Design goal should be an availability factor of not less than 81 percent (Section 5.5.7).

9.9 ALTERNATIVE FUEL CAPABILITY

The application of imported oil or imported coal as a standby fuel in lieu of as a supporting fuel to a boiler designed for Lakhra coal will result in the following:

- If techniques such as increased excess air for combustion, biased firing, flue gas recirculation or back pass dampering are not applied when firing oil fuel there will be derated unit performance due to low steam temperatures (Section 5.5.8).

- The heating surfaces of the boiler can be designed for imported coal at the expense of constant de-superheating sprays for main steam and reheat steam when firing the base fuel, Lakhra coal (Section 5.5.8).

- Localized areas of the furnace can be refractory coated prior to switching to imported coal or future burners that were plugged can be activated or biased firing and the use of back pass dampers can be utilized or high excess air and biased firing can be utilized or as a last resort install gas recirculation fans to reduce the effects of low steam temperatures when firing the standby imported coal (Section 5.5.8).

9.10 CONSTRUCTION PHASE AND SCHEDULE CONSIDERATIONS

- Manufacturing of most plant equipment will be by overseas vendors. Local manufacturing and construction is available for items such as cement, brick, blocks, and nontechnical buildings such as housing colonies and civil/site work (Section 5.6.3).

- The project schedule is aggressive, but achievable. It has been concluded that the project would best be executed through the use of an A/E and a turnkey contractor (Section 5.6.1).

9.11 INSTITUTIONAL DEVELOPMENT

This section of the study has resulted in findings and conclusions in eight classifications of function that are summarized as follows:

- Organization - The organizational position of the coal projects should be modified by WAPDA. Temporary delegation of special powers to Chief Engineers has been made in the past. WAPDA should strive to give stronger emphasis to the development of the Coal Power Projects Department (Section 6.2.1).

- Staffing - The immediate needs of Pakistan national coal development can be better met if WAPDA adds staff with coal-related skills directly to the Coal Power Projects Department. The development of the Coal Power Projects Department will benefit from WAPDA encouraging a strong research orientation and from compensation policy receiving special attention. WAPDA should improve its methods of controlling and distributing personnel service rules (Section 6.2.1).

- Management Methods - Performing various detailed administrative functions occupies an extraordinary amount of time on the part of WAPDA technical officers which can be reduced if improvements are made to WAPDA's approach to definition of organization and job responsibilities (Section 6.2.1).

- Planning - The Coal Power Projects Department is not prepared to perform full scope feasibility studies (Section 6.2.1).

- Design and Construction - The Coal Power Projects Department needs extensive training and exchange of technology

exposure to be capable of managing, performing or overseeing the design and construction of coal-fired plant (Section 6.2.1).

- Operations and Maintenance - WAPDA has no major coal-fired power plant in its system (Section 6.2.1).

- Financial - WAPDA should provide additional staff support to assure that adequate management and control is established and maintained for Coal Power Projects Department budgets and accounts (Section 6.2.1).

- Administration and Services - WAPDA's data processing services are adequate for Coal Power Projects Department major applications. Procurement and stores methods require minor modifications to be able to serve the needs of the Coal Power Projects Department. The negotiation and administration of contracts for coal will require specialized attention. The Coal Power Projects Department head office and projects will require adequate transportation equipment and services. WAPDA's file and record handling methods are generally adequate, but the Coal Power Projects Department and WAPDA would benefit from stronger standards (Section 6.2.1).

9.12 TRAINING

These findings for training are inter-related with those of institutional development and are summarized as follows:

- The availability of engineering graduates is good, but their availability to WAPDA is limited by differential salaries compared to the private sector (Section 7.2.1).

- The WAPDA academy at Tarbela offers training that relates to management functions of the Coal Power Projects Department, but needs to add courses that specifically relate to planning, constructing and operating thermal power plants (Section 7.2.1).

- At least two impediments exist at WAPDA training institutes that impact WAPDA's ability to attract and retain a qualified training staff (Section 7.2.3).

- The training programs available at Tarbela Academy and the Training Institutes meet WAPDA's current needs and are generally applicable to coal-fired power plants, but do need to be reviewed for their adequacy in support of coal projects (Section 7.3.1).

- Present training simulators are oriented to oil/gas-fired power plants which are not adequate for training staff for coal-fired power plants (Sections 7.2.3, 7.3.3 and 7.4.2).

9.13 CAPITAL COST ANALYSIS

- The Khanot site would have the lowest cost of the sites considered in this feasibility study (See Chapter 8, Tables 8.1 through 8.16).

