General layout of the irrigation system is illustrated in Fig. 3.4 and list of commanding area for each of canals is shown in Tables 3.6 and 3.7.

3.3.2 Design Conditions

(1) Design Discharge

Design discharge for determining flow capacity of the canals is decided using the following equations:

$$Q = a \times q$$

where; Q ; Design discharge (l/sec)
a ; Commanding area of the canal (feddan)
q ; Unit design discharge (l/sec/feddan)

i) Link canal, Main canal, and Major canal

$$Q = a \times 0.45 \text{ l/sec/feddan } (8.17 \text{ m}^3/\text{s} / (22{,}620 / 5 \times 4)$$

ii) Minor canal

$$Q = (0.45 \times 6 \times 3{,}600 \times a/2) + 0.90 \times a/2 \quad ; \text{ for upper half}$$
$$Q = (0.45 \times 6 \times 3{,}600 \times a) + 0.90 \times a \quad ; \text{ for lower half}$$

iii) Abu XX

$$Q = a \times 1.82 \text{ l/sec/feddan (for Fodder, } 78.9 \text{ m}^3/\text{day/feddan)}$$

3.3.3 Proposed Works

The proposed works for the Project are:

- Construction of one integrated pumping station and power supply system;
- Construction of a link canal;
- Construction of a sand settling pond;
- Construction of a bifurcation;
- Extension and rehabilitation of canal system;
- Replacement and provision of structures related to canals.

(1) Pumping Station

Features of proposed pumping station is presented in ANNEX E; PUMPING STATION AND POWER SUPPLY SYSTEM.

(2) Link Canal and Bifurcation

A link canal would connect the discharge basin of the pumping station and the main canals for the Hurga and Nur El Din areas through a bifurcation. The link canal, with a discharge capacity of 8.0 m^3/sec, is of earth canal with a trapezoidal flow sections and a total length of 450 m including a sand settling basin located at the lower end. Hydraulic elements of the canal is summarized in Table 3.8.

The sand settling is tentatively designed to be 130 m long and 50 m wide, but the size of the basin is subject to change because the proposed site for the basin is expected to be utilized as borrow area for embankment materials.

Plan of the link canal is shown in Figs. 3.5 and 3.6. Longitudinal profile and typical cross section of the link canal is illustrated in Figs. 3.7 and 3.8, respectively.

The bifurcation would be provided at the end of the link canal. It has two flow sections consisting of a fixed type weir with a sluice gate each for the Hurga and Nur El Din main canals, design discharge capacity of which are 4.9 m^3/sec and 3.1 m^3/sec, respectively. The crest of the weirs are designed to keep perfect overflow regardless discharges to be diverted. General layout of the bifurcation is shown in Fig. 3.9.

(3) Canal System for Hurga and Nur El Din Areas

The proposed main canals are of earth canals with trapezoidal cross sections. The main canal for the Hurga, having a design discharge of 4.9 m^3/sec at its head, is 5.82 km long, of which 0.49 km is new canal and the rest is rehabilitation canal. The main canal for the Nur El Din, with a design capacity of 3.1 m^3/sec at its head, is 11.32 km in total length, of which first 1.86 km is a new construction canal while the remaining 9.46 km are of rehabilitation ones. As shown in Fig. 3.5, uppermost reaches of the main canals for the Hurga and Nur El Din areas would be newly constructed to connect the link canal with the respective existing main canals. All of the rehabilitation portion is in need of heightening canal base by about 1.5 m at maximum.

Heightening of the existing major canal in the Hurga area is proposed for whole the reach of 5.6 km. Its design capacity is 2.3 m^3/sec at its head.

Out of 12 minor canals with a total length of 52.4 km for the Hurga area, one Gannabia of 4.4 km long and one minor canal of 6.0 km are new canals, while the others are of rehabilitation canals with need of heightening. Five minor canals with a total length of 27.1 km are proposed for the Nur El Din area. All of these canals also are in need of heightening. All the minor canals have storage function as discussed in previous Section 3.4.1 "Irrigation System" by giving additional water depths, which vary ranging from 0.35 m to 0.80 m in accordance with required storage capacity.

Hydraulic elements of the proposed canals are shown in Table 3.8. Longitudinal profile of the main and major canals are shown in Figs. 3.10 to 3.12.

The following structures would be provided at strategic points of the canals:

Type of Structure	Hurga (Nos.)	Nur El Din (Nos.)
Movable weir	13	5
Well head regulator	4	2
Cross regulator (Pipe regulator)	14	2
Field Outlet Pipe	221	114

Breakdown of the above is tabulated in Table 3.9.

The movable weir is a head regulator installed at the head of major and minor canals. It consists of a steel made broad crest mounted on the top of slide gate and fixed gate at lower side with brick masonry retaining wall. General layout of this type of structure is shown in Fig. 3.13.

Well-head regulator would be provided at the head of double Abu XX. General layout of this regulator is shown in Fig.3.14.

The pipe regulator would be provided in the main, major and minor canals as a cross regulator. Field outlet pipe (FOP) would be installed at the head of Abu XX. It consists of steel slide gate with spindle hoist and steel pipe of 35 cm in diameter. General layout of the cross regulator and FOP are shown in Figs. 3.15 and 3.16.

3.4 Drainage

3.4.1 The Drainage System

Because of the nature of the soil and absence of a high water table, no subsurface drainage system is proposed. A surface drainage system is proposed to remove surface runoff by rainfall or excess irrigation water. Surface runoff from the fields is led to a minor drain, from which it flows into collector drains. The collector drains would be connected to natural drainage paths.

3.4.2 Drainage Requirement

Design discharges for the drainage canals and related structures for the Project are estimated using the following formula which is presently employed by MOI;

$$Q = \frac{150 \times a^{2/3}}{(24 \times 3{,}600)}$$

where; Q ; Design discharge (m^3/sec)
a ; Catchment area (feddans)
150 ; Runoff factor

3.4.3 Proposed Works

Proposed drainage system is shown in Fig. 3.4. Drainage canal system consists of 4 collector drains with a total length of 23.4 km and 15 minor drains having a total length of 51.4 km. Surface runoff caused by precipitation or excess water of irrigation in the "Number" would be led to minor drain through field drainage canals, and then it would be conveyed to collector drain by the minor drains and to further natural drainage. The canal is of earth canal with a trapezoidal cross sections. At the junction point of the drainage canals, riprap protection would be provided to prevent scouring of the canals. Length and hydraulic parameters of each drainage canal are summarized in Table 3.10. Protection work at the junction point is shown in Fig. 3.17.

3.5 Operation and Maintenance

3.5.1 Operation

(1) Water Indenting

Water indenting would be informed to the Chief Engineer for the new pumping station by the Assistant Divisional Engineer for the Hurga and Nur El Din every 10 days. Quantity of the indent would be computed based on the consumptive use of water by crop taking into account actual cultivated area, type of the crop and growth stage.

(2) Pump Operation

In response to indenting by the Assistant Divisional Engineer, operating hours and operating unit numbers of pumps would be decided by the Chief Engineer, and the pumps would be run accordingly. At peak water demand, three units of pumps would be operated for 18 hours from 0:00 to 18:00. It is recommendable that pump operation started at fixed time (0:00) and time of terminating operation be changed in accordance with the water demand to minimize effect of time lag traveling water.

(3) Gate Control

Gate control of the bifurcation structure, movable weirs and well-head regulators would be made in timing with pump operation. It is, therefore, magnitude of the opening of those gates could theoretically be changed once a 10-day. Needless to say, minor adjustment of those gate opening should be made from time to time. Whilst the gate for FOP would be opened at 6:00 in the morning and closed at 18:00 in the evening every day.

3.5.2 Maintenance

Maintenance works necessary of the Project are those for the pumping station and canals. The canal maintenance works will be discussed in this section, while those for the pumping station will be incorporated in "ANNEX E : PUMPING STATION AND POWER SUPPLY

SYSTEM". The canal maintenance works would consist of; i) removal of silt and sand from the sand settling basin and from the canal sections, ii) weed clearance from the canal sections, iii) maintenance works of operation and maintenance roads, and iv) maintenance of metal works.

3.5.3 Field Organization for Operation and Maintenance

It is proposed that present joint management system by MOI and SGB stated in Chapter I is retained.

Operation and maintenance (O&M) of the new pumping station is proposed to be made under supervision of a Chief Electrical Engineer at Wad Medani instead of the Chief Mechanical Engineer who is in charge of O&M of the existing Hurga and Nur El Din pumping stations. In addition to one Mechanical Engineer presently assigned, one Chief Engineer and one Electrical Engineer is proposed to be assigned for O&M of pumps and electrical equipment and facilities. The proposed organization structure for O&M of the pumping station is shown in Fig. 3.18.

For O&M of the canal systems between the head of the link canal and major canal and maintenance of the minor canals, one Assistant Divisional Engineer is presently assigned under Divisional Engineer of Wad Medani. At least two members of field staff (Section Engineer) for the Assistant Divisional Engineer are recommended to; i) control magnitude of opening of the bifurcation, movable weirs, and well-head regulators on the main and the major canals, ii) record discharges at those structures, iii) conduct regular inspection of those facilities, etc. The proposed organization structure for O&M of the canal system is shown in Fig. 3.19.

Present two acting Block inspectors are proposed to be substituted by new exclusive Block inspectors for the Project area. Three field inspectors for the Hurga area and two for the Nur El Din area are expected to be assigned. To control 335 numbers of FOP gates consisting of 221 FOPs for the Hurga area and 114 FOPs for the Nur El Din area, 11 and 7 water Ghaffirs are proposed.

Silt clearance as well as weed clearance would be executed by Earth Moving Corporation under supervision of the Divisional Engineer Wad Medani, Under-secretariat for Irrigation Service for Gezira and Managil.

TABLES

Table 1.1 EXISTING CANAL SYSTEM

1) Hurga Scheme

Name of Canal	Length of Canal (km)	Location of Canal Head	Command Area (fd)
Main Canal	6.17	Pumping Station	13,903
Major Canal	5.62	Km 0.88 of Main Canal	6,668
Gannabia No.1	2.83	Major Canal	685
Gannabia No.2	4.70	Km 0.88 of Main Canal	1,170
Gannabia No.3	2.10	Km 0.88 of Main Canal	441
Canal No.1	1.51	Km 2.49 of Major Canal	640
Canal No.2	7.20	Tail of Major Canal	1,240
Canal No.2(P)*	6.0	Tail of Major Canal	985
Canal No.3	4.13	Tail of Major Canal	1,970
Canal No.4	4.26	Km 2.91 of Main Canal	770
Canal No.5	5.60	Tail of Main Canal	1,293
Canal No.6	6.16	Tail of Main Canal	2,835
Canal No.7	3.52	Tail of Main Canal	315
D/Abu XX-3.1	1.43	Tail of Canal No.3	450
D/Abu XX-3.2	0.59	Tail of Canal No.3	170
D/Abu XX-6.1	1.11	Km 1.73 of Canal No.6	255
D/Abu XX-6.2	0.65	Km 2.49 of Canal No.6	415

* Never constructed yet

2) Nur El Din Scheme

Name of Canal	Length of Canal (km)	Location of Canal Head	Command Area (fd)
Main Canal	8.18	Pumping Sration	9,719
Canal No.1	1.96	Km 0.95 of Main Canal	608
Canal No.2	5.94	Km 4.91 of Main Canal	1,827
Canal No.3	6.70	Tail of Main Canal	3,753
Canal No.4	6.50	Km 2.88 of Canal No.3	2,385
Canal No.5	2.58	Tail of Main Canal	1,407
D/Abu XX No.1	1.04	Km 1.73 of Canal No.2	270
D/Abu XX No.2	0.89	Km 2.62 of Canal No.5	360

Table 1.2 (1/4) NET COMMAND AREA OF THE EXISTING CANALS
(Hurga Scheme)

1) Hurga Scheme(1/4)

Unit of Area	Command Area(fd)	Main Canal	Command Area(fd)	Unit of Area
		(13,903.0)		
Number	36.0			
Gann. No.3	441.0		6,668.0	Major Canal
			65.0	Number
			1,170.0	Gann. No.2
Canal No.4	770.0			
Number	65.0			
			1,293.0	Canal No.5
			2,835.0	Canal No.6
			315.0	Canal No.7
Number	50.0			
Number	55.0			
Number	50.0			
Number	45.0			
Number	45.0			

Unit of Area	Command Area(fd)	Major Canal	Command Area(fd)	Unit of Area
		(6,668.0)		
			Number	45.0
			Number	45.0
			Number	45.0
			Number	30.0
			Number	10.0
Number	52.0		Number	56.0
Number	50.0			
Number	10.0		Number	40.0
Canal No.1	640.0		Number	65.0
Number	125.0		Number	55.0
Gann. No.1	685.0		Number	50.0
			Number	25.0
			Number	35.0
Canal No.3	1,970.0		Canal No.2(P)	985.0
Number	120.0		Number	105.0
Number	95.0		Number	90.0
Canal No.2	1,240.0			

Unit of Area	Command Area(fd)	Gannabia No.3	Command Area(fd)	Unit of Area
		(441.0)		
Number	45.0			
Number	87.0			
Number	87.0			
Number	87.0			
Number	40.0			
Number	35.0			
Number	40.0			
Number	20.0			

Unit of Area	Command Area(fd)	Gannabia No.1	Command Area(fd)	Unit of Area
		(685.0)		
Number	105.0			
Number	85.0			
Number	85.0			
Number	85.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			

Table 1.2 (2/4) NET COMMAND AREA OF THE EXISTING CANALS (Hurga Scheme)

1) Hurga Scheme(2/4)

Unit of Area	Command Area(fd)	Canal No.4	Command Area(fd)	Unit of Area
		(770.0)		
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			45.0	Number
			20.0	Number
		(445.0)		
Number	55.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			

Unit of Area	Command Area(fd)	Canal No.1	Command Area(fd)	Unit of Area
		(640.0)		
Number	80.0			
Number	75.0			
Number	75.0			
Number	75.0			
Number	55.0			
Number	30.0			
Number	10.0			
Number	90.0			
Number	90.0			
Number	60.0			

Unit of Area	Command Area(fd)	Gannabia No.2	Command Area(fd)	Unit of Area
		(1,170.0)		
	Table 2.8.2 (2/4) N		65.0	Number
			65.0	Number
			80.0	Number
			75.0	Number
			20.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			85.0	Number
			80.0	Number
			25.0	Number
			10.0	Number

Unit of Area	Command Area(fd)	Canal No.2(P)	Command Area(fd)	Unit of Area
		(985.0)		
Number	20.0			
Number	20.0			
Number	25.0			
Number	50.0			
Number	75.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	70.0			
Number	55.0			
Number	40.0			

Table 1.2 (3/4) NET COMMAND AREA OF THE EXISTING CANALS
(Hurga Scheme)

1) Hurga Scheme(3/4)

Unit of Area	Command Area(fd)	Canal No.5	Command Area(fd)	Unit of Area
		(1,293.0)		
			17.0	Number
			22.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			67.0	Number
			67.0	Number
			15.0	Number
			25.0	Number
			40.0	Number
			60.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			60.0	Number
		(520.0)		
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			45.0	Number
			20.0	Number

Unit of Area	Command Area(fd)	Canal No.2	Command Area(fd)	Unit of Area
			(1,240.0)	
Number	75.0			
Number	55.0			
Number	20.0			
Number	60.0			
Number	75.0			
Number	85.0			
Number	100.0			
Number	15.0			
Number	50.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	95.0			
Number	90.0			
Number	85.0			
Number	85.0			
Number	85.0			
Number	45.0			
Number	25.0			

Table 1.2 (4/4) NET COMMAND AREA OF THE EXISTING CANALS
(Hurga Scheme)

1) Hurga Scheme(4/4)

Unit of Area	Command Area(fd)	Canal No.6	Command Area(fd)	Unit of Area
	(2,835.0)			
Number	55.0			
Number	60.0			
Number	65.0			
Number	70.0			
Number	75.0			
Number	90.0			
Number	95.0			
D/Abu XX -6.1	255.0			
Number	60.0			
Number	75.0			
Number	75.0			
Number	75.0			
D/Abu XX -6.2	415.0			
	(1,370.0)			
Number	65.0		135.0	Number
Number	70.0		135.0	Number
Number	80.0		135.0	Number
Number	80.0		90.0	Number
Number	70.0		90.0	Number
Number	60.0		90.0	Number
Number	25.0		90.0	Number
Number	20.0		65.0	Number
Number	15.0		55.0	Number

Unit of Area	Command Area(fd)	D/Abu XX -6.1	Command Area(fd)	Unit of Area
	(255.0)			
Number	95.0			
Number	80.0			
Number	55.0			
Number	25.0			

Unit of Area	Command Area(fd)	D/Abu XX -6.2	Command Area(fd)	Unit of Area
	(415.0)			
Number	75.0			
Number	75.0			
Number	75.0			
Number	75.0			
Number	25.0			
Number	65.0			
Number	25.0			

Unit of Area	Command Area(fd)	Canal No.3	Command Area(fd)	Unit of Area
	(1,970.0)			
Number	80.0			
Number	75.0			
Number	75.0			
	(1,235.0)			
Number	50.0		85.0	Number
Number	50.0		85.0	Number
Number	50.0		85.0	Number
Number	95.0		85.0	Number
Number	95.0		85.0	Number
Number	95.0		85.0	Number
Number	95.0		80.0	Number
D/Abu XX -3.2	450.0		170.0	D/Abu XX -3.

Unit of Area	Command Area(fd)	D/Abu XX -3.2	Command Area(fd)	Unit of Area
	(170.0)			
			65.0	Number
			40.0	Number
			35.0	Number
			30.0	Number

Unit of Area	Command Area(fd)	D/Abu XX -3.1	Command Area(fd)	Unit of Area
	(450.0)			
Number	50.0			
Number	70.0			
Number	70.0			
Number	55.0			
Number	55.0			
Number	55.0			
Number	63.0			
Number	32.0			

Unit of Area	Command Area(fd)	Canal No.7	Command Area(fd)	Unit of Area
	(315.0)			
Number	35.0		70.0	Number
Number	35.0		70.0	Number
Number	35.0		70.0	Number

Table 1.3 (1/2) NET COMMAND AREA OF THE EXISTING CANALS
(Nur El Din Scheme)

1) Nur El Din Scheme(1/2)

Unit of Area	Command Area(fd)	Main Canal	Command Area(fd)	Unit of Area
		(8,719.2)		
			608.0	Canal No.1
			77.5	
			1,827.0	Canal No.2
			70.0	Number
			25.2	Number
			45.0	Number
			75.0	Number
			92.5	Number
			90.0	Number
			98.0	Number
			78.0	Number
			78.0	Number
			88.0	Number
			98.0	Number
			110.0	Number
			99.0	Number
Canal No.5	1,407.0		3,753.0	Canal No.3

Unit of Area	Command Area(fd)	Canal No.3	Command Area(fd)	Unit of Area
		(3,753.0)		
			80.0	Number
			75.0	Number
			60.0	Number
Canal No.4	2,385.0		55.0	Number
			70.0	Number
			70.0	Number
			90.0	Number
			90.0	Number
			80.0	Number
			60.0	Number
			75.0	Number
			90.0	Number
			88.0	Number
			70.0	Number
			75.0	Number
			75.0	Number
			70.0	Number
			95.0	Number

Unit of Area	Command Area(fd)	Canal No.1	Command Area(fd)	Unit of Area
		(608.0)		
Number	70.0		70.0	Number
Number	73.0		70.0	Number
Number	85.0			
Number	85.0			
Number	85.0			
Number	70.0			

Unit of Area	Command Area(fd)	Canal No.2	Command Area(fd)	Unit of Area
		(1,827.0)		
			82.5	Number
			82.5	Number
			84.5	Number
			82.5	Number
			78.0	Number
			270.0	Abu XX No.1
			100.0	Number
			85.0	Number
			95.0	Number
			60.0	Number
Number	35.0		60.0	Number
Number	35.0		45.0	Number
Number	35.0		45.0	Number
Number	45.0		45.0	Number
Number	45.0		45.0	Number
Number	45.0		45.0	Number
Number	35.0			
Number	35.0			
Number	90.0			
Number	40.0			
Number	32.0			
Number	25.0			
Number	25.0			

Table 1.3 (2/2) NET COMMAND AREA OF THE EXISTING CANALS (Nur El Din Scheme)

2) Nur El Din Scheme(2/2)

Unit of Area	Command Area(fd)	Canal No.4	Command Area(fd)	Unit of Area
	(2,385.0)			
Number	35.0		75.0	Number
Number	55.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	90.0		60.0	Number
Number	90.0		60.0	Number
Number	90.0		60.0	Number
Number	115.0		55.0	Number
Number	115.0		60.0	Number

Unit of Area	Command Area(fd)	D/Abu XX No.1	Command Area(fd)	Unit of Area
		(270.0)		
			100	Number
			100	Number
			40	Number
			30	Number

Unit of Area	Command Area(fd)	Canal No.5	Command Area(fd)	Unit of Area
		(1,407.0)		
			90.0	Number
			70.0	Number
			70.0	Number
			90.0	Number
Number	75.0			
Number	75.0			
Number	75.0			
Number	75.0			
Number	52.0			
D/AbuXX No.2	360.0		75.0	Number
			75.0	Number
			75.0	Number
			75.0	Number
			75.0	Number

Unit of Area	Command Area(fd)	D/AbuXX No.2	Command Area(fd)	Unit of Area
		(360.0)		
			90.0	Number
			90.0	Number
			90.0	Number
			90.0	Number

Table 1.4 ACTUAL IRRIGATION AREA

(Unit: fd)

	Hurga Scheme			Nur El Din Scheme		
Year	Cotton	Sorghum	Total	Cotton	Sorghum	Total
1976/77	4,270	3,725	7,995	3,145	3,155	6,300
1977/78	4,270	4,270	8,540	3,155	3,155	6,310
1978/79	3,725	4,270	7,995	3,155	3,155	6,310
1979/80	4,270	3,725	7,995	3,155	3,155	6,310
1980/81	0	4,270	4,270	1,500	3,155	4,655
1981/82	0		0	0		0
1982/83	0		0	0		0
1983/84	0		0	0		0
1984/85	0		0	0		0
1985/86	0		0	0		0
1986/87	0		0	0		0
1987/88	0		0	0		0
1988/89	0		0	0		0
1989/90	0		0	0		0
1990/91	0		0	0		0

Source: Agricutur Manager's Office,SGB

Table 1.5 IRRIGATION WATER SUPPLIED FOR SORGHUM IN 1990

Year	Month	Operation Hours (hr/month)	Discharge* (m3/month)	Water** Pumped (mm/month)	Water*** Supplied (mm/month)	Rainfll (mm/month)	Total Water Available (mm/month)	(mm/day)
Hurga scheme (2,260 fd)								
1990	Jul	107	404,460	43	38	21	59	4.0
	Aug	464	1,753,920	185	166	1	167	5.4
	Sept	538	2,033,640	214	193	28	220	7.3
	Oct	322	1,217,160	128	115	41	156	5.2
	Total	1,431	5,409,180	570	513	90	603	5.7
Nur El Din scheme (1,260 fd)								
1990	Jul	-						
	Aug	225	324,000	61	55	1	56	1.8
	Sept	494	711,360	134	121	28	149	5.0
	Oct	474	682,560	129	116	41	157	5.2
	Total	1,193	1,717,920	325	292	69	361	4.0

* ; Discharge volume is roughly estimated based on results of pumping tests conducted in September 1990 by HRS,MOI.

** ; Water pumped up in mm/month

***; It is assumed that 90 % Of pumped up water reach to field.

Table 1.6 CROP WATER REQUIREMENT FOR SORGHUM IN 1990

Month	10-Day Period	Crop* Factor	Penman Eo** (mm/day)	Crop Water Requirement (mm/day)	(mm/month)
Jan	1		6.3		
	2		6.4		
	3		6.7		
Feb	1		7.0		
	2		7.3		
	3		7.7		
Mar	1		8.0		
	2		8.4		
	3		8.5		
Apr	1		8.7		
	2		8.8		
	3		8.9		
May	1		9.0		
	2		9.1		
	3		9.4		
Jun	1		9.7		
	2		10.0		
	3		9.5		
Jul	1	800.0 ***	9.0	0.2	
	2	0.50	8.5	4.3	3.0
	3	0.55	8.4	4.6	
Aug	1	0.70	8.2	5.8	
	2	0.94	8.1	7.6	7.3
	3	1.10	7.9	8.7	
Sep	1	1.14	7.6	8.7	
	2	1.08	7.4	8.0	7.8
	3	0.93	7.3	6.8	
Oct	1	0.80	7.2	5.8	
	2	0.70	7.1	5.0	5.4
	3		6.9		
Nov	1		6.7		
	2		6.5		
	3		6.4		
Dec	1		6.3		
	2		6.2		
	3		6.3		

* ; Crop Factor used in Gezira Irrigation Scheme

** ; Evaporation by Peman Eo, average Eo between 1980 - 1990 predicted by Meteorological Department, Wad Medani

***; Pre-irrigation in m3/fd

Table 3.1 CROP FACTORS

10-Day Period After Planting	Cotton (ELS)	Wheat (Gezira vars.)	Dura	Groundnut (Long term)	Fodder
1	0.50	0.50	0.50	0.50	0.50
2	0.50	0.66	0.55	0.53	0.57
3	0.53	0.87	0.70	0.59	0.67
4	0.58	1.07	0.94	0.68	0.72
5	0.65	1.15	1.10	0.78	0.84
6	0.81	1.18	1.12	0.91	0.97
7	1.01	1.11	1.10	1.01	1.08
8	1.10	0.95	1.10	1.09	0.75
9	1.13	0.76	1.04	1.10	0.80
10	1.17	0.60	0.89	1.07	0.85
11	1.20	0.50	0.65	1.03	0.72
12	1.18			0.89	0.80
13	1.16			0.80	0.90
14	1.15				
15	1.11				
16	1.00				
17	0.95				
18	0.86				
19	0.77				
20	0.68				
21	0.68				

Source: Technical Notes on Water-use, No.12, 1976

Table 3. 2 EFFECTIVE RAINFALL

Month	Monthly Rainfall (mm/month)	Crop Water Requirement (mm/month)					Effective Rainfall (mm/month)				
		Cotton	Sorghum	Groundnut	Wheat	Fodder	Cotton	Sorghum	Groundnut	Wheat	Fodder
Jun.	18.6	0	0	102	0	218	-	-	13	-	18
Jul.	47.3	15	98	185	0	247	15	34	39	-	47
Aug.	67.4	115	225	248	0	198	49	61	67	-	58
Sep.	35.7	155	245	235	0	125	28	35	35	-	27
Oct.	8.1	233	173	126	0	0	8	8	8	-	-
Nov.	2.1	231	15	0	80	0	0	0	-	0	-
Dec.	0.0	219	0	0	197	0	0	-	-	0	-
Jan.	0.0	186	0	0	209	0	0	-	-	0	-
Feb.	0.0	126	0	0	115	0	0	-	-	0	-
Mar.	0.0	18	0	0	13	0	0	-	-	0	-
Apr.	0.2	0	0	0	0	0	-	-	-	-	-
May	12.6	0	0	0	0	107	-	-	-	-	9

Table 3.3 MANAGEMENT OF MINOR CANAL DELIVERIES, NOV-DEC 1987 PERFORMANCE RATIONS

Major Canal	Minor Canal	R1 Indent CWR	R2 Auth. Rel Indent	R3 Discharge Auth. Rel	R2*R3	R1*R2*R3
Zananda	Gimeliya	0.69	1.00	0.91	0.91	0.63
	Toman	0.89	1.00	0.42	0.42	0.37
	Wad Numan	0.78	1.43	0.42	0.60	0.47
Gamusia	Hamza	1.72	1.13	0.88	0.99	1.71
	Umm Ud	1.87	0.69	0.79	0.55	1.02
	Fadlein	2.60	1.20	0.64	0.77	2.00
Kab El Gidad	Tuweir	1.35	1.14	1.27	1.45	1.95
	El Mardi	1.67	0.88	1.32	1.16	1.94
	Beibash	2.20	0.66	2.64	1.74	3.83
Means for major canals:						
Zananda		0.79	1.20	0.51	0.61	0.48
Gamusia		1.94	0.99	0.78	0.77	1.50
Kab El Gidad		1.62	0.93	1.55	1.44	2.34
Means for location of minor along major:						
head		1.26	1.11	0.99	1.10	1.38
middle		1.41	0.82	0.80	0.66	0.92
tail		1.27	1.19	0.75	0.89	1.13
Means for all minors (system):		1.31	1.04	0.85	0.88	1.16

Soruce ; Ref. No.1R-302, Minor canal management in the Gezira Irrigation Scheme, Sudan Field Investigations on Selected Minor Canals., 1988

