4.3.3 Link Canal and New Main Canals

The proposed link canal connects the outlet of the pumping station with the Hurga and Nur El Din new main canals. It is 345 m long and includes a sand settling basin and a bifurcation. The sand settling basin deposits suspended solids contained in the pumped up water. The bifurcation structure divides water in the link canal automatically to the Hurga and the Nur El Din main canals in proportion to their respective service areas.

The new main canals are to connect the above link canal with the existing Hurga and Nur El Din canal networks. The length of the Hurga new main canal is 433 m starting at the bifurcation and terminating at the uppermost reaches of the existing Hurga main canal. The Nur El Din new main canal is 1,820 m long traversing from the bifurcation to the upper reaches of the existing Minor canal No.1. Layout of the link canal and the new main canals is shown in Figure 4-8. Alignment of these canals was made in due consideration of topography, present land use, workability for construction and operation and maintenance as well. Location of the bifurcation was determined considering construction cost, present land use, and workability during construction.

Designed water levels of the canals at the end of the Hurga and the Nur El Din new main canal were set at EL. 412.70 m and EL.412.86 m, respectively. This is based on the results of review on the field elevations and required elevations of field channels for the Project area.

Principal design criteria employed for the basic design of the link canal and new main canals were:

- Canal type:	earthen canal at trapezoidal sections
	concrete flume at rectangular sections
	masonry lining at transition sections
- Side slopes:	1:2.0
- Bank top width:	4 m for one side
	4 m for the other side (link canal)
	2 m for the other side (main canal)
- Berm:	1 m wide at every 5 m in height

- Freeboard: 0.8 m for canals
  1.0 m for sand settling basin
- O&M road : Effective width; 5 m.
  Maximum longitudinal slope; 5%
  Minimum curve radius; 30 m
  Road height; 50 cm
- Minimum earth covering of underground structures: 60 cm

The basic designs of the link canal and the new main canals are discussed below. Main features and designed water levels of the canals are shown in Table 4-3.

(1) Link Canal

Design discharge of the link canal is 8.17 m^3/sec. Discharges from the outlet of pumping station would be conveyed through an earthen canal 175 m long to the sand settling basin. The sand settling basin, with a length of 150 m, was designed to deposit the suspended solids carried by the water pumped up from the Blue Nile to minimize desilting works in the existing canal networks. The water flowing out from the sand settling basin would pass through a sudden contraction transition 20 m long made of wet masonry to the bifurcation. The bifurcation is provided immediately after the sand settling basin to divide the water automatically to the Hurga and Nur El Din irrigation systems.

Canal

Hydraulic elements of the earthen canal designed are:

- Bottom width : 6 m
- Canal height : 2.5
- Longitudinal slope: 1/10,000.

Transition sections for the outlet of the pumping station and the sand settling basin were planned to be of masonry works. Maintenance road was located on the left side of the canal considering the topographic conditions.

Sand Settling Basin

The minimum diameter of inflow particles to be deposited in the sand settling basin was estimated at 0.06 mm, which corresponds to around 80% to 90% of suspended solids in the water according to the article size distribution shown in Figure 4-9.

Cross sections of the sand settling basin was designed to be trapezoidal section with a bottom width of 30 m and a total height of 6 m including a freeboard of 1.0 m in height, so that the mean velocity in the basin becomes equal to or less than the critical floating velocity (5 cm/sec) of the articles. The length of the basin was set at 150 m, considering the critical falling velocity of 3 mm/sec of the articles and a safety coefficient. The settling capacity of the sand settling basin is around 15,000 m^3.

The sand settling basin was designed assuming that the deposited materials will be periodically removed by a pump suction dredger. The disposed silt and sand by the dredger was planned to be poured into a box culvert to flush out to the Blue Nile downstream of the pumping station.

Bifurcation

The bifurcation proposed for the Project is a jet flow division works consisting of inlet transition sections, approach channel, overflow sections, outlet channels and outlet transitions sections. This type of structure was chosen taking the following conditions into account for easier operation and less maintenance requirement:

- To divide the water automatically for all discharges at a fixed proportion;
- To attain complete overflow or jet flow at all discharges to avoid affect from tail water; and
- To measure discharge in the structure easily.

The inlet transition is 20 m long and warped one with wet stone masonry lining. The approach channel is of rectangular concrete flume with a bottom width of 8.17 m. It is connected to overflow sections having a broad crested weir. Two(2) outlet channels with rectangular concrete flumes are connected to the downstream apron of the weir. The one with the bottom width of 4.77 m is for the Hurga main canal and the other 2.90 m wide is for the Nur El Din main canal. The former is about 55 m long, while the latter is about 50 m long. Each outlet channel is connected to the new main canal through the outlet warped transition of 20 m length each lined with wet stone masonry.

A bridge is planned to cross the outlet channels for the existing road connecting the Hurga and Nur El Din areas.

(2) New Main Canals

New main canals consist of the Hurga and Nur El Din main canals. The design discharges of the Hurga and Nur El Din main canals are 5.02 m^3/sec and 3.15 m^3/sec, respectively. The basic designs are as follows.

Hurga Main Canal

Hydraulic elements of the Hurga main canal of 433 m length are:

- Bottom width; 6.0 m
- Canal height; 2.1 m
- Longitudinal slope; 1/10,000

A dry masonry lining was designed for the transition sections 10 m long between the outlet of the bifurcation and the main canal. A maintenance road was located on the left side of the canal.

Nur El Din Main Canal

Hydraulic elements of the Nur El Din main canal with a length of 1,820 m are:

- Bottom width; 4 m
- Canal height; 2.0 m

- Longitudinal slope; 1/10,000

A dry masonry lining was designed for the transition sections 10 m long immediately after the outlet of the bifurcation. A maintenance road was located on the right side of the canal.

4.3.4 Power Supply System

(1) 33 kV Distribution Line

The technical particulars of 33 kV distribution line are diagramed in Figure 4-10 and shown below:

Voltage	33 kV	
Length	9.5 km	
Number of circuit	Single	
Formation	Triangular formation	
Conductor	ACSR 95 sq.mm	
Insulators	33 kV pin type insulator and suspension insulator (254 x 146 mm, 3 nos. per set)	
Standard span	80 m	
Support	Pre-cast concrete pole	
	Length	11.0 m
	Dimension at top	115 x 145 mm
	Dimension at bottom	175 x 430 mm

The support for river crossing was designed to be a self-supported latticed steel tower with the following conditions:

Span length	362 m	
Conductor	ACSR 95 sq.mm	
Groundwire	Galvanized steel wire, 38 mm^2	
Maximum working tension	Conductor	1,100 kg
	Groundwire	750 kg
Height above G.L.	Upper crossarm	23.5 m
	Lower crossarm	26.0 m
	Top	29.3 m

(2) 33 kV Outdoor Switchgears

Outdoor type 33 kV switchgears would receive the power through the 33 kV distribution line and would supply to indoor switchgears at a 11 kV voltage level.

Main features of equipment are as follows:

Main transformer	Type	Three phase, outdoor use
	Cooling	Oil immersed self cooled
	Capacity	3,000 kVA
	Voltage	Primary 31,000 V Secondary 11,000 kV
Circuit breaker	Type	Three phase, outdoor use
	Rated voltage	36 kV
	Rated current	800 A
	Rated interrupting capacity	25 kA
Disconnecting switch	Type	Three phase, outdoor use
	Rated voltage	36 kV
	Rated current	600 A
Metering outfit	Type	Three phase, outdoor use
	Rated voltage	36 kV
Lightning arrester	Type	Single phase, outdoor use
	Rated voltage	42 kV

The include voltage detector would be used for detecting high voltage.

(3) 11 kV Indoor Switchgears

Indoor switchgears were designed to be contained in the metal enclosed cubicles. The following cubicles are to be installed.

Control panel (for outdoor switchgears)	1 set
11 kV panel (for transformer secondary)	1 set
Station service transformer of 50 kVA	1 set
Motor starter panel	4 sets
Battery & battery charger	1 set

Motor starter panels were designed to the following conditions:

(i) Reactor starting method is employed to suppress starting current. The capacity of reactor is 750 kW and provided with 50-60-80% taps.
(ii) Static capacity of 250 kVA is provided for motor circuit to improve the power factor.
(iii) Three elements (3-E) protective relay and grounding overcurrent relay are employed for protection of motor.

4.3.5 Equipment for the Desilting Work

As desilting by draglines and by pump suction dredgers are conceivable in the sand settling basin, the following comparative study was made to chose better equipment for the Project.

(1) Desilting by Pump Suction Dredger

i) Work plan
To remove the deposits in the sand settling basin and dispose them through the box culvert provided on the outer slope of the left bank of the sand settling basin.

ii) Equipment plan

Capacity of the pump suction dredger was determined so that residual sediments in the sand settling basin will not exceed the sediment capacity (15,000 m^3) of the basin through a simulation study. It was made by using estimated influx of suspended solids shown in Table 4-4 and desilting volume of the dredger under 12 hours operation a day. Based on the simulation study shown in Figure 4-11, design capacity of the dredger was determined to be 155 m^3/hr considering 10% allowance of the required capacity of 140 m^3/hr.

(2) Desilting by Dragline

i) Work plan

- Desilting by dragline placed on the top of both banks of the sand settling basin,
- Loading the sediments removed from the basin on dump truck by wheel-loader,
- Hauling them to downstream of the pumping site by the dump truck, and
- Shaping a dump by bulldozer.

ii) Equipment plan

Conditions considered for equipment plan are:

- Maximum residual sediments in the basin is 15,000 m^3,
- Actual working hours of equipment are 6 hr/day, and
- Disposing of sediments removed by the dragline will be made throughout a year.

Thus estimated equipment requirement is as follows:

1. Dragline (3.6 m^3)	:	5	nos.
2. Wheel-loader (1.5 m^3)	:	3	nos.
3. Dump truck (11 ton)	:	6	nos.
4. Bulldozer (21 ton)	:	2	nos.

(3) Proposed Plan

Based on the equipment plans discussed above, cost comparison was made as shown below:

Description	Pump Dredger	Dragline
Procurement cost (1,000 yen)	99,200	682,500
Running costs (£S 1,000)	808	1,571

Cost comparison revealed economic advantage of pump dredger. Further, desilting by dragline requires a fleet of equipment entailing more maintenance compared with that by pump dredger. Thus, desilting by pump dredger with the following specification was designed for the Project.

Pump suction dredger	:	1	no.
- Capacity	:	155	m^3/hr
- Dredging depth	:	5	m
- Discharge distance	:	200	m
- Inlet	:	Cutterless type	

4.4 Implementation Plan

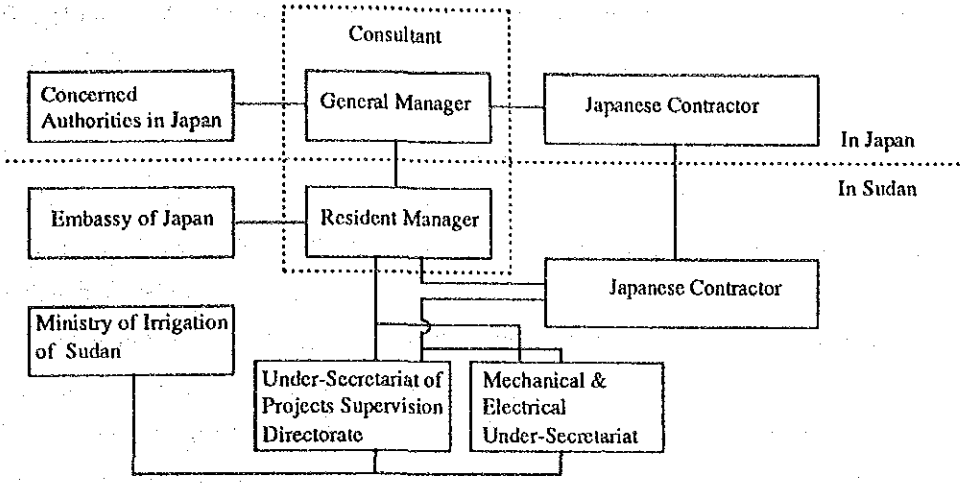
4.4.1 Construction Condition

The Project would be implemented by the following executing system mentioned hereinafter in cooperation with the concerned agencies of the Governments of Sudan and Japan and the concerned companies.

The Ministry of Irrigation (MOI), the Republic of Sudan, will be the executing agency for the Project. The practical agencies for the construction works covered by the Japanese Grant Aid will be the Supervision Directorate of the Under-Secretariat of Projects and the Mechanical & Electrical Under-Secretariat. The former will take charge of the civil works and the latter will take charge of the works of pumping equipment and the power supply system. MOI will be authorized to execute the following work items till the completion of the construction works.

1) Execution of all construction works,
2) Execution of the contracts for consultancy services and contractor,
3) Approval of design,
4) Tendering and evaluation of tenders,
5) Approval of payments,
6) Management of all contracts,
7) Acceptance of completed works, and
8) Liaison and coordination with other government agencies.

The overall organization structure for the Project is outlined as follows:



4.4.2 Implementation Method

The following plans for the construction and the procurement of materials will be adopted to execute the works with due considerations of local conditions and general construction conditions in the Project area.

Construction Works for the Pumping Station

The construction works of the sub-structure for the pumping station was scheduled to start during the low water stage of the Blue Nile and to be completed before the rainy season when the water level of the Blue Nile rises. The works would be commenced first at the sheet pile works around the inlet. Concrete for the pumping station would be transported and placed to the required points by agitator trucks from a batching plant provided near the pumping station.

Installation of the Pumping Equipment

The construction works of pumping equipment would be commenced by installing suction pipes and an overhead crane by using a truck crane. These works would start immediately after the completion of construction of the pump house in the dry season. Pumping equipment within the pump house would be installed by the overhead crane. The delivered materials other than

piping materials would be stored within the pump house and no storage house would be constructed for pumping equipment.

Construction Works for the Canal Facilities

The embankment and excavation works for the canal facilities would be conducted by heavy construction equipment. Finishing works for the canal slopes would be carried out manually. Embankment materials would be hauled from borrow areas to be selected at appropriate places near the working sites. Concrete for the canal related structures would be transported and placed at the required points by agitator trucks from the batching plant mentioned above.

Construction Works for the Power Supply System

The setting works for the pre-cast concrete poles and the wiring works for the distribution lines would be executed manually except for transporting materials.

Procurement of Construction Materials

The following construction materials would be procured from local traders concerned;

- Aggregates and cement for concrete works
- Crushed stones for stone works
- Laterite pavement materials
- Bricks for brick works
- Fuel and lubricant for construction equipment

4.4.3 Construction and Supervisory Plan

Immediately after the Exchange of Notes (E/N) between both Governments, the consultants will enter into a contract with the Ministry of Irrigation (MOI), the executing agency of the Government of Sudan, on the consultancy services. The detailed design work will be carried out by the

Consultant, holding close discussion with MOI. At the same time, MOI will undertake such works as preparation of the temporary office, which are to be executed by the Sudan side and required before commencement of the main construction works. The design work will be undertaken by the consultant either at the construction site in Sudan or in Japan.

MOI's approval will be needed for the design documents before tendering. Tendering work will be commenced at the pre-qualification for the applicant contractors. The advertisement of tender will be run in major Japanese papers in the name of MOI of Sudan. The tender documents will be delivered to the consultant's head office and publicly opened after acceptance of scaled ones in the presence of representative of the Government of Sudan. The consultants will assist the Sudan Government in evaluating tenders and drafting the contract.

Construction supervision will be carried out for effective and the smooth construction progress and completion of the works on schedule, paying special attention to Sudan natural features, customs, religion, traditions, and systems.

After signing the construction contract, the consultant's representative will discuss with the contractor on the construction methods and construction schedule. The consultant's resident engineer will then be posted at the construction site to supervise the construction works on site during the whole construction period.

The resident engineer will regularly report construction progress and related matters to MOI of the Government of Sudan as well as to the Embassy of Japan and JICA in Sudan and will coordinate all construction-related matters with concerned officials of the Project. In addition, the consultant will dispatch to the country several specialists for short term periods to supervise the construction works, keeping space with the construction progress. Engineers to be engaged in the construction supervision work are summarized below:

Engineers	Person	Scope of Work
(Resident Specialists)		
Resident Engineer	1	- Overall supervision during the whole construction period and reports to the concerned agencies
Irrigation Engineer	1	- Supervision for the works of irrigation facilities
(Short-time Specialists)		
General Manager	1	- Arrangement of the construction contract and instructions to the other engineers
Pump Engineer	1	- Review of the construction drawings of pumping equipment and inspection of installation works
Electric Engineer	1	- Supervision for the works of power supply system
Architect	1	- Supervision for the works of building on the pumping station

4.4.4 Procurement Plan

The construction materials will be procured in Sudan as much as possible. However, materials which is difficult to procure or obtain of sufficient quality in Sudan will be procured from Japan. Procurement plan for the main construction materials is listed below:

Materials	Procured in Sudan	Procured from Japan
Concrete materials	Aggregates	Admixture
	Cement	
Wooden materials		Timbers
		Plywoods
Steel materials		Reinforcing bars
		Shape steels
Fuel and lubricant	Gasoline	
	Diesel	
	Oil	
Building materials	Bricks	Iron fittings
Materials for power supply system	Electric poles	Conductors
		Frames for steel towers
Pumping equipment		Pumps
		Motors
Construction equipment		Heavy equipment
		Trucks
O&M Equipment		Pump suction dredger

The cargoes from Japan for the Project will be unloaded at the Port Sudan, from where they will be delivered to the Project site by trucks through a road of about 1,000 km. The transportation period of cargoes from Japan to the Project site was estimated at about 3.3 months, taking into account the period required for marine transportation from Japan to the Port Sudan, unloading, custom formalities at the Port Sudan, and inland transportation to the Project site.

4.4.5 Implementation Schedule

A tentative implementation schedule for the works to be undertaken by the Government of Japan is shown in Figure 4-12. The required period for the detailed design will be 3 months and that for the construction works including the procurement work for construction materials and equipment will be 12 months. Since the substructure works of the pumping station and embankment are quite difficult to carry out during the rainy season due to less trafficability, this period is avoided in scheduling of the construction works.