9.14 WORK PLAN

In the work plan presented by GCII for the Lakhra Power Feasibility Study several questions were posed. These questions represent the concerns of USAID and other donor agencies for the project. Resolving these questions is the basic objective of the study. The conclusions that have been reached as a result of the work contained in the study and are summarized as direct answers to the original questions as follows:

1) Is the quality of Lakhra lignite suitable for use as fuel for a steam generator?

Response:

The combustion testing studies have shown that Lakhra coal is suitable for use as fuel in a utility boiler. The design parameters established as a result of the combustion testing must be followed, as the use of Lakhra coal involves a high potential for slagging and fouling. However, this lignite provides a good, stable combustion flame and is easily controllable (Sections 4.1, 4.4, 4.5, 4.6 and 4.8).

2) What is the impact on the steam generator and its auxiliaries and fuel handling equipment of the use of cleaned coal compared to raw coal?

Response:

The second phase combustion test and the washability analyses performed indicate that, other than emitting less SO_2 per day than the World Bank Standards, there is a minimum of positive impacts that result from the use of washed coal. Washing of Lakhra coal increases somewhat the slagging and fouling indices of the fuel. The work done in these studies indicates that an approximately 20 percent reduction in sulfur content and up to a 50 percent reduction in ash content may be realized. The reduction in sulfur content is sufficient to allow omission of

any SO_2 removal pollution control equipment. Likewise, the reduction in ash content will require less capacity in ash removal and transport equipment and a reduction in total ash storage area. However, it is expected that these impacts may not be sufficient to justify the costs of coal washing (Sections 4.1, 4.2, 4.7, 4.8, 5.5.7, 8.1, 8.2 and 8.3).

3 and 4) What are the site considerations with respect to coal delivery for a mine mouth vs. non-mine mouth plant?

Response:

The basic site considerations for delivery of coal are shown on the site general arrangement drawings included with this report. It has been determined through the results of the J. T. Boyd coal transportation study that a short haul rail system is the most practical for either of the near Indus sites (Khanot or Jamshoro) but not at the mine mouth Lakhra site. The cost of fuel transportation to the Lakhra site is obviously less; however, delivery to the sites remote from the mine is feasible and the cost of this delivery must be weighed against other factors in an overall site comparison (Sections 5.3.1, 5.3.2 and 5.3.3).

5) What are the realistic installed plant and power production costs for a two x 350 MW net output power plant fired with Lakhra lignite?

6) Should the units be located at the mine mouth or remote from the mine at Jamshoro or Khanot?

Response:

The decision on the final siting of the plant must also include input from J. T. Boyd, Dr. Art Helweg, ICF and ESE. It is the opinion of GCII at this time that an overall review of the advantages and disadvantages offered by each site will favor the selection of the Khanot site as the optimum location. Although the plant located at the Khanot site is somewhat lower in capital cost than a plant at the Lakhra site, it is expected that the total evaluated cost of the plant will favor Lakhra. (See Chapter 8 for capital costs.) The reason for this is the additional cost of coal to transport it from the mine to Khanot.

7, 8 and 9) What is the impact of makeup water supply at the various plant sites?

Response:

Makeup water at the Jamshoro site may be obtained from the Kotri pool area of the Indus River. The makeup water system initially laid out for the oil-fired units at Jamshoro may be extended for the coal-fired units if located at that site.

This study has determined that adequate makeup water supply for a power plant at Khanot or Lakhra is available from the area adjacent to the Maqdoom Irrigation Pumping Station. Water flow data gathered for the study and interviews with Sind Irrigation Department personnel indicate that water supply at this plant in the Indus River is reliable.

In terms of makeup water, the Jamshoro and Khanot sites are essentially equal. Studies also indicate that water must be taken from the river, as no reliable ground water sources have been found.

The location of the Lakhra site, approximately 20 kilometers west of the Indus, provides the most difficulty in supplying adequate water for plant requirements. However, it is feasible to install a pumping system at Khanot and to forward the necessary mine and plant makeup water supplies to Lakhra through a pipeline system. The primary impact of the extended water supply system is in the capital cost of the pipeline. Energy for pumping makeup water to the Lakhra site is minor due to the relatively small quantity of water required by cooling towers compared to a once through cooling system (Sections 5.3.1, 5.3.2, 5.3.3 and Chapter 8).

10) What are the impacts on the environment and the costs of air pollution control devices to reduce emissions of sulfur oxides and particulate matter from the unit to a level consistent with World Bank guidelines?