Table 3. 4 IRRIGATION WATER REQUIREMENT

		Irrigation Requirement at P/S; 24 hrs/day (m3/s)						Irrigation Requirement at P/S; 18 hrs/day (m3/s)					
Month	10-day	Cotton	Sorghum	Groundnut	Wheat	Fodder	Total	Cotton	Sorghum	Groundnut	Wheat	Fodder	Total
Jun.	1st	0.00	0.00	1.98	0.00	1.51	3.50	0.00	0.00	2.64	0.00	2.02	4.66
	2nd	0.00	0.00	2.46	0.00	1.80	4.27	0.00	0.00	3.28	0.00	2.40	5.69
	3rd	0.00	1.67	1.24	0.00	1.96	4.87	0.00	2.23	1.65	0.00	2.61	6.49
Jul.	1st	0.00	1.78	1.09	0.00	1.89	4.76	0.00	2.37	1.46	0.00	2.52	6.34
	2nd	0.84	2.17	1.20	0.00	1.69	5.90	1.11	2.89	1.60	0.00	2.26	7.86
	3rd	1.00	1.00	1.41	0.00	1.54	4.95	1.33	1.33	1.88	0.00	2.05	6.60
Aug.	1st	1.14	1.07	1.39	0.00	1.24	4.84	1.52	1.42	1.85	0.00	1.66	6.45
	2nd	0.67	1.43	1.57	0.00	1.19	4.88	0.90	1.91	2.10	0.00	1.59	6.50
	3rd	0.70	1.67	1.64	0.00	1.15	5.15	0.93	2.22	2.19	0.00	1.53	6.87
Sep.	1st	0.94	1.92	1.88	0.00	1.39	6.13	1.25	2.56	2.51	0.00	1.85	8.17
	2nd	1.08	1.85	1.78	0.00	0.87	5.58	1.44	2.47	2.37	0.00	1.16	7.44
	3rd	1.34	1.77	1.61	0.00	0.34	5.07	1.79	2.36	2.15	0.00	0.45	6.75
Oct.	1st	1.78	1.85	1.65	0.00	0.00	5.29	2.38	2.47	2.21	0.00	0.00	7.05
	2nd	1.96	1.54	0.99	0.00	0.00	4.49	2.61	2.06	1.32	0.00	0.00	5.98
	3rd	2.00	0.87	0.42	1.14	0.00	4.42	2.66	1.16	0.56	1.51	0.00	5.89
Nov.	1st	2.06	0.38	0.00	1.54	0.00	3.99	2.75	0.51	0.00	2.06	0.00	5.32
	2nd	2.03	0.00	0.00	1.91	0.00	3.94	2.71	0.00	0.00	2.55	0.00	5.26
	3rd	1.99	0.00	0.00	1.14	0.00	3.14	2.66	0.00	0.00	1.52	0.00	4.18
Dec.	1st	1.93	0.00	0.00	1.44	0.00	3.38	2.58	0.00	0.00	1.92	0.00	4.50
	2nd	1.87	0.00	0.00	1.69	0.00	3.55	2.49	0.00	0.00	2.25	0.00	4.73
	3rd	1.80	0.00	0.00	1.87	0.00	3.67	2.40	0.00	0.00	2.50	0.00	4.90
Jan.	1st	1.70	0.00	0.00	1.92	0.00	3.62	2.27	0.00	0.00	2.56	0.00	4.83
	2nd	1.58	0.00	0.00	1.82	0.00	3.41	2.11	0.00	0.00	2.43	0.00	4.54
	3rd	1.48	0.00	0.00	1.62	0.00	3.10	1.98	0.00	0.00	2.16	0.00	4.14
Feb.	1st	1.35	0.00	0.00	1.35	0.00	2.71	1.81	0.00	0.00	1.81	0.00	3.61
	2nd	1.27	0.00	0.00	1.11	0.00	2.39	1.70	0.00	0.00	1.48	0.00	3.18
	3rd	0.88	0.00	0.00	0.71	0.00	1.59	1.17	0.00	0.00	0.95	0.00	2.12
Mar.	1st	0.47	0.00	0.00	0.35	0.00	0.82	0.63	0.00	0.00	0.46	0.00	1.09
	2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr.	1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3rd	0.00	0.00	0.00	0.00	1.67	1.67	0.00	0.00	0.00	0.00	2.23	2.23
May	1st	0.00	0.00	0.00	0.00	1.99	1.99	0.00	0.00	0.00	0.00	2.65	2.65
	2nd	0.00	0.00	0.00	0.00	2.45	2.45	0.00	0.00	0.00	0.00	3.26	3.26
	3rd	0.00	0.00	1.52	0.00	1.36	2.88	0.00	0.00	2.03	0.00	1.81	3.84

Table 3.5 CROP WATER REQUIREMENT

(Unit; mm/day)

Month	10-day	Ep (Penman) mm/day	Cotton			Sorghum			Groundnut			Wheat			Fodder		
			1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Jun.	1st	9.7	-	-	-	-	-	-	4.85	-	-	-	-	-	6.98	6.50	5.53
	2nd	10.0	-	-	-	-	-	-	5.30	5.00	-	-	-	-	8.40	7.20	6.70
	3rd	9.5	-	-	-	-	-	-	5.61	5.04	4.75	-	-	-	9.22	7.98	6.84
Jul.	1st	9.0	-	-	-	4.50	-	-	6.12	5.31	4.77	-	-	-	9.72	8.73	7.56
	2nd	8.5	-	-	-	4.68	4.25	-	6.63	5.78	5.02	-	-	-	6.38	9.18	8.25
	3rd	8.4	4.18	-	-	5.86	4.60	4.18	7.61	6.53	5.69	-	-	-	6.69	6.28	9.04
Aug.	1st	8.2	4.12	4.12	-	7.74	5.76	4.53	8.32	7.49	6.42	-	-	-	7.00	6.59	6.18
	2nd	8.1	4.29	4.05	4.05	8.91	7.61	5.67	8.83	8.18	7.37	-	-	-	5.83	6.89	6.48
	3rd	7.9	4.56	4.17	3.93	8.81	8.65	7.39	8.65	8.57	7.95	-	-	-	6.29	5.66	6.69
Sep.	1st	7.6	4.96	4.43	4.05	8.40	8.55	8.40	8.17	8.40	8.32	-	-	-	6.87	6.11	5.50
	2nd	7.4	5.99	4.81	4.29	8.14	8.14	8.29	7.62	7.92	8.14	-	-	-	-	6.66	5.92
	3rd	7.3	7.37	5.91	4.75	7.59	8.03	8.03	6.50	7.52	7.81	-	-	-	-	-	6.57
Oct.	1st	7.2	7.92	7.27	5.83	6.41	7.49	7.92	5.76	6.41	7.42	-	-	-	-	-	-
	2nd	7.1	8.02	7.81	7.17	4.62	6.32	7.38	-	5.68	6.32	-	-	-	-	-	-
	3rd	6.9	8.07	7.80	7.59	-	4.49	6.14	-	-	5.52	-	-	-	-	-	-
Nov.	1st	6.7	8.04	7.84	7.57	-	-	4.36	-	-	-	3.35	-	-	-	-	-
	2nd	6.5	7.67	7.80	7.61	-	-	-	-	-	-	4.29	3.25	-	-	-	-
	3rd	6.4	7.42	7.55	7.68	-	-	-	-	-	-	5.57	4.22	3.20	-	-	-
Dec.	1st	6.3	7.25	7.31	7.43	-	-	-	-	-	-	6.74	5.48	4.16	-	-	-
	2nd	6.2	6.88	7.13	7.19	-	-	-	-	-	-	7.13	6.63	5.39	-	-	-
	3rd	6.3	6.27	6.96	7.21	-	-	-	-	-	-	7.39	7.21	6.71	-	-	-
Jan.	1st	6.3	6.02	6.33	7.03	-	-	-	-	-	-	7.03	7.47	7.28	-	-	-
	2nd	6.4	5.50	6.08	6.40	-	-	-	-	-	-	6.08	7.10	7.55	-	-	-
	3rd	6.5	5.03	5.62	6.21	-	-	-	-	-	-	4.97	6.21	7.25	-	-	-
Feb.	1st	6.7	4.53	5.13	5.73	-	-	-	-	-	-	4.00	5.07	6.33	-	-	-
	2nd	6.8	4.62	4.62	5.24	-	-	-	-	-	-	3.40	4.08	5.17	-	-	-
	3rd	7.3	-	4.99	4.99	-	-	-	-	-	-	-	3.67	4.40	-	-	-
Mar.	1st	7.9	-	-	5.35	-	-	-	-	-	-	-	-	3.93	-	-	-
	2nd	8.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3rd	8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr.	1st	8.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2nd	8.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3rd	8.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	1st	9.0	-	-	-	-	-	-	-	-	-	-	-	-	4.50	-	-
	2nd	9.1	-	-	-	-	-	-	-	-	-	-	-	-	5.19	4.55	-
	3rd	9.4	-	-	-	-	-	-	-	-	-	-	-	-	6.30	5.36	4.70

Table 3.6 (1/4) NET COMMAND AREA OF THE PROPOSED CANALS
(Hurga Scheme)

1) Hurga scheme(1/4)

Unit of Area	Command Area(fd)	Main Canal	Command Area(fd)	Unit of Area
		(13,903.0)		
Gann. No.3	477.0		6,668.0	Major Canal
			1,235.0	Gann. No.2
Canal No.4	835.0			
			1,293.0	Canal No.5
			2,885.0	Canal No.6
			510.0	Canal No.7

Unit of Area	Command Area(fd)	Major Canal	Command Area(fd)	Unit of Area
		(6,668.0)		
			501.0	Gann. No.4(P)
Canal No.1	752.0			
Gann. No.1	810.0			
Canal No.3	1,970.0			
Canal No.2	1,455.0		1,180.0	Canal No.2(P)

Unit of Area	Command Area(fd)	Gannabia No.1	Command Area(fd)	Unit of Area
		(810.0)		
Number	125.0			
Number	105.0			
Number	85.0			
Number	85.0			
Number	85.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			

Unit of Area	Command Area(fd)	Gannabia No.2	Command Area(fd)	Unit of Area
		(1,235.0)		
			65.0	Number
			65.0	Number
			65.0	Number
			80.0	Number
			75.0	Number
			20.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			95.0	Number
			85.0	Number
			80.0	Number
			25.0	Number
			10.0	Number

Table 3.6 (2/4) NET COMMAND AREA OF THE PROPOSED CANALS
(Hurga Scheme)

1) Hurga scheme(2/4)

Unit of Area	Command Area(fd)	Gannabia No.3	Command Area(fd)	Unit of Area
		(477.0)		
Number	36.0			
Number	45.0			
Number	87.0			
Number	87.0			
Number	87.0			
Number	40.0			
Number	35.0			
Number	40.0			
Number	20.0			

Unit of Area	Command Area(fd)	Gannabia No.4(P)	Command Area(fd)	Unit of Area
		(501.0)		
			45.0	Number
			45.0	Number
			45.0	Number
			30.0	Number
			10.0	Number
			56.0	Number
			40.0	Number
Number	55.0		65.0	Number
Number	50.0		25.0	Number
			35.0	Number

Unit of Area	Command Area(fd)	Canal No.1	Command Area(fd)	Unit of Area
		(752.0)		
Number	52.0			
Number	50.0			
Number	10.0			
Number	80.0			
Number	75.0			
Number	75.0			
Number	75.0			
Number	55.0			
Number	30.0			
Number	10.0			
Number	90.0			
Number	90.0			
Number	60.0			

Unit of Area	Command Area(fd)	Canal No.2	Command Area(fd)	Unit of Area
		(1,455.0)		
Number	120.0			
Number	95.0			
Number	75.0			
Number	55.0			
Number	20.0			
Number	60.0			
Number	75.0			
Number	85.0			
Number	100.0			
Number	15.0			
Number	50.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	95.0			
Number	90.0			
Number	85.0			
Number	85.0			
Number	85.0			
Number	45.0			
Number	25.0			

Table 3.6 (3/4) NET COMMAND AREA OF THE PROPOSED CANALS
(Hurga Scheme)

1) Hurga scheme(3/4)

Unit of Area	Command Area(fd)	Canal No.2(P)	Command Area(fd)	Unit of Area
		(1,180.0)		
Number	105.0			
Number	90.0			
Number	20.0			
Number	20.0			
Number	25.0			
Number	50.0			
Number	75.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	90.0			
Number	70.0			
Number	55.0			
Number	40.0			

Unit of Area	Command Area(fd)	Canal No.3	Command Area(fd)	Unit of Area
		(1,970.0)		
Number	80.0			
Number	75.0			
Number	75.0			
Number	50.0		85.0	Number
Number	50.0		85.0	Number
Number	50.0		85.0	Number
Number	95.0		85.0	Number
Number	95.0		85.0	Number
Number	95.0		85.0	Number
Number	95.0		80.0	Number
D/Abu XX -3.1	450.0		170.0	D/Abu XX -3.2

Unit of Area	Command Area(fd)	Canal No.4	Command Area(fd)	Unit of Area
		(835.0)		
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			45.0	Number
			20.0	Number
Number	55.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			
Number	65.0			

Unit of Area	Command Area(fd)	Canal No.5	Command Area(fd)	Unit of Area
		(1,293.0)		
			17.0	Number
			22.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			67.0	Number
			67.0	Number
			15.0	Number
			25.0	Number
			40.0	Number
			60.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			40.0	Number
			60.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			65.0	Number
			45.0	Number
			20.0	Number

Table 3.6 (4/4) NET COMMAND AREA OF THE PROPOSED CANALS (Hurga Scheme)

1) Hurga scheme(4/4)

Unit of Area	Command Area(fd)	Canal No.6	Command Area(fd)	Unit of Area
	(2,885.0)			
Number	50.0			
Number	55.0			
Number	60.0			
Number	65.0			
Number	70.0			
Number	75.0			
Number	90.0			
Number	95.0			
D/Abu XX-6.1	255.0			
Number	60.0			
Number	75.0			
Number	75.0			
Number	75.0			
D/Abu XX-6.2	415.0			
Number	65.0		135.0	Number
Number	70.0		135.0	Number
Number	80.0		135.0	Number
Number	80.0		90.0	Number
Number	70.0		90.0	Number
Number	60.0		90.0	Number
Number	25.0		90.0	Number
Number	20.0		65.0	Number
Number	15.0		55.0	Number

Unit of Area	Command Area(fd)	D/Abu XX -3.2	Command Area(fd)	Unit of Area
	(170.0)			
			65.0	Number
			40.0	Number
			35.0	Number
			30.0	Number

Unit of Area	Command Area(fd)	Canal No.7	Command Area(fd)	Unit of Area
	(510.0)			
Number	55.0		50.0	Number
			45.0	Number
			45.0	Number
Number	35.0		70.0	Number
Number	35.0		70.0	Number
Number	35.0		70.0	Number

Unit of Area	Command Area(fd)	D/Abu XX -3.1	Command Area(fd)	Unit of Area
	(450.0)			
Number	50.0			
Number	70.0			
Number	70.0			
Number	55.0			
Number	55.0			
Number	55.0			
Number	63.0			
Number	32.0			

Unit of Area	Command Area(fd)	D/Abu XX -6.1	Command Area(fd)	Unit of Area
	(255.0)			
Number	95.0			
Number	80.0			
Number	55.0			
Number	25.0			

Unit of Area	Command Area(fd)	D/Abu XX -6.2	Command Area(fd)	Unit of Area
	(415.0)			
Number	75.0			
Number	75.0			
Number	75.0			
Number	75.0			
Number	25.0			
Number	65.0			
Number	25.0			

Table 3.7 (1/2) NET COMMAND AREA OF THE PROPOSED CANALS
(Nur El Din Scheme)

1) Nur El Din Scheme(1/2)

Unit of Area	Command Area(fd)	Main Canal	Command Area(fd)	Unit of Area
		(8,719.2)		
			608.0	Canal No.1
Canal No.5	2,453.7		1,904.5	Canal No.2
			1,368.0	Canal No.3
			2,385.0	Canal No.4

Unit of Area	Command Area(fd)	Canal No.1	Command Area(fd)	Unit of Area
		(608.0)		
Number	70.0		70.0	Number
Number	73.0		70.0	Number
Number	85.0			
Number	85.0			
Number	85.0			
Number	70.0			

Unit of Area	Command Area(fd)	Canal No.2	Command Area(fd)	Unit of Area
		(1,904.5)		
			77.5	Number
			82.5	Number
			82.5	Number
			84.5	Number
			82.5	Number
			78.0	Number
			270.0	D/Abu XX No.1
			100.0	Number
			85.0	Number
			95.0	Number
			60.0	Number
Number	35.0		60.0	Number
Number	35.0		45.0	Number
Number	35.0		45.0	Number
Number	45.0		45.0	Number
Number	45.0		45.0	Number
Number	45.0		45.0	Number
Number	35.0			
Number	35.0			
Number	90.0			
Number	40.0			
Number	32.0			
Number	25.0			
Number	25.0			

Unit of Area	Command Area(fd)	Canal No.3	Command Area(fd)	Unit of Area
		(1,368.0)		
			80.0	Number
			75.0	Number
			60.0	Number
			55.0	Number
			70.0	Number
			70.0	Number
			90.0	Number
			90.0	Number
			80.0	Number
			60.0	Number
			75.0	Number
			90.0	Number
			88.0	Number
			70.0	Number
			75.0	Number
			75.0	Number
			70.0	Number
			95.0	Number

Table 3.7 (2/2) NET COMMAND AREA OF THE PROPOSED CANALS
(Nur El Din Scheme)

1) Nur El Din Scheme(2/2)

Unit of Area	Command Area(fd)	Canal No.4	Command Area(fd)	Unit of Area
	(2,385.0)			
Number	35.0		75.0	Number
Number	55.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	75.0		75.0	Number
Number	90.0		60.0	Number
Number	90.0		60.0	Number
Number	90.0		60.0	Number
Number	115.0		55.0	Number
Number	115.0		60.0	Number

Unit of Area	Command Area(fd)	D/Abu XX No.1	Command Area(fd)	Unit of Area
	(270.0)			
Number	100.0			
Number	100.0			
Number	40.0			
Number	30.0			

Unit of Area	Command Area(fd)	Canal No.5	Command Area(fd)	Unit of Area
	(2,453.7)			
			70.0	Number
			25.2	Number
			45.0	Number
			75.0	Number
			92.5	Number
			90.0	Number
			98.0	Number
			78.0	Number
			78.0	Number
			88.0	Number
			98.0	Number
			110.0	Number
Number	75.0		99.0	Number
Number	75.0		90.0	Number
Number	75.0		70.0	Number
Number	75.0		70.0	Number
Number	52.0		90.0	Number
D/Abu XX No.2	360.0		75.0	Number
			75.0	Number
			75.0	Number
			75.0	Number
			75.0	Number

Unit of Area	Command Area(fd)	D/Abu XX No.2	Command Area(fd)	Unit of Area
	(360.0)			
			90.0	Number
			90.0	Number
			90.0	Number
			90.0	Number

Table 3.8 HYDRAULIC ELEMENTS OF CANALS

1) Link Canal

Name of Canals	Length of Canal (km)	Location of Canal Head	Command Area (fd)	Design Discharge (m3/s)	Max. Storage (m3)	Bed Width (m)	Side Slope Inner	Side Slope Outer	Water Slope
1 Linkcanal	0.45	Pumping Station	22,622.2	8.17	-	6.0	1 : 2	1 : 2	1 / 10,000

2) Hurga Scheme

Name of Canals	Length of Canal (km)	Location of Canal Head	Command Area (fd)	Design Discharge (m3/s)	Max. Storage (m3)	Bed Width (m)	Side Slope Inner	Side Slope Outer	Water Slope
1 Main Canal	5.82	EP of Link Canal	13,903.0	5.02	-				
	0.49	BP - K 0.49	13,903.0	5.02	-	6.0	1 : 2	1 : 2	1 / 10,000
	2.08	K 0.49 - K 2.57	5,523.0	1.99	-	2.0	1 : 2	1 : 2	1 / 10,000
	3.25	K 2.57 - EP(K 5.82)	4,688.0	1.69	-	2.0	1 : 2	1 : 2	1 / 10,000
2 Major Canal	5.62	K 0.49 of Main Canal	6,668.0	2.41					
	0.60	BP - K 0.60	6,668.0	2.41	-	2.0	1 : 2	1 : 2	1 /5,000
	1.89	K 0.60 - K 2.49	6,167.0	2.23	-	2.0	1 : 2	1 : 2	1 /5,000
	3.13	K 2.49 - EP(K 5.62)	4,605.0	1.66	-	1.5	1 : 2	1 : 2	1 /5,000
Minor Canal									
3 Gannabia No.1	2.83	K 2.49 of Major Canal	810.0	0.29	6,299	0.5	1 : 2	1 : 2	1 /4,000
4 Gannabia No.2	4.70	K 0.49 of Main Canal	1,235.0	0.44	9,603	1.0	1 : 2	1 : 2	1 / 6,000
5 Gannabia No.3	2.10	K 0.49 of Main Canal	477.0	0.17	3,709	0.5	1 : 2	1 : 2	1 / 3,000
6 Gannabia No.4 (I	4.40	K 0.60 of Major Canal	501.0	0.18	3,896	0.5	1 : 2	1 : 2	1 / 3,000
7 Canal No.1	1.51	K 2.49 of Major Canal	752.0	0.27	5,848	0.5	1 : 2	1 : 2	1 /4,000
8 Canal No.2	7.20	EP of Major Canal	1,455.0	0.52	11,314	1.0	1 : 2	1 : 2	1 / 7,000
9 Canal No.2 (P)	6.00	EP of Major Canal	1,180.0	0.42	9,176	1.0	1 : 2	1 : 2	1 / 6,000
10 Canal No.3	4.13	EP of Major Canal	1,970.0	0.71	15,319	1.0	1 : 2	1 : 2	1 / 8,000
11 Canal No.4	4.26	K 2.57 of Main Canal	835.0	0.30	6,493	0.5	1 : 2	1 : 2	1 /4,000
12 Canal No.5	5.60	EP of Main Canal	1,293.0	0.47	10,054	1.0	1 : 2	1 : 2	1 / 6,000
13 Canal No.6	6.16	EP of Main Canal	2,885.0	1.04	22,434	2.0	1 : 2	1 : 2	1 / 10,000
14 Canal No.7	3.52	EP of Main Canal	510.0	0.18	3,966	0.5	1 : 2	1 : 2	1 / 3,000
D/Abu XX									
15 D/Abu XX - 3.1	1.43	EP of Canal No.3	450.0	0.16	-	0.5	1 : 2	1 : 1.5	1 / 3,000
16 D/Abu XX - 3.2	0.59	EP of Canal No.3	170.0	0.06	-	0.3	1 : 2	1 : 1.5	1 / 2,000
17 D/Abu XX - 6.1	1.11	K 1.73 of Canal No.6	255.0	0.09	-	0.3	1 : 2	1 : 1.5	1 / 2,000
18 D/Abu XX - 6.2	0.65	K 2.49 of Canal No.6	415.0	0.15	-	0.5	1 : 2	1 : 1.5	1 / 3,000

3) Nur El Din Scheme

Name of Canals	Length of Canal (km)	Location of Canal Head	Command Area (fd)	Design Discharge (m3/s)	Max. Storage (m3)	Bed Width (m)	Side Slope Inner	Side Slope Outer	Water Slope
1 Main Canal	11.32	EP of Link Canal	8,719.2	3.15	-				
	1.86	BP - K 1.86	8,719.2	3.15	-	4.0	1 : 2	1 : 2	1 / 10,000
	4.46	K 1.86 - K 6.32	8,111.2	2.93	-	4.0	1 : 2	1 : 2	1 / 10,000
	5.00	K 6.32 - EP(K 11.32)	3,753.0	1.36	-	1.5	1 : 2	1 : 2	1 / 10,000
Minor Canal									
2 Canal No.1	1.46	K 1.86 of Main Canal	608.0	0.22	4,728	0.5	1 : 2	1 : 2	1 / 3,000
3 Canal No.2	5.94	K 6.32 of Main Canal	1,904.5	0.69	14,809	1.5	1 : 2	1 : 2	1 / 7,000
4 Canal No.3	4.97	EP of Main Canal	1,368.0	0.49	10,638	1.0	1 : 2	1 : 2	1 / 6,000
5 Canal No.4	7.65	EP of Main Canal	2,385.0	0.86	18,546	1.5	1 : 2	1 : 2	1 / 8,000
6 Canal No.5	7.07	K 6.32 of Main Canal	2453.7	0.88	19,080	1.5	1 : 2	1 : 2	1 / 9,000
D/Abu XX									
7 D/Abu XX No.1	1.04	K 1.73 of Canal No.2	270.0	0.10	-	0.3	1 : 2	1 : 1.5	1 / 2,000
8 D/Abu XX No.2	0.89	K 5.89 of Canal No.5	360.0	0.13	-	0.5	1 : 2	1 : 1.5	1 / 3,000

Table 3.9 LIST OF RELATED STRUCTURES

	B.F	F.O.P.	W.H.R.	P.R.	M.W.	J.C.
I. Irrigation Canal						
1. Link Canal	1	0	0	0	0	-
2. Hurga Scheme						
Main Canal	0	0	0	1	7	-
Major Canal	0	0	0	1	6	-
Gannabia No.1	0	10	0	1	0	-
Gannabia No.2	0	17	0	1	0	-
Gannabia No.3	0	9	0	1	0	-
Gannabia No.4(P)	0	12	0	1	0	-
Canal No.1	0	13	0	1	0	-
Canal No.2	0	21	2	1	0	-
Canal No.2(P)	0	17	0	1	0	-
Canal No.3	0	17	0	1	0	-
Canal No.4	0	14	0	1	0	-
Canal No.5	0	28	0	1	0	-
Canal No.6	0	30	2	1	0	-
Canal No.7	0	10	0	1	0	-
D/AbuXX-3.1	0	8	0	0	0	-
D/AbuXX-3.2	0	4	0	0	0	-
D/AbuXX-6.1	0	4	0	0	0	-
D/AbuXX-6.2	0	7	0	0	0	-
3. Nur El Din Scheme						
Main Canal	0	0	0	1	5	-
Canal No.1	0	8	0	1	0	-
Canal No.2	0	29	1	1	0	-
Canal No.3	0	18	0	1	0	-
Canal No.4	0	32	0	1	0	-
Canal No.5	0	27	1	1	0	-
D/AbuXX No.1	0	4	0	0	0	-
D/AbuXX No.2	0	4	0	0	0	-
II. Drainage Canal						
1. Hurga Scheme	-	-	-	-	-	3
2. Nur El Din Scheme	-	-	-	-	-	7

Remarks : F.O.P. : Field Outlet Pipe
W.H.R. : Well Head Regulator
P.R. : Pipe Regulator
M.W. : Movable Weir
J.C. : Drainage Junction

Table 3.10 PROPOSED DRAIN SYSTEM

	Name of Drain	Length of Drain (km)	Location of Drain Tail	Catchment Area (fd.)	Max. Run-Off (m3/s)	Bed Width (m)	Side Slope	Water Slope
	Collector Drain							
1	Collector Drain No.1	2.70	Natural Drainage Path	2,215.0	0.30	0.50	1: 2.0 1/	2,500
2	Collector Drain No.2	4.20	Natural Drainage Path	6,600.0	0.61	1.00	1: 2.0 1/	2,500
3	Collector Drain No.3	9.30	Natural Drainage Path	6,682.5	0.62	1.00	1: 2.0 1/	4,500
4	Collector Drain No.4	7.20	Natural Drainage Path	3,718.7	0.42	1.00	1: 2.0 1/	4,500
	Minor Drain							
1	Minor Drain No.1	4.70	Natural Drainage Path	1,180.0	0.19	0.50	1: 1.5 1/	4,500
2	Minor Drain No.2	1.35	BP of Collector Drain No.1	340.0	0.08	0.30	1: 1.5 1/	2,000
3	Minor Drain No.3	2.80	BP of Collector Drain No.1	1,210.0	0.20	0.50	1: 1.5 1/	2,000
4	Minor Drain No.4	7.70	BP of Collector Drain No.2	4,320.0	0.46	1.00	1: 1.5 1/	11,000
5	Minor Drain No.5	3.10	K 2.20 of Minor Drain No.4	1,727.0	0.25	0.50	1: 1.5 1/	5,000
6	Minor Drain No.6	2.10	BP of Collector Drain No.2	415.0	0.10	0.30	1: 1.5 1/	3,500
7	Minor Drain No.7	1.55	Natural Drainage Path	1,725.0	0.25	0.50	1: 1.5 1/	500
8	Minor Drain No.8	3.95	K 4.80 of Collector Drain No.3	890.0	0.16	0.50	1: 1.5 1/	5,500
9	Minor Drain No.9	6.25	K 2.00 of Collector Drain No.3	1,850.5	0.26	0.50	1: 1.5 1/	7,000
10	Minor Drain No.10	1.40	K 4.85 of Minor Drain No.9	305.0	0.08	0.30	1: 1.5 1/	4,500
11	Minor Drain No.11	4.25	K 3.55 of Collector Drain No.3	1,363.0	0.21	0.50	1: 1.5 1/	5,000
12	Minor Drain No.12	5.10	K 5.25 of Collector Drain No.3	1,120.0	0.19	0.50	1: 1.5 1/	4,000
13	Minor Drain No.13	3.30	BP of Collector Drain No.4	1,046.7	0.18	0.50	1: 1.5 1/	6,000
14	Minor Drain No.14	1.40	BP of Collector Drain No.4	320.0	0.08	0.30	1: 1.5 1/	1,500
15	Minor Drain No.15	2.40	K 3.50 of Collector Drain No.4	352.0	0.09	0.30	1: 1.5 1/	1,500
16	Others	-	Natural Drainage Path	501.0	-	-	-	-
	Total			22,622.2				