4.4.6 Scope of Works

The works which will be covered under Japanese Grant Aid and the Government of Sudan were tentatively decided as tabulated below:

by the Government of Japan	by the Government of Sudan
- Pumping station	- Rehabilitation of irrigation canal networks
- Power supply system	- Rehabilitation of drainage canal networks
- Link canal	- Preparation of management office, etc.
- New main canals	
- Procurement of pump dredger	

The works which will be covered by the Government of Sudan is expected to be implemented in time with the construction of the works to be covered under the Grant Aid.

4.5 Project Evaluation and Conclusions

4.5.1 Project Evaluation

Implementation of the Project would provide the beneficiary farmers with a basis for introducing intensive farming under irrigated conditions. As a result, a considerable increase in unit yield of crops and cropping intensity could be expected, leading to substantial improvement of farm incomes.

(1) Increase in Crop Production

Present crop production from the Project area is limited to only 700 tons of sorghum a year because of: i) water supply shortage caused by deterioration of the existing pumping stations and canal networks; ii) low cropping intensity of 16 %; and iii) low unit yield of sorghum due to extensive farming practices. By implementation of the Project, however, it is expected that crop production from the Project area will be considerably increased as shown below:

(Unit:£S)

Crop	Cropping Area (feddan)	Unit Yield (kg/feddan)	Production (ton)
Cotton	4,524	900	4,072
Wheat	4,524	920	4,162
Sorghum	2,262	1,000	2,262
Groundnuts	2,2,62	1,000	2,262
Fodder	4,524	1,500	6,786

Source; The Feasibility Report on the Hurga Nur El Din Pump Scheme Rehabilitation Project, Main Text, August 1991

(2) Improvement of Farm Budget

An increase in crop production would drastically improve the farm incomes for the beneficiary tenants of 1,512 households (12,100 persons), and bring about a great improvement in farm budget as shown below:

(Unit:£S)

Items	Without-Project		With-Project
	Hurga	Nur El Din	Whole area
Farm size(feddan)	15	15	15
1) Gross income	12,400	10,200	44,800
Farm income	800	0	41,600
Off-farm income	11,600	10,200	3,200
2) Gross Outgoing	18,100	16,200	31,600
Production Cost	1,400	800	11,900
Living expenses	16,600	15,400	19,700
3) Net Reserve	-5,600	-6,000	13,200

The crop budgets under the with-project condition were estimated based on the proposed cropping pattern, anticipated crop yields, and anticipated farming practices. Farmgate prices of cotton and wheat employed for the estimation are those fixed by GOS, and those of other crops are current farm market prices. The farmgate prices of farm inputs employed are those currently used by SGB for cotton and wheat.

The farm budgets under with-project condition were estimated based on gross farm income, cost for crop production, off-farm incomes such as livestock production and wages/salaries, and living expenses.

(3) Increase in Employment Opportunity

The Project will generate considerable employment opportunities for unskilled labours during the construction period and for seasonal farm labours after implementation of the Project. In addition, expected intensive farming after the implementation of the Project will create a demand for farm machinery presently run by the private sector.

(4) Women Activity

As beneficiary tenants are obliged to depend mostly for their living on off-farm incomes, the family labour force has left their farm to their wives and children. Such present conditions have forced women to work on the farmland in addition to doing housework. Thus, women of the beneficiary households have had little chance to join social activities. After implementation of the Project, however, the family labour force working outside the Project area would return to their farmland and devote themselves to farming. Furthermore, introduction of mechanized farming would considerably mitigate task loads which will increase due to introduction of intensive farming. Thus women would have more time to attend social activities.

(5) Environmental Impact

Since the Project is a rehabilitation project, it is unlikely that implementation of the Project would entail extreme environmental change nor adversely affect the environment in and around the Project area. It is, however, conceivable that perennial irrigation will provide more favourable conditions for vectors and intermediate hosts of water associated diseases, particularly malaria and schistosomiasis.

Aiming at controlling the water associated diseases of malaria, schistosomiasis, and water borne diarrheal diseases in the Gezira-Managil and Rahad Schemes, the Blue Nile Health Project (BNHP) commenced in 1979. According to the report of the activities of BNHP, the prevalence rate of both malaria and schistosomiasis have distinctively decreased since commencement of BNHP.

It is, therefore, proposed that a similar programme to BNHP be introduced to the Project or that BNHP's programme be extended to the Project area after implementation of the Project.

4.5.2 Conclusions and Recommendations

Both direct and indirect benefits are expected by implementing the Project. All the beneficiary tenants, who had once enjoyed cotton production, have been forced to remain in unstable living conditions of relying on temporary wages/salaries and/or capricious remittances since early 1990s' because of severely depressed agricultural production. By implementation of the Project, the agricultural infrastructure will be restored and thereby decisive constraints for revitalization of the present depressed condition will be removed as keenly expected by the beneficiary tenants.

The Ministry of Irrigation (MOI) has had ample experience on similar projects and is quite reliable as the executing agency for the implementation of the Project. It was confirmed that operation and maintenance of the Project after implementation be jointly carried out by MOI and Sudan Gezira Board (SGB). Since this joint management system has been adopted for the Gezira-Managil Scheme, no management difficulty are expected in the future operation and maintenance.

The implementation of the Project requested by the Government of Sudan was considered to be practical and justifiable. In addition, the Project has been formulated in conformity with the national development programme of Sudan and will become the first comprehensive rehabilitation project among the schemes studied in "the Blue Nile Modernization Study".

For the smooth implementation, operation, and maintenance of the Project, the following recommendations are made to the Government of Sudan:

- To complete as scheduled the works to be covered by the Government of Sudan;
- To secure budgetary arrangements and staff members necessary for implementation, maintenance, and operation of the Project;

- To execute periodical maintenance and repairs of the Project facilities and equipment;
- To strengthen agricultural supporting services including extension services, training of farmers and supply of agricultural inputs; and
- To introduce a similar programme as BNHP for malaria and schistosomiasis.

Tables

Table 2-1 Summary of Meteorological Record

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Rainfall(mm/month)	0.0	0.0	0.0	0.2	17.4	25.7	65.3	92.9	49.3	11.2	2.9	0.0	264.9
Max.Temperature(C)	33.1	34.5	38.3	41.0	41.5	40.0	37.1	35.7	36.4	38.7	36.6	33.2	37.2
Min.Temperature(C)	14.7	16.1	19.9	21.7	24.8	25.3	23.8	23.2	22.6	22.6	18.7	15.5	20.7
Max.Relative Humidity(%)	52	42	36	29	44	61	76	83	82	64	47	49	55.4
Min.Relative Humidity(%)	19	16	14	13	21	26	37	41	38	27	20	21	24.4
Wind Speed(m/sec)	2.4	2.4	2.5	2.4	2.8	4.1	4.1	3.3	2.1	1.6	2.0	2.1	2.7
Sunshine Duration(%)	91	88	82	85	72	66	60	63	72	83	92	91	78.8
Evaporation (Penman; mm/day)	6.4	7.3	8.4	8.8	9.1	10.0	8.5	8.1	7.4	7.1	6.5	6.2	7.8

Source; Wad Medani Meteorological Station
Rainfall ; 1980 - 1990
Temperature ; 1980 - 1989
Humidity ; 1986 - 1990
Wind Speed ; 1980 - 1989
Sunshine ; 1980 - 1989
Evaporation ; 1980 - 1990

Table 2-2 Monthly Mean Water Level of the Blue Nile

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
WAD EL NAU	390.66	390.59	390.62	390.90	391.03	391.63	394.87	398.40	397.36	394.66	392.18	390.96	392.82
HAG ABDALLA	395.20	395.19	395.13	395.36	395.47	396.01	398.76	402.30	400.85	398.46	396.04	395.35	397.01
HAG-WAD	4.54	4.60	4.52	4.46	4.44	4.38	3.89	3.90	3.49	3.80	3.86	4.39	4.19
NUR EL DIN	392.08	392.02	392.02	392.28	392.41	392.99	396.08	399.61	398.45	395.85	393.38	392.32	394.12
HURGA	391.87	391.82	391.82	392.09	392.22	392.79	395.91	399.44	398.30	395.68	393.21	392.13	393.94

* W.L. at gauging stations and pumping stations are shown on Irrigation Datum (EL. 360.00 m, Khartoum). The above values should be deducted 80 cm for the purpose of designing facilities for the Project.

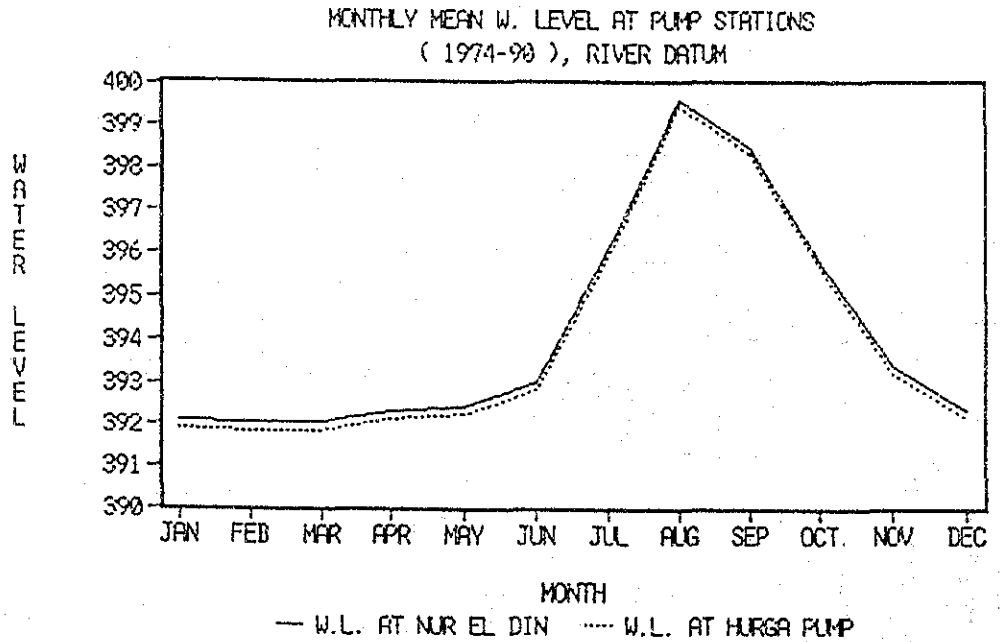


Table 3-1 Water Requirement and Water Level Fluctuation at Pumping Station

Month	10-DAY	(1) Discharge (m3/sec)	(2) Suction level (EL)	(3) Discharge level (EL)	(4) Static pump head (m)
Jan	1	4.83	391.07	413.6	22.53
	2	4.54	391.07	413.6	22.53
	3	4.14	391.07	413.6	22.53
Feb	1	3.61	391.02	413.6	22.58
	2	3.18	391.02	413.6	22.58
	3	2.12	391.02	413.6	22.58
Mar	1	1.09	391.02	413.6	22.58
	2	0.00	391.02	413.6	22.58
	3	0.00	391.02	413.6	22.58
Apr	1	0.00	391.29	413.6	22.31
	2	0.00	391.29	413.6	22.31
	3	2.23	391.29	413.6	22.31
May	1	2.65	391.42	413.6	22.18
	2	3.26	391.42	413.6	22.18
	3	3.84	391.42	413.6	22.18
Jun	1	4.66	391.99	413.6	21.61
	2	5.69	391.99	413.6	21.61
	3	6.49	391.99	413.6	21.61
Jul	1	6.34	395.11	413.6	18.49
	2	7.86	395.11	413.6	18.49
	3	6.60	395.11	413.6	18.49
Aug	1	6.45	398.64	413.6	14.96
	2	6.50	398.64	413.6	14.96
	3	6.87	398.64	413.6	14.96
Sept	1	8.17	397.50	413.6	16.10
	2	7.44	397.50	413.6	16.10
	3	6.75	397.50	413.6	16.10
Oct	1	7.05	394.88	413.6	18.72
	2	5.98	394.88	413.6	18.72
	3	5.89	394.88	413.6	18.72
Nov	1	5.32	392.41	413.6	21.19
	2	5.26	392.41	413.6	21.19
	3	4.18	392.41	413.6	21.19
Dec	1	4.50	391.33	413.6	22.27
	2	4.73	391.33	413.6	22.27
	3	4.90	391.33	413.6	22.27

Notes :

(1) as 18 hrs operation per day
(2) average water level between 1974-1990
(4) static head ((3)-(2))

Design Condition of Pump :

FWL : EL 402.11 (100-year probable)
HWL : EL 398.64
LWL : EL 391.02
L.LWL EL 389.02 (June 1990)
Setting EL of Motor : EL 402.50

Table 4-1 Main Features of Pumping Equipment

1. PUMP

Type of Pump	: vertical shaft double suction volute pump
Diameter of Pump	: 900mm X 800 mm
Rated Discharge	: 148m3/min per unit
Rated Design Head	: 25 m
Specific Speed	: 448 rpm-m
Quantity	: 4 sets

2. MOTOR

Type	: totally enclosed self-cooling vertical shaft squirrel cage induction motor
Output	: 760 kW
Voltage	: 11 kV
Number of Pole	: 10 poles
Speed	: 583 rpm (including 3% slip)
Quantity	: 4 sets

3. OVERHEAD CRANE

Type	: electrically operated,wire rope hoist with travelling and transverse gear unit
Capacity	: 15 tons
Quantity	: 1 set

4. SUCTION PIPE

Type	: concrete encased welded steel pipe
Diameter	: 1,100 mm to 900 mm
Length	: approx. 22 m
Quantity	: 4 lanes

5. DISCHARGE PIPE

Type	: welded steel pipe with manifold type confluence pipe
Diameter	: 800 mm,900 mm,1,100 mm,and 1,800 mm
Length	: approx.60 m
Quantity	: 4 lanes for each pump unit and 1 lane of confluence discharge pipe

6. SUCTION VALVE

Type	: manually operated sluice valve
Diameter	: 900 mm
Quantity	: 4 sets

7. DISCHARGE VALVE

Type	: electrically operated butterfly valve
Diameter	: 900 mm
Quantity	: 4 sets

8. CHECK VALVE

Type	: swing type check valve
Diameter	: 900 mm
Quantity	: 4 sets

Table 4-2 Head Loss Calculation

Description of Loss	Flow (m3/scc)	Diameter of Pipe (mm)	Flow Velocity (m/sec)	Coefficient of Loss	Head Loss (m)
Suction Loss					
-Inlet (Bellmouth)	2.467	1100	2.596	0.300	0.103
-90 deg Bend (D/R=1.00	2.467	1100	2.596	0.294	0.101
-Taper Pipe (Convergent	2.467	1100-900	3.878	0.025	0.098
-Sluice Valve	2.467	900	3.878	0.050	0.038
-Friction of Pipe	2.467	900	3.878	0.016	0.142
l=9m,c=110					
Sub-total					0.483
Discharge Loss					
-Taper Pipe (Divergent)	2.467	900	3.878	0.135	0.007
D1=900 D2=800	2.467	800	4.908		
-Check Valve	2.467	900	3.878	0.500	0.384
-90 deg Bend	2.467	900	3.878	0.294	0.226
-Butterfly Valve	2.467	900	3.878	0.200	0.153
-90 deg Bend	2.467	1100	2.596	0.294	0.101
-Friction of Pipe	2.467	1100	2.596	0.006	0.102
l=17m,c=110					
-Taper Pipe (Divergent)	2.467	1100	2.596	0.260	0.022
D1=1100 D2=900	2.467	900	3.878		
-Confluence at T-pipe	2.467	1100	2.596	1.461	0.280
D1=1100 D2=1800	4.934	1800	1.939		
-19 deg Bend	7.401	1800	2.908	0.084	0.036
-19 deg Bend	7.401	1800	2.908	0.084	0.036
-Friction of Pipe	7.401	1800	2.908	0.004	0.176
l=42m,c=110					
-Taper Pipe (Divergent)	7.401	2400	1.636	0.317	0.026
D1=1800 D2=2400	7.401	1800	2.908		
-Outlet	7.401	2400	1.636	1.000	0.137
Sub-total					1.686
Total					2.168

Table 4-3 Hydraulic Elements of Canals and Related Facilities

Canal Facilities	Dimensions		Designed Water Level	
Discharge Outlet	Length	10 m	B.P.	EL. 413.60 m
	Width	8 m		
	Height	6 m		
	Freeboard	1 m	E.P.	EL. 413.58 m
Link Canal				
Canal	Type	Earth Canal with Trapezoidal Section	B.P.	EL. 413.58 m
	Slope	1: 2.0		
	Length	175 m		
	Base Width	6 m		
	Height	2.5 m		
	Freeboard	0.8 m	E.P.	EL. 413.56 m
Sand Settling Basin	Type	Earth Canal with Trapezoidal Section	B.P.	EL. 413.56 m
	Slope	1: 2.0		
	Length	150 m		
	Base Width	30 m		
	Height	6 m		
	Freeboard	1 m	E.P.	EL. 413.54 m
Bifurcation	Type	Jet Flow Division Works	B.P.	EL. 413.53 m
	Diversion Width	8.17 m	Diversion W.L.	413.53 m
	Overflow Depth	0.66 m	E.P. for Hurga Canal	
	Freeboard	0.8 m		EL. 412.74 m
			E.P. for Nur El Din Canal	
				EL. 413.04 m
New Main Canals				
Hurga Main Canal	Type	Earth Canal with Trapezoidal Section	B.P.	EL. 412.74 m
	Slope	1: 2.0		
	Length	433 m		
	Base Width	6 m		
	Height	2.1 m		
	Freeboard	0.8 m	E.P.	EL. 412.70 m
Nur El Din Main Canal	Type	Earth Canal with Trapezoidal Section	B.P.	EL. 413.04 m
	Slope	1: 2.0		
	Length	1,820 m		
	Base Width	4 m		
	Height	2.0 m		
	Freeboard	0.8 m	E.P.	EL. 412.86 m