Response:

The potential for impact of liquid effluents from SO_2 scrubber sludge or ash ponds on the environment is expected to be minor since maximum reuse of water will be made. Ultimate discharge will be routed to an evaporation pond. All ponds for ashes, liquid wastes and SO_2 sludges should be lined where the potential exists for contamination of surface water or usable ground water. Specific air pollution impacts have been addressed by ESE. The cost of air pollution control equipment needed to meet World Bank guidelines is provided in Chapter 8.

11) What are the differences in environmental impact considerations for the three plant sites?

Response:

A full consideration of environmental impacts among site alternatives will require evaluations provided by other Lakhra contractors, especially the social soundness contractor (A. Helweg, et al) and environmental assessment contractor (ESE). However, GCII perceives air quality as the most important difference among sites from an environmental standpoint.

Potential for adverse impact from air quality degradation appears to be greatest at Jamshoro due to the nearness of sensitive receptors (universities, hospital) and lower air quality in Hyderabad, relative to corresponding conditions at the other two sites. GCII has therefore developed design specifications and costs for an FGD system, and has assumed necessity for such a system for both units with the understanding that plume dispersion modeling studies by ESE indicate that ground level concentrations do not require scrubbing to meet World Bank guidelines, but the point source emission rate does for unwashed coal.

Potential for impact to surface water is expected to be similarly low at all sites, since no surface water discharges are anticipated. GCII has postulated lining of solid waste disposal areas and treatment ponds at all three sites to minimize seepage losses and afford ground water protection. However, further evaluation by ESE indicates that linings may not be required at a given site, insofar as ground water protection is concerned.

Potential social and infrastructural impacts are perceived to differ widely among the sites, meriting close consideration of evaluations provided by the social soundness contractor. Provisions for infrastructure at the three sites are addressed in this report, Sections 5.3 and 8.1.5.

Land requirements and consequent alterations of existing land use and natural habitat, differ among sites. Additional area would be required for SO_2 sludge disposal at all sites; Jamshoro would also preclude the greatest amount of land for railroad construction, but no new transmission is required. Land alterations for roadway, pipeline, and transmission line installation would be greatest for the Lakhra site (Sections 5.4, 5.5.6.1, 5.5.6.2, 5.5.6.3 and 5.5.6.4).

12) What considerations must be met for disposal of coal ashes?

Response:

The following considerations were made in the selection of ash disposal modes:

1. Wet sluicing of bottom ash and fly ash was selected. However, flexibility was maintained for potential sale of ash by providing separate disposal sites for fly ash and bottom ash, and by providing equipment to permit dry collection and truck transportation of sold fly ash.

2. Wet sluicing of ash was chosen in part due to lower costs, equipment requirements, and fugitive dusting problems.

3. Lining of ash disposal ponds was considered; however, the environmental assessment contractor has determined that lined ponds are not necessary.

13) What are the impacts of transporting coal ashes back to the mine for disposal?

Response:

The impact of transporting coal ashes back to the mine for disposal is dependent on the type of mine: open cut or underground. If there is no ground water in either type of mine then ashes could be placed with minimal considerations for leachate prevention.

The logistics and costs of returning ashes to the mines must be worked out in detail by subsequent investigations if this method of ash disposal is given serious consideration:

1. An inactive worked out mining area is judged best for disposal of ashes so as not to interfere with mining operations.

2. The cost will be greater as the ashes will require more handling. Pumping the ashes is one method, but the disadvantage of pumping is returning water to the remote plant for reuse. Truck or rail delivery of ashes to the mine mouth is a second method, but this adds costs for trucks or rail wagons and the handling and storage facilities at the mine. Trucks would require an all weather road, and rail wagons might require special handling before coal could be sent to the river based site (Sections 5.3.1, 5.3.2 and 5.3.3).

14) Can it be demonstrated that two Lakhra lignite-fired 350 MW units are required to meet forecast loads; are least costly of alternatives available and will produce satisfactory economics and financial rates of return on investment?

Response: Based on planning studies conducted by WAPDA and GCII, GCII is of the opinion that two 350 MW domestic coal-fired units are components of a long-range generation expansion program for the WAPDA system. The units are required to meet the load forecast and are competitive over the long-range planning period with other generation expansion alternatives, such as imported coal-fired and imported oil-fired units. The subject of financial soundness of the project is being addressed by other consultants working on this feasibility project.