FIGURES

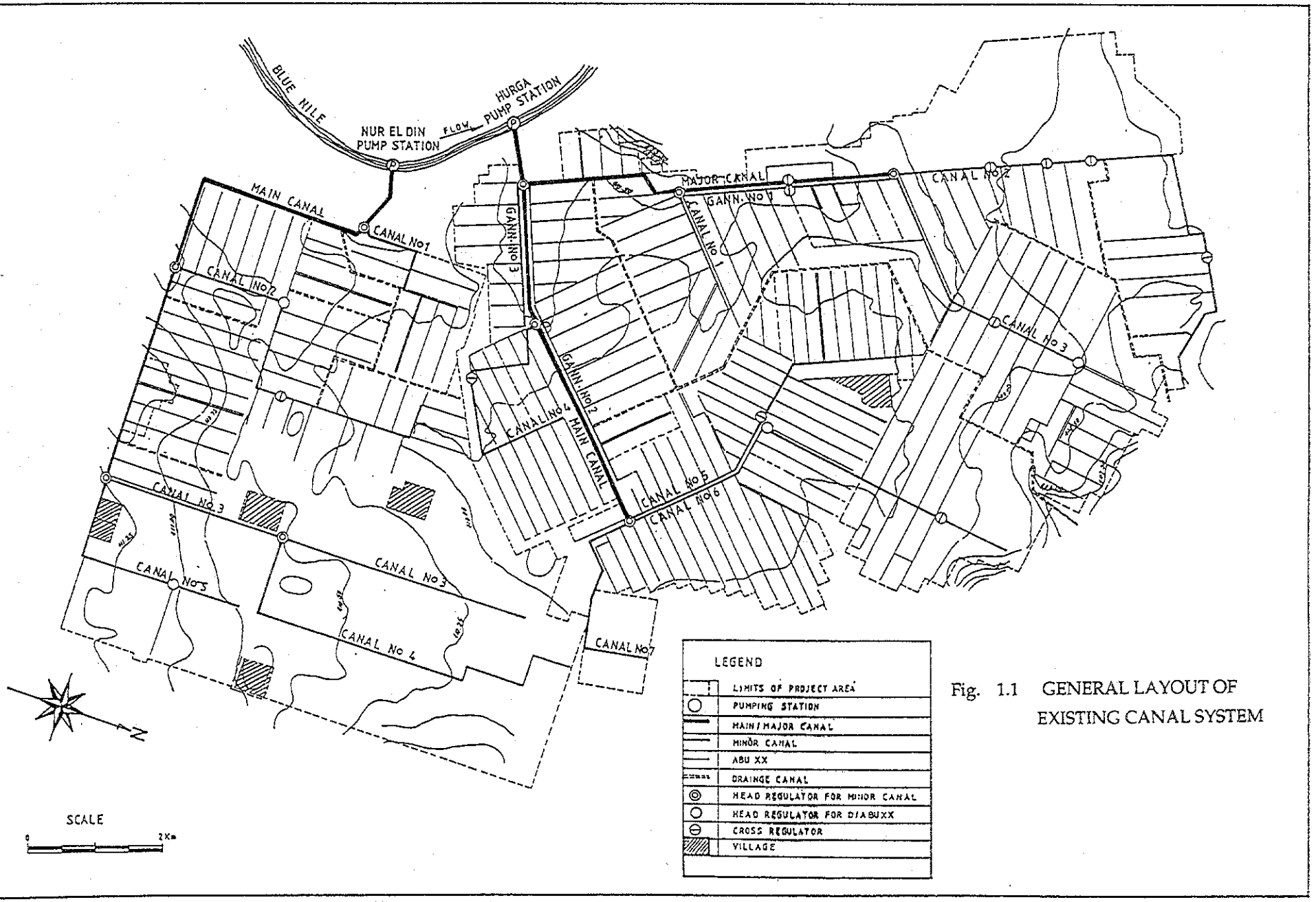


Fig. 1.1 GENERAL LAYOUT OF EXISTING CANAL SYSTEM

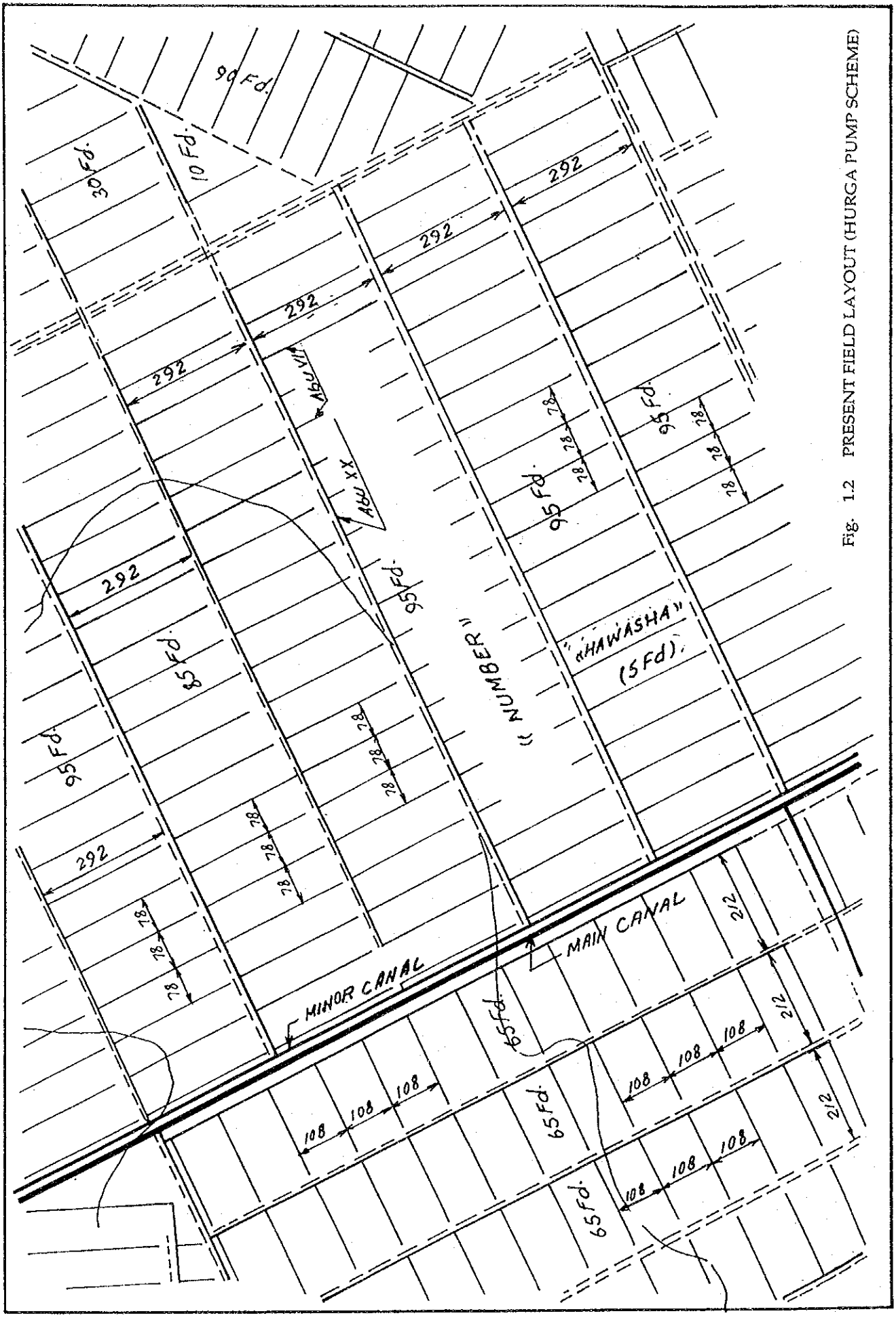


Fig. 1.2 PRESENT FIELD LAYOUT (HURGA PUMP SCHEME)

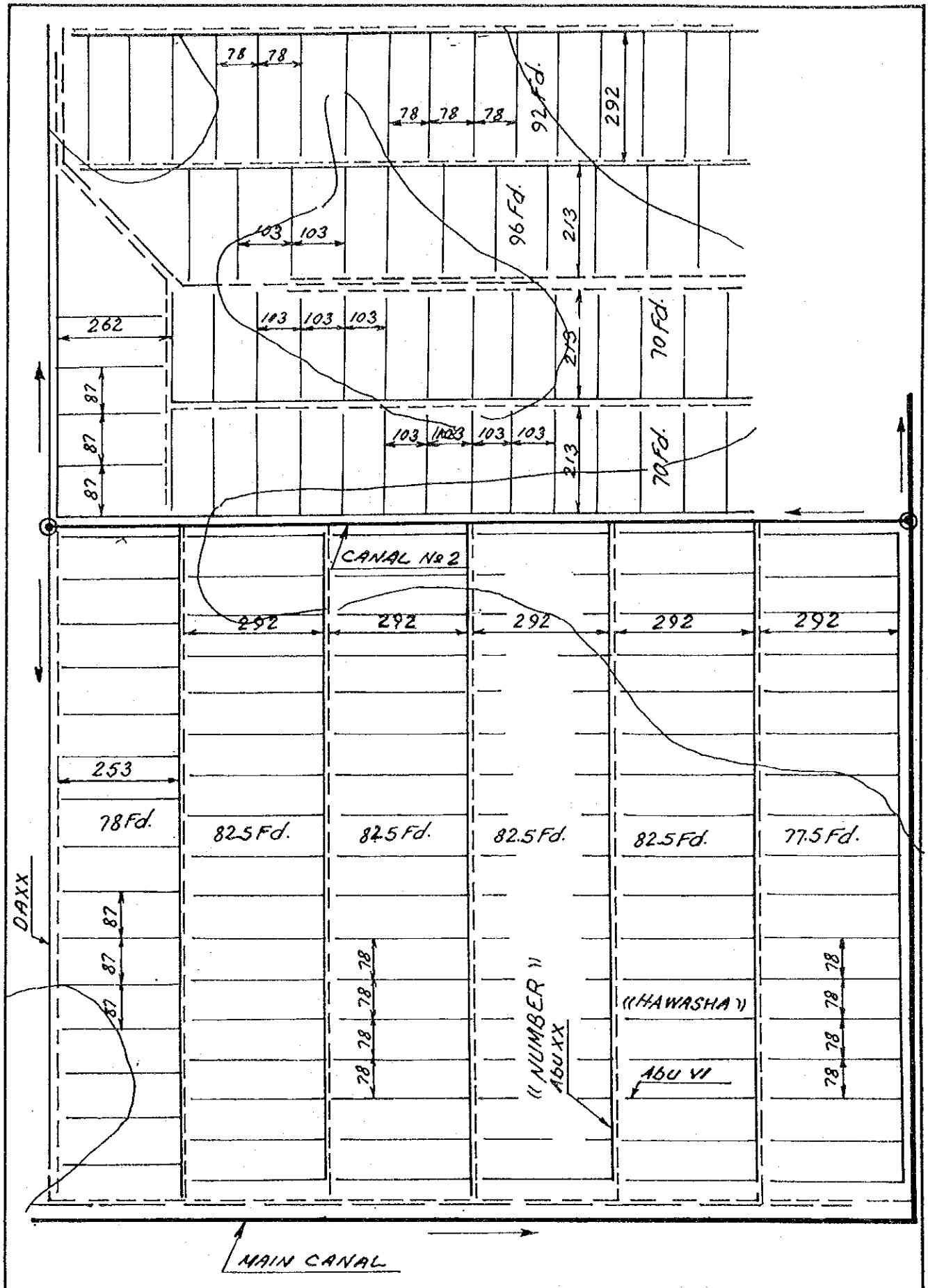


Fig. 1.3 PRESENT FIELD LAYOUT (NUR EL DIN PUMP SCHEME)

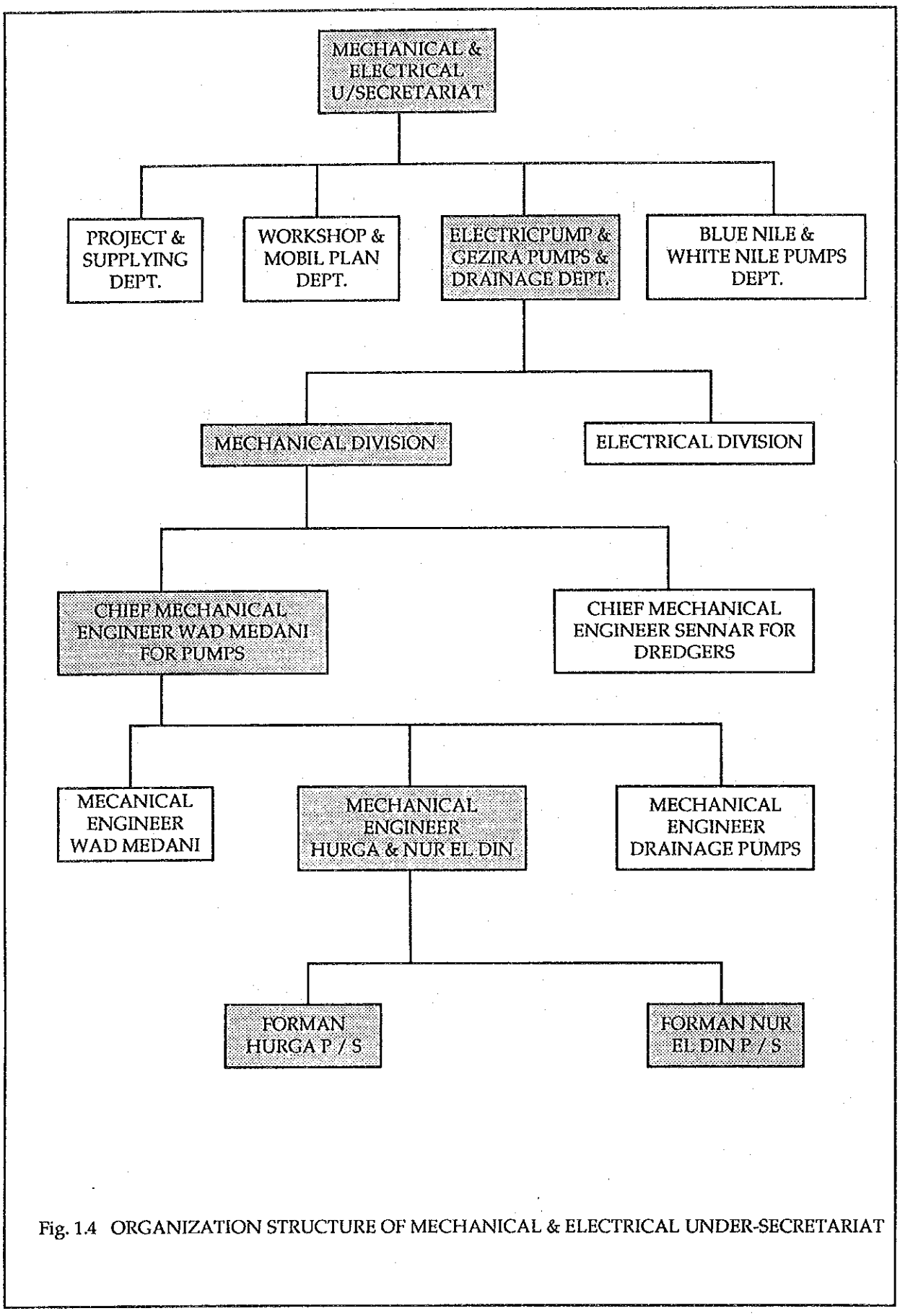


Fig. 1.4 ORGANIZATION STRUCTURE OF MECHANICAL & ELECTRICAL UNDER-SECRETARIAT

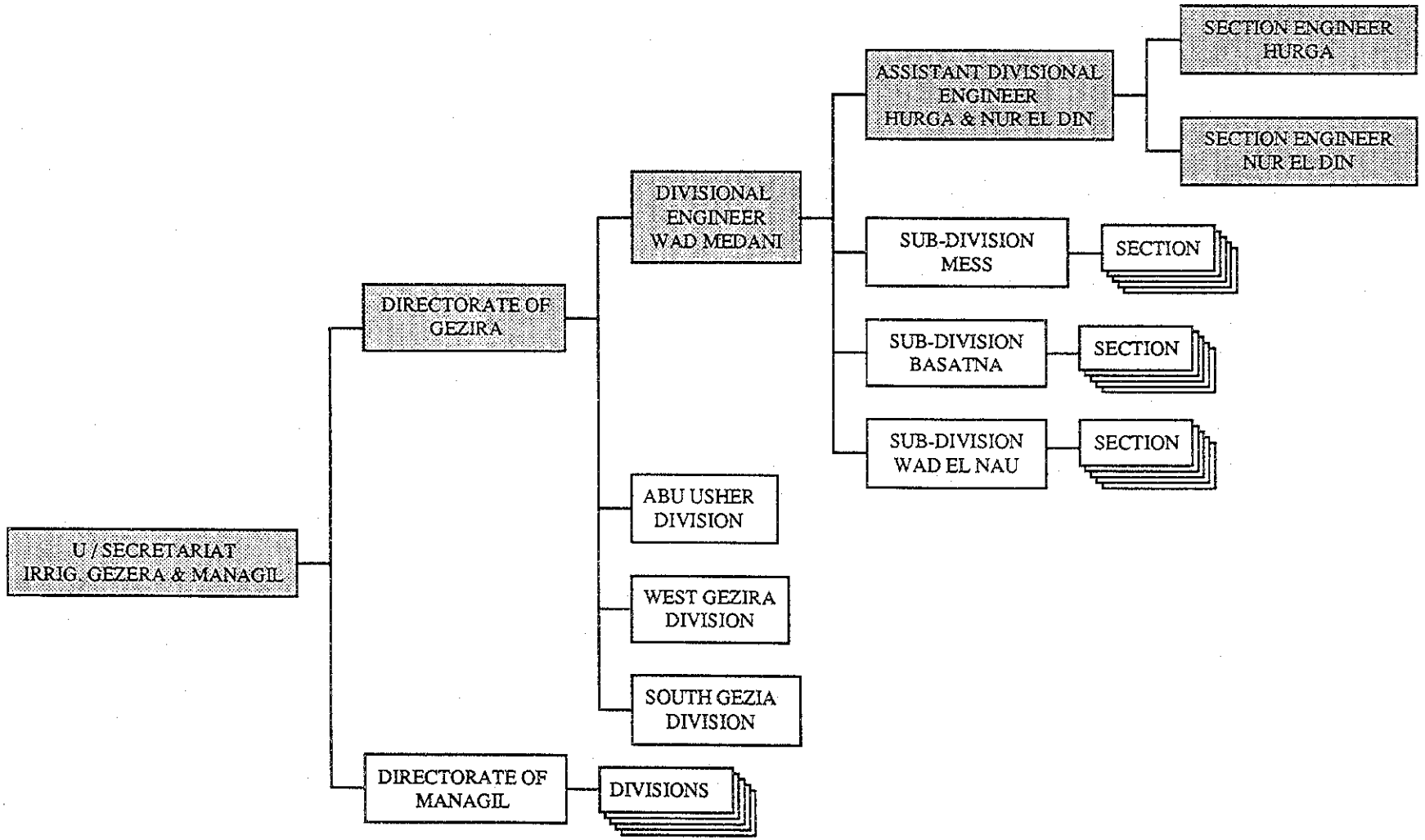


Fig. 1.5 ORGANIZATION STRUCTURE OF UNDER-SECRETARIAT FOR IRRIGATION, GEZIRA & MANAGIL

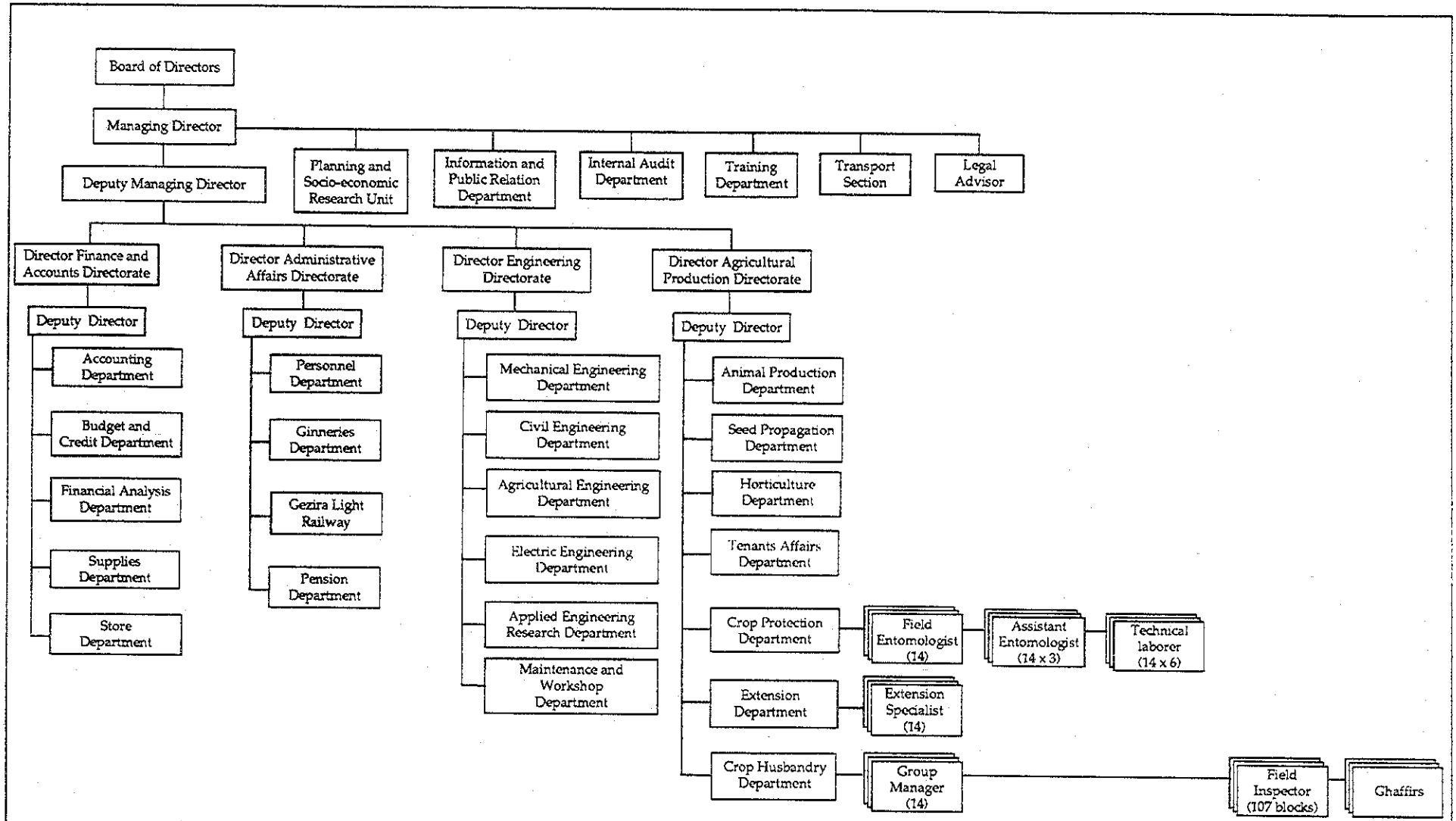


Fig. 1.6 ORGANIZATION STRUCTURE OF THE SUDAN GEZIRA BOARD

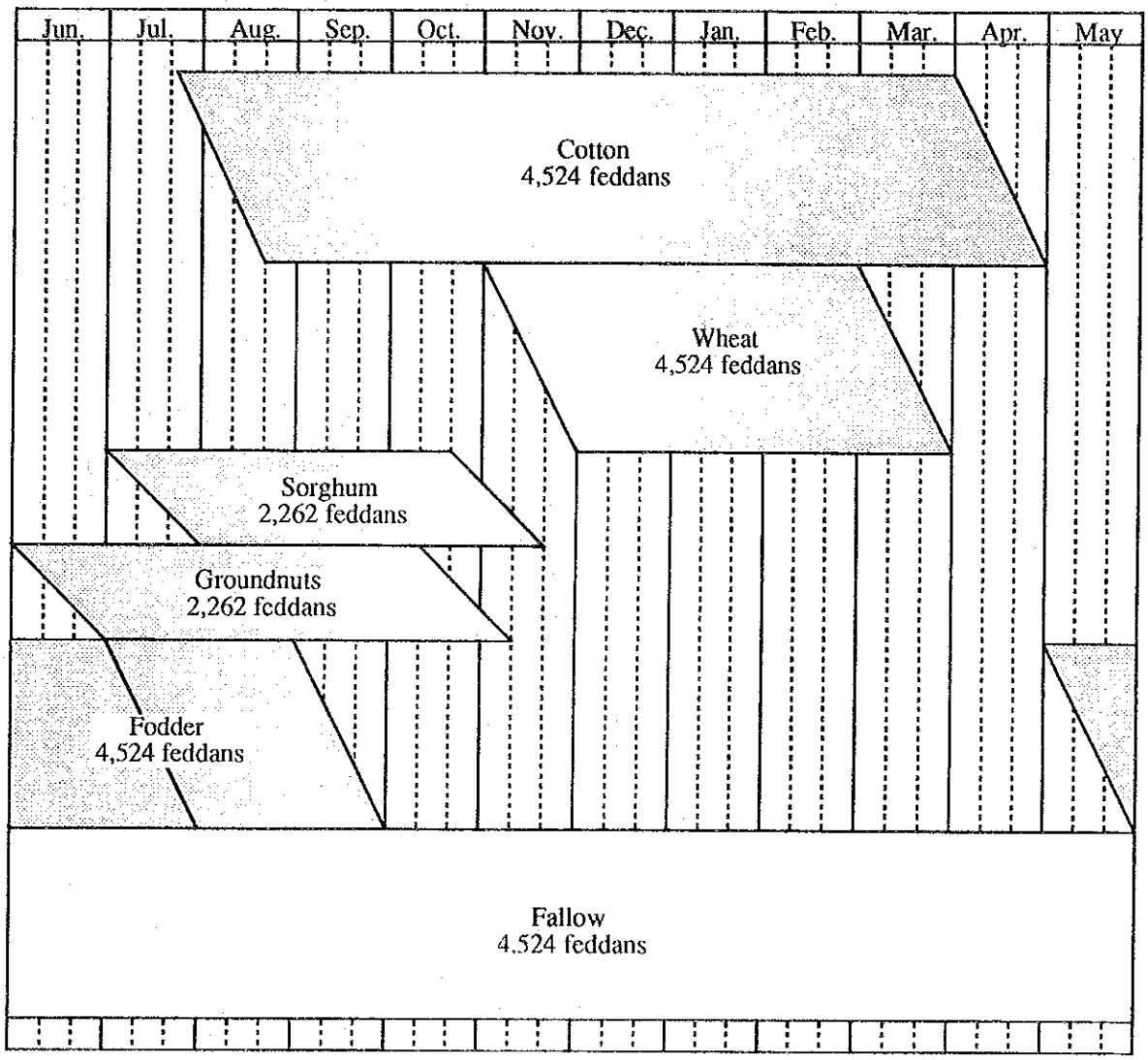


Fig. 3.1 PROPOSED CROPPING PATTERN AND CALENDER

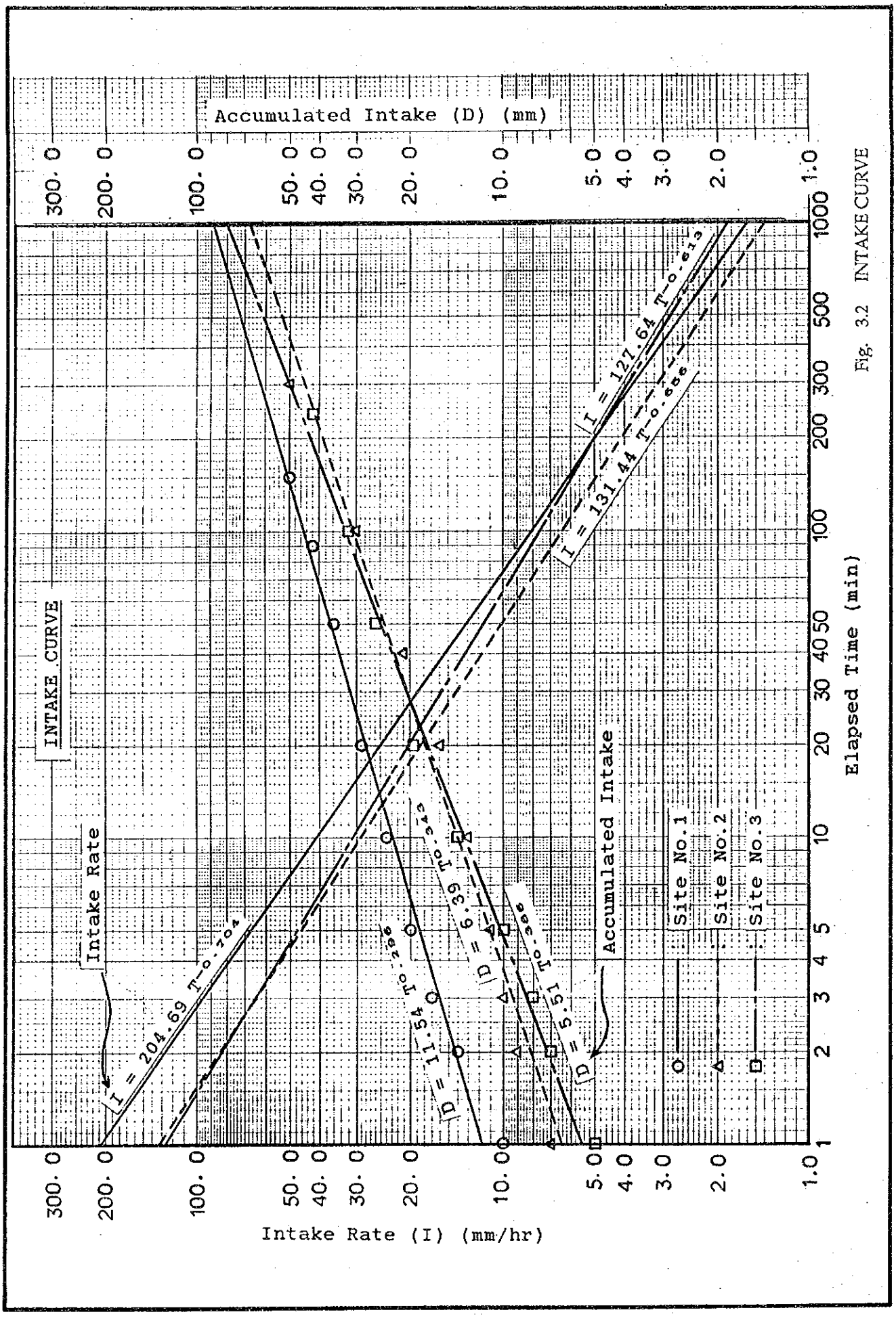


Fig. 3.2 INTAKE CURVE

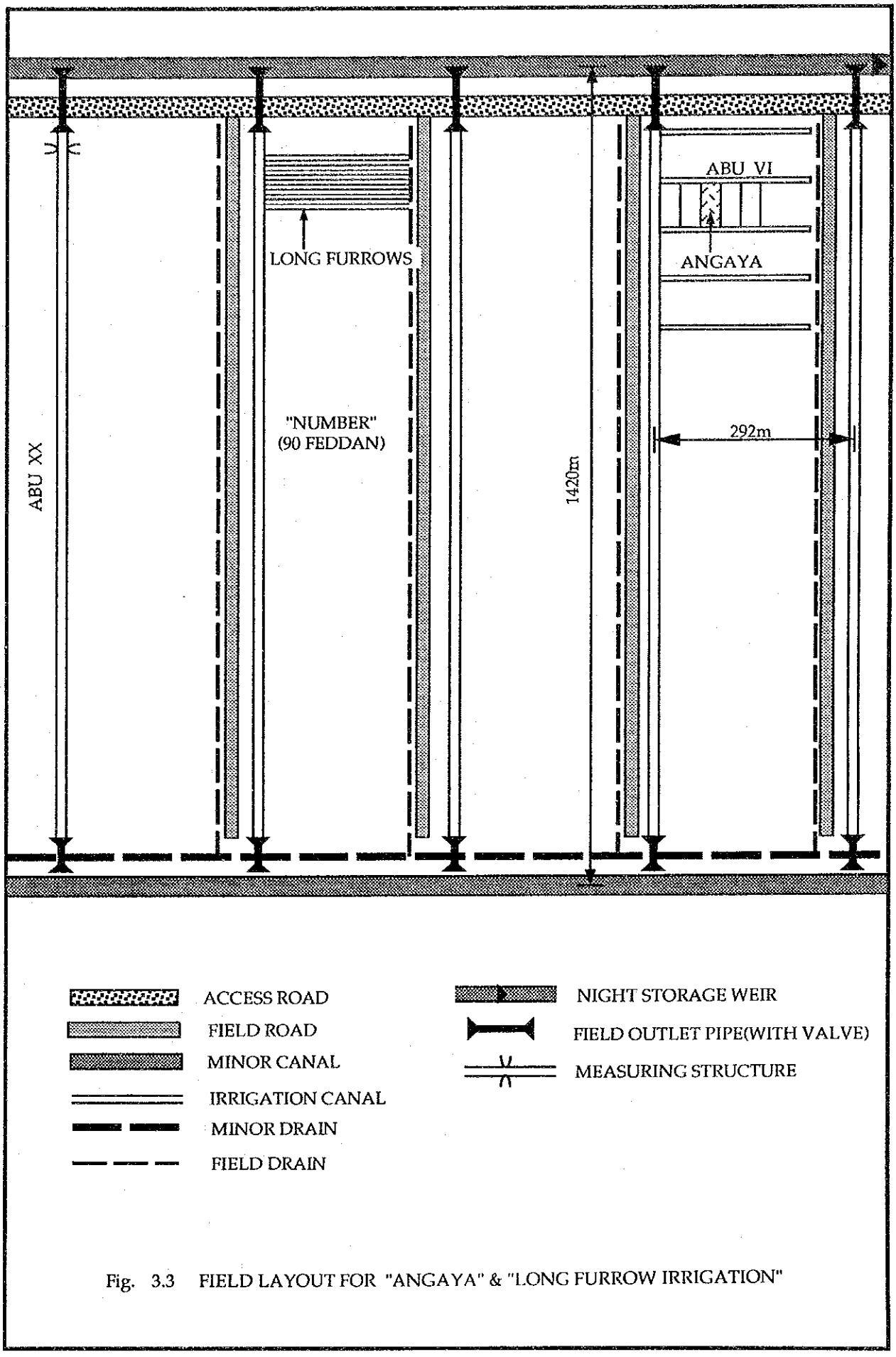


Fig. 3.3 FIELD LAYOUT FOR "ANGAYA" & "LONG FURROW IRRIGATION"