Table 4-4 Estimated Sediment Volume in Sand Settling Basin

	Calculation	Unit	Jun.	Jul.			Aug.			Sept.			Oct.	Total
			21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	1-10	
Numbers of days		day	10	10	10	11	10	10	11	10	10	10	10	112
1. Release from Sennar Dam*		M. m3/day	54.36	80.68	146.61	224.36	335.06	368.52	414.52	354.28	252.45	183.85	129.93	2,545
2. Sediment Load of Blue Nile*		M. ton/day	0.20	0.45	1.20	2.30	3.20	3.20	2.50	1.90	0.90	0.40	0.20	16.45
3. Water Requirement (second)		m3/sec	6.49	6.34	7.86	6.60	6.45	6.50	6.87	8.17	7.44	6.75	7.05	
4. Water Requirement (day)		M. m3/day	0.42	0.41	0.51	0.43	0.42	0.42	0.45	0.53	0.48	0.44	0.46	
5. Water Requirement (10 days)		M. m3	4.21	4.11	5.09	4.70	4.18	4.21	4.90	5.29	4.82	4.37	4.57	50.46
6. Sediment Load per unit volume	2.÷1.	0.001* ton/m3	3.68	5.58	8.18	10.25	9.55	8.68	6.03	5.36	3.57	2.18	1.54	
7. Weight of Inflow Sand	5.×6.	T. ton	15.5	22.9	41.7	48.2	39.9	36.6	29.5	28.4	17.2	9.5	7.0	296.5
8. Volume of Inflow Sand	7.÷1.8 t/m3	T. m3	8.6	12.7	23.2	26.8	22.2	20.3	16.4	15.8	9.5	5.3	3.9	164.7
9. Estimated Sediment Volume**		T. m3	7.7	11.5	20.8	24.1	20.0	18.3	14.8	14.2	8.6	4.8	3.5	148.2