10.0 CONCLUSIONS

Revised April, 1987

10.0 CONCLUSIONS

10.1 INTRODUCTION

This discussion has been organized to present a summary of conclusions as encountered in the feasibility study from Chapters 3 to 9 and from the work plan. The conclusions are summarized by subject area. Where possible, two or more related conclusions were combined into a single statement. The text and discussion that led to or that support the conclusion are noted in parentheses.

10.2 SYSTEM PLANNING AND TRANSMISSION SYSTEM STUDIES

The computer planning studies conducted by GCII have produced the conclusions presented below.

System Planning

The following conclusions are based on WASP studies that do not include shadow pricing factors in the determination of the economic loading order of various existing and future WAPDA generating units. Appendix 3.6 presents the results of including shadow pricing in the studies.

- The Lakhra Underground Plant is economically attractive at $22.50 per metric ton. The net present worth of the plan utilizing Lakhra saves $61 million versus the plan without Lakhra.

- The Lakhra surface case is not economically attractive with oil at $16 per barrel in 1991, costing an additional $62 million in net present worth as compared to the plan without Lakhra. However, the Lakhra surface case is economically attractive if the price of oil rises to $24 per barrel in 1991. This would result in a savings of $257 million in net present worth when compared to the plan without Lakhra.

Transmission System Studies

The results of GCII's transmission system studies for the Lakhra, Jamshoro, and Khanot sites, which included load flow, transient stability and short circuit analyses, indicate that:

- At the Jamshoro site both 250 MW coal-fired units should be connected to the existing 220 kV Jamshoro bus. If the two 500 kV Jamshoro-Dadu circuits and two 450 MVA, 500/220 kV transformers at Jamshoro are in service, as is

currently planned, no additional transmission will be required for Unit 1. However, a third 450 MVA, 500/220 kV transformer should be installed at Jamshoro when Unit 2 is placed in service.

- For either the Lakhra or Khanot site, both coal-fired units should be connected to the 500 kV transmission which is currently planned to be put in service. Again it is recommended that a third 450 MVA, 500/220 kV transformer be installed at Jamshoro when Unit 2 is placed in service.

10.3 LAKHRA COAL CHARACTERISTICS

The feasibility studies by GCII, John T. Boyd Company, Combustion Engineering Inc. and Roberts & Schaefer Company have drawn the following conclusions:

- Lakhra coals provide a good, intense, stable flame; are easy to pulverize; are classified as severe slagging and low to severe fouling; have a low gross calorific value due to high ash and high moisture content and can be effectively utilized in a power generation boiler with the application of specific design parameters tailored to the unique characteristics of Lakhra coals (Section 4.1).

- Washing of Lakhra coal indicated that the gross calorific value of the fuel can be improved by 16 percent (8,400 to 9,740 Btu/lb - dry), and the ash and sulfur burdens can be reduced by up to 40 percent and 27 percent, respectively (Section 4.1).

- The mineral characteristics of the ash do not materially change when baseline Lakhra coal is washed (Section 4.1).

10.4 COMBUSTION TEST BURNS

The results of the combustion test burns of baseline Lakhra coal from PMDC No. 2, washed Lakhra coal from PMDC No. 2, and run of mine Lakhra coal from the BT-11 test shaft are:

- Combustion testing of unwashed and washed Lakhra coal has shown no differences in the severe slagging and low to severe fouling potentials, which results in no physical differences in design parameters for a boiler sized for unwashed or washed Lakhra coal (Sections 4.4 and 4.5).

- Combustion testing of Lakhra coal from the test shaft at bore hole BT-11 has resulted in no differences of design parameter considerations for any of the three coals used

in the test burns, BT-11 Seams 1 and 2, baseline PMDC No. 2 or washed PMDC No. 2 (Section 4.6).

10.5 SIMILAR COAL TO LAKHRA COAL

The investigation by GCII has determined there are two power plants in Spain and one in the USA that are burning a coal that is similar to Lakhra; they are:

- The 448 MW Babcock & Wilcox Steam Generator at San Miguel power station which is operated by Brazos Electric Power Cooperative (Section 4.7, Figures 4.7-1, 4.7-2).
- The 125 MW Combustion Engineering Steam Generators at the Alcudia II power station of Gas y Eletricidad, SA (Section 4.7, Figures 4.7-3 and 4.7-4).
- The 350 MW Foster-Wheeler Steam Generators at the Teruel power station of Empresa Nacional de Eletricidad, SA (Section 4.7, Figures 4.7-5, 4.7-6, 4.7-7 and 4.7-9).