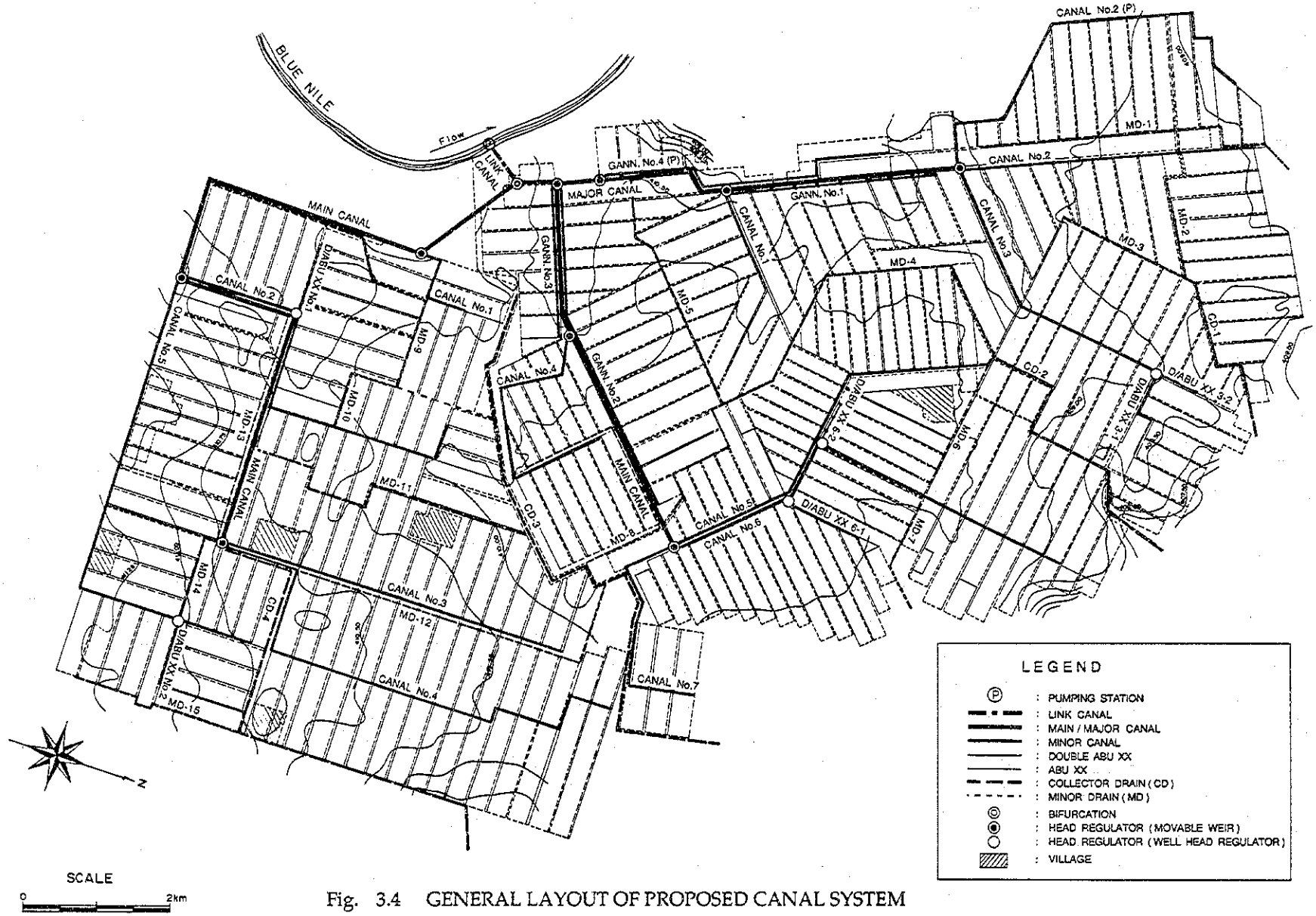


Fig. 3.4 GENERAL LAYOUT OF PROPOSED CANAL SYSTEM

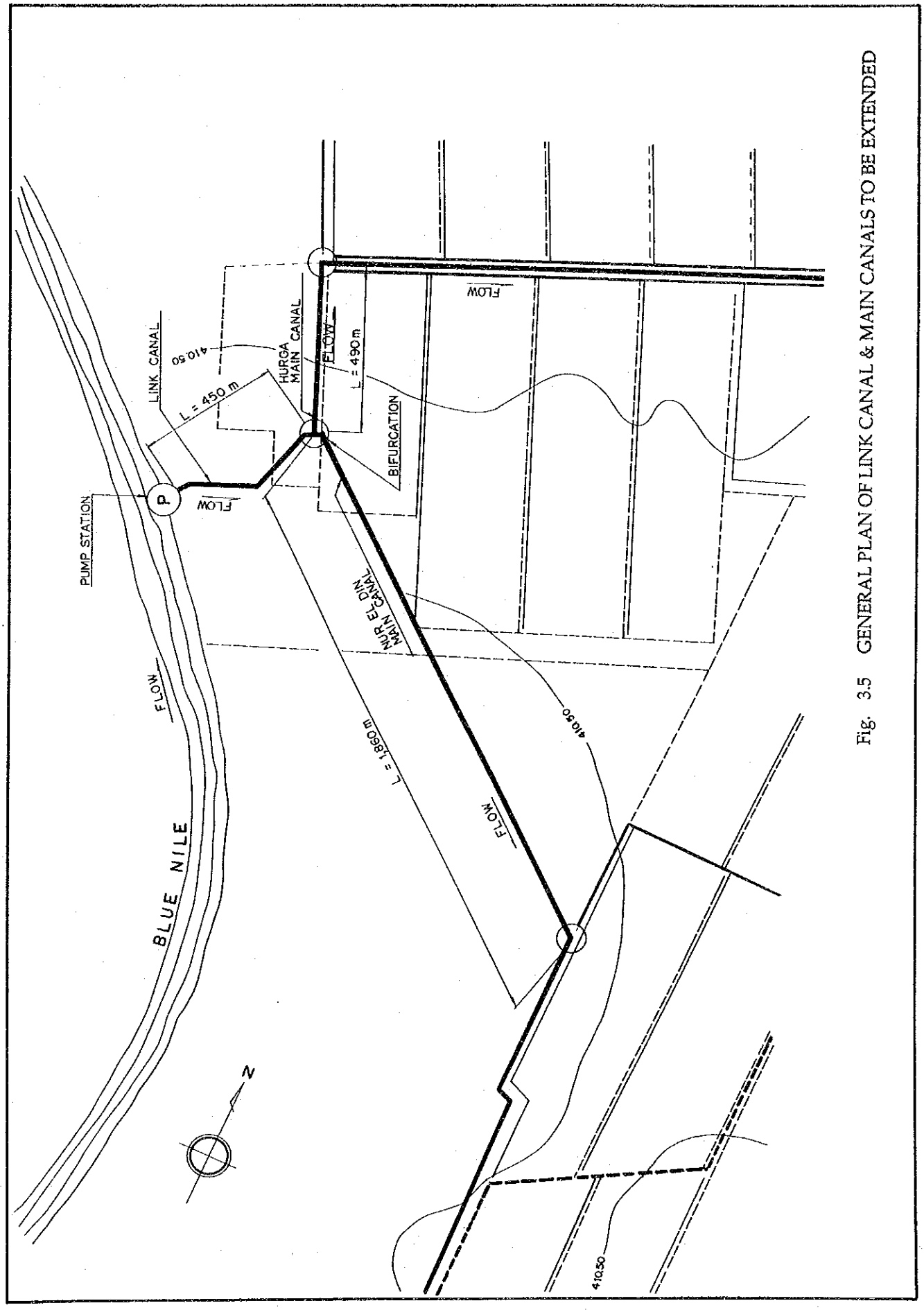


Fig. 3.5 GENERAL PLAN OF LINK CANAL & MAIN CANALS TO BE EXTENDED

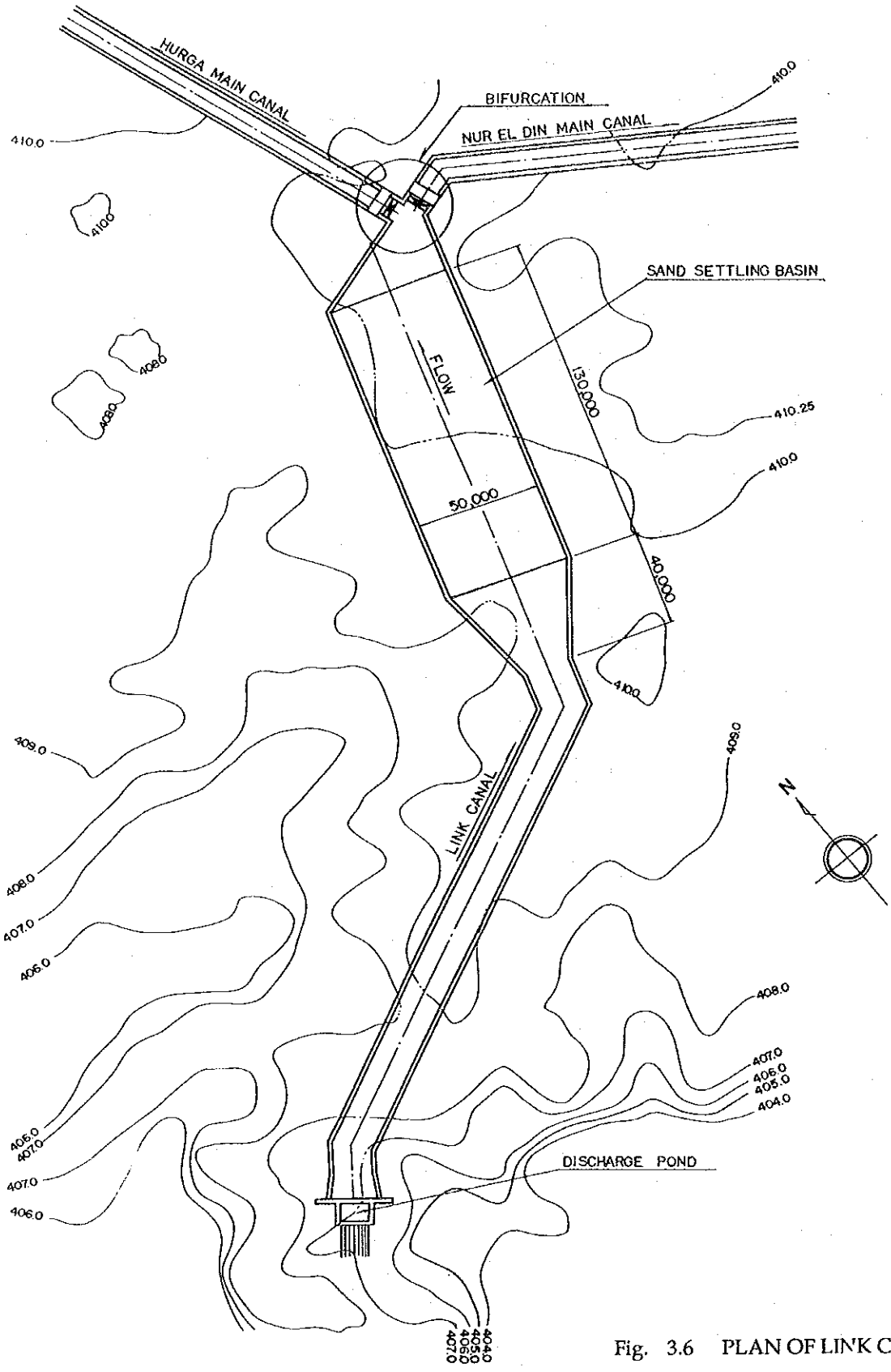
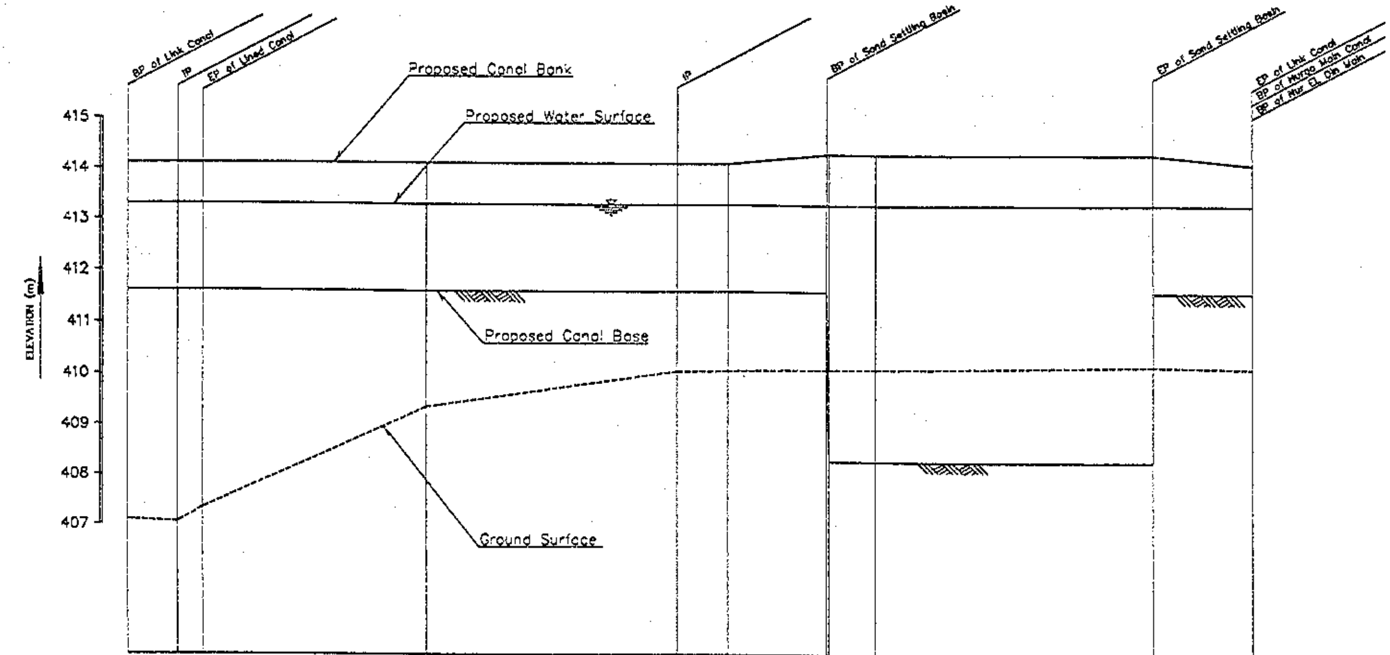


Fig. 3.6 PLAN OF LINK CANAL

PLATE NO.



CANAL TYPE	LINING			I=1/10,000 Q=8.17 m3/s				Sand Settling Basin Q=3.17 m3/s		I=1/10,000 Q=8.17 m3/s		
PROPOSED DESIGN: CANAL BANK ELEVATION	414.11	414.11	414.11	414.10	414.09	414.09	414.27	414.27	414.27	414.26	414.09
PROPOSED DESIGN: WATER SURFACE ELEVATION	413.30	413.30	413.30	413.29	413.28	413.28	413.27	413.27	413.27	413.26	413.25
PROPOSED DESIGN: CANAL BASE ELEVATION	411.61	411.61	411.61	411.60	411.59	411.59	411.53	408.27	408.27	408.26 / 411.57	411.56
EXISTING CONDITIONS: CANAL BANK ELE.(LEFT)											
EXISTING CONDITIONS: CANAL BANK ELE.(RIGHT)											
EXISTING CONDITIONS: GROUND SURFACE ELEVATION	407.10	407.05	407.34	409.35	410.05	410.06	410.08	410.08	410.09	410.15	410.10
REDUCED DISTANCE	0	20	30	120	220	240	260	261	300	410	450
DISTANCE		20	10	90	100	20	40	1	39	110	40
STATION NO.	BP	K 0.020	K 0.030	K 0.120	K 0.220	K 0.240	K 0.260	K 0.261	K 0.300	K 0.410	EP

HORIZONTAL SCALE (m)
0 20 40 60 80 100

Fig. 3.7 PROFILE OF LINK CANAL

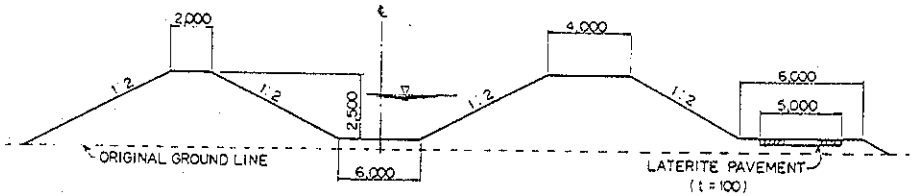
THE REPUBLIC OF THE SUDAN
THE HURGA AND NUR EL DIN PUMP SCHEME
REHABILITATION PROJECT

TITLE OF DRAWING
PROFILE OF LINK CANAL

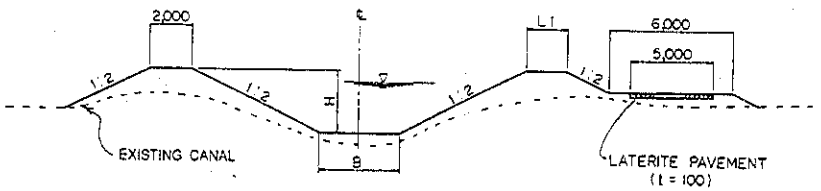
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) | DWG. NO.

IRRIGATION CANAL

(1) LINK CANAL



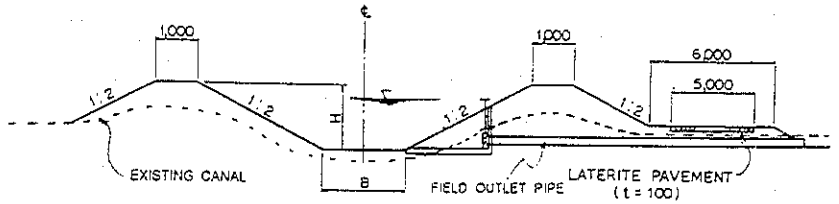
(2) MAIN & MAJOR CANAL



Dimension Table

Canal	Sta No.	B	H	L1	Canal	Sta No.	B	H	L1
	(km)	(m)	(m)	(m)		(km)	(m)	(m)	(m)
(1) Hurga Main					(3) Hurga Major				
Canal	BP - K 0.49	6.0	2.1	4.0	Canal	BP - K 0.60	2.0	1.9	2.0
	K 0.49 - K 2.57	2.0	2.0	4.0		K 0.60 - K 2.49	2.0	1.9	2.0
	K 2.57 - K 5.82	2.0	1.9	4.0		K 2.49 - K 5.62	1.5	1.8	2.0
(2) Nur El Din									
Main Canal	BP - K 1.86	4.0	2.0	4.0					
	K 1.86 - K 6.32	4.0	2.0	4.0					
	K 6.32 - K 11.32	1.5	1.9	4.0					

(3) MINOR CANAL

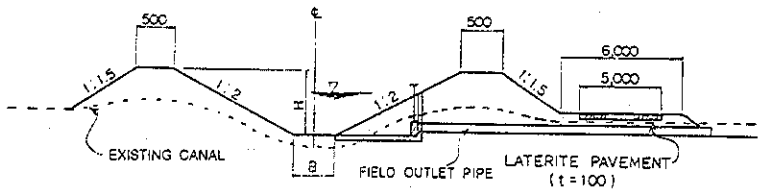


Dimension Table

Canal Name	B	H	Canal Name	B	H
	(m)	(m)		(m)	(m)
H-Ga. No.4(p), H-No.7	0.5	1.3	H-No.2, N-No.3	1.0	1.7
H-Ga. No.3, H-No.4	0.5	1.5	H-No.3	1.0	2.0
H-Ga. No.1	0.5	1.7	N-No.2	1.5	1.7
N-No.1	0.5	1.8	N-No.4	1.5	1.8
H-No.1	0.5	1.9	N-No.5	1.5	1.9
H-No.2(p)	1.0	1.5	H-No.6	2.0	2.0
H-Ga. No.2, H-No.5	1.0	1.6			

Note : H : Hurga Scheme, N : Nur El Din Scheme

(4) DOUBLE ABU XX



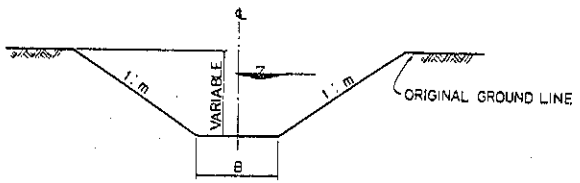
Dimension Table

Canal Name	B	H	Canal Name	B	H
	(m)	(m)		(m)	(m)
H-3.2	0.3	0.5	N-No.2	0.5	0.6
H-6.1, N-No.1	0.3	0.6	H-3.1, H-6.2	0.5	0.7

Note : H : Hurga Scheme, N : Nur El Din Scheme

DRAINAGE CANAL

(1) COLLECTOR & MINOR DRAIN

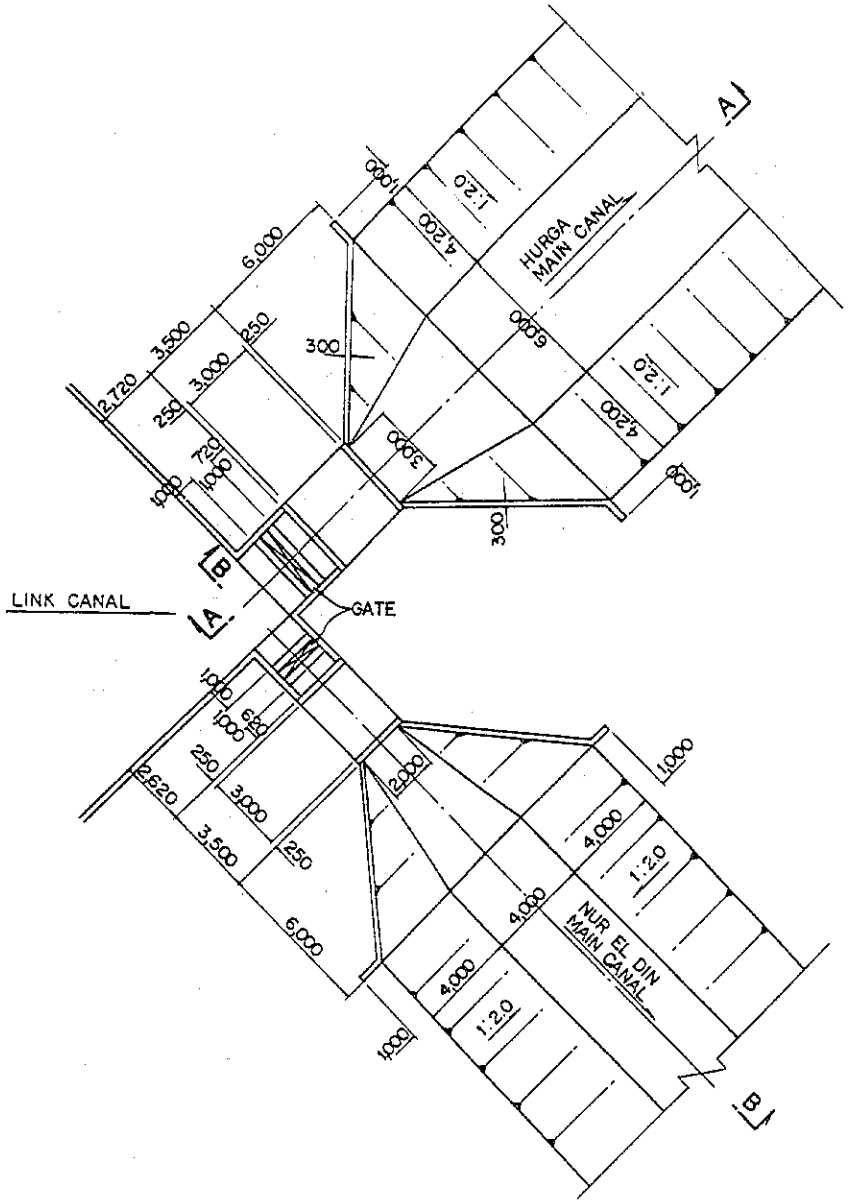


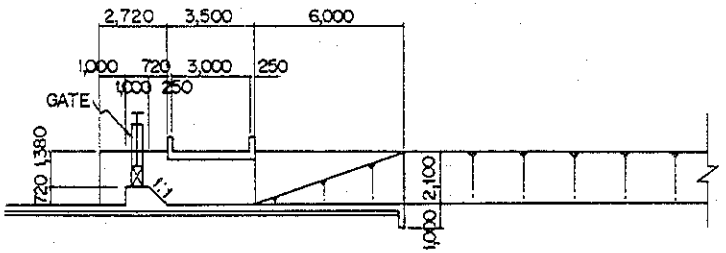
Dimension Table

Canal Name	B	m	Canal Name	B	m
	(m)			(m)	
H-CD.1	0.5	2.0	H-MD.1, H-MD.3, H-MD.5	0.5	1.5
H-CD.2, N-CD.3, N-CD.4	1.0	2.0	H-MD.7, H-MD.8, N-MD.9,	0.5	1.5
H-MD.2, H-MD.6, N-MD.10	0.3	1.5	N-MD.11, N-MD.12, N-MD.13	0.5	1.5
N-MD.14, N-MD.-15	0.3	1.5	H-MD.4	1.0	1.5

Note : H : Hurga Scheme, N : Nur El Din Scheme

Fig. 3.8 TYPICAL CROSS SECTION OF CANAL AND DRAIN





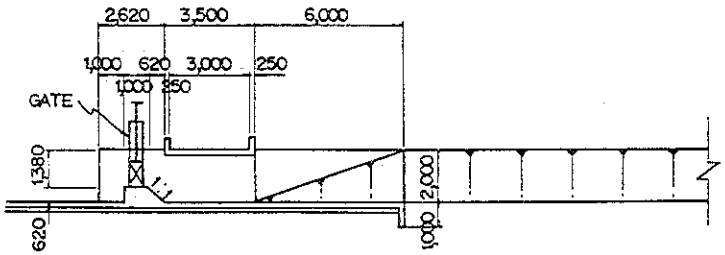
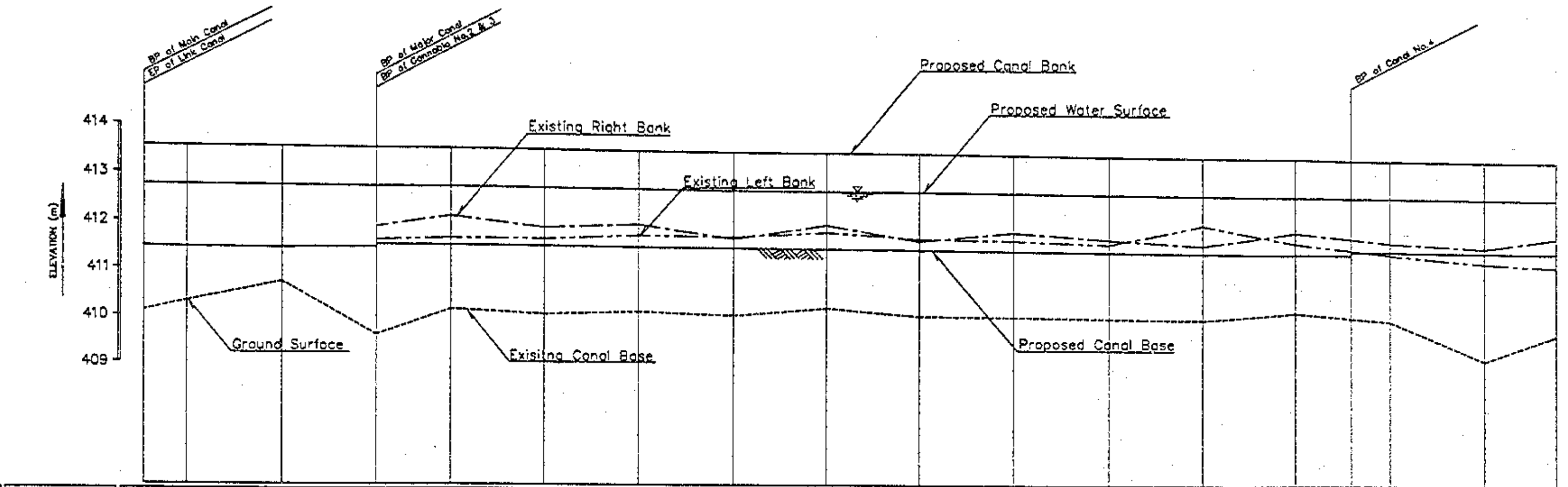


Fig. 3.9 BIFURCATION

PLATE NO.