* Data of Feasibility Study in 1991

** 90% of suspended solid would be deposited in the sand settling basin.

Figures

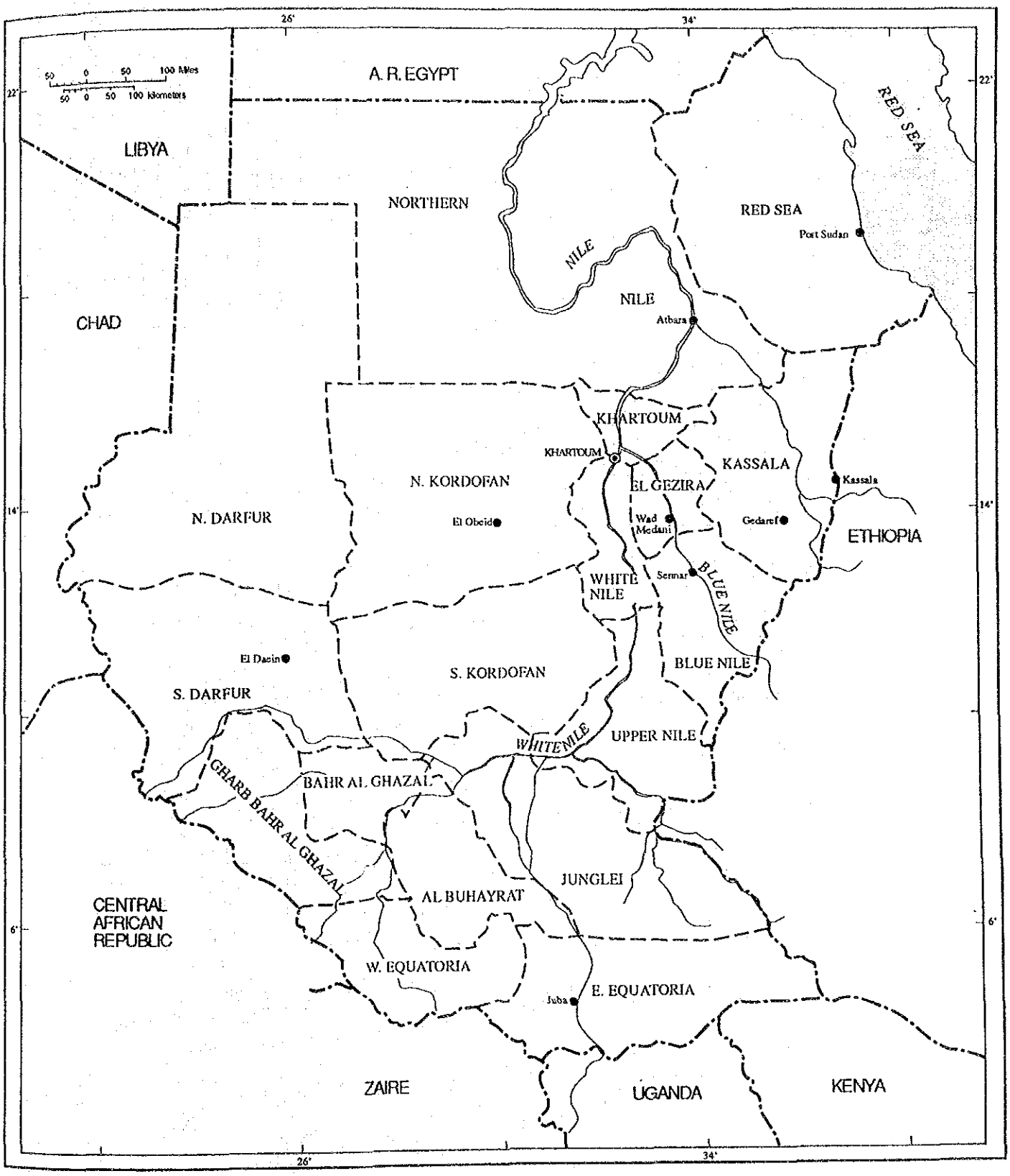


Fig. 2-1 General Map of Sudan

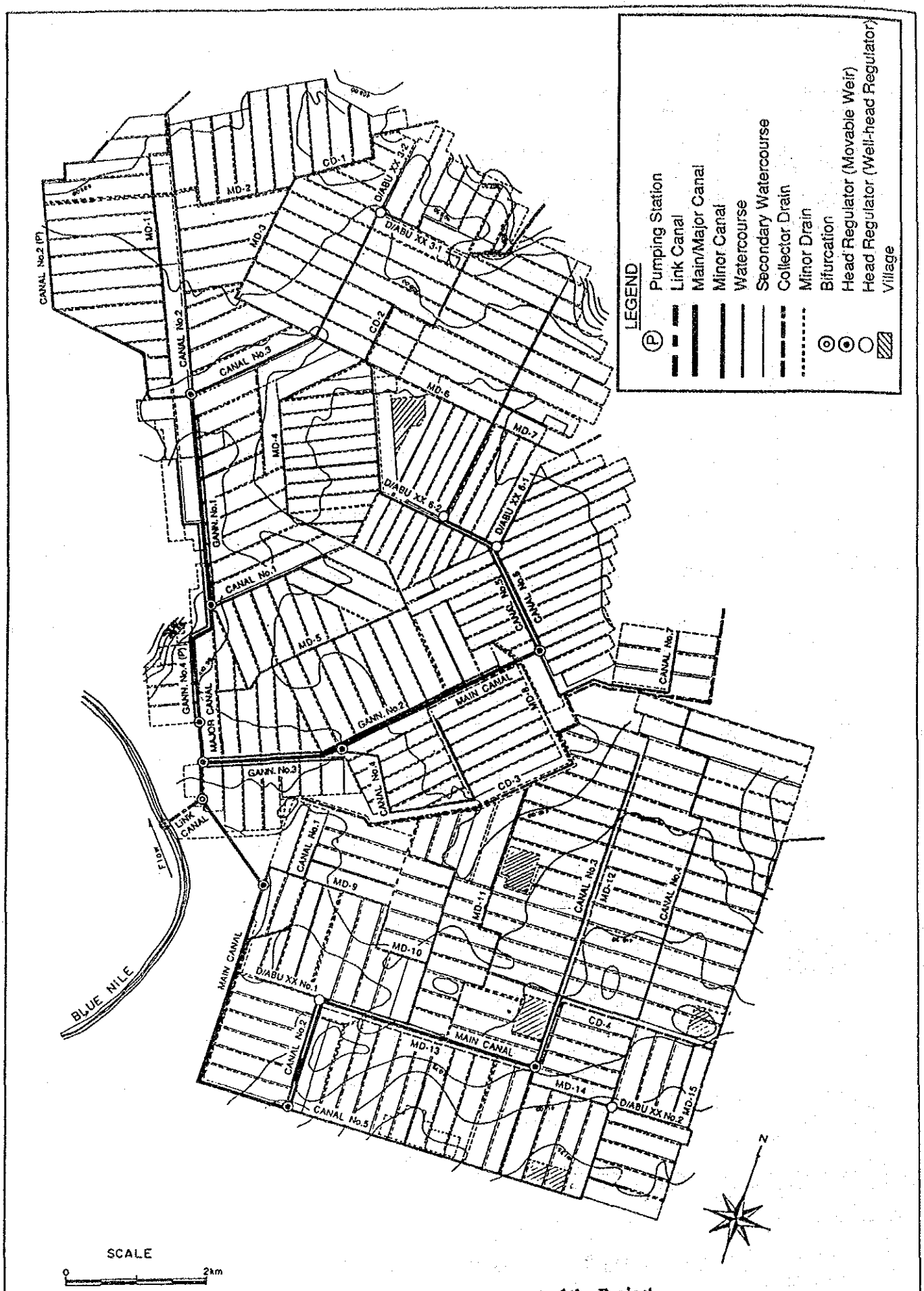


Fig. 2-2 General Layout of the Project

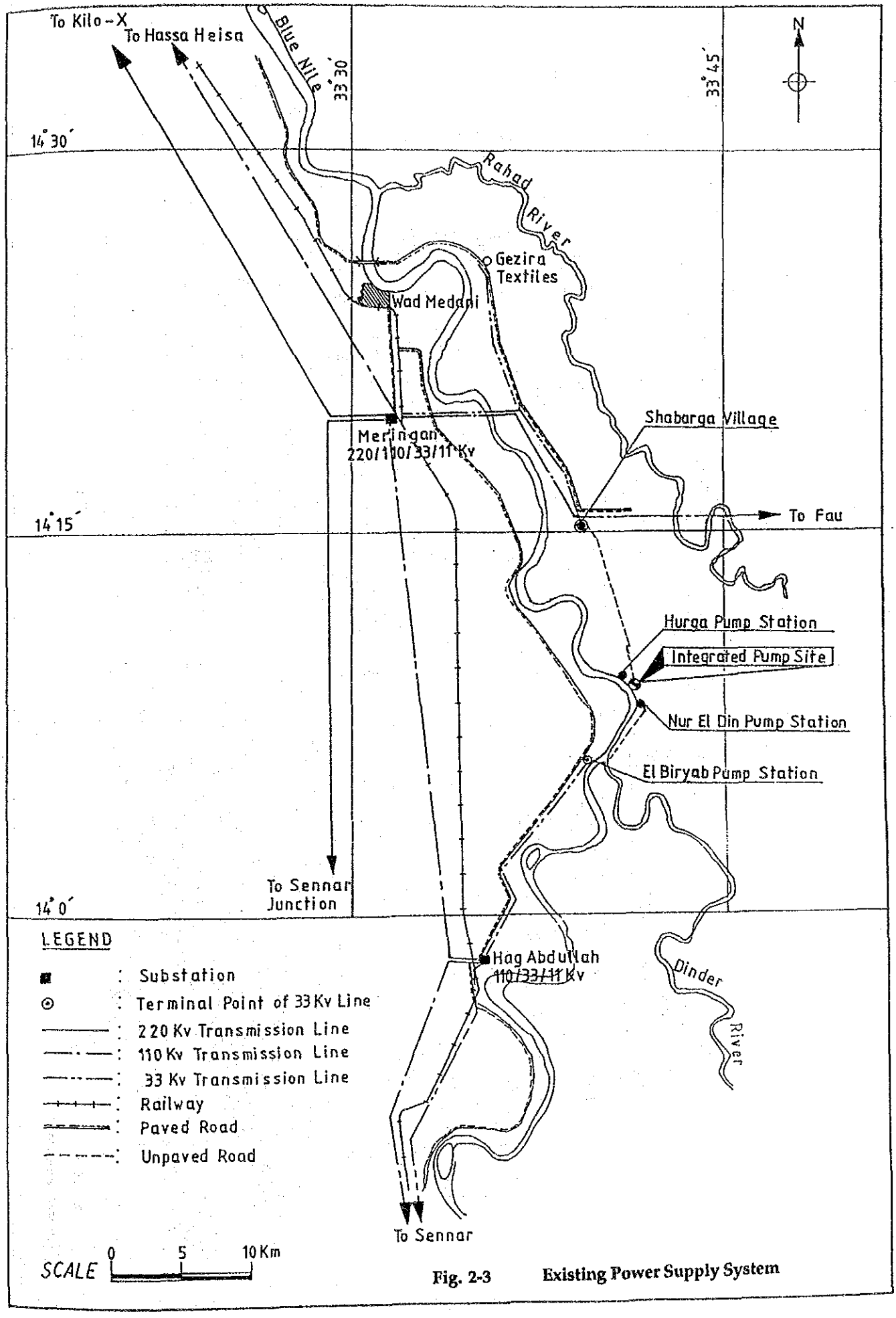


Fig. 2-3 Existing Power Supply System

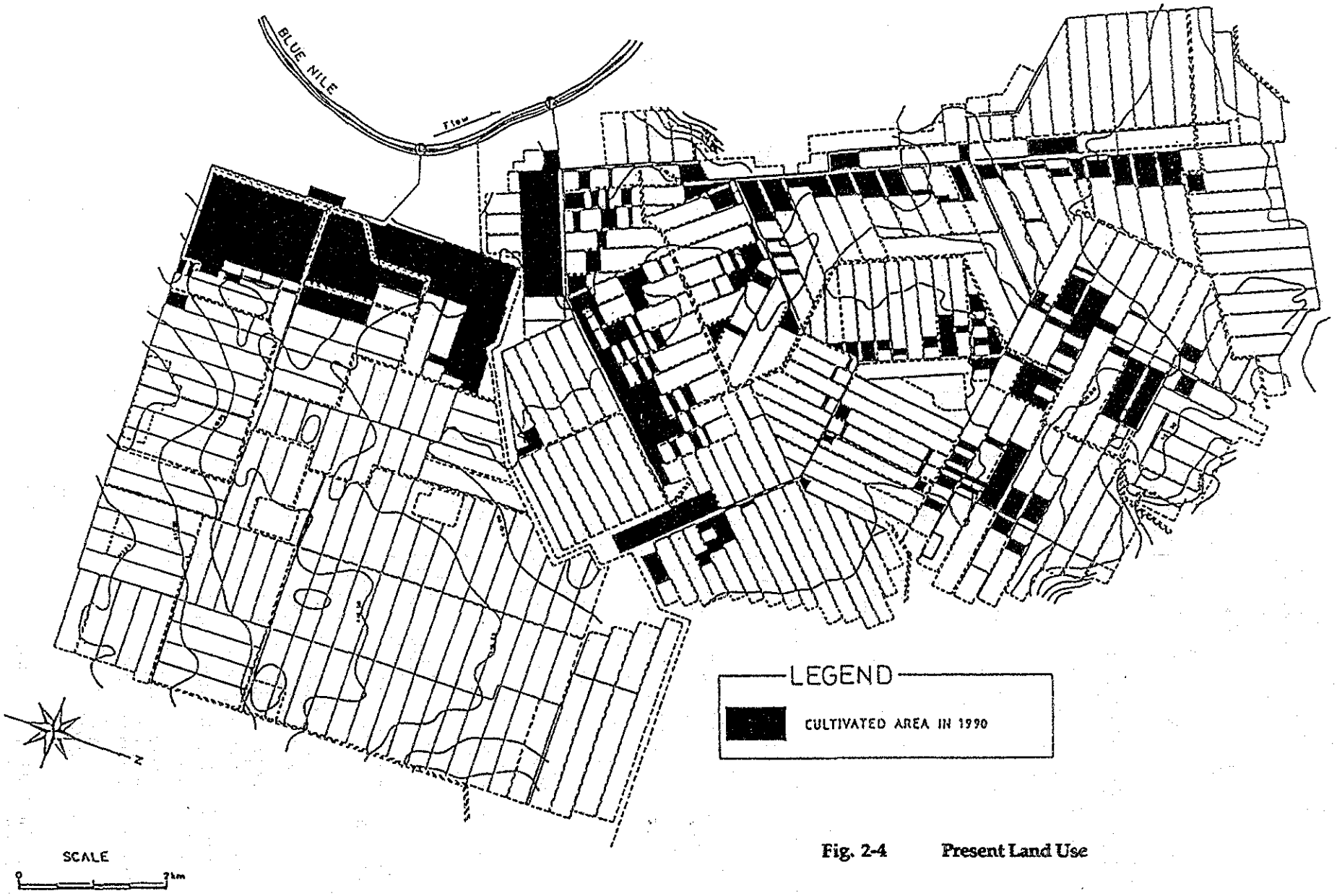


Fig. 2-4 Present Land Use

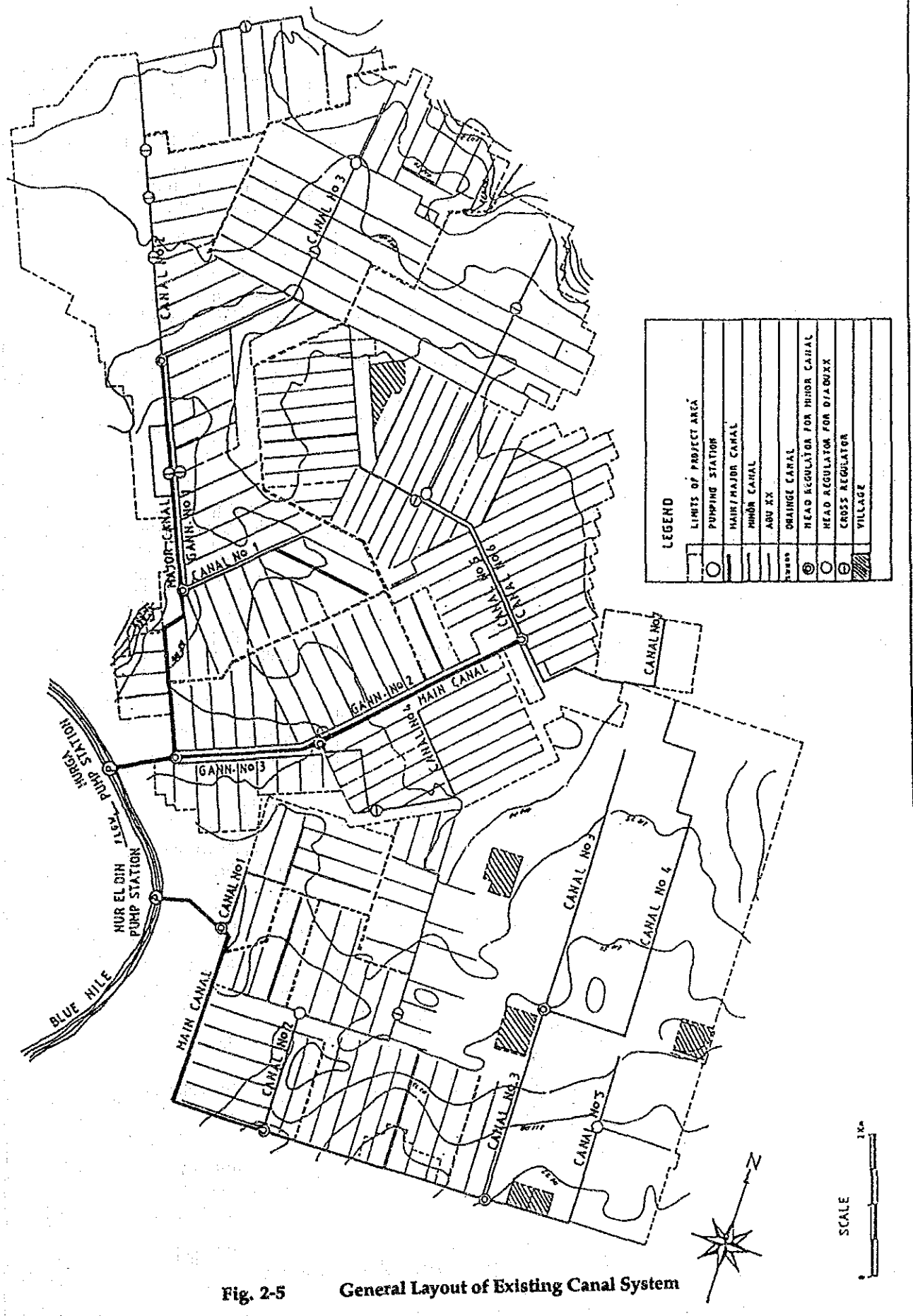


Fig. 2-5 General Layout of Existing Canal System

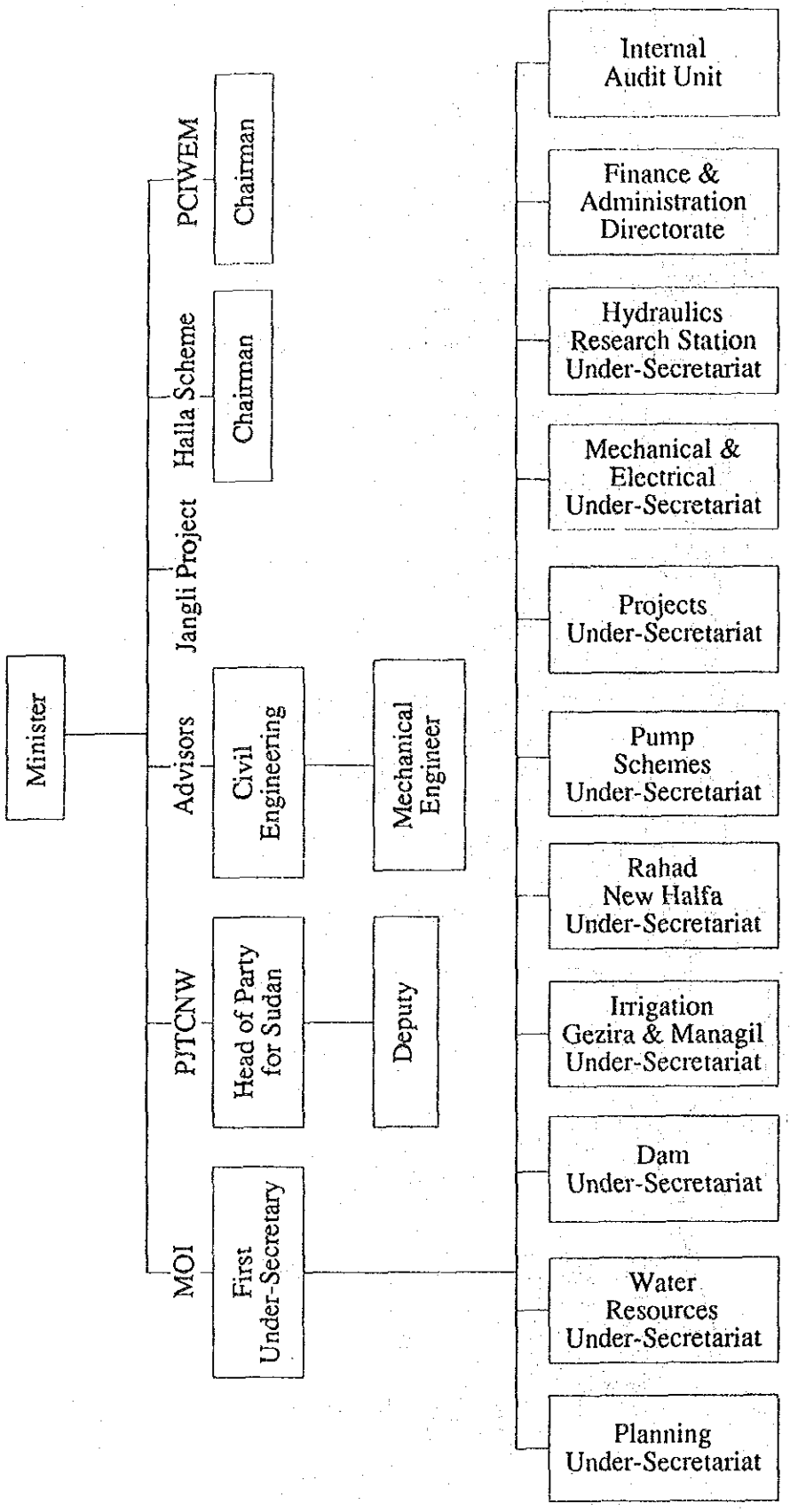


Fig. 3-1 Organization Structure of MOI

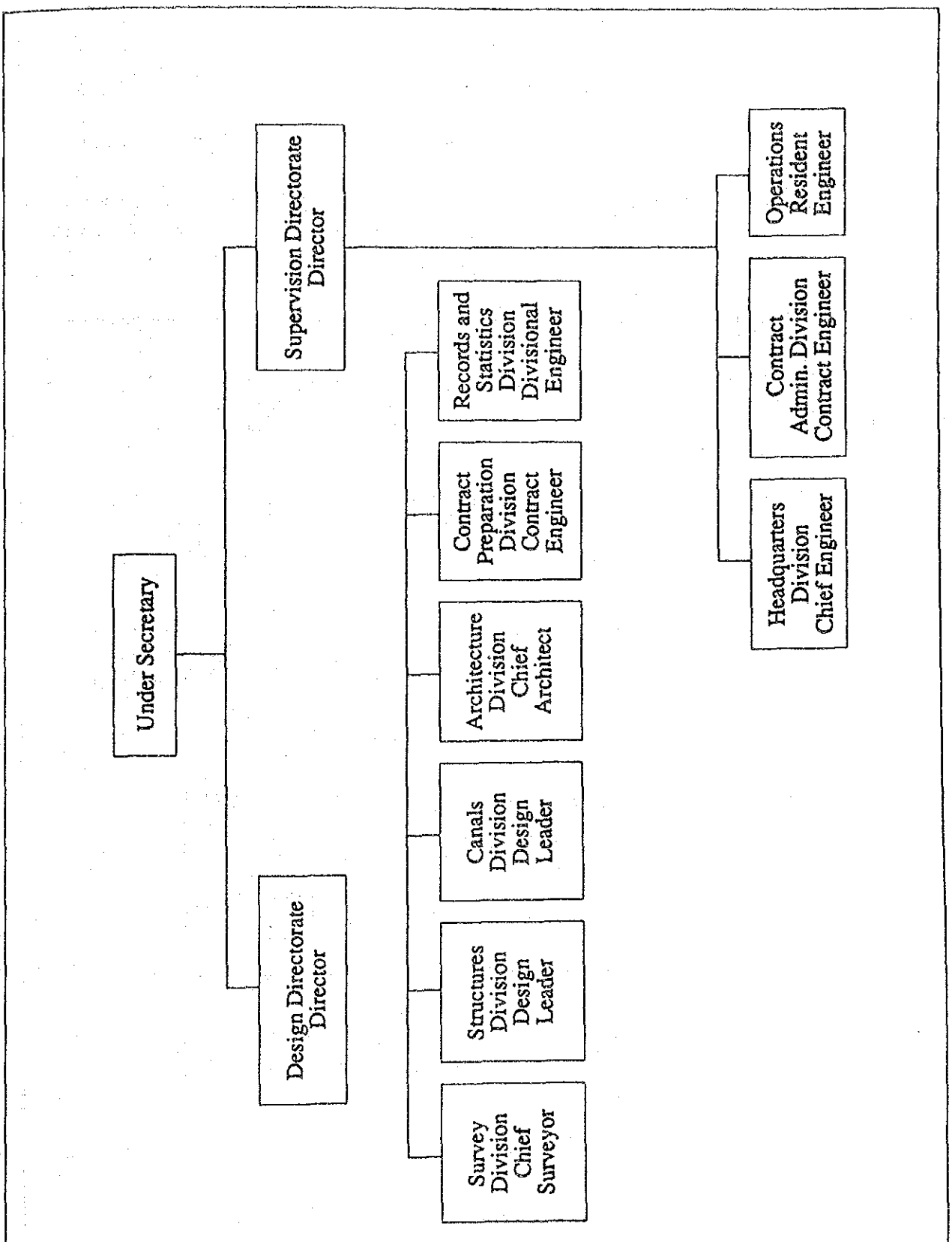


Fig. 3-2 **Organization Structure of Projects Under-Secretariat, MOI**

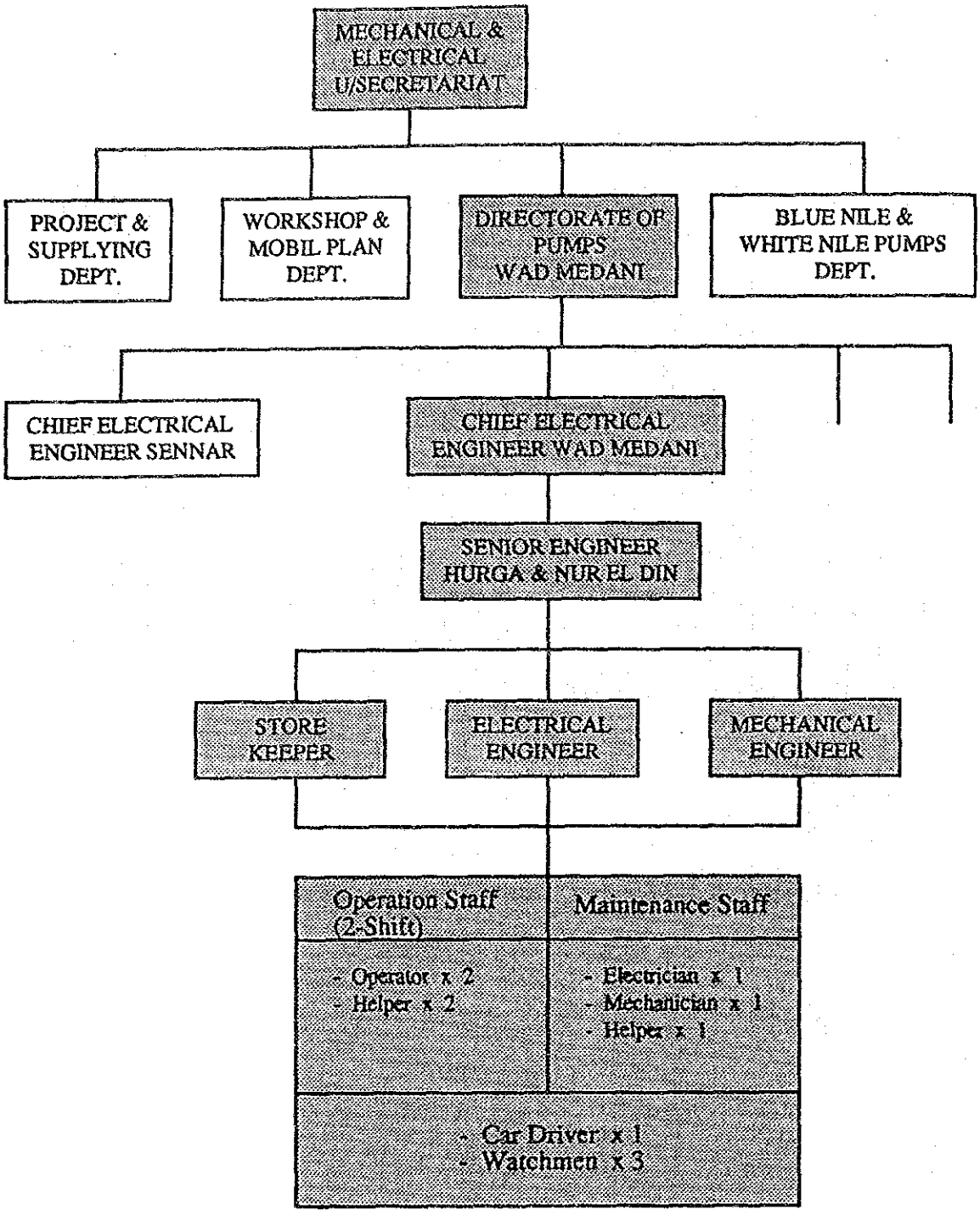


Fig. 3-3 **Organization Structure of Mechanical and Electrical Under-Secretariat, MOI**

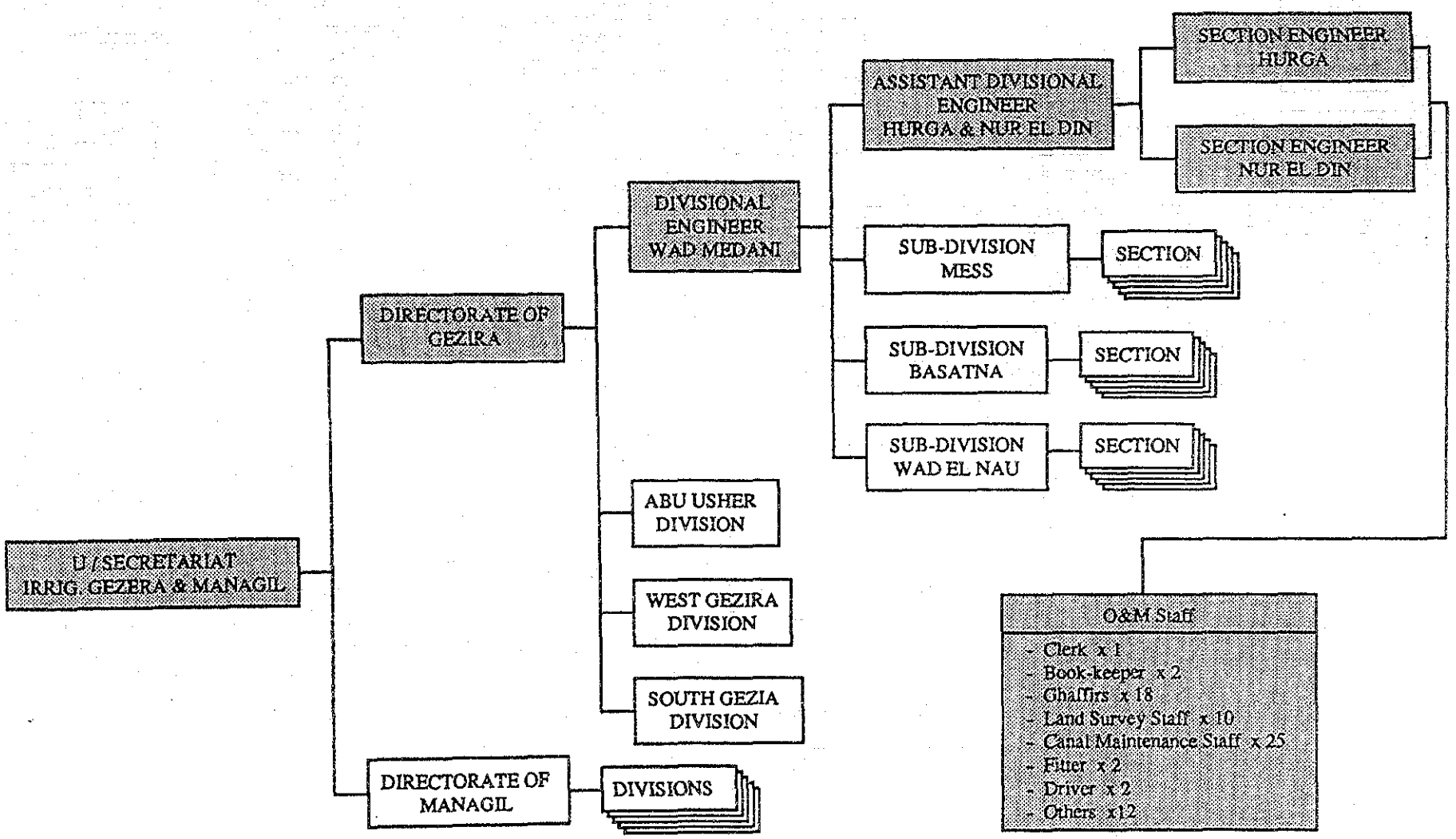


Fig. 3-4 Organization Structure of Irrigation Gezira & Managil Under-Secretariat, MOI