10.6 BOILER DESIGN PARAMETERS FOR LAKHRA COAL

The conclusions drawn by GCII from various study work and discussions with others such as Babcock & Wilcox, J. T. Boyd, Combustion Engineering, Foster-Wheeler and Roberts & Schaefer are:

- The severe slagging potential requires a net heat input per unit of furnace plan area of not greater than 14,775 $mJ/h \cdot m^2$ (1.3 million $Btu/h \cdot ft^2$), an average furnace exit gas temperature not greater than 1175°C (2150°F) with a maximum not to exceed 1230°C (2250°F) at any point leaving the furnace exit plane and excess air leaving the furnace not less than 25 percent (Section 4.8).
- The medium to high fouling potential requires wide tube spacing with clear spaces between tubes ranging from 63.5 to 560 mm (2.5 to 22 inches) depending on gas temperature, and the abrasiveness of the ash requires a gas velocity not exceeding 13.7 m/s (45.0 fps) at 25 percent excess air (Section 4.8).
- The air heater exit flue gas temperature shall be not less than 150°C (300°F) over the load range of the boiler (Section 4.8).

- Other furnace design parameters for Lakhra coal are net heat input rates not to exceed 1025 $mJ/h \cdot m^2$ (90,000 $Btu/h \cdot ft^2$) for EPRS, nor 3,125 $mJ/h \cdot m^2$ (275,000 $Btu/h \cdot ft^2$) for the burner zone (Section 4.8).

10.7 ENVIRONMENTAL CONTROL TECHNOLOGIES

The environmental control technologies that should be applied to the Lakhra Power Plant are:

- The steam generator should be specified to be furnished with low NO_x burners. Other technologies, such as off-stoichiometric firing and flue gas injection at the burners should be specified as not acceptable (Section 5.5.6.1).

- An electrostatic precipitator of the rigid discharge electrode and collecting electrode type should be specified for Lakhra Power Plant. There should be a spare electrical field so that emission guarantees can be met with one electrical field out of service (Sections 4.8 and 5.5.6.2).

- Any required gas desulfurization system for the third and fourth Lakhra 250 MW power plants should be a wet limestone slurry system that produces a throwaway calcium sulfate product (Section 5.5.6.3).

- The mean uncontrolled SO_2 emissions for two 250 MW Lakhra lignite fired units is less than 1,000 tons per day, calculated in accordance with World Bank Standards.

- Wherever possible, effluent waste water should be reused, treated and reused, or treated and evaporated on-site. No discharges should be made to the Indus River (Section 5.5.6.4).

10.8 AVAILABILITY

- The Lakhra Power Plant design goal should be an availability factor of not less than 85.3 percent (Section 5.5.7).

10.9 ALTERNATIVE FUEL CAPABILITY

The application of imported oil or imported coal as a standby fuel in lieu of as a supporting fuel to a boiler designed for Lakhra coal will result in the following:

- If techniques such as increased excess air for combustion, burner tilt-up, biased firing, flue gas recirculation or back-pass dampering are not applied when firing oil fuel,

there will be derated unit performance due to low steam temperatures (Section 5.5.8).

- The heating surfaces of the boiler can be designed for imported coal at the expense of constant de-superheating sprays for main steam and reheat steam when firing the base fuel, Lakhra coal (Section 5.5.8).

- Localized areas of the furnace can be refractory coated prior to switching to imported coal; or future burners that were plugged can be activated; or biased firing and the use of back-pass dampers can be utilized; or high excess air and biased firing or tilt-up can be utilized; or as a last resort install gas recirculation fans to reduce the effects of low steam temperatures when firing the standby imported coal (Section 5.5.8).

10.10 CONSTRUCTION PHASE AND SCHEDULE CONSIDERATIONS

- Manufacturing of most plant equipment will be by overseas vendors. Local manufacturing and construction are available for items such as cement, brick, blocks, and nontechnical buildings such as housing colonies and civil/site work (Section 5.6.3).

- The project schedule is aggressive, but achievable. It has been concluded that the project would best be executed through the use of an A/E and a turnkey contractor (Sections 5.6.1 and 5.6.2).

10.11 INSTITUTIONAL DEVELOPMENT

This section of the study has resulted in findings and conclusions in eight classifications of function that are summarized as follows:

- Organization - The organizational position of the coal projects should be modified by WAPDA. Temporary delegation of special powers to Chief Engineers has been made in the past. WAPDA should strive to give stronger emphasis to the development of the Coal Power Projects Department (Section 6.2.1).