CANAL TYPE: I=1/10,000, Q= 5.02 m3/s (0 – 490); I=1/10,000, Q= 1.99 m3/s (490 – 2570); I=1/10,000, Q= 1.59 m3/s (2570 – 3000)

STATION NO.	DISTANCE	REDUCED DISTANCE	PROPOSED DESIGN: CANAL BANK ELEVATION	PROPOSED DESIGN: WATER SURFACE ELEVATION	PROPOSED DESIGN: CANAL BASE ELEVATION	EXISTING CONDITIONS: CANAL BANK ELE.(LEFT)	EXISTING CONDITIONS: CANAL BANK ELE.(RIGHT)	EXISTING CONDITIONS: CANAL BASE ELEVATION
[illegible]		0	413.55	412.75	411.45			410.10
K 0.090	90	90	413.54	412.74	411.44			410.30
K 0.280	200	280	413.52	412.72	411.42			410.71
K 0.490	200	490	413.49	412.70	411.40 / 411.49	411.58	411.87	409.56
K 0.650	160	650	413.48	412.69	411.48	411.83	412.06	410.13
K 0.850	200	850	413.46	412.67	411.46	411.61	411.85	410.03
K 1.050	200	1050	413.44	412.65	411.44	411.69	411.92	410.09
K 1.250	200	1250	413.42	412.63	411.42	411.66	411.62	410.01
K 1.450	200	1450	413.40	412.61	411.40	411.78	411.81	410.18
K 1.650	200	1650	413.38	412.59	411.38	411.62	411.57	409.99
K 1.850	200	1850	413.36	412.57	411.36	411.58	411.79	409.88
K 2.050	200	2050	413.34	412.55	411.34	411.51	411.81	409.93
K 2.250	200	2250	413.32	412.53	411.32	411.92	411.49	409.93
K 2.450	200	2450	413.30	412.51	411.30	411.54	411.77	410.05
K 2.570	120	2570	413.27	412.49	411.28 / 411.37	411.40	411.84	409.97
K 2.651	61	2651	413.26	412.48	411.36	411.30	411.55	409.90
K 2.851	200	2851	413.24	412.46	411.34	411.12	411.44	409.06
K 3.000	149	3000	413.23	412.45	411.33	411.05	411.65	409.60

HORIZONTAL SCALE (m) 0 100 200 300 400 500

Fig. 3.10 (1/2) PROFILE OF MAIN CANAL FOR HURGA

THE REPUBLIC OF THE SUDAN
THE HURGA AND NUR EL DIN PUMP SCHEME
REHABILITATION PROJECT

TITLE OF DRAWING
PROFILE OF HURGA
MAIN CANAL (1/2)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
DWG. NO.

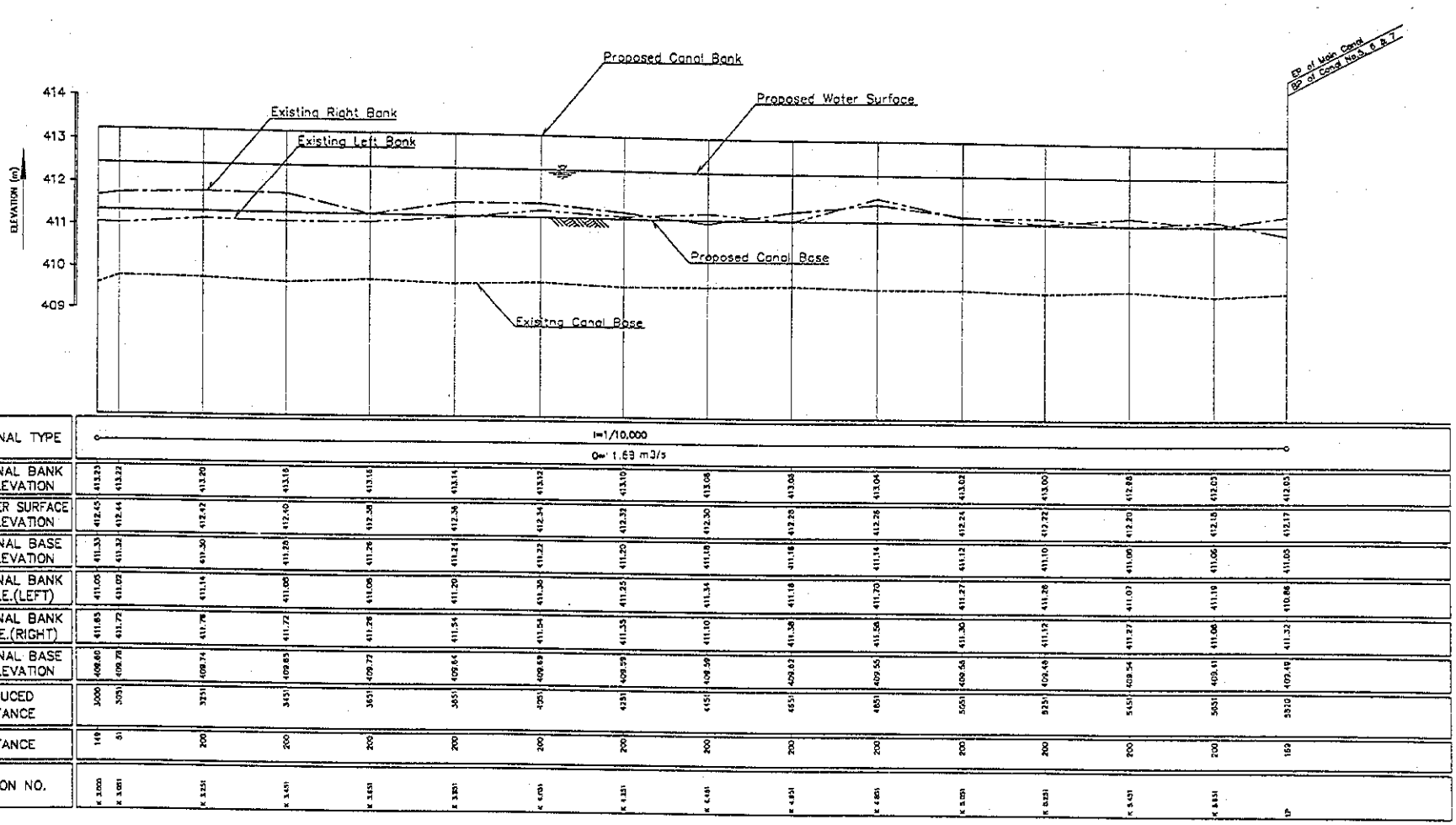


Fig. 3.10 (2/2) PROFILE OF MAIN CANAL FOR HURGA

HORIZONTAL SCALE (m)
0 100 200 300 400 500

THE REPUBLIC OF THE SUDAN
THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

TITLE OF DRAWING
PROFILE OF HURGA MAIN CANAL (2/2)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DWG. NO.

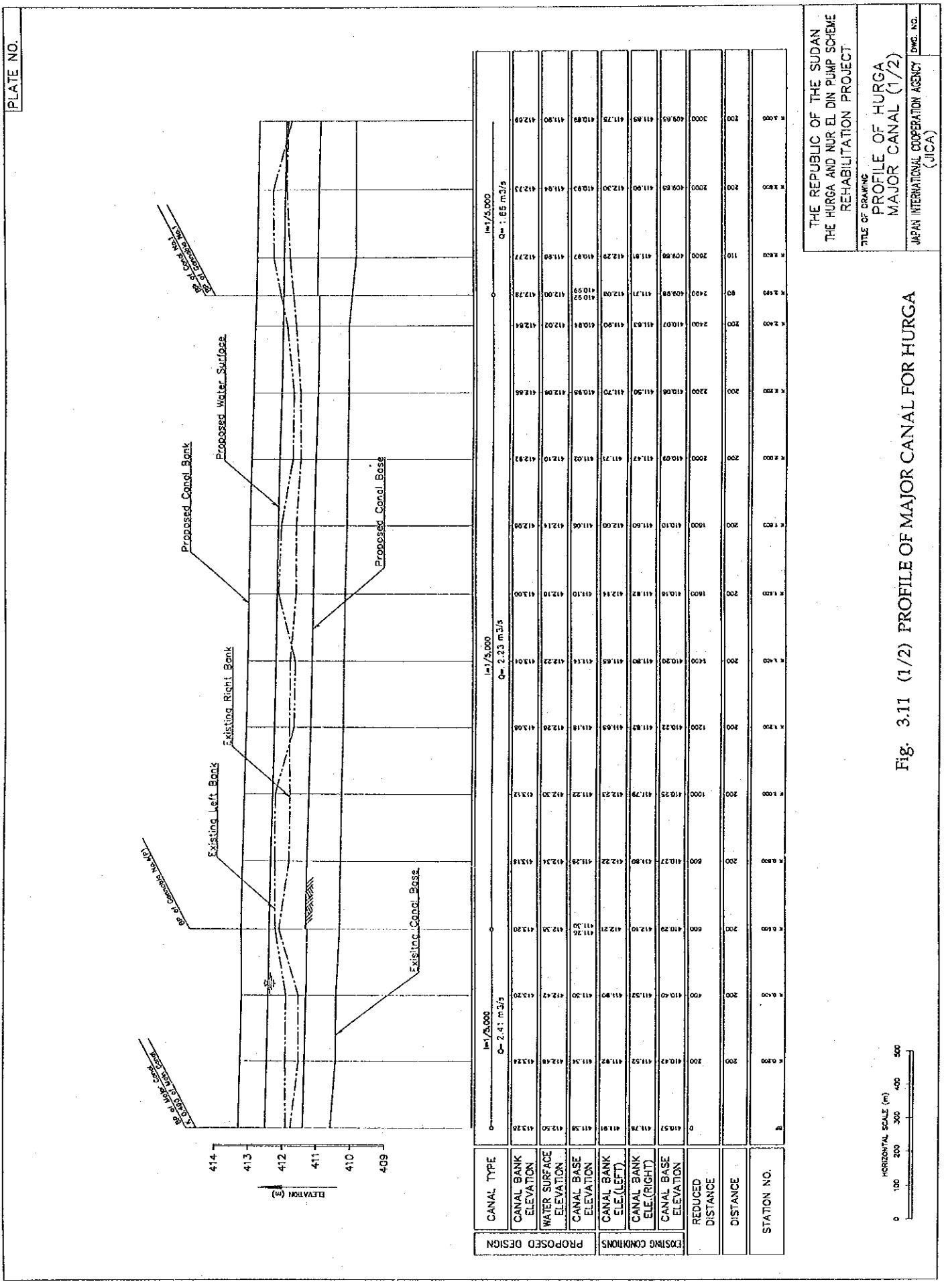
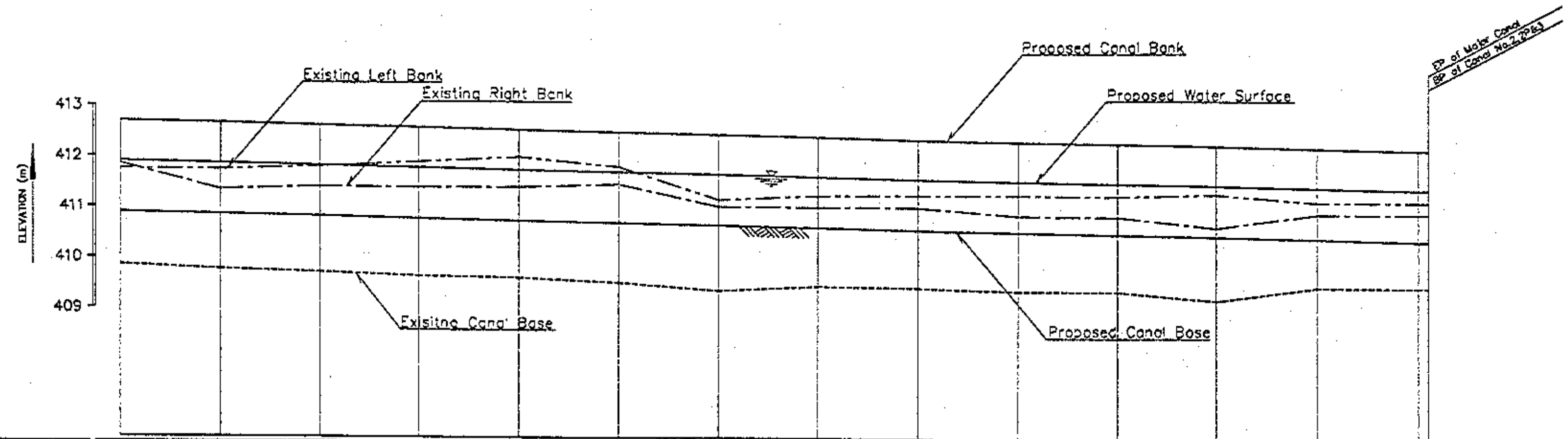


Fig. 3.11 (1/2) PROFILE OF MAJOR CANAL FOR HURGA



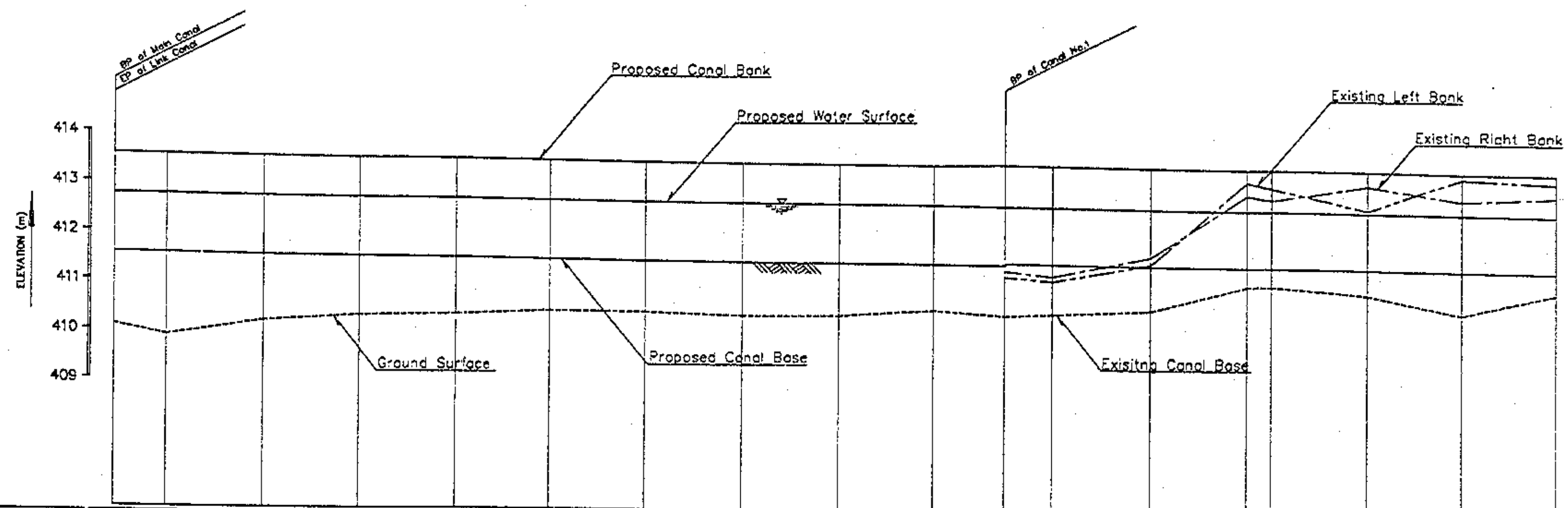
PROPOSED DESIGN	CANAL TYPE	I=1/5,000 Q= 1.66 m2/s													
	CANAL BANK ELEVATION	412.89	412.85	412.81	412.57	412.53	412.49	412.45	412.41	412.37	412.33	412.29	412.25	412.21	412.17 412.17
	WATER SURFACE ELEVATION	411.90	411.86	411.82	411.78	411.74	411.70	411.66	411.62	411.58	411.54	411.50	411.46	411.42	411.38 411.38
	CANAL BASE ELEVATION	410.89	410.85	410.81	410.77	410.73	410.69	410.65	410.61	410.57	410.53	410.49	410.45	410.41	410.37 410.37
EXISTING CONDITIONS	CANAL BANK ELE.(LEFT)	411.75	411.74	411.80	411.90	412.00	411.81	411.18	411.25	411.27	411.27	411.25	411.29	411.14	411.14 411.14
	CANAL BANK ELE.(RIGHT)	411.85	411.34	411.40	411.39	411.40	411.46	411.03	411.02	411.03	410.86	410.84	410.83	410.80	410.80 410.80
	CANAL BASE ELEVATION	409.85	409.78	409.70	409.63	409.60	409.51	409.38	409.45	409.43	409.37	409.38	409.19	409.45	409.45 409.45
REDUCED DISTANCE		3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000	5200	5400	5600 5620
DISTANCE			200	200	200	200	200	200	200	200	200	200	200	200	200 20
STATION NO.		K 3.000	K 3.200	K 3.400	K 3.600	K 3.800	K 4.000	K 4.200	K 4.400	K 4.600	K 4.800	K 5.000	K 5.200	K 5.400	K 5.600 6

HORIZONTAL SCALE (m) 0 100 200 300 400 500

Fig. 3.11 (2/2) PROFILE OF MAJOR CANAL FOR HURGA

THE REPUBLIC OF THE SUDAN THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT	
TITLE OF DRAWING PROFILE OF HURGA MAJOR CANAL (2/2)	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	DWG. NO.

PLATE NO.



		Station 0	K 0.110	K 0.310	K 0.510	K 0.710	K 0.910	K 1.110	K 1.310	K 1.510
	CANAL TYPE	I=10,000, Q=3.15 m3/s								
PROPOSED DESIGN	CANAL BANK ELEVATION	413.55	413.54	413.52	413.50	413.48	413.46	413.44	413.42	413.40
	WATER SURFACE ELEVATION	412.75	412.74	412.72	412.70	412.68	412.66	412.64	412.62	412.60
	CANAL BASE ELEVATION	411.55	411.54	411.52	411.50	411.48	411.46	411.44	411.42	411.40
EXISTING CONDITIONS	CANAL BANK ELE.(LEFT)									
	CANAL BANK ELE.(RIGHT)									
	CANAL BASE ELEVATION	410.10	409.89	410.20	410.31	410.34	410.42	410.41	410.35	410.35
	REDUCED DISTANCE	0	110	310	510	710	910	1110	1310	1510
	DISTANCE		110	200	200	200	200	200	200	200
	STATION NO.	0	K 0.110	K 0.310	K 0.510	K 0.710	K 0.910	K 1.110	K 1.310	K 1.510

		K 1.710	K 1.860	K 1.960	K 2.160	K 2.360	K 2.410	K 2.610	K 2.810	K 3.000
	CANAL TYPE		I=1/10,000, Q= 2.93 m3/s							
PROPOSED DESIGN	CANAL BANK ELEVATION	413.38	413.40	413.39	413.37	413.35	413.35	413.33	413.31	413.29
	WATER SURFACE ELEVATION	412.58	412.56	412.55	412.53	412.51	412.51	412.49	412.47	412.45
	CANAL BASE ELEVATION	411.38	411.36 / 411.40	411.39	411.37	411.35	411.35	411.33	411.31	411.29
EXISTING CONDITIONS	CANAL BANK ELE.(LEFT)		411.13	411.05	411.41	413.10	412.98	412.54	413.20	413.11
	CANAL BANK ELE.(RIGHT)		411.25	411.15	411.58	412.83	412.74	413.04	412.75	412.84
	CANAL BASE ELEVATION	410.45	410.35	410.39	410.45	410.87	410.98	410.82	410.45	410.87
	REDUCED DISTANCE	1710	1860	1960	2160	2360	2410	2610	2810	3000
	DISTANCE	200	150	100	200	200	50	200	200	190
	STATION NO.	K 1.710	K 1.860	K 1.960	K 2.160	K 2.360	K 2.410	K 2.610	K 2.810	K 3.000

HORIZONTAL SCALE (m)
0 100 200 300 400 500

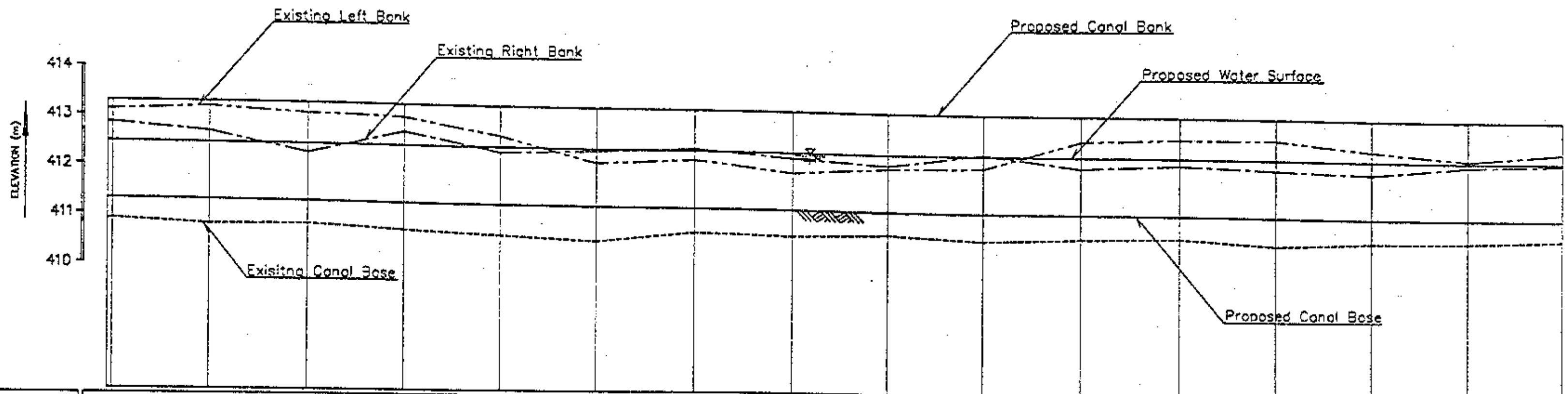
Fig. 3.12 (1/4) PROFILE OF MAIN CANAL FOR NUR EL DIN

THE REPUBLIC OF THE SUDAN
THE HURGA AND NUR EL DIN PUMP SCHEME
REHABILITATION PROJECT

TITLE OF DRAWING
PROFILE OF NUR EL DIN
MAIN CANAL (1/4)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DWG. NO.



PROPOSED DESIGN	CANAL TYPE	I=1/10,000 Q= 2.93 m3/s															
	CANAL BANK ELEVATION	413.29 / 413.28	413.27	413.25	413.23	413.21	413.19	413.17	413.15	413.13	413.11	413.09	413.07	413.05	413.03	413.01	412.99
	WATER SURFACE ELEVATION	412.45 / 412.45	412.43	412.41	412.39	412.37	412.35	412.33	412.31	412.29	412.27	412.25	412.23	412.21	412.19	412.17	412.15
	CANAL BASE ELEVATION	411.29 / 411.28	411.27	411.25	411.23	411.21	411.19	411.17	411.15	411.13	411.11	411.09	411.07	411.05	411.03	411.01	410.99
EXISTING CONDITIONS	CANAL BANK ELE.(LEFT)	413.11 / 413.11	413.17	413.04	412.97	412.60	412.07	412.15	411.90	412.01	412.02	412.55	412.62	412.82	412.40	412.21	412.35
	CANAL BANK ELE.(RIGHT)	412.84 / 412.84	412.68	412.23	412.87	412.27	412.31	412.38	412.20	412.07	412.30	412.03	412.09	412.01	411.83	412.09	412.12
	CANAL BASE ELEVATION	410.87 / 410.89	410.78	410.79	410.68	410.59	410.49	410.68	410.82	410.87	410.55	410.59	410.61	410.48	410.53	410.55	410.59
REDUCED DISTANCE		3000 / 3010	3210	3410	3610	3810	4010	4210	4410	4610	4810	5010	5210	5410	5610	5810	6000
DISTANCE		190 / 10	200	200	200	200	200	200	200	200	200	200	200	200	200	200	190
STATION NO.		K 3,000 / 3,010	K 3,210	K 3,410	K 3,610	K 3,810	K 4,010	K 4,210	K 4,410	K 4,610	K 4,810	K 5,010	K 5,210	K 5,410	K 5,610	K 5,810	K 6,000

HORIZONTAL SCALE (m)
0 100 200 300 400 500

Fig. 3.12 (2/4) PROFILE OF MAIN CANAL FOR NUR EL DIN

THE REPUBLIC OF THE SUDAN
THE HURGA AND NUR EL DIN PUMP SCHEME
REHABILITATION PROJECT

TITLE OF DRAWING
PROFILE OF NUR EL DIN
MAIN CANAL (2/4)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) | DWG. NO.