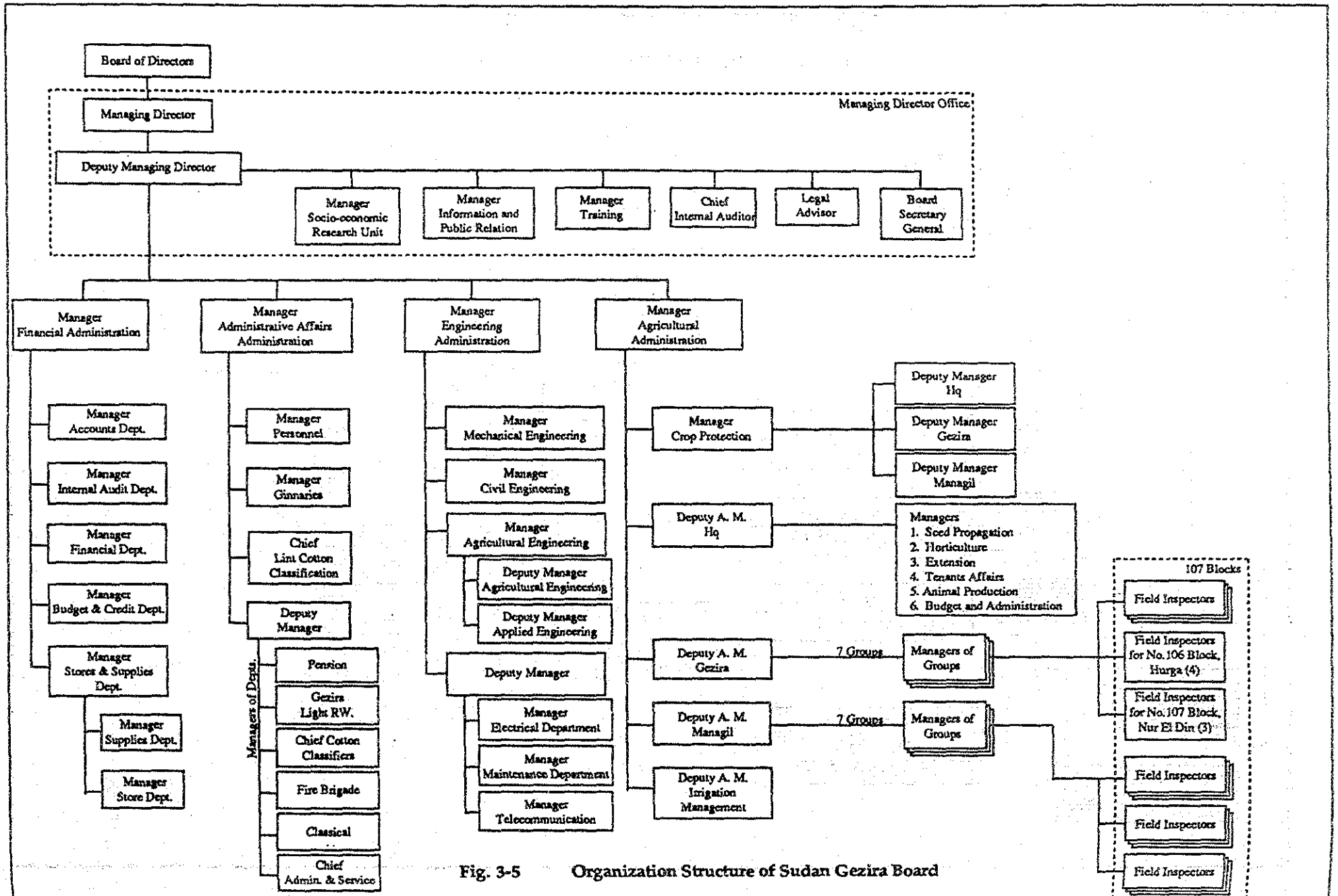


Fig. 3-5 Organization Structure of Sudan Gezira Board

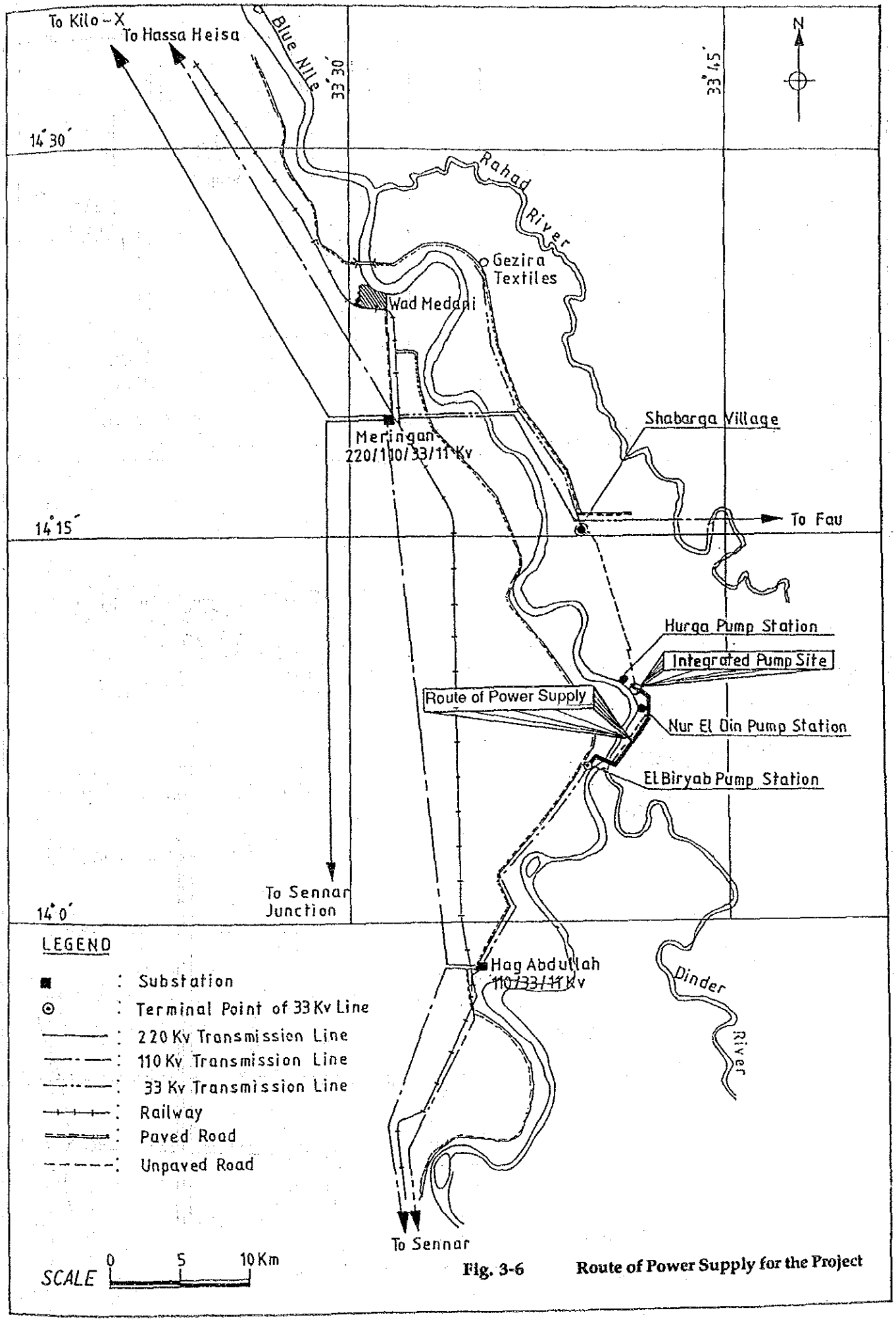


Fig. 3-6 **Route of Power Supply for the Project**

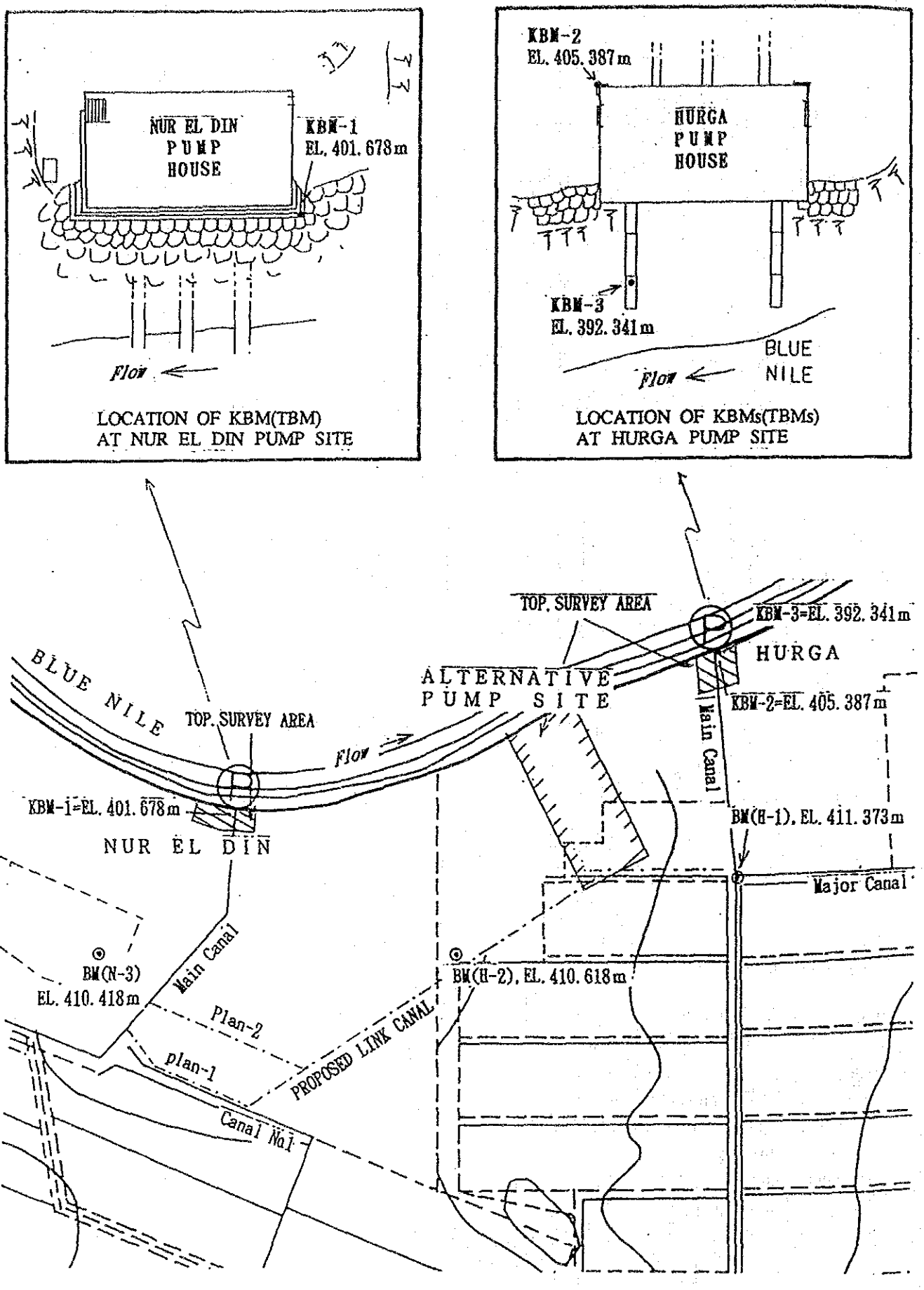


Fig. 4-1 Location Map of Bench Marks

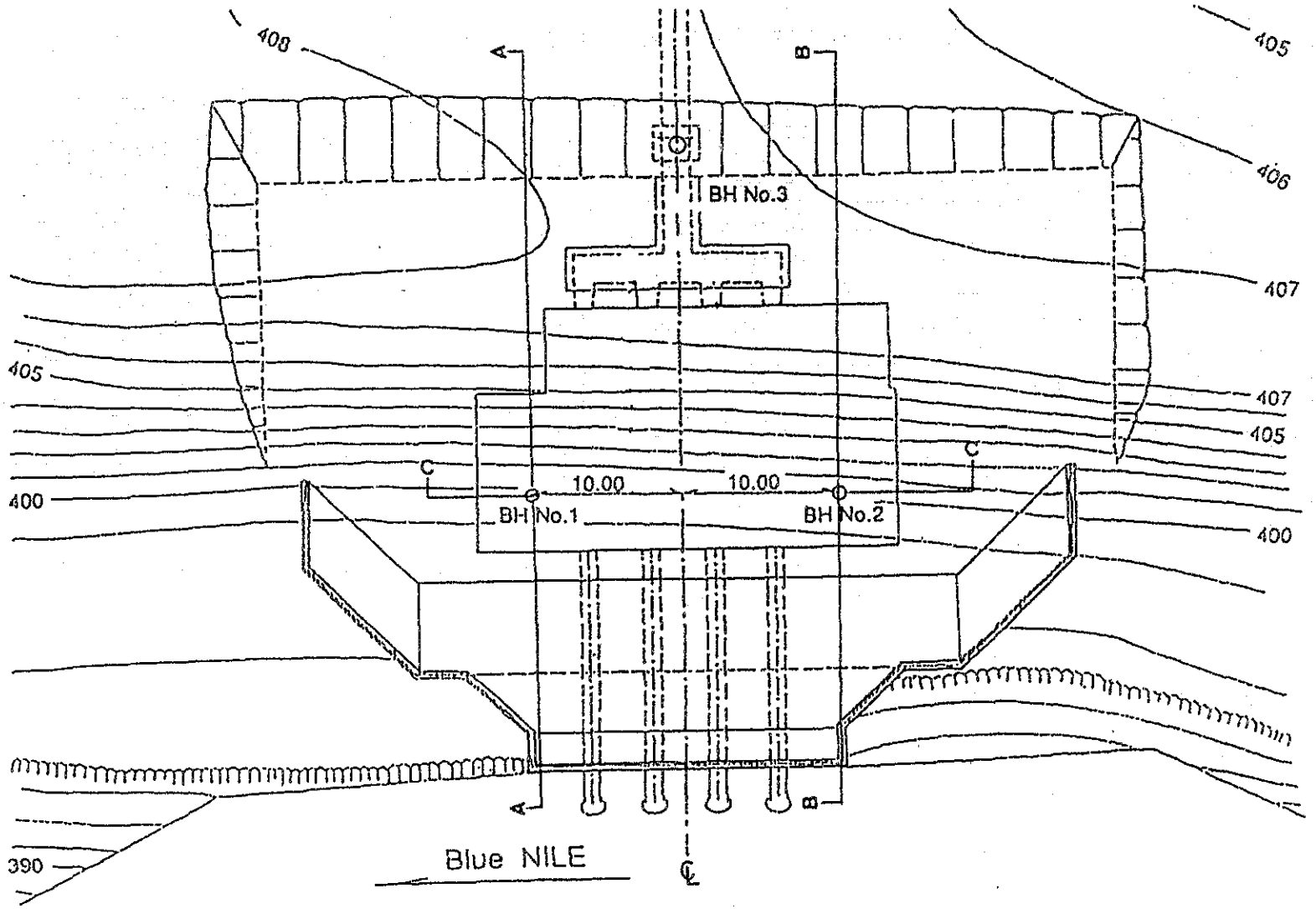


Fig. 4-2 Location Map of Geotechnical Investigation

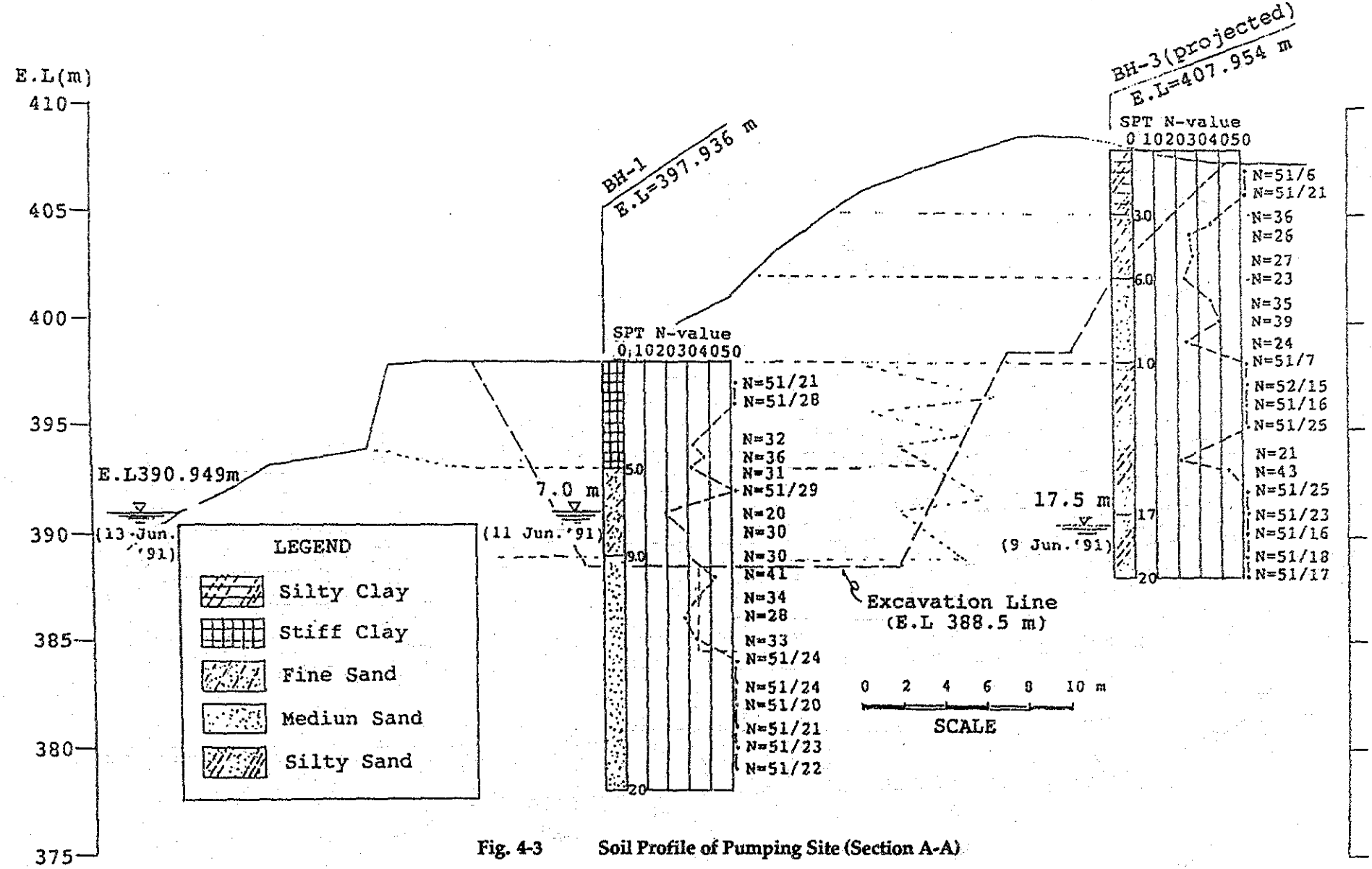


Fig. 4-3 Soil Profile of Pumping Site (Section A-A)