- Staffing - The immediate needs of Pakistan national coal development can be better met if WAPDA adds staff with coal-related skills directly to the Coal Power Projects Department. The development of the Coal Power Projects Department will benefit from WAPDA encouraging a strong research orientation and from compensation policy receiv-

ing special attention. WAPDA should improve its methods of controlling and distributing personnel service rules (Section 6.2.1).

- Management Methods - Performing various detailed administrative functions occupies an extraordinary amount of time on the part of WAPDA technical officers which can be reduced if improvements are made to WAPDA's approach to definition of organization and job responsibilities (Section 6.2.1).

- Planning - The Coal Power Projects Department is not prepared to perform full scope feasibility studies (Section 6.2.1).

- Design and Construction - The Coal Power Projects Department needs extensive training and exchange of technology exposure to be capable of managing, performing or overseeing the design and construction of coal-fired plant (Section 6.2.1).

- Operations and Maintenance - WAPDA has no major coal-fired power plant in its system (Section 6.2.1).

- Financial - WAPDA should provide additional staff support to assure that adequate management and control is established and maintained for Coal Power Projects Department budgets and accounts (Section 6.2.1).

- Administration and Services - WAPDA's data processing services are adequate for Coal Power Projects Department major applications. Procurement and stores methods require minor modifications to be able to serve the needs of the Coal Power Projects Department. The negotiation and administration of contracts for coal will require specialized attention. The Coal Power Projects Department head office and projects will require adequate transportation equipment and services. WAPDA's file and record handling methods are generally adequate, but the Coal Power Projects Department and WAPDA would benefit from stronger standards (Section 6.2.1).

10.12 TRAINING

These findings for training are inter-related with those of institutional development and are summarized as follows:

- The availability of engineering graduates is good, but their availability to WAPDA is limited by differential salaries compared to the private sector (Section 7.2.1).

- The WAPDA academy at Tarbela offers training that relates to management functions of the Coal Power Projects Department, but needs to add courses that specifically relate to planning, constructing and operating thermal power plants (Section 7.2.1).

- At least two impediments exist at WAPDA training institutes that impact WAPDA's ability to attract and retain a qualified training staff; these include the lack of a career path for the director within the WAPDA training organization, and insufficient fringe benefits for the training staff (Section 7.2.3).

- The training programs available at Tarbela Academy and the Training Institutes meet WAPDA's current needs and are generally applicable to coal-fired power plants, but do need to be reviewed for their adequacy in support of coal projects (Section 7.3.1).

- Present training simulators are oriented to oil/gas-fired power plants which are not adequate for training staff for coal-fired power plants (Sections 7.2.3, 7.3.3 and 7.4.2).

10.13 CAPITAL COST ANALYSIS

- The Khanot site would have the lowest capital cost of the sites considered in this feasibility study in terms of direct power plant related costs (See Chapter 8, Tables 8.1 through 8.28).

10.14 INFRASTRUCTURE

Chapter 9 investigates the need for the project to fund improvements to physical components of the existing human infrastructure in the Lakhra-Khanot area. From 2,000 to 7,900 workers will be involved annually over a 6-year period to build and start-up the mine and power plant. Operation of the mine and power plant over a 30-year project life will employ annually 3,000 to 3,400 workers. The arrival of dependents will gradually swell the total population in the residential colony to about 22,600 residents over the life of the project. Based on experience at the Guddu Generating Station, an estimated 8,000 people will also be attracted to the Lakhra-Khanot area as secondary population growth (see Section 9.1).

Housing, health care, education and police protection for the workers and their dependents will be provided by WAPDA and the

mine operator as a part of overall project costs. Provision of housing for secondary population growth in the Khanot-Lakhra area will be the responsibility of the new residents. Health care, education and police protection services will be the responsibility of the Government of Sind, or Dadu District. The cost of new services for secondary population growth will be more than offset by the payment of workers' income taxes, coal separation taxes, import duties and other assessments. The assumption is made that revenues collected by the Government of Pakistan will at least in part be channeled back to the Sind Province and Dadu District governments (see Section 9.8).

Examination of the transportation and telephone system indicated that other than upgrading the Khanot-Lakhra road, project funds would not be needed to upgrade highways or telephone systems. Upgrading of the Khanot-Lakhra road is already proposed as part of Lakhra Project costs. Other existing highways are considered adequate to handle the anticipated traffic volume increases and the transport of oversized or heavy loads. Previously planned improvements to the Hyderabad area telephone system by the Telephone and Telegraph Authority of Pakistan will provide a system more than adequate to serve all project needs. However, since the existing telephone system is greatly overloaded, any delays in making these improvements will seriously curtail telephone communications for the Lakhra Project (see Sections 9.6 and 9.7).