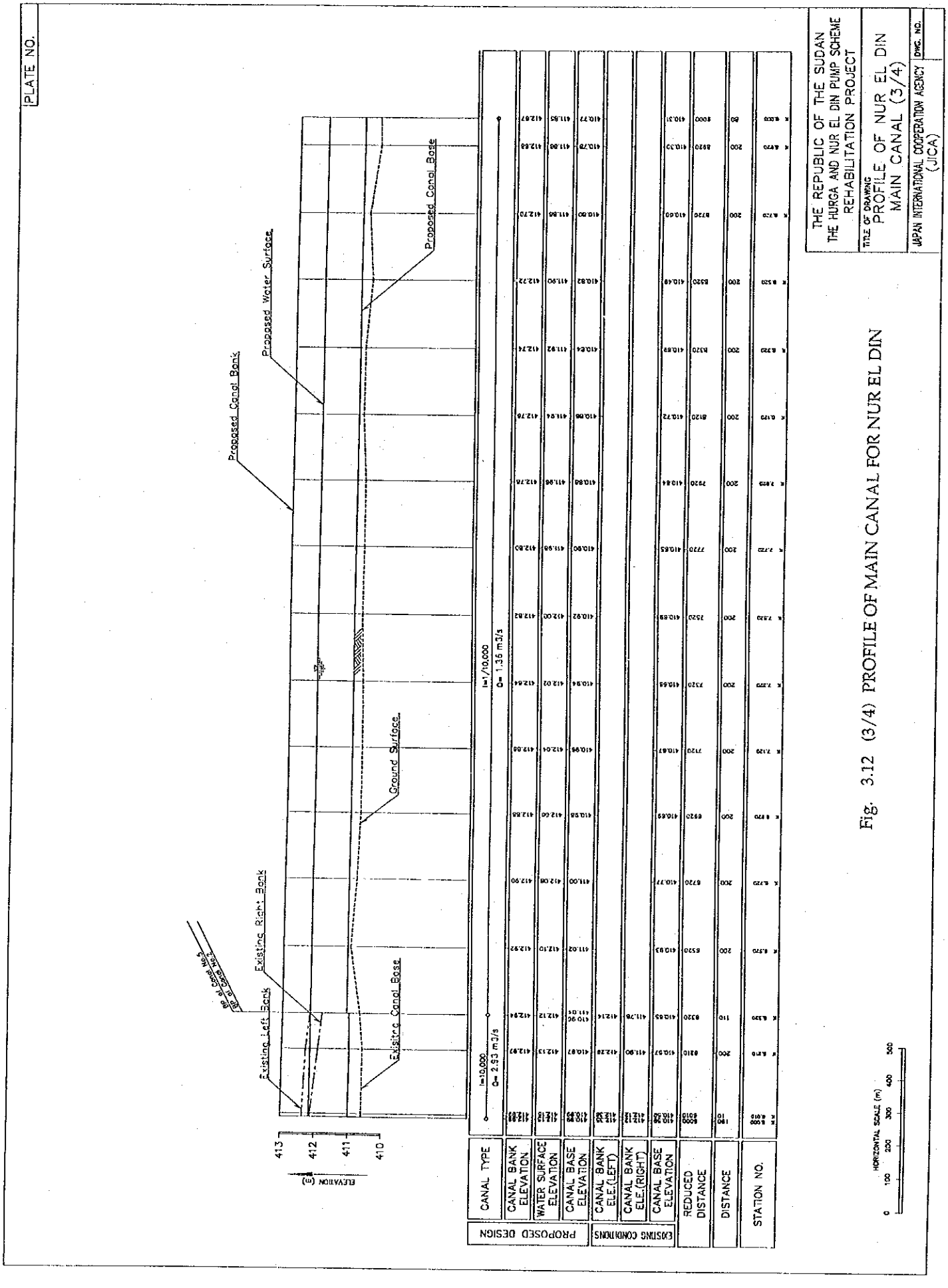


Fig. 3.12 (3/4) PROFILE OF MAIN CANAL FOR NUR EL DIN

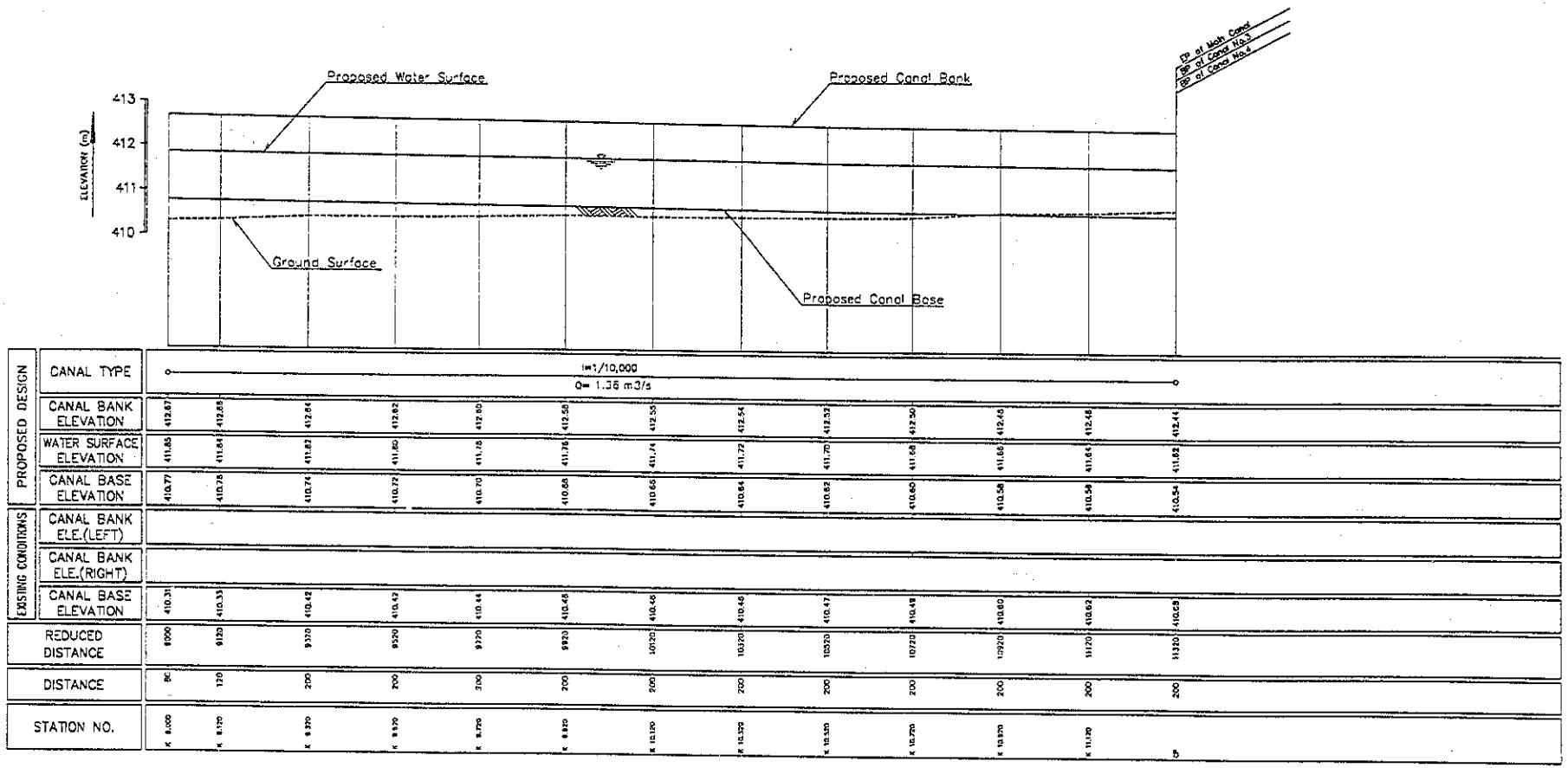


Fig. 3.12 (4/4) PROFILE OF MAIN CANAL FOR NUR EL DIN

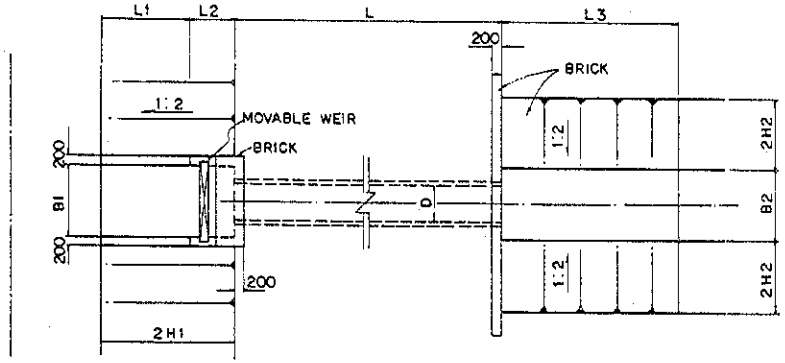
THE REPUBLIC OF THE SUDAN
THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

TITLE OF DRAWING
PROFILE OF NUR EL DIN MAIN CANAL (4/4)

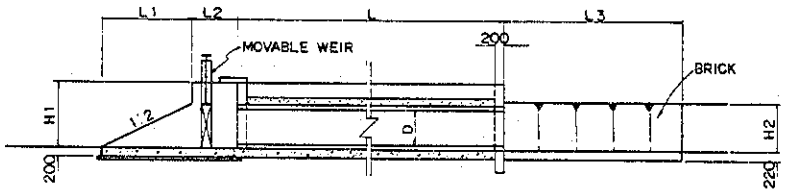
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DWG. NO.

MOVABLE WEIR



PLAN



LONGITUDINAL SECTION

DIMENSION TABLE

Offtake Canal Name	B1 (mm)	H1 (mm)	B2 (mm)	H2 (mm)	D (mm)	L1 (mm)	L2 (mm)	L3 (mm)	L (mm)
(1) Hurga Scheme									
Ga. No.1, No.1	1,000	1,900	500	1,700, 1,900	760	2,300	1,500	5,000	7,500
Ga. No.3	1,000	2,100	500	1,500	500	2,700	1,500	5,000	7,500
No.4	1,000	2,000	500	1,500	760	2,500	1,500	5,000	7,500
No.7,Ga. No.4(p)	1,000	1,900	500	1,300	500	2,300	1,500	5,000	7,500
Ga. No.2	1,500	2,100	1,000	1,800	910	2,700	1,500	5,000	7,500
No.2(p), No.2	1,500	1,800	1,000	1,500, 1,700	760	2,100	1,500	5,000	7,500
No.3	1,500	1,800	1,000	2,000	910	2,100	1,500	5,000	7,500
No.5	1,500	1,900	1,000	1,800	760	2,300	1,500	5,000	7,500
No.6	2,000	1,900	2,000	2,000	1,240	2,300	1,500	5,000	7,500
Major	2,000	2,100	2,000	1,900	1500*1500<1	2,700	1,500	5,000	7,500
(2) Nur El Din Scheme									
No.1	1,000	2,000	500	1,800	760	2,500	1,500	5,000	7,500
No.2	1,500	2,000	1,500	1,700	910	2,500	1,500	5,000	7,500
No.3	1,500	2,000	1,500	1,900	1,010	2,500	1,500	5,000	7,500
No.4	1,500	1,900	1,000	1,700	910	2,300	1,500	5,000	7,500
No.5	1,500	1,900	1,500	1,800	910	2,300	1,500	5,000	7,500

Note : <1 : Box Type

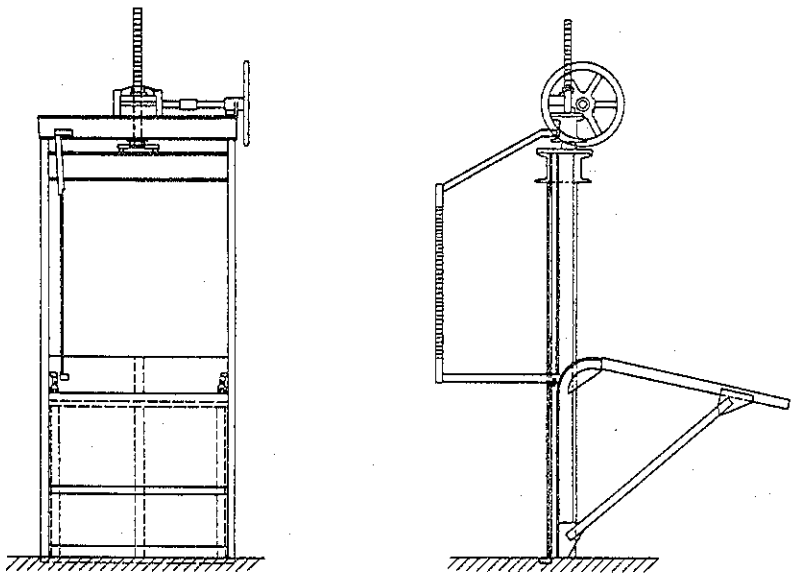
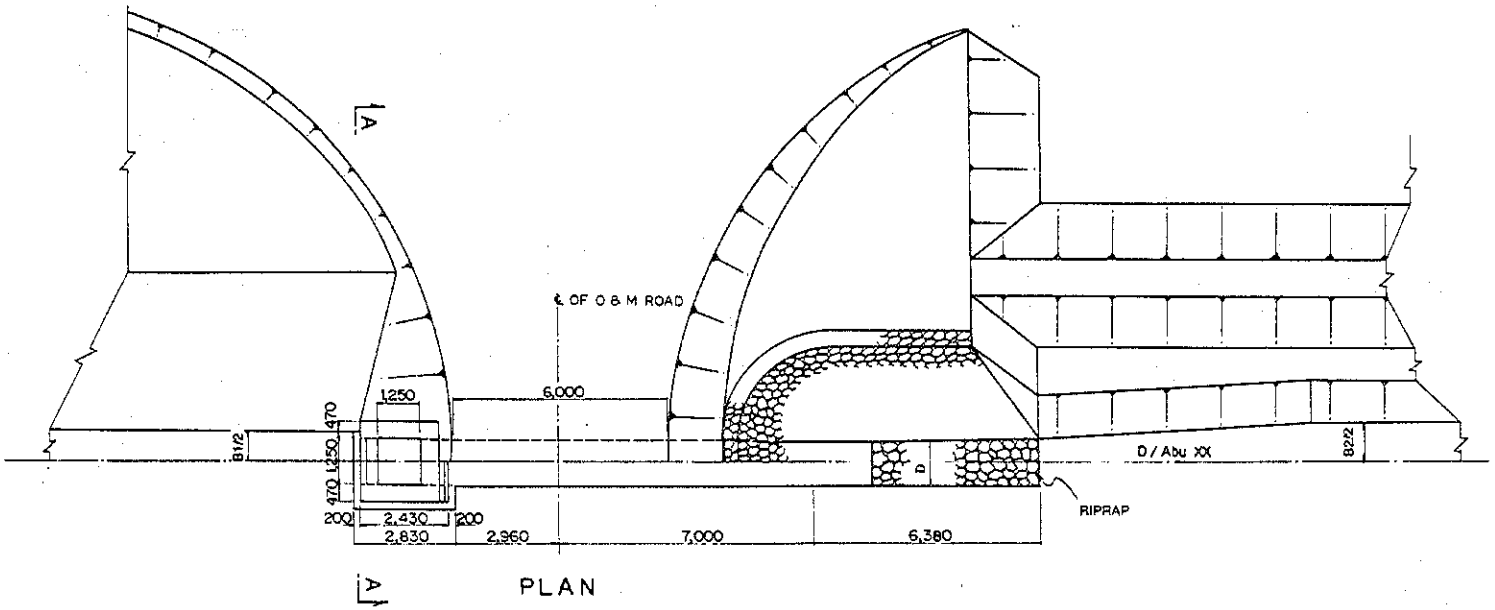
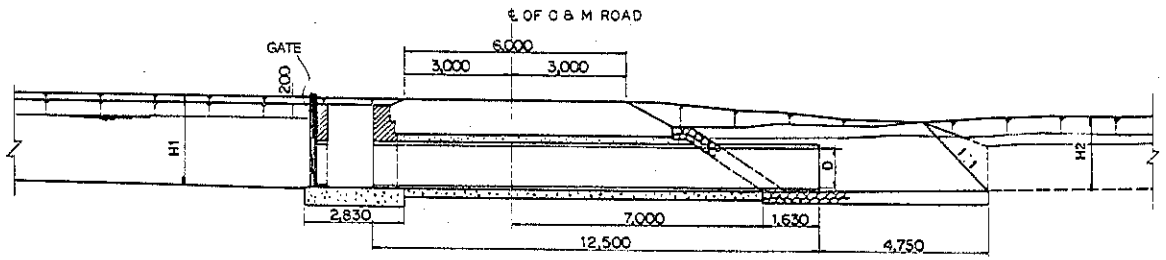
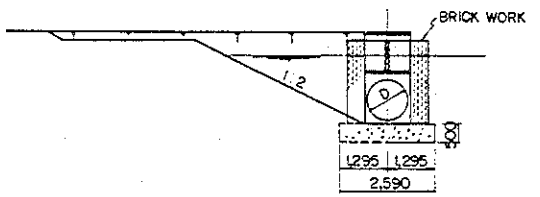


Fig. 3.13 MOVABLE WEIR





LONGITUDINAL SECTION

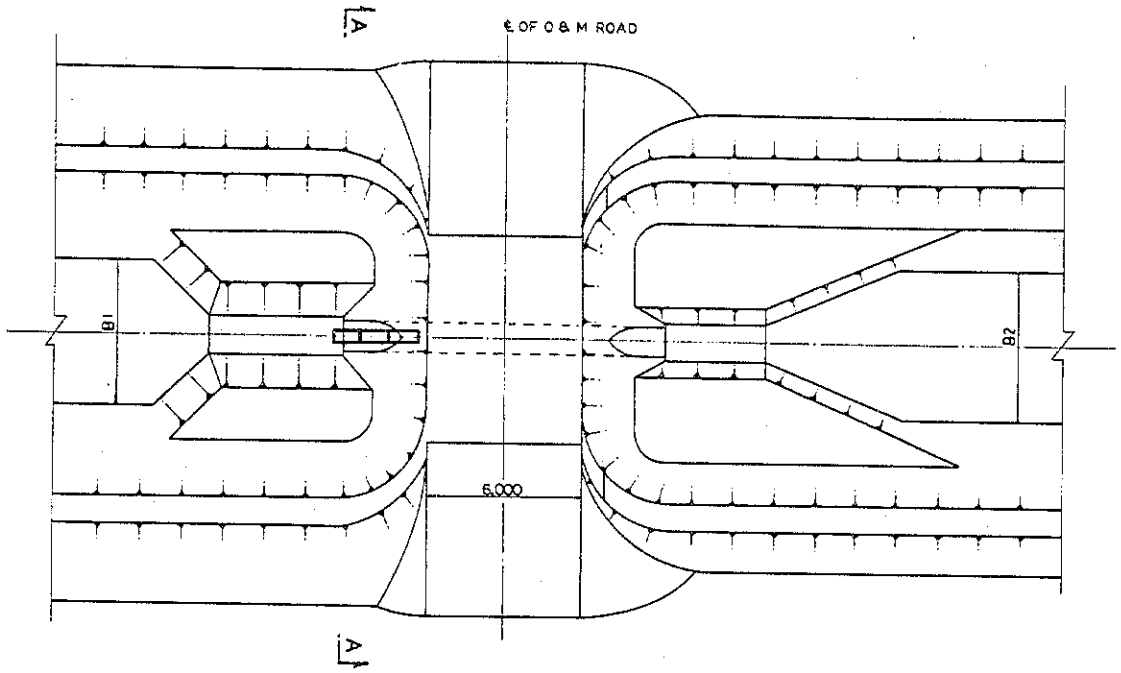


SECTION A-A

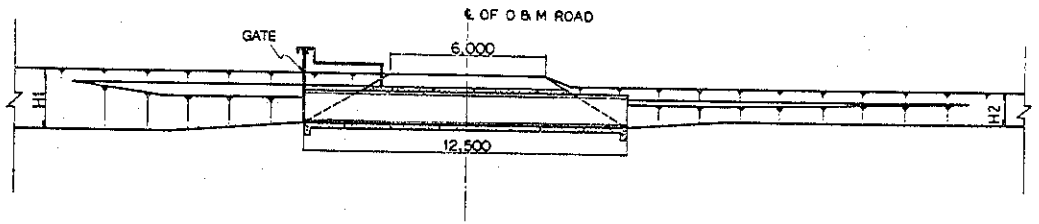
DIMENSION TABLE

Canal Name	B1	H1	B2	H2	D
	(mm)	(mm)	(mm)	(mm)	(mm)
D/Abu xx-3.1	1,000	2,000	500	700	500
D/Abu xx-3.2	1,000	2,000	300	500	350
D/Abu xx-6.1	2,000	2,000	300	600	350
D/Abu xx-6.2	2,000	2,000	500	700	500
D/Abu xx No.1	1,500	1,800	300	600	350
D/Abu xx No.2	1,500	1,700	500	600	500

Fig. 3.14 WELL-HEAD REGULATOR



PLAN



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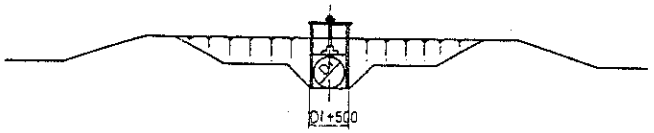
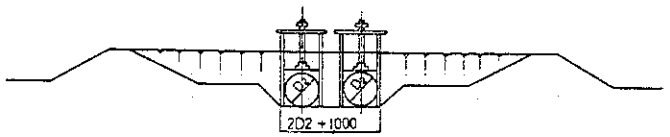


SECTION A-A
(SINGLE PIPE)

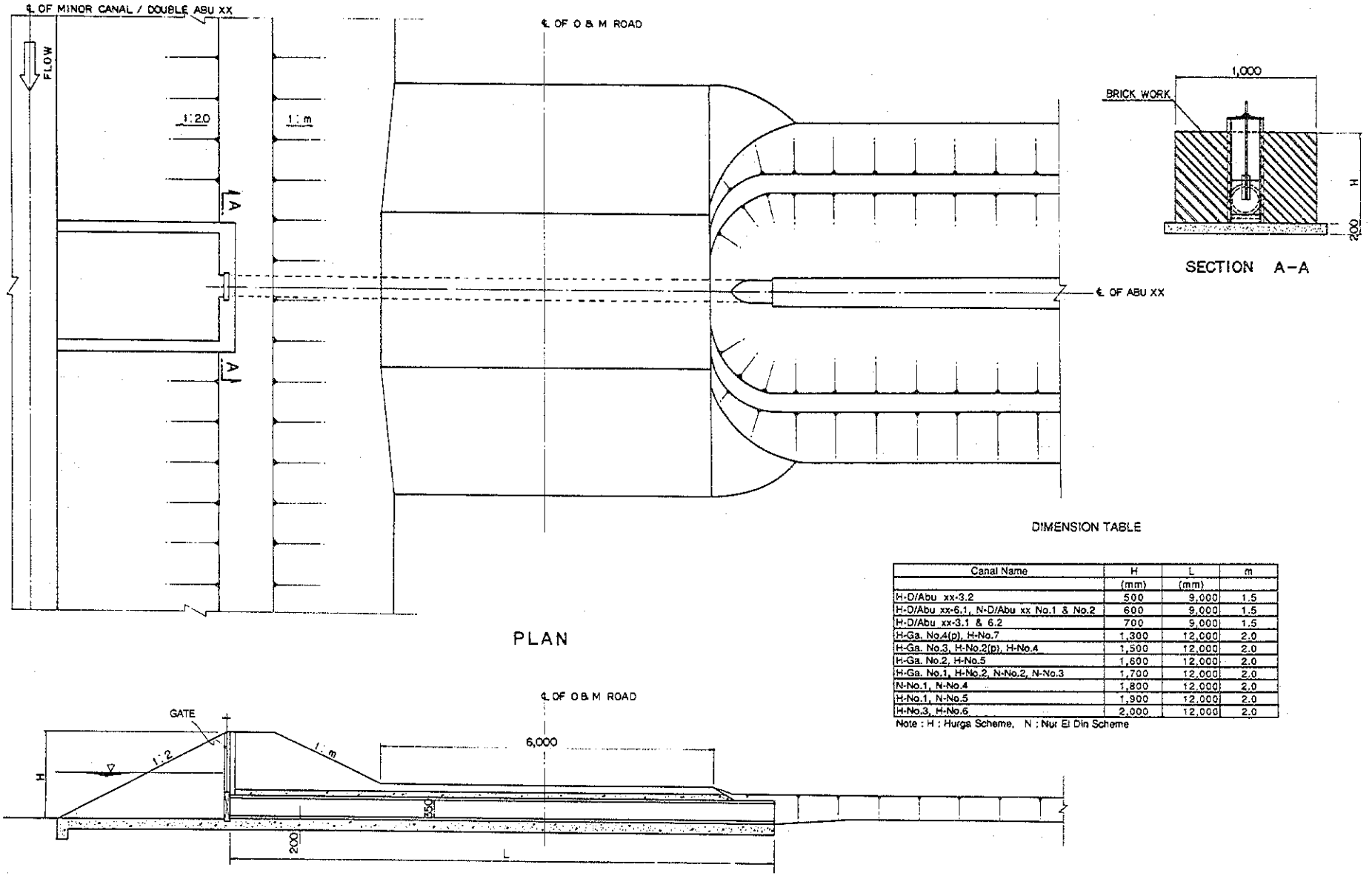


SECTION A-A
(DOUBLE PIPE)

DIMENSION TABLE

TYPE	Q	B1	H1	B2	H2	D1	D2
	(m3/s)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
A	0.0 - 0.2	500	1,300 - 1,500	500	1,300 - 1,500	500	-
B	0.2 - 0.5	500, 1,000	1,500 - 1,900	500, 1,000	1,500 - 1,900	760	-
C	0.5 - 1.0	1,000, 1,500	1,700 - 2,000	1,000, 1,500	1,700 - 2,000	910	-
D	1.0 - 1.5	2,000	2,000	2,000	2,000	1,010	
E	1.5 - 2.0	2,000	2,000	2,000	1,900	-	1,240
F	2.0 -	4,000	2,000	1,500	1,900	-	1,240

Fig. 3.15 CROSS REGULATOR (PIPE REGULATOR)

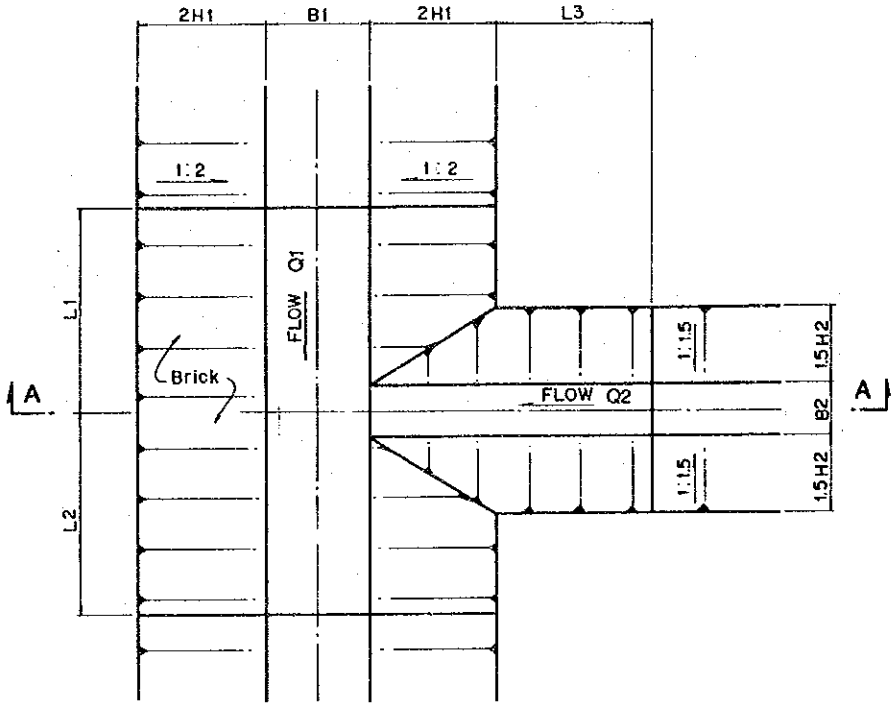


DIMENSION TABLE

Canal Name	H (mm)	L (mm)	m
H-D/Abu xx-3.2	500	9,000	1.5
H-D/Abu xx-6.1, N-D/Abu xx No.1 & No.2	600	9,000	1.5
H-D/Abu xx-3.1 & 6.2	700	9,000	1.5
H-Ga. No.4(p), H-No.7	1,300	12,000	2.0
H-Ga. No.3, H-No.2(p), H-No.4	1,500	12,000	2.0
H-Ga. No.2, H-No.5	1,600	12,000	2.0
H-Ga. No.1, H-No.2, N-No.2, N-No.3	1,700	12,000	2.0
N-No.1, N-No.4	1,800	12,000	2.0
H-No.1, N-No.5	1,900	12,000	2.0
H-No.3, H-No.6	2,000	12,000	2.0

Note : H : Hurga Scheme, N : Nur El Din Scheme

Fig. 3.16 FIELD OUTLET PIPE



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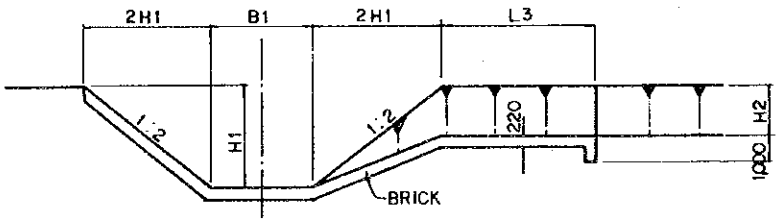

SECTION A-A

DIMENSION TABLE

TYPE	Q1	Q2	B1	H1	B2	H2	L1	L2	L3
	(m3/s)	(m3/s)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
A	0.1 - 0.3	0 .0- 0.1	500	900	300	700	4,000	5,000	3,000
B	0.3 -	0 .0- 0.1	1,000	1,000	300	600	4,000	5,000	3,000
C	0.3 -	0.1 - 0.3	1,000	1,000	500	800	4,000	5,000	3,000
D	0.3 -	0.3 -	1,000	1,000	1,000	1,100	4,000	5,000	3,000