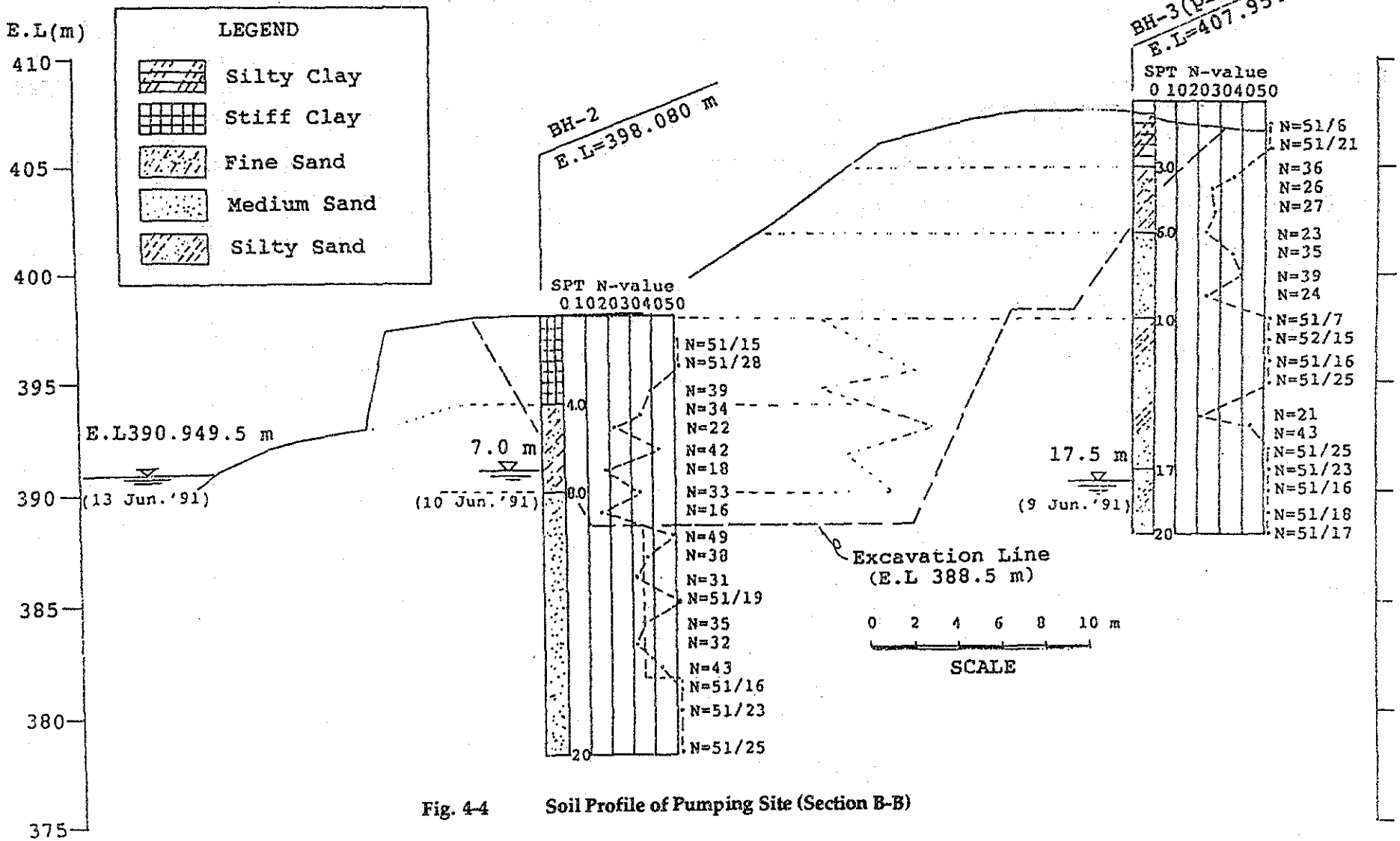


Fig. 4-4 Soil Profile of Pumping Site (Section B-B)

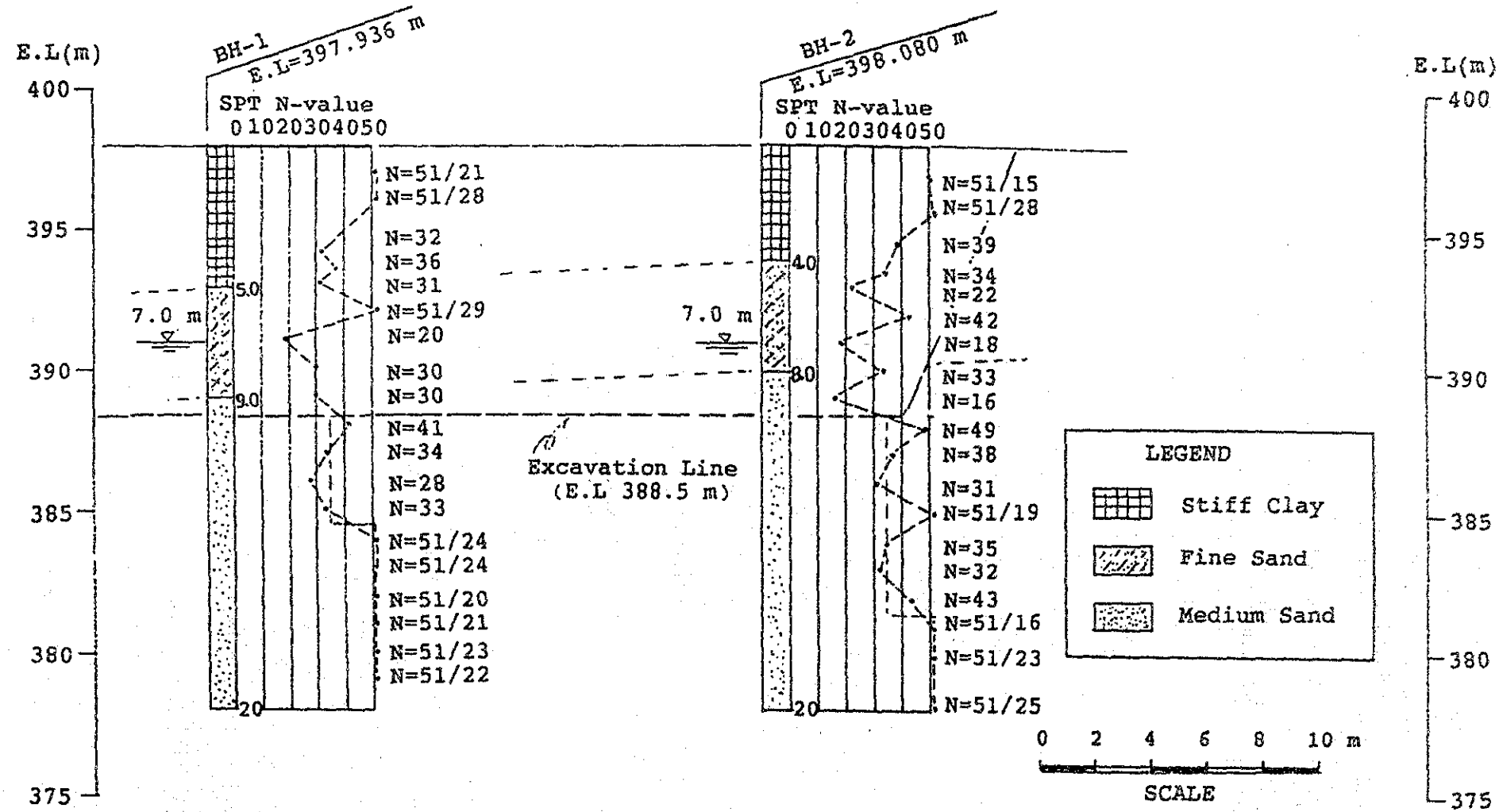


Fig. 4-5 Soil Profile of Pumping Site (Section C-C)