10.15 WORK PLAN

In the work plan presented by GCII for the Lakhra Power Feasibility Study several questions were posed. These questions represent the concerns of USAID and other donor agencies for the project. Resolving these questions is the basic objective of the study. The conclusions that have been reached as a result of the work contained in the study and are summarized as direct answers to the original questions as follows:

1) Is the quality of Lakhra lignite suitable for use as fuel for a steam generator?

Response:

The combustion testing studies have shown that Lakhra coal is suitable for use as fuel in a utility boiler. The design parameters established as a result of the combustion testing must be followed, as the use of Lakhra coal involves a high potential for corrosion, slagging and fouling. However, this lignite provides a good, stable combustion flame and is easily controllable (Sections 4.1, 4.4, 4.5, 4.6 and 4.8).

2) What is the impact on the steam generator and its auxiliaries and fuel handling equipment of the use of cleaned coal compared to raw coal?

Response:

The second phase combustion test and the washability analyses performed indicate that, other than emitting less SO_2 per day than allowed by the World Bank Standards, there is a minimum of positive impacts that result from the use of washed coal. Washing of Lakhra coal may increase somewhat the slagging and fouling indices of the fuel. The work done in these studies indicates that an approximately 20 percent reduction in sulfur content and up to a 40 percent reduction in ash content may be realized. Likewise, the reduction in ash content will require less capacity in ash removal and transport equipment and a reduction in total ash storage area. However, these impacts are not sufficient to justify the costs of coal washing (Sections 4.1, 4.2, 4.7, 4.8, 5.5.7, and Chapter 8).

3 and 4) What are the site considerations with respect to coal delivery for a mine mouth vs. non-mine mouth plant?

Response:

The basic site considerations for delivery of coal are shown on the site general arrangement drawings included with this report. It has been determined through the results of the J. T. Boyd coal transportation study that a short haul rail system is the most practical for either of the near Indus sites (Khanot or Jamshoro) but not at the mine mouth Lakhra site. The cost of fuel transportation to the Lakhra site is obviously less; however, delivery to the sites remote from the mine is feasible and the cost of this delivery must be weighed against other factors in an overall site comparison (Sections 5.3.1 and 5.3.2).

5) What are the realistic installed plant and power production costs for a two x 250 MW net output power plant fired with Lakhra lignite?

6) Should the units be located at the mine mouth or remote from the mine at Jamshoro or Khanot?

Response:

The decision on the final siting of the plant must also include input from J. T. Boyd, Dr. Art Helweg, ICF and ESE. It is the

opinion of GCII at this time that an overall review of the advantages and disadvantages offered by each site will favor the selection of the Lakhra site as the optimum location. Although the plant located at the Khanot site is somewhat lower in capital cost than a plant at the Lakhra site, it is expected that the total evaluated cost of the plant will favor Lakhra. (See Chapter 8 for capital costs.) The reason for this is the additional cost of coal to transport it from the mine to Khanot. Also, environmental impact considerations will favor the Lakhra site.

7, 8 and 9) What is the impact of makeup water supply at the various plant sites?

Response:

Makeup water at the Jamshoro site may be obtained from the Kotri pool area of the Indus River. The makeup water system initially laid out for the oil-fired units at Jamshoro may be extended for the coal-fired units if located at that site.

This study has determined that adequate makeup water supply for a power plant at Khanot or Lakhra is available from the area adjacent to the Maqdoom Irrigation Pumping Station. Water flow data gathered for the study and interviews with Sind Irrigation Department personnel indicate that water supply at this plant in the Indus River is reliable.

In terms of makeup water, the Jamshoro and Khanot sites are essentially equal. Studies also indicate that water must be taken from the river, as no reliable ground water sources have been found.

The location of the Lakhra site, approximately 20 kilometers west of the Indus, provides the most difficulty in supplying adequate water for plant requirements. However, it is feasible to install a pumping system at Khanot and to forward the necessary mine and plant makeup water supplies to Lakhra through a pipeline system. The primary impact of the extended water supply system is in the capital cost of the pipeline. Energy for pumping makeup water to the Lakhra site is minor due to the relatively small quantity of water required by cooling towers compared to a once-through cooling system (Sections 5.3.1, 5.3.2 and Chapter 8).