Fig. 3.17 DRAINAGE JUNCTION

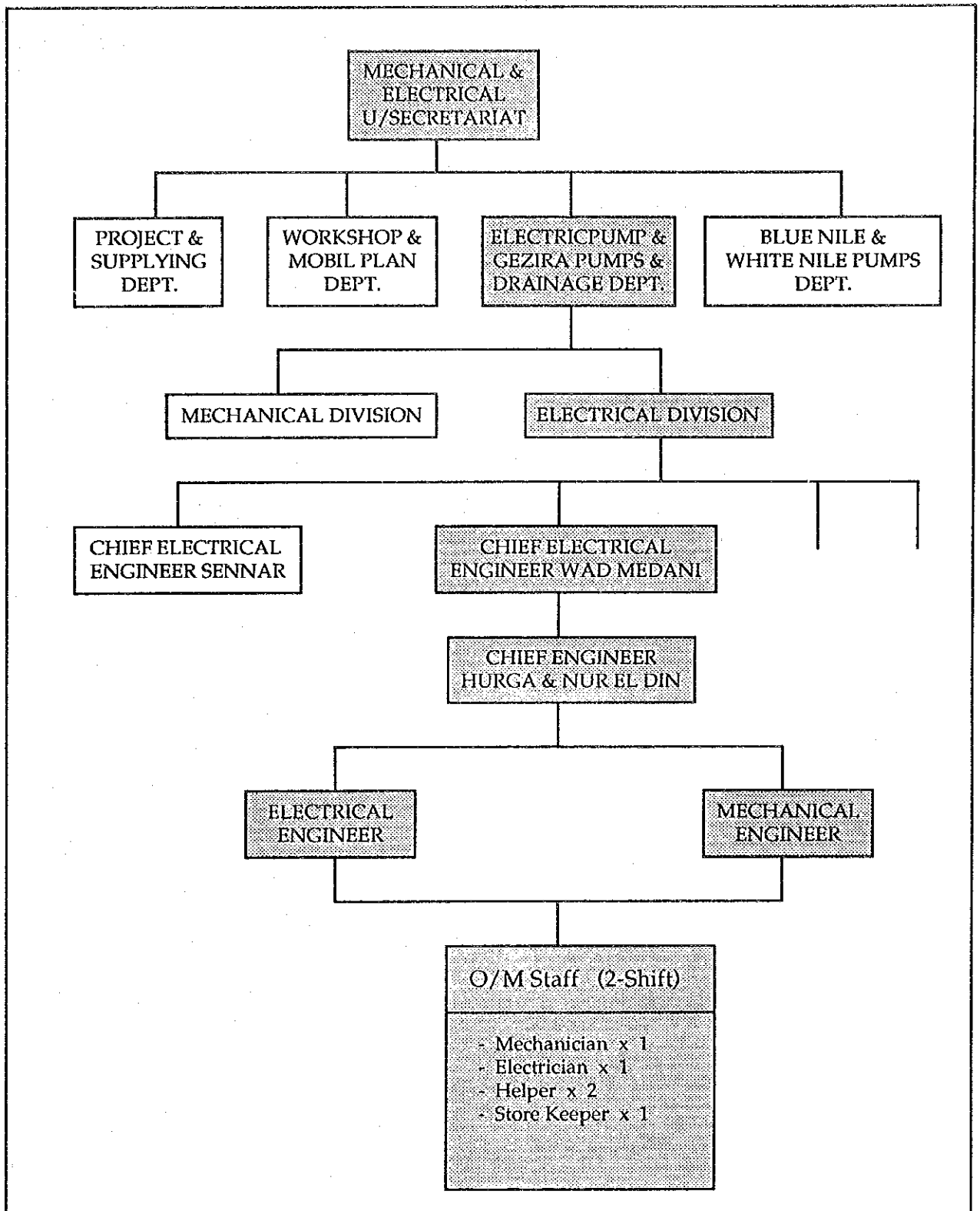

Fig. 3.18 ORGANIZATION STRUCTURE FOR O & M OF PUMPING STATION

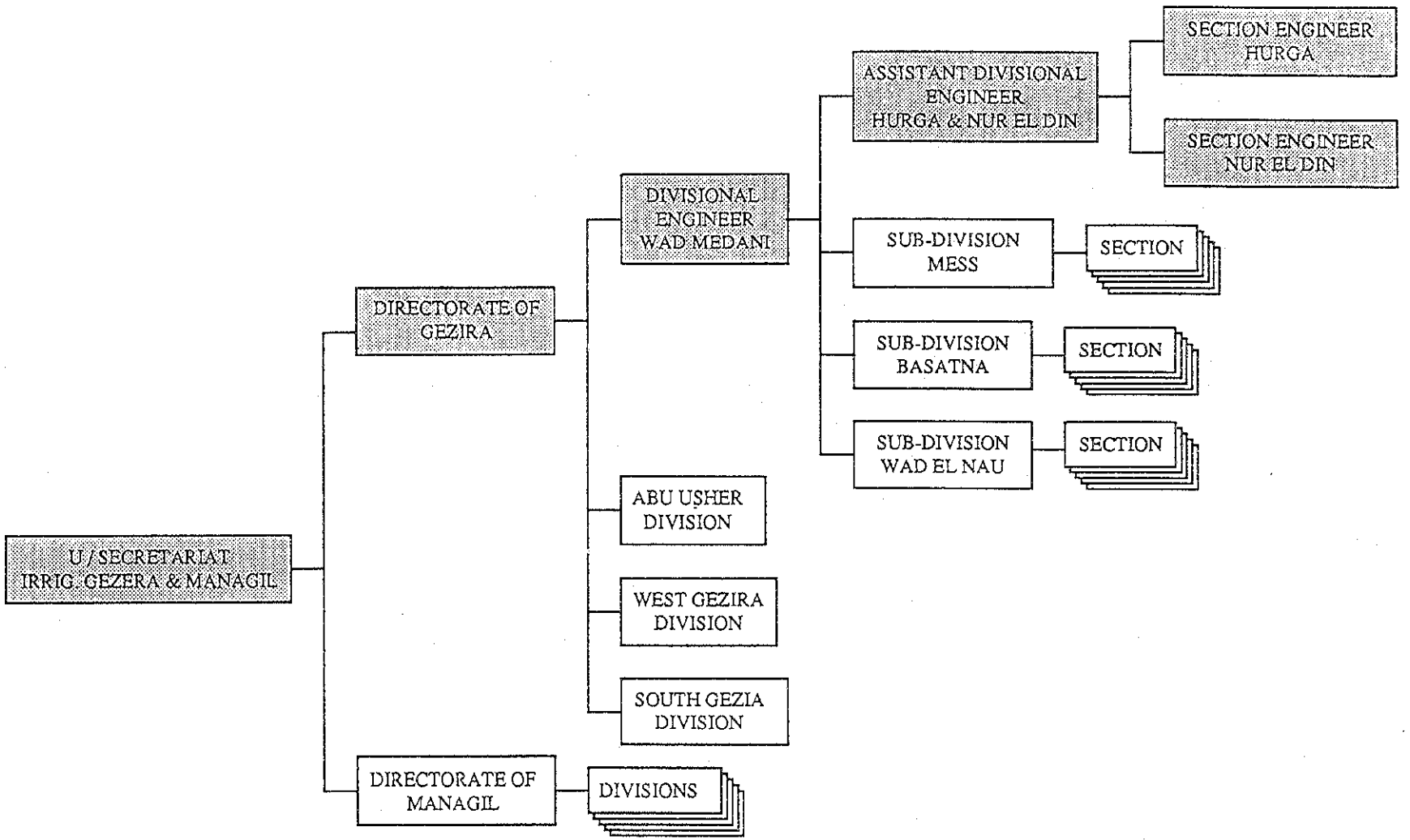

Fig. 3.19 ORGANIZATION STRUCTURE FOR O&M OF CANAL SYSTEM

APPENDIX

APPENDIX-I

FIELD INTAKE RATE TEST

Intake Rate Tests

Intake rate tests by cylinders and ponding method as well were conducted at three sites, No. 1, No. 2, No. 3 during Dec. 2 -4, 1990.

The condition of intake rates is as follows :

1) Location of tests sites is shown in the map attached herewith.

2) Cylinder intake rate test
   - Cylinder, 0.3 m in diameter x o.6 m in height, and
   - Cylinder was driven into the soil to a depth of 30 cm.

3) Furrow intake rate test
   - Furrow, 0.25 m wide x 1.0 m long, and
   - Plates (0.75 m wide x 0.40 m in height) to make the above furrow were driven into the soil to a depth of 30 cm.

INVESTIGATION POINT FOR INTAKE RATE TEST

Intake Rate (No. 1 - Clynder)

Data for Intake Rate (No. 1 - Cylinder)

Time (min.)	Accumulated Time (min.)	Measured Value (mm)	(mm)	Intake (mm)	Accumulated Intake (mm)	Intake Rate (mm/hr)
		185				
1	1	175		10	10	600
1	2	171		4	14	240
1	3	168		3	17	180
2	5	165		3	20	90
5	10	161		4	24	48
5	15	158		3	27	36
5	20	156		2	29	24
10	30	153		3	32	18
10	40	151		2	34	12
10	50	149		2	36	12
10	60	147		2	38	12
30	90	143		4	42	8
30	120	139		4	46	8
30	150	135		4	50	8

Intake Rate (No. 1 - Furrow)

Data for Intake Rate (No. 1 - Furrow)

Time (min.)	Accumulated Time (min.)	Measured Value (mm)	(mm)	Intake (mm)	Accumulated Intake (mm)	Intake Rate (mm/hr)
		153				
1	1	142		11	11	660
1	2	140		2	13	120
1	3	138		2	15	120
2	5	134		4	19	120
5	10	125	132	9	28	108
5	15		125	7	35	84
5	20	148	119	6	41	72
10	30	136		12	53	72
10	40	126	147	10	63	60
10	50		137	10	73	60
10	60	147	127	10	83	60
20	80	132	150	15	98	45
20	100		135	15	113	45
20	120	140	120	15	128	45
30	150	117		23	151	46

Intake Rate (No. 2 - Clynder)

Data for Intake Rate (No. 2 - Cylinder)

Time (min.)	Accumulated Time (min.)	Measured Value (mm)	(mm)	Intake (mm)	Accumulated Intake (mm)	Intake Rate (mm/hr)
		87				
1	1	80		7	7	420
1	2	78		2	9	120
1	3	77		1	10	60
2	5	76		1	11	30
5	10	74		2	13	24
5	15	72.5		1.5	14.5	18
5	20	71		1.5	16	18
10	30	68		3	19	18
10	40	66		2	21	12
20	60	63		3	24	9
20	80	60	75	3	27	9
20	100		72	3	30	9
20	120	81	69	3	33	9
30	150	76		5	38	10
30	180	72		4	42	8
60	240	68		4	46	4
60	300	64		4	50	4

Intake Rate (No. 2 - Furrow)

Data for Intake Rate (No. 2 - Furrow)

Time (min.)	Accumulated Time (min.)	Measured Value (mm)	(mm)	Intake (mm)	Accumulated Intake (mm)	Intake Rate (mm/hr)
		116				
1	1	107		9	9	540
1	2	105		2	11	120
1	3	103		2	13	120
2	5	99	114	4	17	120
5	10	127	109	5	22	60
5	15	122		5	27	60
5	20	117		5	32	60
10	30	109	125	8	40	48
10	40		118	7	47	42
20	60	125	104	14	61	42
20	80	109	126	16	77	48
20	100	125	111	15	92	45
20	120	110	124	15	107	45
30	150	123	104	20	127	40
30	180	104	126	19	146	38
30	210		105	21	167	42

Intake Rate (No. 3 - Clynder)

Data for Intake Rate (No. 3 - Cylinder)

Time (min.)	Accumulated Time (min.)	Measured Value (mm)	(mm)	Intake (mm)	Accumulated Intake (mm)	Intake Rate (mm/hr)
		146				
1	1	141		5	5	300
1	2	139		2	7	120
1	3	138		1	8	60
2	5	136		2	10	60
5	10	132		4	14	48
5	15	129		3	17	36
5	20	126.5		2.5	19.5	30
10	30	123		3.5	23	21
10	40	121.5		1.5	24.5	9
10	50	120		1.5	26	9
10	60	119		1	27	6
20	80	116		3	30	9
20	100	114		2	32	6
20	120	112		2	34	6
30	150	110		2	36	4
30	180	108		2	38	4
60	240	104		4	42	4

Intake Rate (No. 3 - Furrow)

Data for Intake Rate (No. 3 - Furrow)

Time (min.)	Accumulated Time (min.)	Measured Value (mm)	(mm)	Intake (mm)	Accumulated Intake (mm)	Intake Rate (mm/hr)
		169				
1	1	161		8	8	480
1	2	159		2	10	120
1	3	158		1	11	60
2	5	155		3	14	90
5	10	150		5	19	60
5	15	144		6	25	72
5	20	140	167	4	29	48
10	30		159	8	37	48
10	40		150.5	8.5	45.5	51
10	50	169	142	8.5	54	51
10	60	160		9	63	54
20	80	143	168	17	80	51
20	100	171	152	16	96	48
20	120	156	170	15	111	45
30	150	167	147	23	134	46
30	180	143		24	158	48

(No. 1 - Clynder)

Regression Output:

Constant	1.062
Std Err of Y Est	0.025
R Squared	0.986
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	0.2956
Std Err of Coef.	0.0101

(1) Accumulated Intake (mm) : $D = CT^n$

$Y = 1.062222 + 0.2956 X$

$\text{Log } D = \text{Log } C + n \text{ Log } T$

$\text{Log } C = 1.0622$

$C = 11.540$

$n = 0.2956$

$D = 11.54043 \; T^{0.2956}$

(2) Intake Rate (mm/hr)

$I = 60 \; C \; n \; T^{(n-1)}$

$I = 204.6855 * T^{(-0.704)}$

(3) Basic Intake Rate : Ib (mm/hr)

$T = 600 \; (1-n)$

$= 422.6361$ (min.)

$Ib = 2.893163$ (mm/hr)

(No. 2 - Clynder)

Regression Output:

Constant	0.805
Std Err of Y Est	0.037
R Squared	0.981
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.3430
Std Err of Coef.	0.0122

(1) Accumulated Intake (mm) : $D = CT^n$

$Y = 0.805255 + 0.3430 X$

$\text{Log } D = \text{Log } C + n \text{ Log } T$

$\text{Log } C = 0.8052$

$C = 6.3863$

$n = 0.3430$

$D = 6.386395 \; T^{0.3430}$

(2) Intake Rate (mm/hr)

$I = 60 C n T^{(n-1)}$

$I = 131.4388 * T^{(-0.656)}$

(3) Basic Intake Rate : Ib (mm/hr)

$T = 600 (1-n)$

$= 394.1892$ (min.)

$Ib = 2.590550$ (mm/hr)

(No. 3 - Clynder)

Regression Output:

Constant	0.740
Std Err of Y Est	0.029
R Squared	0.989
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.3862
Std Err of Coef.	0.0102

(1) Accumulated Intake (mm) : $D = CT^n$

$Y = 0.740933 + 0.3862 X$

$\text{Log } D = \text{Log } C + n \text{ Log } T$

$\text{Log } C = 0.7409$

$C = 5.5072$

$n = 0.3862$

$D = 5.507239 \; T^{0.3862}$

(2) Intake Rate (mm/hr)

$I = 60 \; C \; n \; T^{(n-1)}$

$I = 127.6389 * T^{(-0.613)}$

(3) Basic Intake Rate : Ib (mm/hr)

$T = 600 \; (1-n)$

$= 368.2342$ (min.)

$Ib = 3.396970$ (mm/hr)

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(1) DATA

Ref. No.	Title	Prepared by	Date Prepared
IR-101	DRG: MIR/72-13901 N.W. Sennar Pump Scheme Major No.1 Main Canal Regular Weir K.3,600	MOI	
IR-102	DRG: SID/46-1/1097 Movable Weirs Series 2. or S.G.4755 General Arrangement of Movable and Fixed Weirs 1.00 m Span	MOI	
IR-103	DRG: SID/65-13462 Type Well Head	MOI	
IR-104	DRG: SID/65/13487 Circular Night Storage Weirs General Drawing	MOI	
IR-105	DRG: MIR/82-3524 R.G.4.00 m Span x 3.2 High Roller Gate-General Arrangement	MOI	
IR-106	DRG: SID/65-13485 Pipe Regulator for Grader Type Canal Section	MOI	
IR-107	DRG: CS/23-7175 Gezira Irrigation Scheme Canalization Doors for Pipe Regulators 35 cm DIA	MOI	
IR-108	DRG: SID/67-1/7843 S.W.E - 0.35 DIA. Steel Liner with F.O.P. Valve	MOI	
IR-109	DRG: MIR/86-15182 Field Outlet Valve Sliding Gate	MOI	
IR-110	DRG: SID/68-13605 Shawal-Managil Extension, Light Traffic Road Bridge	MOI	

(1) DATA (2/2)

Ref. No.	Title	Prepared by	Date Prepared
IR-111	DRG: SID/68-13600 Shawal-Managil Extension, Heavy Traffic Road Bridge	MOI	
IR-112	MAP: MIR/77-3418 (MIR 14849) BNP Southern Gezira District - Nur El Din, 2-24" Pump Scheme Scale 1:10000	MOI	
IR-113	MAP: MIR/77-3419 (MIR 14849) Blue Nile Province Right Bank - Hurga Pump Scheme Layout, Scale 1:10000	MOI	
IR-114	MAP: MIR/81-14849 Nur El Din 2-24 Pump Scheme - Block No.107 & Hurga Pump Scheme 2-30" Pump Block No.106, Scale 1:20000	MOI	Aug.'81

(2) REPORTS

Ref. No.	Title	Prepared by	Date Prepared
IR-201	Blue Nile Pump Schemes Modernization Study, Final Report, Vol.2 Main Report	Sir Alexander Gibb & Partner	Mar.'90
IR-202	Blue Nile Pump Schemes Modernization Study, Final Report, Vol.7 Annex G,H,I,J	Sir Alexander Gibb & Partner	Mar.'90
IR-203	Gezira Rehabilitation and Modernization Project I, Vol.I Main Report	Euroconsult	Jun.'90
IR-204	Gezira Rehabilitation and Modernization Project I, Vol.IV Annex-E & F	Euroconsult	Jun.'82
IR-205	Gezira Rehabilitation and Modernization Project I, Vol.VI Annex-J,K,L & M	Euroconsult	Jun.'82
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IR-209	Blue Nile Water Study, Phase IC Wad Salman Study Feasibility Study, Vol.II Supporting Report II Irrigation	S.M.Macdonald & Hunting Technical Service Ltd.	Apr.'79
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(3) PUBLICATION/PAPERS(1/3)

Ref. No.	Title	Issued by	Date Prepared
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IR-302	Minor Canal Management in the Gezira Irrigation Scheme, Sudan Field Investigations on Selected Minor Canals	Hydraulic Research Ltd.,UK & Hydraulic Research Station	Nov.'88
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IR-308	Calibration of the New Abu XX	Salih Hamad Hamid Hydraulic Research Station,MOI	Sep.'89
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(3) PUBLICATION(2/3)

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IR-311	Technical Notes on Water Use, Serial No.1, "Rainfall of 1975, Gezira and Managil"	H.S. Adam & H.G. Farbrother	Oct.'75
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IR-313	Technical Notes on Water Use, Serial No.3, "The Planting Water Requirements of Wheat in the Gezira and Managil, 1975"	H.G. Farbrother	Dec.'75
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IR-316	Technical Notes on Water Use, Serial No.11, "Changes in the Use of the Term: 'Pre-Water'"	H.G. Farbrother	Jun.'76
IR-317	Technical Notes on Water Use, Serial No.12, "Crop-Water-Use in Irrigation and Rainfed Agriculture in Sudan"	H.S. Adam & H.G. Farbrother	Jul.'76
IR-318	Technical Notes on Water Use, Serial No.13, "Crop-Water-Requirements of the Gezira and Managil, Jun-Aug 1976"	H.G. Farbrother	Sep.'76
IR-319	Technical Notes on Water Use, Serial No.14, "Water-for-Wheat 1976	H.G. Farbrother	Oct.'76

(3) PUBLICATION(3/3)

Ref. No.	Title	Issued by	Date Prepared
IR-320	Technical Notes on Water Use, Serial No.18, "Long-Furrow & Siphon Irrigation Trials in Block II, Rahad"	H.G. Farbrother	Feb.'78
IR-321	Technical Notes on Water Use, Serial No.21, "Water Requirements of the Gezira & Managil for the 1977/78 Season"	H.G. Farbrother	Mar.'78
IR-322	Technical Notes on Water Use, Serial No.23, "A Field Calibration of Gezira Research Station Water-Meters"	H.G. Farbrother A.P.van der Boom	Jun.'78
IR-323	Field Behavior of Gezira Clay Under Irrigation, Cotton Growing Review Vol.49,No.1	H.G.Farbrother	Jun.'72
IR-324	SGB Handbook for New Field Inspector (Arabic)	Sudan Gezira Board	
IR-325	Irrigation and Drainage Paper No.25, Effective Rainfall	FAO	'74
IR-326	Irrigation and Drainage Paper No.24, Crop Water Requirement	FAO	'77
IR-327	Irrigation and Drainage Paper No.33, Yield Response to Water	FAO	'79
IR-328	Data for Design Estimate & Construction	MOI	

ANNEX-G

IMPLEMENTATION PLAN AND COST ESTIMATE

FINAL REPORT

FOR

THE FEASIBILITY STUDY

ON

THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

ANNEX G: IMPLEMENTATION PLAN AND COST ESTIMATE

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1. IMPLEMENTATION PLAN

1.1 Construction Work

The proposed construction works are broadly divided into two(2) categories; construction works for pumping station and construction works for other irrigation and drainage system.

The construction works for other irrigation system consist of construction works for sand settling basin, link canal and canal network.

Main works for each category are as follows:

i) Pumping Station
   - Pump house
   - Pump equipment and appurtenant facilities

ii) Sand Settling Basin

iii) Link Canal
   - Link canal
   - Bifurcation

iv) Canal Network
   - Main canal, major canal, minor canal, Gannabia and Double Abu XX with related structures

v) Drainage system
   - Collector and minor drains with related structures

1.2 Implementation Schedule

The implementation schedule of the Project is prepared as shown in Fig. 1.1. It includes work period for detailed design stage and construction works as well.

The detailed design stage would require about 12 months including the time necessary for detailed design works and tendering. While, the construction stage would last for about 19 months to complete all the project works.

The basic considerations for the implementation schedule are as follows:

i) Since most of the construction works include a large volume of earth work, the mechanized construction method would be applied.

ii) Major construction equipment and machinery required for the construction works were preliminarily estimated based on assumed construction period, workable days, capacity of the equipment and machinery, etc. As heavy construction equipment are not available in Sudan, most of them are expected to be brought into Sudan from abroad by contractor(s).

iii) Construction works for irrigation and drainage system would be carried out almost simultaneously with those for pumping station so that the Project benefits may accrue immediately after the completion of the entire construction works.

iv) Competent foreign consultant(s) would be engaged in detailed design, preparation of tender documents, technical guidance for pre-qualification and tendering works, and supervision of the construction works.

v) Since the ownership of all land in Sudan belongs to the Government, no compensation nor land acquisition would be made for the right of way for project works.

vi) Annual workable days for the construction works were estimated at about 200 days by excluding suspension days due to rainfall, national holidays and Fridays from 365 days as shown in Table 1.1.

As shown in Fig. 1.1, the construction works were assumed to be commenced in October 2nd year by starting mobilization and be completed in April of the 4th year, taking a period of 1.6 years.

1.3 Construction

(1) Pumping station

Construction of substructure of the pumping station would be mainly executed during the low water stage of the Blue Nile. A closing sheet pile would be firstly constructed and, this would be immediately followed by foundation excavation and concreting for substructure.

Concrete for pumping station would be produced by movable concrete mixers with batching plant to be installed at the vicinity of the pumping station site.

(2) Other Irrigation System

Earth work for the link canal, main and major canals, and minor and Gannabia canals would be carried out mainly by heavy equipment such as backhoes and bulldozers, while that for the Double Abu XX would be made mainly by backhoes. The trimming of canal side slopes would be made by manual labor or trimming machine. The compaction for canal embankment would be made by compacting roller after conditioning fill materials to have an optimum moisture content in the required range. The embankment materials would be obtained from suitable excavated

materials in canals and drains, elevated area nearby, and/or the site of sand settling basin as borrow-pit.

Concrete for canal lining and large structures would be produced by the batching plant to be installed at the vicinity of pumping station site and transported by agitator trucks, while that for small structures would be produced by potable concrete mixers to be installed at construction sites of respective structures.

(3) Drainage System

Earth work for the collector drains would be made a combination of bulldozers assisted by backhoes, while that for the minor drains would be made mainly by backhoes. Excavated materials would firstly be used for embankment of irrigation canals as much as possible, and remaining excavated materials would be as spoil bank along the drains.

(4) Borrow-pit and Concrete Aggregates

Lateritic soil and aggregate materials are available nearby Miheila about 30 km northeast of the Project area, details of which are discussed in the Annex A, TOPOGRAPHY AND GEOLOGY. Crashed stones for masonry work are obtainable at Fau about 60 km east of the Project area, information on which is also given in the Annex A.

Sands for concrete and mortar is available on the Blue Nile nearby El Hurga village. Hauling distance is about 5 km.

Work quantities of the major construction works are presented in Table 1.2. Major equipment required for the construction works of the Project is listed in Table 1.3.

2. COST ESTIMATE

2.1 General

The project cost consists mainly of (i) construction cost for pumping station and (ii) that for other irrigation and drainage system. These costs were estimated based on the preliminary design of the facilities, construction methods, construction time schedule, construction materials, construction equipment and man-power and job-site conditions.

The costs for the implementation of the Project were estimated on the following conditions and assumptions:

i) The price level employed for cost estimate is December 1990. Exchange rates employed are :

US$ 1.0 = £S 12.3 = J.Yen 135.0.

ii) The project works will be carried out under contract basis with international competitive bidding. Equipment required for the construction works be mobilized by the contractor.

iii) Taxes on construction materials, machinery and equipment to be imported from abroad will be exempted.

iv) Neither compensation nor acquisition charges will be imposed in use of lands necessary for work execution such as borrow area for earth materials, quarry site for aggregates, masonry stone and the contractor's camp.

v) Depreciation costs for the construction equipment were computed in conformity with calculation formulae prescribed by the Japanese Industrial Standards Committee in Japan. The price of equipment used in this calculation covers the transportation costs from Japan to the project site through Port Sudan.

vi) The construction cost comprises local and foreign currency portions. The local currency portion was estimated based on the current prices in Wad Medani as of December 1990 and the data collected from on-going projects in those areas. The foreign currency portion was estimated based on the CIF prices at Port Sudan referring to the FOB prices of materials, machinery and equipment in Japan in December 1990. The classification of local and foreign currency portions is defined as follows:

Local currency portion

- Labor force,
- Sand, gravel and brick,
- Fuel, oil, etc.,
- Inland transportation costs,

- Administration expenses,
- Contractors' general expenses and profit,
- Expenses of engineering services for local consultant, and
- Minor works.

Foreign currency portion

- Reinforcement bar and structural steel,
- Cement and wooden materials,
- Pumping plant and electrical facilities,
- Deprecation costs for construction machinery and equipment,
- O&M equipment for the project operation,
- Contractors' general expenses and profit, and
- Expenses and fees of engineering services by foreign consultant.

vii) Physical contingency is taken as 10.0% of direct construction cost for the civil works.

2.2 Cost Estimate

(1) Construction cost and annual disbursement schedule

The total project cost was estimated at £S 360 million (J.Yen 3,954 million) equivalent, comprising £S 269 million (J.Yen 2,959 million) of foreign currency portion and £S 91 million (J.Yen 995 million) equivalent of local currency portion as summarized in Table 2.1.

The breakdowns of the construction cost and other related cost are shown in Table 2.2 to Table 2.4. The prices of basic materials and labor wages used in the estimate and the unit cost for major work items are shown in Tables 2.5 and 2.6, respectively.

The annual disbursement schedule is worked out based on the construction schedule as shown in Table 2.7.

(2) Operation and maintenance costs

Operation and maintenance costs at the full operation stage of the Project is estimated at £S 5,269 thousand equivalent, including (i) operation and maintenance of the Project office and (ii) operation and maintenance of the Project facilities. These costs are shown in Table 2.8.

(3) Replacement cost of the Project facilities

Pumping equipment and electrical facilities have to be periodically replaced. The useful life and replacement cost are given in Table 2.9.