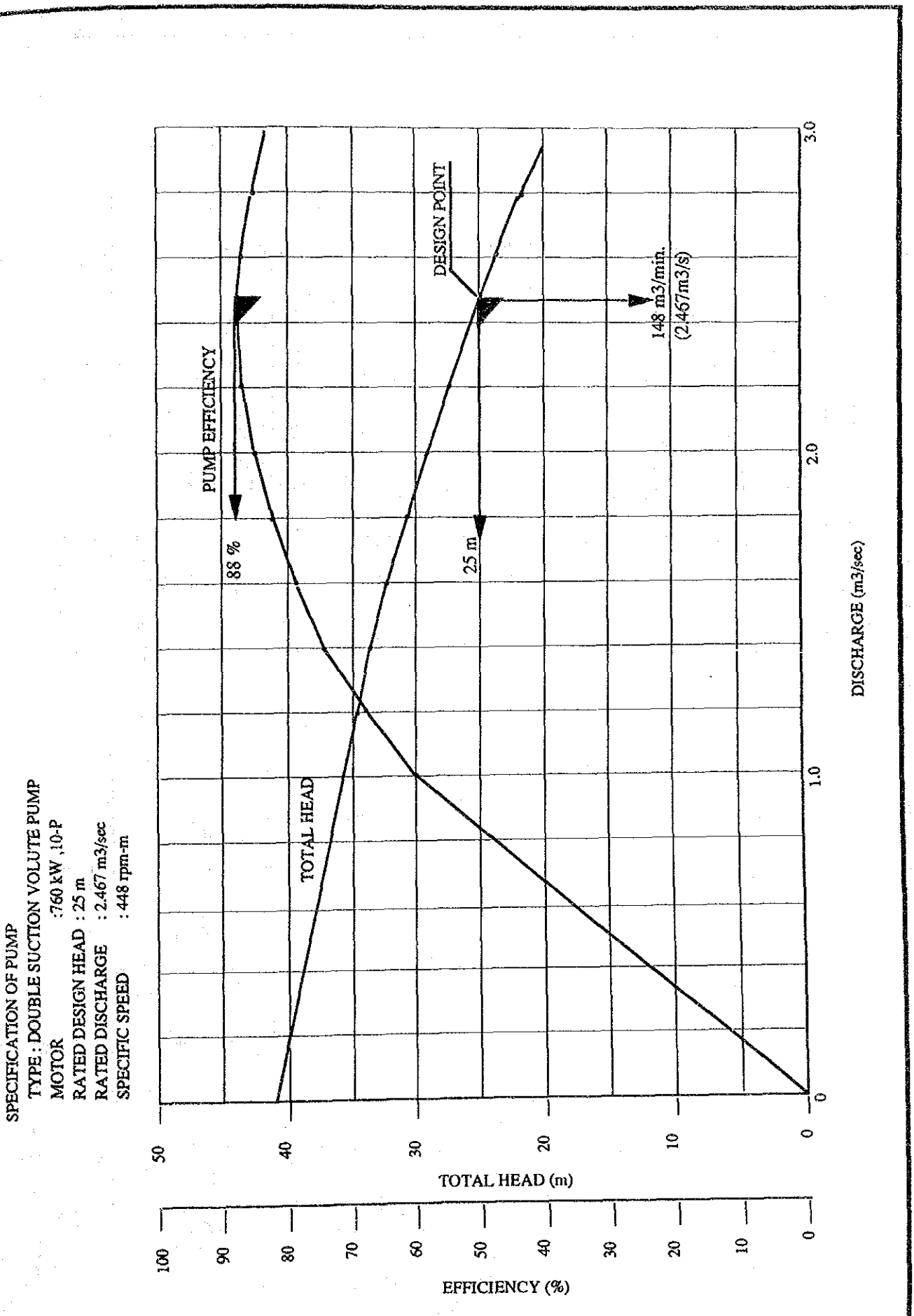


Fig. 4-6 Expected Characteristic Curve of Pumps

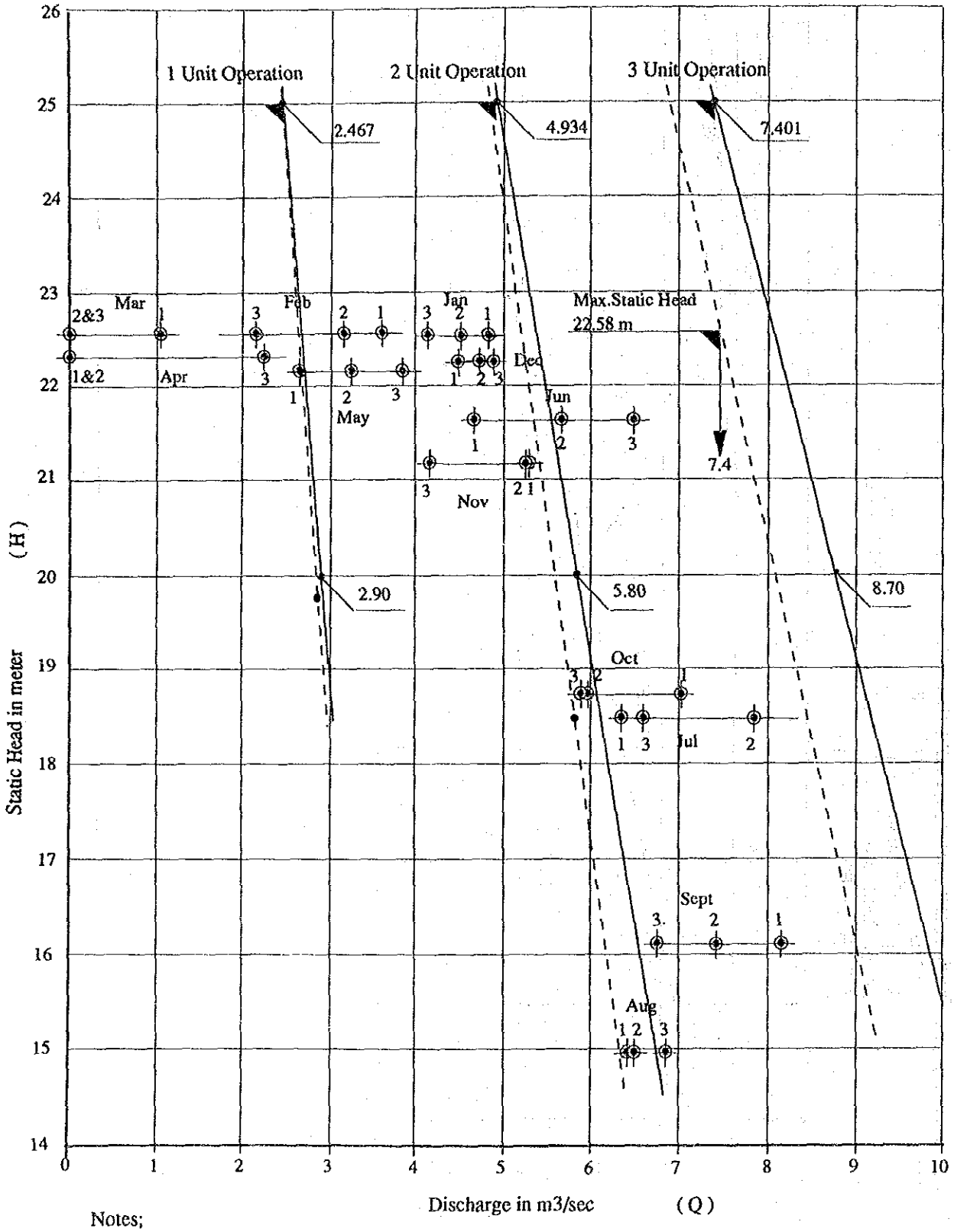


Fig. 4-7 System Curve of Pumps

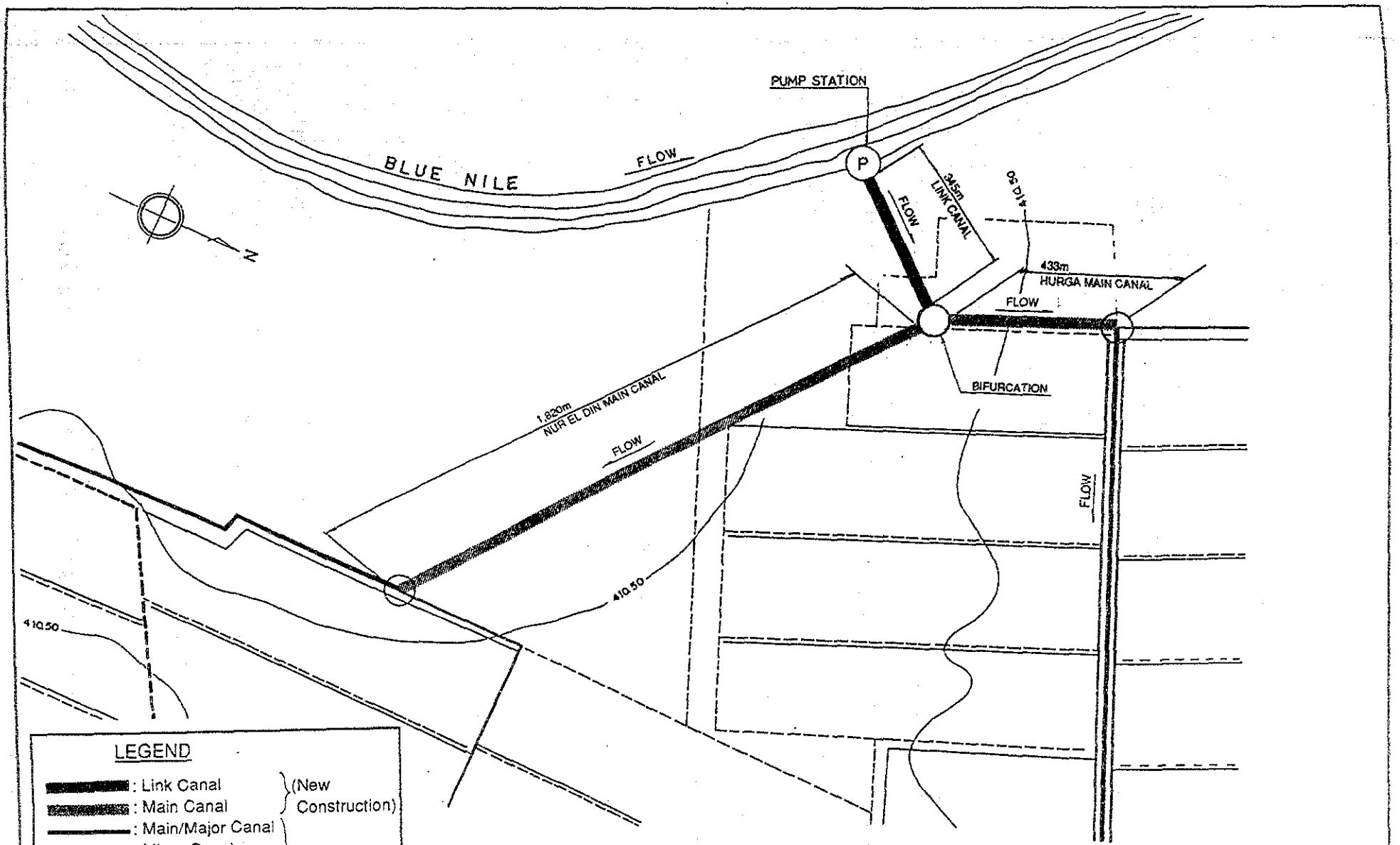
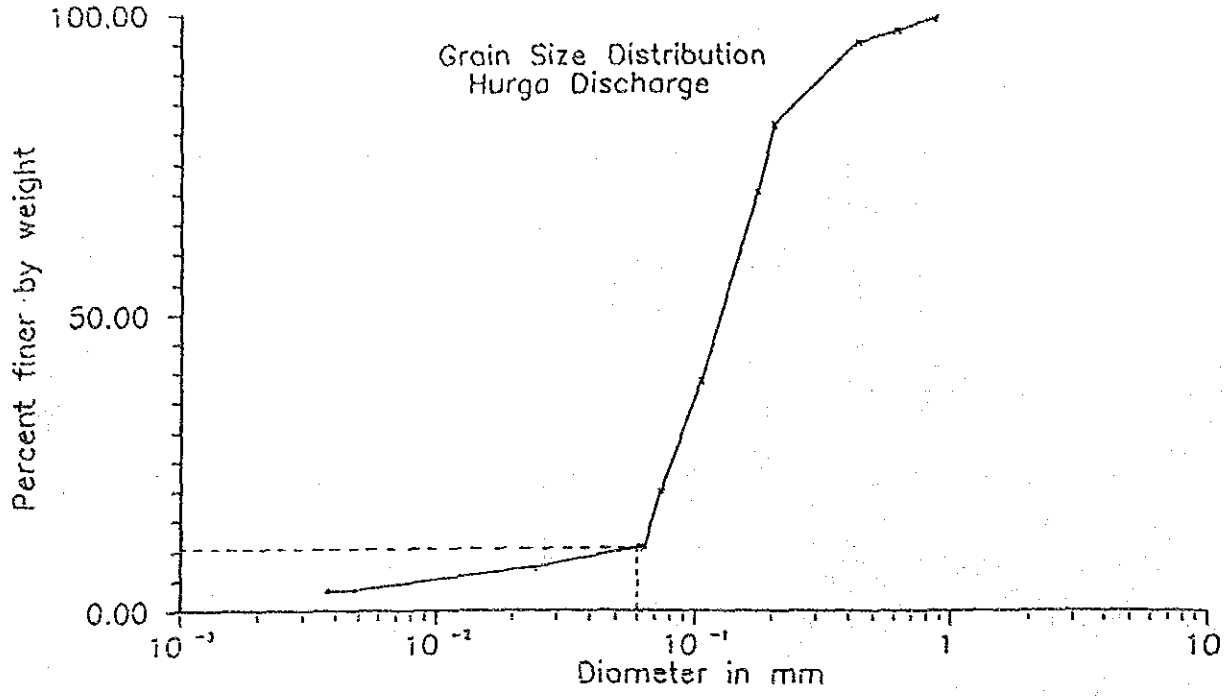


Fig. 4-8 Route Map of Link Canal and New Main Canals



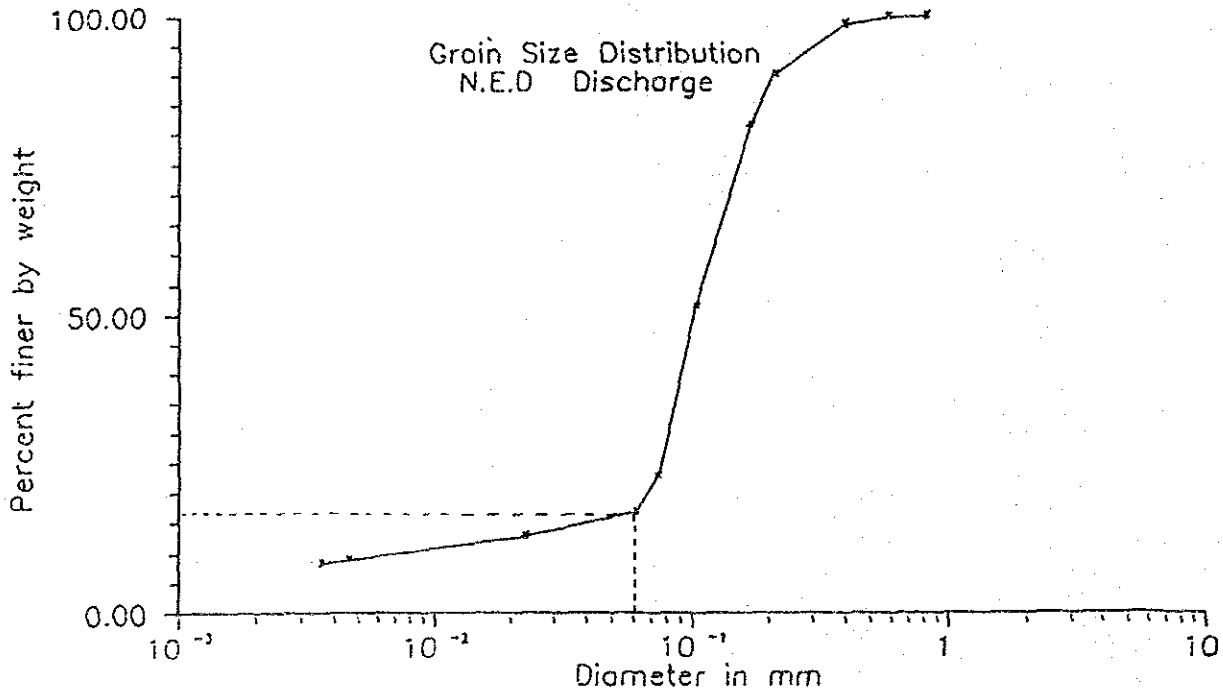


Fig. 4-9 Particle Size Distribution of Suspended Solids

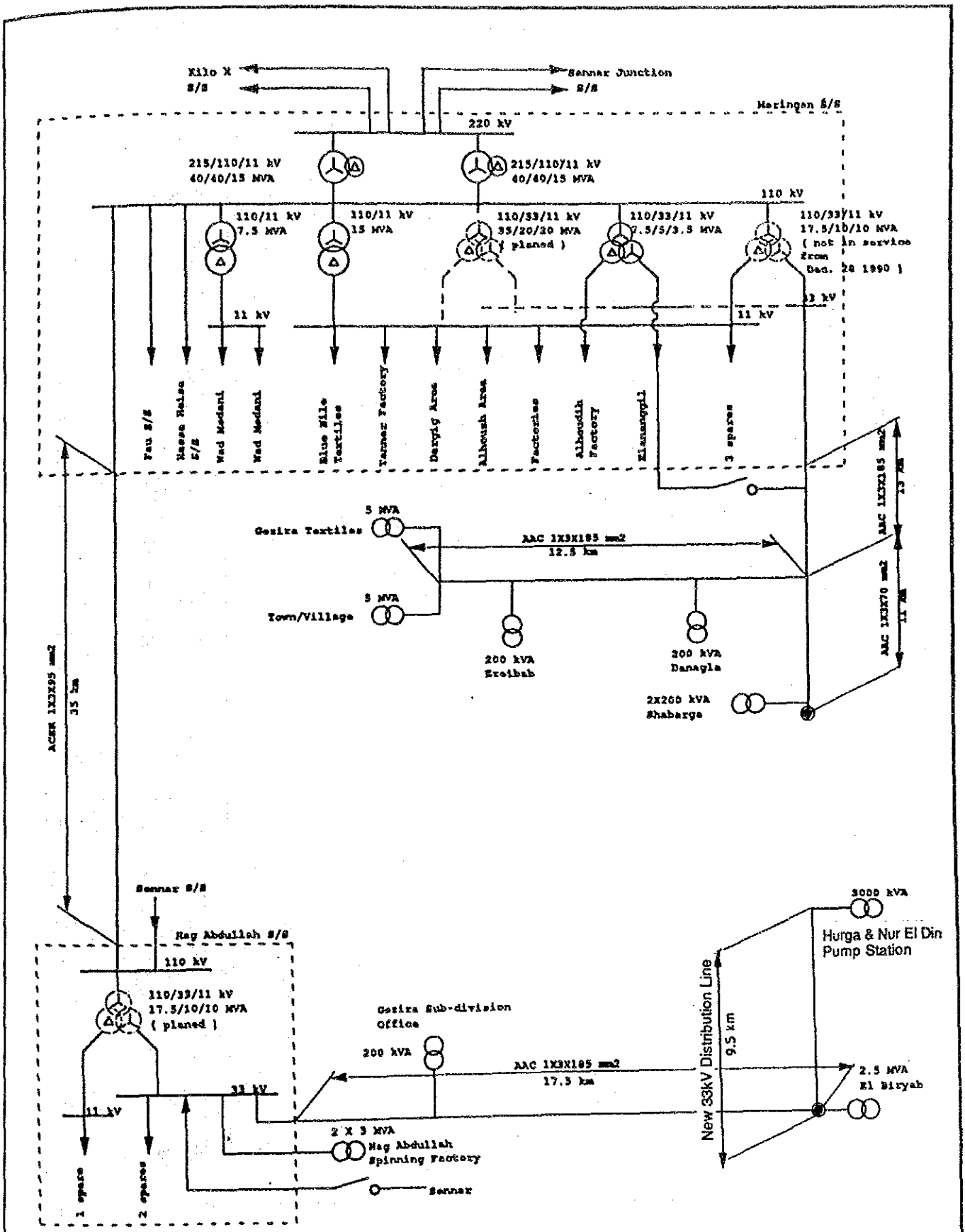


Fig. 4-10 Power Supply Diagram

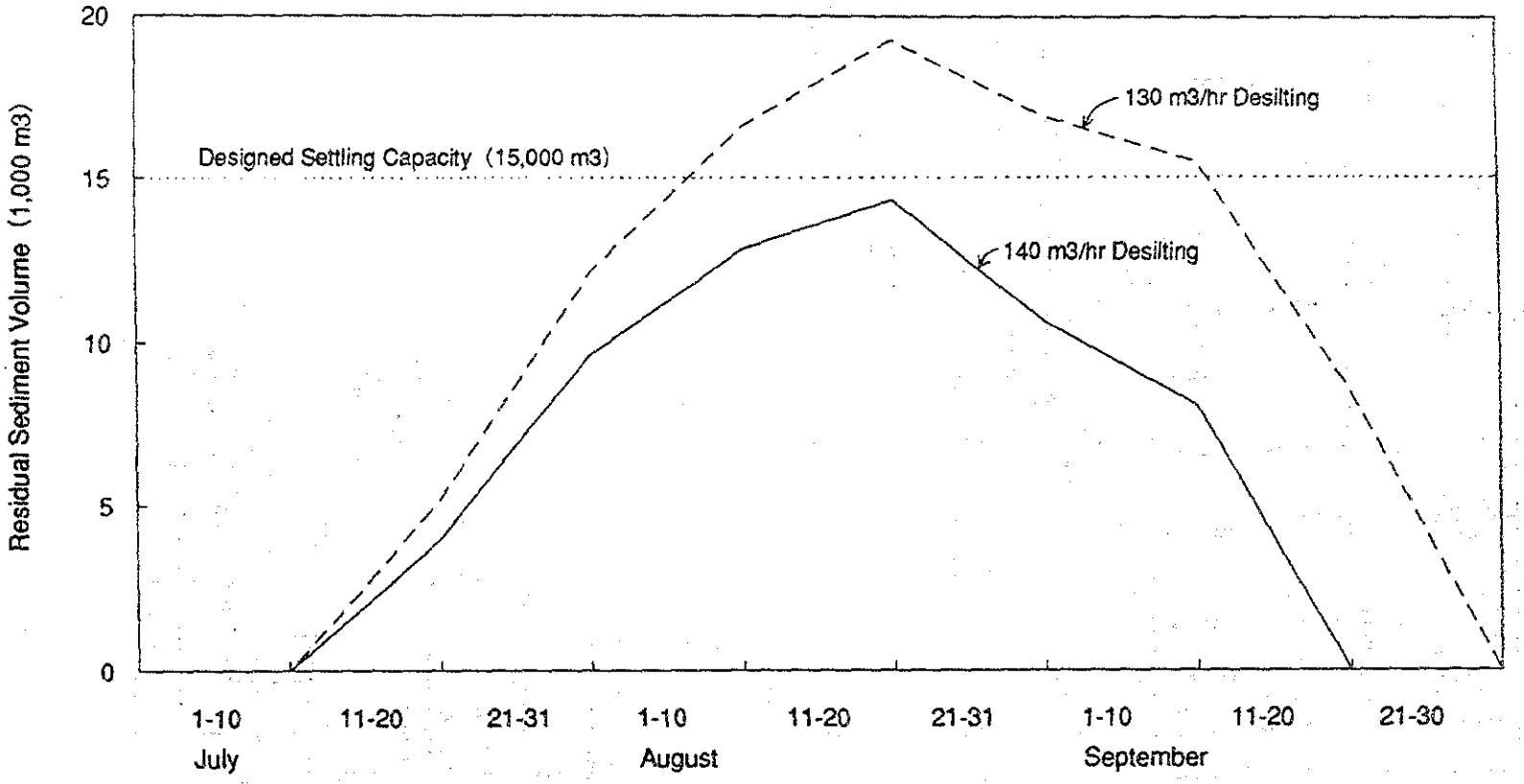
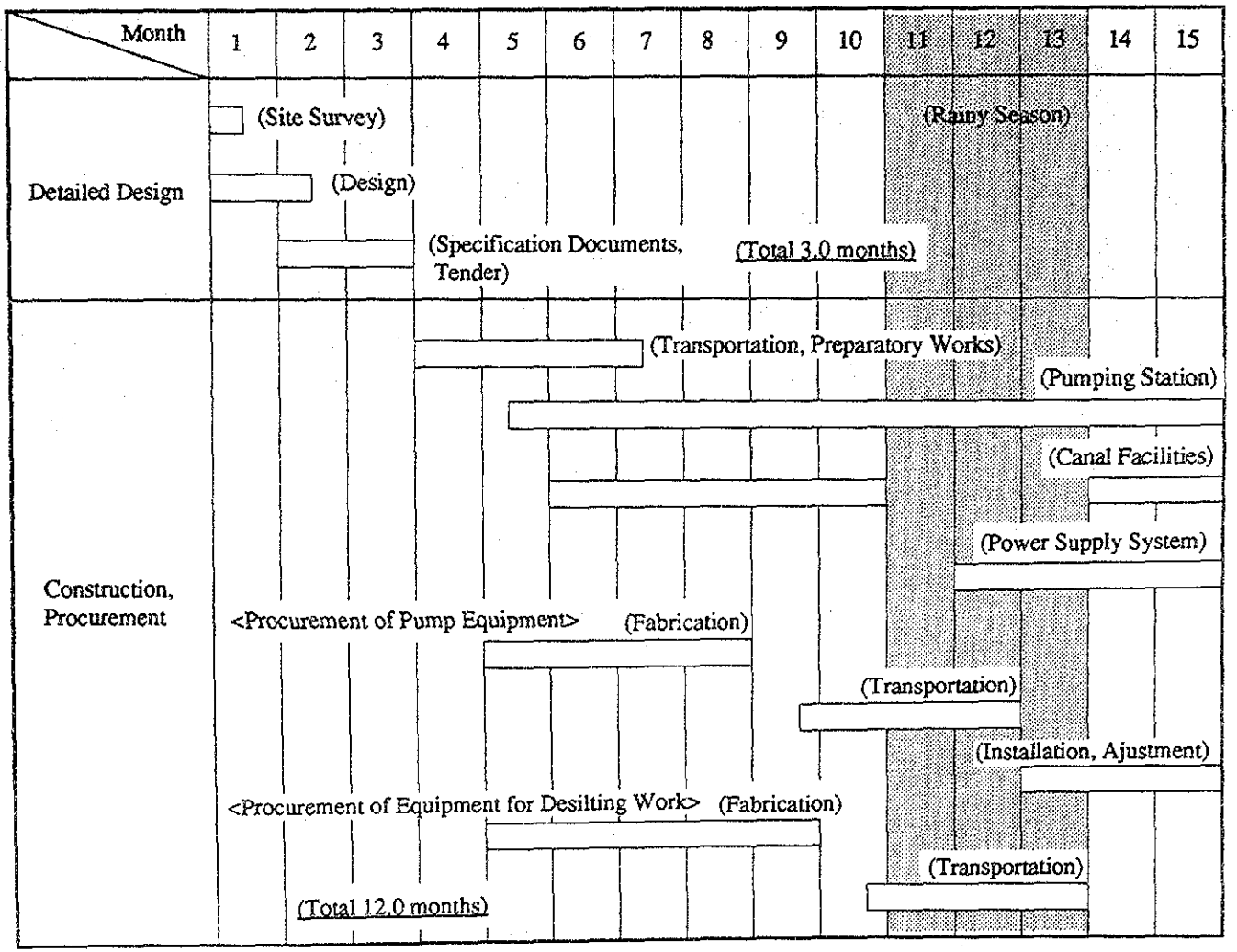


Fig. 4-11 Simulation of Residual Sediment Volume in Sand Settling Basin

Fig. 4-12 Tentative Implementation Schedule of the Project



Appendixes

Member List of Survey Team

Title	Name	Belonging Office
Team Leader	Kenichi Shishido	Grant Aid Study and Design Department, JICA
Irrigation and Drainage	Hiroshi Kobayashi	Hokkaido Development Agency
Plan of Irrigation and Drainage	Seiji Koyanagi	Nippon Koei Co., Ltd.
Plan of Operation and Maintenance	Kozo Yamada	Nippon Koei Co., Ltd.
Civil Engineering Design	Koji Naito	Nippon Koei Co., Ltd.
Equipment Design	Akimitsu Arai	Nippon Koei Co., Ltd.
Architectural Design	Kenichi Hara	Nippon Koei Co., Ltd.
Cost Estimate	Shinichi Hamada	Nippon Koei Co., Ltd.