10) What are the impacts on the environment and the costs of air pollution control devices to reduce emissions of sulfur oxides and particulate matter from the unit to a level consistent with World Bank guidelines?

Response:

The potential for impact of liquid effluents from future SO_2 scrubber sludge or ash ponds on the environment is expected to be minor since maximum reuse of water will be made. Ultimate discharge will be routed to an evaporation pond. All ponds for ashes, liquid wastes and SO_2 sludges should be lined where the potential exists for contamination of surface water or usable ground water. Specific air pollution impacts have been addressed by ESE. The cost of air pollution control equipment needed to meet World Bank guidelines for units larger than 2 X 250 MW is provided in Chapter 8.

11) What are the differences in environmental impact considerations for the three plant sites?

Response:

A full consideration of environmental impacts among site alternatives will require evaluations provided by other Lakhra contractors, especially the social soundness contractor (A. Helweg, et al) and environmental assessment contractor (ESE). However, GCII perceives air quality as the most important difference among sites from an environmental standpoint.

Potential for adverse impact from air quality degradation appears to be greatest at Jamshoro due to the nearness of sensitive receptors (universities, hospital) and lower air quality in Hyderabad, relative to corresponding conditions at the other two sites. GCII has therefore developed design specifications and costs for an FGD system, and has assumed necessity for such a system for units larger than 275 MW.

Potential for impact to surface water is expected to be similarly low at all sites, since no surface water discharges are anticipated. GCII has postulated lining of solid waste disposal areas and treatment ponds at all three sites to minimize seepage losses and afford ground water protection. However, further evaluation by ESE indicates that linings may not be required at a given site, insofar as ground water protection is concerned.

Potential social and infrastructural impacts are perceived to differ widely among the sites, meriting close consideration of evaluations provided by the social soundness contractor. Provisions for infrastructure at the three sites are addressed in this report in Sections 5.3, 8.1.5 and Chapter 9.

Land requirements and consequent alterations of existing land use and natural habitat differ among sites. Additional area

would be required for SO_2 sludge disposal at all sites; Jamshoro would also require the greatest amount of land for railroad construction, but no new transmission is required. Land alterations for roadway, pipeline, and transmission line installation would be greatest for the Lakhra site (Sections 5.4, 5.5.6.1, 5.5.6.2, 5.5.6.3 and 5.5.6.4).

12) What considerations must be met for disposal of coal ashes?

Response:

The following considerations were made in the selection of ash disposal modes:

1. Wet sluicing of bottom ash and fly ash was selected. However, flexibility was maintained for potential sale of ash by providing separate disposal sites for fly ash and bottom ash, and by providing equipment to permit dry collection and truck transportation of sold fly ash.

2. Wet sluicing of ash was chosen in part due to lower costs, equipment requirements, and fugitive dusting problems.

3. Lining of ash disposal ponds was considered; however, the environmental assessment contractor has determined that lined ponds are not necessary.

13) What are the impacts of transporting coal ashes back to the mine for disposal?

Response:

The impact of transporting coal ashes back to the mine for disposal is dependent on the type of mine: open cut or underground. If there is no ground water in either type of mine, then ashes could be placed with minimal considerations for leachate prevention.

The logistics and costs of returning ashes to the mines must be worked out in detail by subsequent investigations if this method of ash disposal is given serious consideration:

1. An inactive worked out mining area is judged best for disposal of ashes so as not to interfere with current mining operations.

2. The cost will be greater as the ashes will require more handling. Pumping the ashes is one method, but

the disadvantage of pumping is returning water to the power plant for reuse. Truck or rail delivery of ashes to the mine mouth is a second method, but this adds costs for trucks or rail wagons and the handling and storage facilities at the mine. Trucks would require an all-weather road, and rail wagons might require special handling before coal could be sent in them to the river based site (Sections 5.3.1 and 5.3.2).

14) Can it be demonstrated that two Lakhra lignite-fired 250 MW units are required to meet forecast loads; are least costly of alternatives available and will produce satisfactory economics and financial rates of return on investment?

Response: Based on planning studies conducted by WAPDA and GCII, GCII is of the opinion that two 250 MW domestic coal-fired units are components of a long-range generation expansion program for the WAPDA system. The units are required to meet the load forecast and are competitive over the long-range planning period with other generation expansion alternatives, such as imported coal-fired and imported oil-fired units. The subject of financial soundness of the project is being addressed by other consultants working on this feasibility project.