Survey Schedule

No.	Date		K. Shishido	H. Kobayashi	S. Koyanagi	K. Yamada
1	Oct. 13	Sun	Leaving Tokyo for Paris.			
2	14	Mon	Leaving Paris for Khartoum.			
3	15	Tue	Courtesy call on MOI, MOFEP and EOJ			
4	16	Wed	Meeting and Discussion with MOI (Khartoum). Trip to Wad Medani.			
5	17	Thu	Discussion with MOI (Discussion with First Under-Secretary, Working Meeting)			
6	18	Fri	Inspection to the Project Area and Gezira Area			
7	19	Sat	Discussion with MOI. Draft up Minutes of Discussion.			
8	20	Sun	Trip (Wad Medani to Khartoum)		Survey on Prices.	Scheduling of Survey works.
9	21	Mon	Joint Meeting with MOI/MOFEP		Survey on Prices.	Scheduling of Fabrication of Survey markers.
10	22	Tue	Signing Minutes of Discussion. Report to EOJ.		Request answer to Questionnaire, SGB	
					Trip (Wad Medani to Khartoum)	Instruction of Fablication works.
11	23	Wed	Leving Khartoum for Frankfurt		Background Survey, MOFEP	Survey on O&M matters
					Trip (Khartoum to Wad Medani)	Inspection of irrigation facilities to Gezira Area.
12	24	Thu	Leaving Frankfurt.		Hearing O&M matters, SGB	
					Survey on Prices.	Instruction of Fablication works.
13	25	Fri	Arriving in Tokyo.		Arranging data.	
14	26	Sat			Survey on the Project Area (Tentative pegs)	
15	27	Sun			Survey on Prices and O&M matters	Survey on River crossing point.
16	28	Mon			Survey on Prices and O&M matters	Survey on Canals.
17	29	Tue			Survey on Prices and O&M matters	Placing Concrete Markers.
18	30	Wed			Survey on Prices and O&M matters	Check survey.
19	31	Thu			Visiting similar project (Shasheina and Suki Area)	
20	Nov. 1	Fri			Arranging data.	
21	2	Sat			Visiting similar project (Rahad Area)	
22	3	Sun			Greeting to MOI. Trip (Wad Medani to Khartoum)	
23	4	Mon			Receive Answer to Questionnaire. Greeting to MOI. Reporting to EOJ and JICA Office.	
24	5	Tue			Leaving Khartoum for Paris.	
25	6	Wed			Arriving in Tokyo.	

Member List of Working Group

1.	Eng.Kamal Mohamad Abdu	Deputy First Under-Secretary, MOI
2.	Eng.Ghafar Mahgouub	Under-Secretary for Irrigation Gezira & Managil, MOI
3.	Eng.Ahmed Abdel Bashir	Under-Secretary for Mechanical & Electrical Administaration
4.	Eng.Ahmed Abdel Wahab Ahmed	Under-Secretary for Projects, MOI
5.	Dr.Siddig Hussein Abbo	Director of Planning, MOI
6.	Eng.Abbas Abdalla Ibrahin	Director of Irrigation Gezira, MOI
7.	Eng.Elzein Abdel Rahim Ibrahim	Director of Projects for Design, MOI
8.	Eng.Abdalla Babiker Saad	Director of Projects for Supervision & Follow-up, MOI
9.	Eng.Osman Abuzeid	Director of Electrical Pumps, MOI
10.	Dr.Khalir Abdel Gadir	Divisional Engineer Wad Medani, Irrigation, MOI
11.	Eng.Mohamad Nur El Dayem	Project Division, Projects, MOI
12.	Dr.Hasim Ahmed El Obeid	Manager for Planning & Socio-economic Research Unit,SGB
13.	Eco.Abdel Hadi Mohamad	Project Preparation Unit, MOFEP
14.	Eco.Ismat El Jack Suliman	Agriculture Sector, Planning, MOFEP

MOI ; Ministry of Irrigation
SGB ; Sudan Gezira Board
MOFEP ; Ministry of Finance and Economic Planning

MINUTES OF DISCUSSION
ON THE BASIC DESIGN STUDY
ON THE HURGA AND NUR EL DIN PUMP SCHEME
REHABILITATION PROJECT

In response to the request of the Government of the Republic of Sudan, the Government of Japan decided to conduct a Basic Design study on the Hurga and Nur El Din Pump Scheme Rehabilitation Project (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Sudan a study team, headed by Mr.Kenichi Shishido, Project Officer, Grant Aid Study and Design Department, JICA from October 15 to November 5, 1991.

The team held discussions with the officials concerned of the Government of the Sudan and conducted a field survey at the study area.

In the course of discussions and field survey, both parties have confirmed the main items on the attached sheets. The team will proceed to further works and prepare the Basic Design Study Report.

Khartoum, October 22, 1991

Mr. Kenichi Shishido
Leader,
Basic Design Study Team,
JICA

Dr. Ahmed M. Adam
First Under Secretary,
Ministry of Irrgation and
Water Resources

Dr. M. Kheir Elzubear
First Under Secretary (Planning)
Ministry of Finance and
Economical Planning

ATTACHMENT

1. The Objectives of the Project

The objectives of the Project are to increase food production and to improve living standard of the farmers in the Project area through rehabilitation of exsiting irrigation scheme in Hurga and Nur El Din, and thus contributing to the improvement of self-sufficiency in wheat at a national level.

2. The Project Site

The Project area is shown in ANNEX Ⅰ .

3. Executing Agency

Ministry of Irrigation is responsible for the administration and execution of the Project. The organization chart is shown in ANNEX Ⅱ .

4. Project Components

(1) The Government of Sudan has requested the following components to be coverd under the Japanese Grant Aid out of the plan proposed in the F/S Report prepared by JICA, 1991.

a) Construction of a pumping station

b) Construction of a power supply system

c) Construction of a link canal including a sand settling basin and a bifurcation

d) Construction of new main canals connecting the link canal and existing canals.

(2) The Government of Sudan has explained following components will be implemented in accordance with the plan proposed in the F/S Report by its own side.

e) Rehabilitation of canal sysytem

f) Rehabilitation of drainage canals

g) Construction of operation and maintenance facilities

(3) However final component may differ based on further studies.

5. Other Important Information

The Sudanese side was requested to submit a concrete implementation plan of the Sudanese works by the end of field survey of the team because it was indispensable to justify the Project.

6. Operation and Maintenance Plan

The Government of Sudan has explained a operation and maintenance plan as follows;

(1) Ministry of Irrigation(MOI) will be responsible for operation and maintenance(O&M) of the pumping station and the main canal systems, while Sudan Gezira Board(SGB) will be responsible for O&M of the field canal sysytem;

(2) O&M of the pumping station and the main canal systems will be managed by Mechanical & Electrical Under Secretariat and Irrigation, Gezira and Managil Under Secretariat of MOI, respectively;

(3) Expected organization of those Under-Secretariats are presented in Annex Ⅱ.

7. Grant Aid Programme Explained by the Team

(1) The Government of Sudan has understood the system of Japanese Grant Aid Programme explained by the Team.

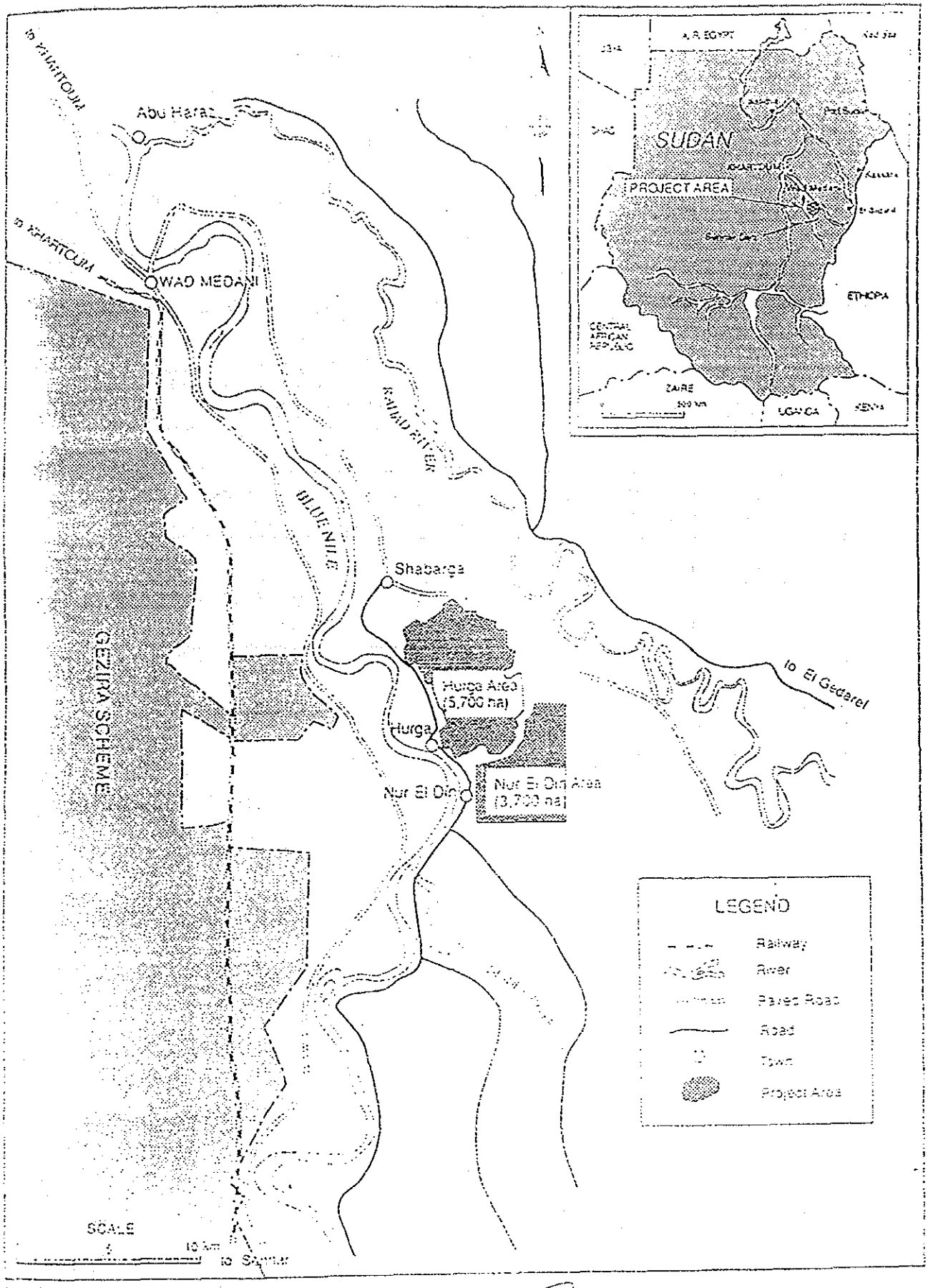
(2) The Government of Sudan will take the neccesary measures described in Annex Ⅲ for smooth implementation of the Project on condition that the Grant Aid Assistance by the Government of Japan is extended to the Project.

8. Schedule of the Study

(1) The Consultants will proceed to further studies in the Sudan until November 5, 1991.

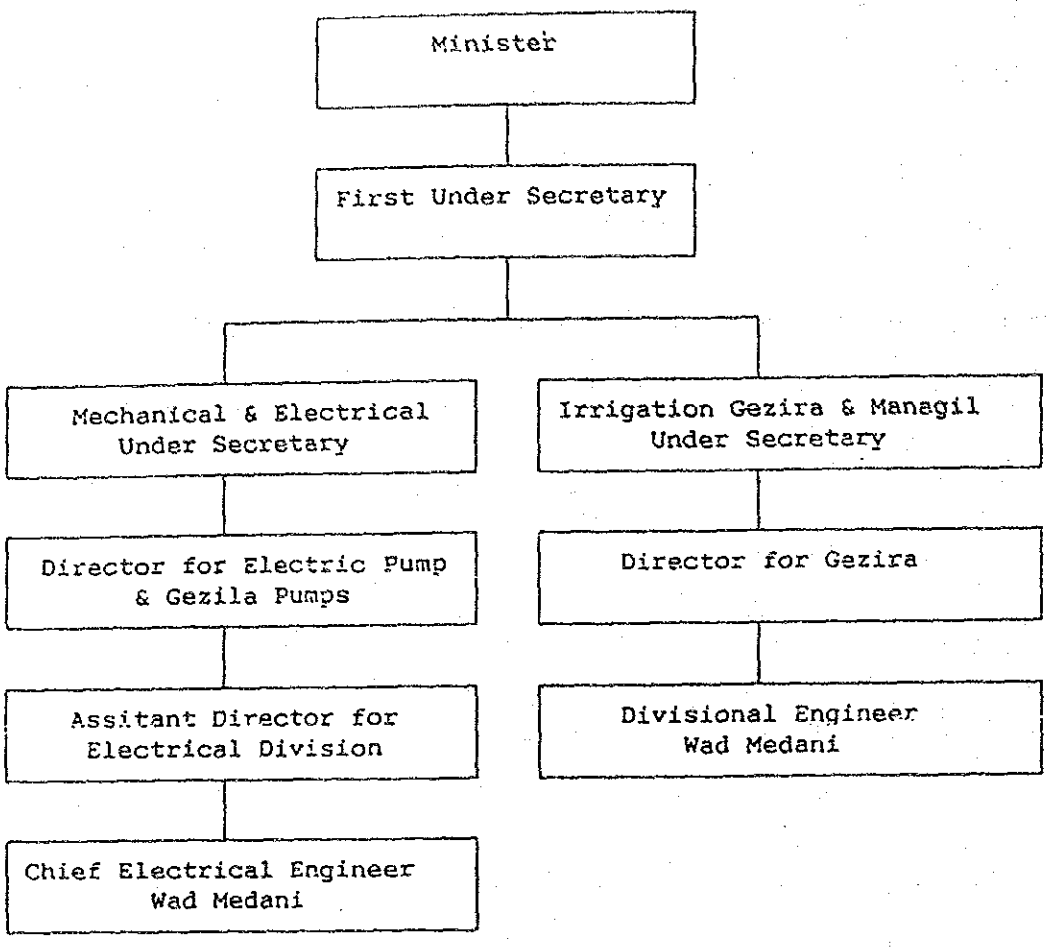
(2) Based on the Minutes of Discussion and technical examination of the study results, JICA will complete the final report on the Project and send it to the Government of Sudan by the end of March, 1992.

ANNEX I : Project Location Map



Annex II : Organization Chart

Ministry of Irrigation & Water Resources



ANNEX III : Necessary measures to be taken by the Government of Sudan

1. To provide data and information necessary for implementation of the Project.

2. To secure the land for the Project and to clear the site as needed before commencement of construction.

3. To ensure prompt unloading, tax exemption, customs clearance of the goods for the Project at the port of disembarkation in Sudan and prompt internal transportation therein of the products purchased under the Grant Aid.

4. To exempt Japanese nationals engaged in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in Sudan with respect to the supply of the products and services under the verified contracts.

5. To accord Japanese nationals whose services may be required in connection with the Project under the verified contracts such facilities as may be necessary for their entry into Sudan and stay therein for the duration of their work stay.

6. To provide necessary permissions, licences and other authorization for carrying out the Project.

7. To bear two kinds of commissions to the Japanese foreign exchange bank for the banking services based on the Banking Arrangement as follows;
(1)Advising commission to the Authorization to Pay
(2)Payment commission

8. To bear all the expenses, other than those to be borne by the Grant Aid.

9. To ensure the necessary budget and personnel for the proper and effective implementation of the Project, including operation and maintenance of the equipment provided under the Grant Aid.