TABLES

Table 1.1 WORKABLE DAYS FOR CONSTRUCTION WORK

1. Conditions for workable day estimate

(1) Daily rainfall (mm)	0 - 3	3 - 10	10 - 30	more than 30	Jul. - Sep.
(2) Time needed for suspension (day)	0.5	2.0	3.0	4.0	all days

2. Estimate of workable days (reference years of 1981 - 1990)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Average Rainfall (mm/month)	0.0	0.0	0.0	0.2	18.0	26.0	54.0	95.0	51.7	11.8	3.2	0.0	259.9
Ave. No Rain Days (days/month)	31.0	28.0	31.0	29.9	28.1	25.7	25.3	23.9	24.3	28.8	29.9	31.0	336.9
Ave. Rain Days (days/month)	-	-	-	0.1	2.9	4.3	5.7	7.1	5.7	2.2	0.1	-	28.1
0 - 3 mm	-	-	-	0.1	1.3	2.0	2.2	3.1	2.3	1.2	-	-	12.2
3 - 10 mm	-	-	-	0.0	1.1	1.5	1.4	1.1	1.4	0.7	-	-	7.2
10 - 30 mm	-	-	-	0.0	0.4	0.7	1.7	1.8	1.7	0.2	-	-	6.5
more than 30 mm	-	-	-	0.0	0.1	0.1	0.4	1.1	0.3	0.1	0.1	-	2.2
(1) Time length to be suspended	-	-	-	0.5	3.5	6.5	31.0	31.0	30.0	3.0	0.5	-	106.0
(2) Fridays & national holidays	8	4	5	11	6	5	11	4	4	6	4	7	75
Annual mean suspension days	8	4	5	12	10	12	31	31	30	9	5	7	164

3. Annual workable days

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Annual workable days	23	24	26	18	21	18	0	0	0	22	25	24	201

Table 1.2 WORK QUANTITY OF MAJOR CIVIL WORKS

Item	Excavation	Embankment	Backfill	Laterite Pavement	Reinforcement Concrete	Plain Concrete	Reinforcement Bar	Steel Pipe	Form	Brick Structure	Gate	Steel Sheet Pile (Piling)
	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(ton)	(m)	(m2)	(m3)	(set)	(m)
1. Pump Station	23,400	2,600	11,600	0	2,450	690	200	0	12,540	950	0	2,900
2. Link Canal and New Construction Portion of Main Canal												
- Link Canal	8,100	62,200	80	230	95	20	8	0	380	0	2	0
- Main Canal	0	155,700	0	1,180	0	0	0	0	0	0	0	0
3. Hurga Scheme												
- Main Canal	600	242,300	230	2,660	5	100	0.4	70	300	190	9	0
- Major Canal	500	145,800	190	2,810	2	90	0.1	70	250	160	8	0
- Minor Canal	9,300	720,400	2,520	26,210	0	1,740	0	2,580	3,640	870	214	0
- D/Abu xx	2,700	12,800	230	1,890	0	140	0	207	340	20	23	0
4. Nul El Din Scheme												
- Main Canal	600	283,500	180	4,730	3	100	0.1	63	280	150	7	0
- Minor Canal	14,800	287,600	1,330	13,550	0	970	0	1,491	1,960	540	121	0
- D/Abu xx	1,100	3,600	80	970	0	50	0	72	120	10	8	0
5. Drainage Canal												
- Collector Drain	82,300	0	0	0	0	0	0	0	0	250	0	0
- Minor Drain	120,500	0	0	0	0	0	0	0	0	60	0	0

Table 1.3 REQUIRED MAJOR CONSTRUCTION EQUIPMENT

	Equipment	Spec.	Necessary Nos.
A.	Earth Moving Equipment		
	1. Bulldozer	15 ton	18
	2. Bulldozer	21 ton	18
	3. Backhoe	0.7 m3	6
	4. Backhoe	1.0 m3	6
	5. Wheel loader	2.3 m3	10
	6. Dump truck	11 ton	18
	7. Tire roller	11-30 ton	9
	8. Vibration roller	15 ton	9
	9. Motor grader	3.7 m	4
B.	Concrete Equipment		
	1. Batching plant	1.5 m3	1
	2. Truck mixer	1 m3	3
	3. Truck mixer	1.5 m3	3
	4. Portable Concrete mixer	0.5 m3	3
C.	Other Equipment		
	1. Cargo truck	10 ton	6
	2. Cargo truck w/ 2t crane	4 ton	6
	3. Water tank rolly	10 kl	9
	4. Crawler crane	16 ton	1
	5. Crawler crane	40 ton	1
	6. Diesel pile hammer	1.5 ton	1
	7. Submergible drainage pump	80 mm	4
	8. Air compressor	1.4 m3/min	2
	9. Diesel generator	50 kVA	3
	10. Diesel generator	100 kVA	2

Table 2.1 SUMMARY OF PROJECT COST

Item	Foreign Currency	Local Currency	Total
A. Direct Cost			
I. Civil Works	125,100	78,071	203,171
	(1,373.0)	(856.9)	(2,229.9)
1. Preparatory Work	11,373	7,097	18,470
	(124.8)	(77.9)	(202.7)
2. Pumping Station	14,821	8,127	22,948
	(162.7)	(89.2)	(251.9)
3. Canal System (New)	10,278	4,326	14,604
	(112.8)	(47.5)	(160.3)
4. Hurga Canal System	52,365	34,278	86,643
	(574.7)	(376.2)	(950.9)
5. Nur El Din Canal System	27,333	18,469	45,802
	(300.0)	(202.7)	(502.7)
6. Drainage System	5,330	1,357	6,687
	(58.5)	(14.9)	(73.4)
7. O & M Facility	0	3,267	3,267
	(0.0)	(35.9)	(35.9)
8. O & M Equipment	3,600	1,150	4,750
	(39.5)	(12.6)	(52.1)
II. Mechanical & Electrical Works	87,031	2,474	89,505
	(955.2)	(27.2)	(982.4)
1. Pumping Equipment	84,124	2,256	86,380
	(923.3)	(24.8)	(948.1)
2. Power Supply System	2,907	218	3,125
	(31.9)	(2.4)	(34.3)
Sub-Total (A)	212,131	80,545	292,676
	(2,328.2)	(884.1)	(3,212.3)
B. Indirect Cost			
1. Engineering Services	44,994	0	44,994
	(493.8)	(0.0)	(493.8)
2. Administration Expenses	0	2,309	2,309
	(0.0)	(25.3)	(25.3)
Sub-Total (B)	44,994	2,309	47,303
	(493.8)	(25.3)	(519.1)
C. Physical Contingency	12,510	7,807	20,317
	(137.3)	(85.7)	(223.0)
Project Cost [Total (A+B+C)]	269,635	90,661	360,296
	(2,959.3)	(995.1)	(3,954.4)

Notes : 1) Exchange Rate, US$ 1.0 = LS 12.30 = J.Yen 135.00
2) Unit : LS 1,000
(J.Yen 1,000,000)

Table 2.2 DIRECT CONSTRUCTION COST

Works	F/C	L/C	Total
I. Civil Works			
1. Preparatory Work	11,373	7,097	18,470
	(124,826)	(77,894)	(202,720)
2. Pump Station	14,821	8,127	22,948
	(162,670)	(89,199)	(251,869)
3. Canal System (New) 1)	10,278	4,326	14,604
	(112,807)	(47,480)	(160,287)
(1) Link Canal (Including Bifurcation & Sand Settling Basin)	4,002	1,590	5,592
	(43,924)	(17,451)	(61,375)
(2) Hurga main Canal (New Construction Portion)	1,242	546	1,788
	(13,632)	(5,993)	(19,625)
(3) Nur El Din Main Canal (New Construction Portion)	5,034	2,190	7,224
	(55,251)	(24,037)	(79,288)
4. Hurga Canal System 2)	52,365	34,278	86,643
	(574,738)	(376,222)	(950,960)
(1) Main Canal	10,277	5,084	15,361
	(112,796)	(55,800)	(168,596)
(2) Major Canal	6,354	3,602	9,956
	(69,739)	(39,534)	(109,273)
(3) Minor Canal	34,747	24,426	59,173
	(381,370)	(268,090)	(649,460)
(4) Double Abu xx	987	1,166	2,153
	(10,833)	(12,798)	(23,631)
5. Nul El Din Canal System 3)	27,333	18,469	45,802
	(299,996)	(202,709)	(502,705)
(1) Main Canal	11,942	6,313	18,255
	(131,071)	(69,289)	(200,360)
(2) Minor Canal	15,065	11,656	26,721
	(165,348)	(127,932)	(293,280)
(3) Double Abu xx	326	500	826
	(3,578)	(5,488)	(9,066)
6. Drainage System	5,330	1,357	6,687
	(58,500)	(14,894)	(73,394)
(1) Collector Drain	2,268	687	2,955
	(24,893)	(7,540)	(32,433)
(2) Minor Drain	3,062	670	3,732
	(33,607)	(7,354)	(40,961)
7. O & M Facility	0	3,267	3,267
	(0)	(35,857)	(35,857)
8. O & M Equipment 4)	3,600	1,150	4,750
	(39,512)	(12,622)	(52,134)
Sub-total (I)	125,100	78,071	203,171
	(1,373,049)	(856,877)	(2,229,926)
II. Mechanical & Electrical Works			
1. Pumping Equipment	84,124	2,256	86,380
	(923,300)	(24,761)	(948,061)
(1) Pumping and Mechanical Equipment	76,242	2,009	78,251
	(836,800)	(22,050)	(858,850)
(2) Electrical Equipment	7,882	247	8,129
	(86,500)	(2,711)	(89,211)
2. Power Supply System	2,907	218	3,125
	(31,900)	(2,393)	(34,293)
(1) 33 kV Distribution Line	2,907	218	3,125
	(31,900)	(2,393)	(34,293)
Sub-total (II)	87,031	2,474	89,505
	(955,200)	(27,154)	(982,354)
Total	212,131	80,545	292,676
	(2,328,249)	(884,031)	(3,212,280)

Notes : 1) Link canal and new construction portion of main canal
2) Rehabilitation of existing irrigation canal system in Hurga scheme
3) Rehabilitation of existing irrigation canal system in Nur El Din scheme
4) Diesel Grab Dredger (Grab : 0.6 m3)
5) Unit : LS 1,000
(J.Yen 1,000)

Table 2.3 COSTS FOR PUMPING EQUIPMENT AND ELECTRICAL FACILITIES

(Unit:Thousand)

ITEMS	Q'ty	FOB Unit	FOB Amount	CIF Port Sudan	Inland Transportation	Erection		Total		
								F/C	L/C	Total
		J.Yen	J.Yen	J.Yen	LS	J.Yen	LS	J.Yen	LS	Equiv. LS
I Pumping and Mechanical Equipment										
1. Pump	4 sets	55,000	220,000	226,600	293	33,000	330	259,600	623	24,275
2. Motor	4 sets	45,000	180,000	185,400	240	27,000	270	212,400	510	19,862
3. Valve	4 sets	26,000	104,000	107,100	139	15,600	156	122,700	295	11,474
4. Pipe	1 lane	77,600	77,600	79,900	103	11,600	116	91,500	219	8,556
5. Overhead crane	1 set	35,000	35,000	36,100	47	5,300	53	41,400	100	3,872
6. Miscellaneous	1 lot	-	92,500	95,300	123	13,900	139	109,200	262	10,211
Sub-total			709,100	730,400	945	106,400	1,064	836,800	2,009	78,251
II Electrical Equipment										
1. 33kV Switchgear	1 lot	10,000	10,000	10,400	19	1,500	15	11,900	34	1,118
2. Main Transformer	1 set	18,000	18,000	18,700	34	2,700	27	21,400	61	2,011
3. 11kV Cubicle	1 lot	27,200	27,200	28,300	52	4,100	41	32,400	93	3,045
4. Control & Low-Tension Cubicle	1 lot	8,000	8,000	8,300	15	1,200	12	9,500	27	893
5. Miscellaneous	1 lot	-	9,500	9,900	18	1,400	14	11,300	32	1,062
Sub-total			72,700	75,600	138	10,900	109	86,500	247	8,129
III 33kV Distribution Line										
1. 33kV Distribution Line	10 km	2,190	20,805	22,700	118	5,800	77	28,500	195	2,792
2. River Crossing Tower	1 lot	-	2,500	2,700	14	700	9	3,400	23	333
Sub-total			23,305	25,400	132	6,500	86	31,900	218	3,125
Total			805,105	831,400	1,215	123,800	1,259	955,200	2,474	89,505
								EQUIVALENT IN J.YEN		982,354

Notes: CONVERSION FACTOR : US$1.0 = J.YEN 135.0 = LS 12.3
The above includes costs for spare parts

Table 2.4 ANNUAL ADMINISTRATION EXPENSES

Detailed Design Stage

(Unit : LS)

Item		Amount
1. Salary and Wages		
(1) Staff Salary	(see Table - a)	331,200
(2) Labour Wages 100 M/M x LS 700		70,000
Sub-total		(401,200)
2. Office Expenses and Other Related Cost	L.S.	100,000
Total		501,200

Table - a Staff Salary in Detailed Design Stage (Administration Office)

(Unit : LS)

Item	Required Number	Monthly Rate	Yearly Amount
(1) Project Manager	1	1,800	21,600
(2) Senior Engineer	4	1,300	62,400
(3) Engineer	8	1,100	105,600
(4) Technician	10	900	108,000
(5) Administrative staff	4	700	33,600
Sub-Total	(27)		(331,200)

Construction Stage

(Unit : LS)

Item		Amount
1. Salary and Wages		
(1) Staff Salary	(see Table - b)	717,600
(2) Labour Wages 360 M/M x LS 700		252,000
Sub-total		(969,600)
2. Office Expenses and Other related Cost	L.S.	160,000
Total		1,129,600

Table - b Staff Salary in Construction Stage (Administration Office)

(Unit : LS)

Item	Required Number	Monthly Rate	Yearly Amount
(1) Project Manager	1	1,800	21,600
(2) Senior Engineer	4	1,300	62,400
(3) Engineer	20	1,100	264,000
(4) Technician	28	900	302,400
(5) Administrative staff	8	700	67,200
Sub-Total	(61)		(717,600)

Table 2.5 PRICES OF BASIC MATERIALS AND LABOR WAGES

	Item	Unit	Unit Price (LS)
A.	Material		
1.	Gravel	m3	350
2.	Sand	m3	100
3.	Masonry Stone	m3	650
4.	Brick	m3	500
5.	Cement	ton	5,400
6.	Timber for form	m3	8,100
B.	Fuel		
1.	Gasoline	gal.	16
2.	Diesel	gal.	10
3.	Engine oil	gal.	110
4.	Grease	kg	25
C.	Labor		
1.	Foreman	Man-day	110
2.	Assistant foreman	Man-day	80
3.	Heavy equipment operator	Man-day	80
4.	Assistant heavy equipment operator	Man-day	50
5.	Light equipment operator	Man-day	75
6.	Assistant light equipment operator	Man-day	45
7.	Common driver	Man-day	55
8.	Carpenter	Man-day	65
9.	Bar bender	Man-day	60
10.	Mason	Man-day	75
11.	Mechanic	Man-day	60
12.	Electrician	Man-day	60
13.	Fitter / Rigger	Man-day	60
14.	Plumber	Man-day	55
15.	Welder	Man-day	60
16.	Skilled labour	Man-day	55
17.	Common labour	Man-day	35

Table 2.6 UNIT COST FOR MAJOR WORK ITEMS

(Unit : LS)

Work Item	Unit	Unit Rate F/C	Unit Rate L/C	Unit Rate Total
A. Excavation				
1. Pump station				
- Pump house	m3	55	30	85
- Discharge pond & pipe	m3	15	20	35
2. River Side				
- Dry condition	m3	80	20	100
- In the water	m3	95	25	120
3. Canal				
- Link Canal	m3	25	5	30
- Main Canal	m3	25	5	30
- Major Canal	m3	25	5	30
- Minor Canal	m3	25	5	30
- Double Abu xx	m3	25	5	30
4. Drain				
- Collector Drain	m3	25	5	30
- Minor Drain	m3	25	5	30
5. Related structure	m3	15	20	35
B. Embankment				
1. Pump station				
- Pump house	m3	40	15	55
- Discharge pond & pipe	m3	40	15	55
2. Canal				
- Link Canal	m3	55	20	75
- Main Canal	m3	40	15	55
- Major Canal	m3	40	15	55
- Minor Canal	m3	40	15	55
- Double Abu xx	m3	40	15	55
3. Farm Road	m3	40	15	55
C. Backfilling				
1. Pump station				
- Pump house	m3	25	20	45
- Discharge pond & pipe	m3	25	20	45
2. Related structure	m3	25	20	45
D. Concrete Works				
1. Concrete				
- Reinforcement concrete	m3	2,160	1,360	3,520
- Plain concrete	m3	1,310	1,040	2,350
- Concrete lining	m3	1,310	1,040	2,350
2. Form for concrete	m2	80	90	170
3. Rainforcement bar	ton	12,660	3,300	15,960
E. Laterite Pavement	m3	40	340	380
F. Other Works				
1. Wet stone masonry	m3	790	1,660	2,450
2. Brick works				
- Brick structure	m3	850	1,100	1,950
3. Steel pipe				
- Dia. 350 mm (L = 3.0 m)	m	380	370	750
- Dia. 500 mm (L = 2.5 m)	m	660	510	1,170
- Dia. 760 mm (L = 2.5 m)	m	960	720	1,680
- Dia. 910 mm (L = 2.5 m)	m	1,120	890	2,010
- Dia. 1,010 mm (L = 2.5 m)	m	1,260	960	2,220
- Dia. 1,240 mm (L = 2.5 m)	m	1,560	1,150	2,710
4. Slide gate				
- 0.5 m x 0.5 m	set	1,040	1,300	2,340
- 1.0 m x 0.5 m	set	1,500	2,000	3,500
- 1.0 m x 1.5 m	set	2,320	3,690	6,010
- 1.5 m x 0.5 m	set	1,970	2,780	4,750
- 1.5 m x 1.0 m	set	2,320	3,690	6,010
- 1.5 m x 1.5 m	set	2,680	4,730	7,410
- 2.0 m x 1.5 m	set	3,030	5,770	8,800
- 3.0 m x 1.5 m	set	3,390	7,720	11,110
5. Movable weir				
- 1.0 m x 1.5 m	set	3,030	8,240	11,270
- 1.5 m x 1.5 m	set	3,390	11,490	14,880
- 2.0 m x 1.5 m	set	4,100	14,740	18,840
6. Demolishing	m3	80	140	220
7. Riprap	m3	0	1,200	1,200
8. Steel sheet pile (Type-II)	m	850	100	950

Table 2.7 ANNUAL DISBURSEMENT SCHEDULE

Description	Total			1 st			2 nd			3 rd			4 th		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
A. Direct Cost															
I. Civil Works	125,100	78,071	203,171	0	0	0	5,687	3,549	9,236	92,656	55,330	147,986	26,759	19,194	45,953
	(1,373,049)	(856,877)	(2,229,926)	(0)	(0)	(0)	(62,418)	(38,952)	(101,370)	(1,016,956)	(607,280)	(1,624,236)	(293,697)	(210,665)	(504,362)
1. Preparatory Work	11,373	7,097	18,470	0	0	0	3,887	3,549	9,236	5,687	3,549	9,236	0	0	0
	(124,826)	(77,894)	(202,720)	(0)	(0)	(0)	(62,418)	(38,952)	(101,370)	(62,418)	(38,952)	(101,370)	(0)	(0)	(0)
2. Pumping Station	14,821	8,127	22,948	0	0	0	0	0	0	13,339	7,314	20,653	1,482	813	2,295
	(162,670)	(89,199)	(251,869)	(0)	(0)	(0)	(0)	(0)	(0)	(146,404)	(80,276)	(226,680)	(16,266)	(8,923)	(25,189)
3. Canal System (New)	10,278	4,326	14,604	0	0	0	0	0	0	10,278	4,326	14,604	0	0	0
	(112,807)	(47,480)	(160,287)	(0)	(0)	(0)	(0)	(0)	(0)	(112,807)	(47,480)	(160,287)	(0)	(0)	(0)
4. Hurga Canal System	52,365	34,278	86,643	0	0	0	0	0	0	36,656	23,995	60,651	15,710	10,283	25,993
	(574,738)	(376,222)	(950,960)	(0)	(0)	(0)	(0)	(0)	(0)	(402,322)	(263,360)	(665,682)	(172,427)	(112,862)	(285,289)
5. Nur El Din Canal System	27,333	18,469	45,802	0	0	0	0	0	0	17,766	12,005	29,771	9,567	6,464	16,031
	(299,996)	(202,709)	(502,705)	(0)	(0)	(0)	(0)	(0)	(0)	(194,993)	(131,762)	(326,755)	(105,004)	(70,946)	(175,950)
6. Drainage System	5,330	1,357	6,687	0	0	0	0	0	0	5,330	1,357	6,687	0	0	0
	(58,500)	(14,894)	(73,394)	(0)	(0)	(0)	(0)	(0)	(0)	(58,500)	(14,894)	(73,394)	(0)	(0)	(0)
7. O & M Facility	0	3,267	3,267	0	0	0	0	0	0	0	1,634	1,634	0	1,634	1,634
	(0)	(35,857)	(35,857)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(17,934)	(17,934)	(0)	(17,934)	(17,934)
8. O & M Equipment	3,600	1,150	4,750	0	0	0	0	0	0	3,600	1,150	4,750	0	0	0
	(39,512)	(12,622)	(52,134)	(0)	(0)	(0)	(0)	(0)	(0)	(39,512)	(12,622)	(52,134)	(0)	(0)	(0)
II. Mechanical & Electrical Works	87,031	2,474	89,505	0	0	0	34,813	989	35,802	43,516	1,237	44,753	8,703	248	8,951
	(955,200)	(27,154)	(982,354)	(0)	(0)	(0)	(382,094)	(10,855)	(392,949)	(477,615)	(13,576)	(491,191)	(95,521)	(2,721)	(98,242)
1. Pumping Equipment	84,124	2,236	86,360	0	0	0	33,650	902	34,552	42,062	1,128	43,190	8,412	226	8,638
	(923,300)	(24,761)	(948,061)	(0)	(0)	(0)	(369,329)	(9,900)	(379,229)	(461,656)	(12,380)	(474,036)	(92,327)	(2,480)	(94,807)
2. Power Supply System	2,907	218	3,125	0	0	0	1,163	87	1,250	1,454	109	1,563	291	22	313
	(31,900)	(2,393)	(34,293)	(0)	(0)	(0)	(12,765)	(955)	(13,720)	(15,959)	(1,196)	(17,155)	(3,194)	(241)	(3,435)
Sub-Total(A)	212,131	80,545	292,676	0	0	0	40,500	4,538	45,038	136,172	56,567	192,739	35,462	19,442	54,904
	(2,328,249)	(884,031)	(3,212,280)	(0)	(0)	(0)	(444,512)	(49,807)	(494,319)	(1,494,571)	(620,856)	(2,115,427)	(389,218)	(213,386)	(602,604)
B. Indirect Cost															
1. Engineering Services	44,994	0	44,994	4,499	0	4,499	13,498	0	13,498	20,247	0	20,247	6,749	0	6,749
	(493,837)	(0)	(493,837)	(49,379)	(0)	(49,379)	(148,149)	(0)	(148,149)	(222,223)	(0)	(222,223)	(74,074)	(0)	(74,074)
2. Administration Expenses	0	2,309	2,309	0	115	115	0	693	693	0	1,155	1,155	0	346	346
	(0)	(25,343)	(25,343)	(0)	(1,262)	(1,262)	(0)	(7,606)	(7,606)	(0)	(12,677)	(12,677)	(0)	(3,798)	(3,798)
Sub-Total(B)	44,994	2,309	47,303	4,499	115	4,614	13,498	693	14,191	20,247	1,155	21,402	6,749	346	7,095
	(493,837)	(25,343)	(519,180)	(49,379)	(1,262)	(50,641)	(148,149)	(7,606)	(155,755)	(222,223)	(12,677)	(234,900)	(74,074)	(3,798)	(77,872)
C1. Physical Contingency	12,510	7,807	20,317	0	0	0	569	355	924	9,266	5,533	14,799	2,676	1,919	4,595
	(137,305)	(85,687)	(222,992)	(0)	(0)	(0)	(6,245)	(3,896)	(10,141)	(101,700)	(60,728)	(162,428)	(29,371)	(21,062)	(50,433)
Project Cost [Total(A+B+C1)]	269,635	90,661	360,296	4,499	115	4,614	54,567	5,586	60,153	165,685	63,255	228,940	44,887	21,707	66,594
	(2,959,391)	(995,061)	(3,954,452)	(49,379)	(1,262)	(50,641)	(598,906)	(61,309)	(660,215)	(1,818,494)	(694,261)	(2,512,755)	(492,663)	(238,246)	(730,909)
C2. Price Contingency															
(1) F/C : 3.5 % , L/C : 10.0 %	28,679	32,196	60,875	157	12	169	3,887	1,173	5,060	18,013	20,937	38,950	6,622	10,074	16,696
	(314,770)	(353,371)	(668,141)	(1,723)	(132)	(1,855)	(42,662)	(12,874)	(55,536)	(197,704)	(229,796)	(427,500)	(72,680)	(110,568)	(183,248)
(2) F/C : 3.5 % , L/C : 20.0 %	28,679	71,836	100,515	157	23	180	3,887	2,458	6,345	18,013	46,050	64,063	6,622	23,305	29,927
	(314,770)	(788,444)	(1,103,214)	(1,723)	(252)	(1,975)	(42,662)	(26,978)	(69,640)	(197,704)	(505,427)	(703,131)	(72,680)	(255,787)	(328,467)
(3) F/C : 3.5 % , L/C : 30.0 %	28,679	119,895	148,574	157	35	192	3,887	3,854	7,741	18,013	75,716	93,729	6,522	40,290	46,912
	(314,770)	(1,315,921)	(1,630,691)	(1,723)	(384)	(2,107)	(42,662)	(42,300)	(84,962)	(197,704)	(831,029)	(1,028,733)	(72,680)	(442,207)	(514,887)
Fund Requirement (1) [Total(A+B+C1+C2)]	298,314	122,857	421,171	4,656	127	4,783	58,454	6,759	65,213	183,698	84,192	267,890	51,509	31,781	83,290
	(3,274,161)	(1,348,432)	(4,622,593)	(51,102)	(1,394)	(52,496)	(641,568)	(74,183)	(715,751)	(2,016,198)	(924,057)	(2,940,255)	(565,343)	(348,814)	(914,157)
Fund Requirement (2) [Total(A+B+C1+C2)]	298,314	162,497	460,811	4,656	138	4,794	58,454	8,044	66,498	183,698	109,305	293,003	51,509	45,012	96,521
	(3,274,161)	(1,783,505)	(5,057,666)	(51,102)	(1,514)	(52,616)	(641,568)	(88,287)	(729,855)	(2,016,198)	(1,199,688)	(3,215,886)	(565,343)	(494,033)	(1,059,376)
Fund Requirement (3) [Total(A+B+C1+C2)]	298,314	210,556	508,870	4,656	150	4,806	58,454	9,440	67,894	183,698	138,971	322,669	51,509	61,997	113,506
	(3,274,161)	(2,310,982)	(5,585,143)	(51,102)	(1,646)	(52,748)	(641,568)	(103,609)	(745,177)	(2,016,198)	(1,525,290)	(3,541,488)	(565,343)	(680,453)	(1,245,796)

Notes : 1) Price Level, Dec.,1990
2) Exchange Rate, US$ 1.0 = LS 12.30 = Yen 135.00
3) Unit : LS 1,000
(J.Yen 1,000)

Table 2.8 ANNUAL OPERATION AND MAINTENANCE COST

(Unit : LS)

Item	Amount
1. Salary and Wages	
i) Staff Salary (see Table - c)	336,000
ii) Labour Wages 100 M/M x LS 700	70,000
2. Operation Cost	
i) Electric Power Consumption Cost	3,150,000
ii) Fuel,etc. for Equipment & Vehicles	150,000
3. Office Expenses	100,000
4. Repair and Maintenance Cost (0.5 % of direct construction cost)	1,463,000
Total	5,269,000

Table - c Staff Salary at O/M Stage (Administration Office)

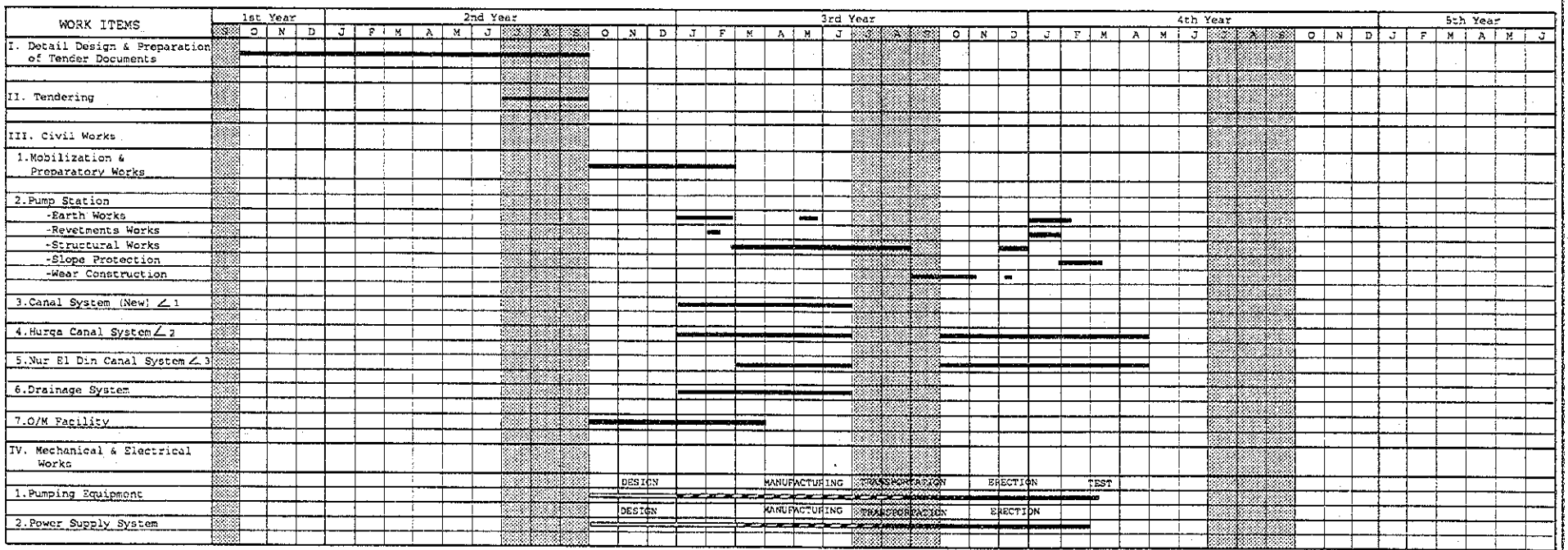
(Unit : LS)

Item	Required Number	Monthly Rate	Yearly Amount
(1) Chief Enginner	1	1,800	21,600
(2) Electrical Engineer	1	1,300	15,600
(3) Mechanical Engineer	1	1,300	15,600
(4) Block Inspector	2	1,600	38,400
(5) 2nd Field Inspector	2	1,300	31,200
(6) 3rd Field Inspector	1	1,100	13,200
(7) Assistant Divisional Engineer	1	1,600	19,200
(8) Section Engineer	2	1,100	26,400
(9) Technician	5	900	54,000
(10) Administrative Staff	12	700	100,800
Total	28		336,000

Table 2.9 REPLACEMENT COST AND USEFUL LIFE

Item	Useful Life (Years)	Replacement Cost (LS 1,000)
1. Project Facilities		
(1) Pump	25	24,275
(2) Electrical Equipment & Motor	25	27,991
(3) Transmission lines	25	3,125
(4) Irrigation Facilities (Gates & Pipes)	25	19,199
2. O & M Equipment	10	4,750

FIGURES



NOTES:

1 :Link canal and new construction portion of main canal
2 :Rehabilitation of existing irrigation canal system in Hurga scheme
3 :Rehabilitation of existing irrigation canal system in Nur El Din scheme

Fig. 1.1 IMPLEMENTATION SCHEDULE

ANNEX-H

PROJECT EVALUATION

FINAL REPORT

FOR

THE FEASIBILITY STUDY

ON

THE HURGA AND NUR EL DIN PUMP SCHEME REHABILITATION PROJECT

ANNEX H : PROJECT EVALUATION

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1. GENERAL

The Hurga and Nur El Din Pump Scheme Rehabilitation Project primarily aims at the maximum development of potential irrigable area as upland crop field. Furthermore, it is proposed to promote the increment of crop production and improvement of living standard of tenants.

The objective of the project evaluation is to assess the economic and financial feasibility of the Project. For the economic evaluation, three measures of project worth, namely, economic internal rate of return (EIRR), benefit-cost ratio (B/C) and benefit minus cost (B-C) were examined. In addition, a sensitivity analysis in terms of EIRR was made to evaluate the economic viability of the Project against possible changes in the future in project costs, benefits and built-up period. The impact of the Project to the beneficiary tenants is analyzed in the farm budget assessment. The indirect benefits and socio-economic effects, which would impact on the regional and national economy, were also studied briefly.

2. ECONOMIC EVALUATION

2.1 Basic Assumptions

From the viewpoint of the national economy, the project evaluation was made on the following basis and assumptions:

a) The Project covers a net service area of 22,620 feddans or 9,500 ha.

b) The construction period of the Project is will be 31 months lasting for five (4) years including 12 months for detailed design and preparation of tender documents.

c) The useful life of the Project is taken as 50 years from project implementation.

d) For the calculation of EIRR, only direct benefits are counted, and neither indirect nor intangible benefits are taken into account.

e) The exchange rate of Sudanese Pounds (£S) to US. Dollar (US$) is: £S 12.30 equivalent to US$1.00.

f) Price level employed is 1990 constant prices.

g) Standard Conversion Factor (SCF) employed is 0.41, Shadow Wage Rate (SWR) adopted is 0.35.

h) Price contingency and direct transfer payment are excluded from the economic project cost.

2.2 Economic Prices

(1) Trade Goods

The economic farm gate prices of export oriented goods such as cotton, sorghum and groundnuts were estimated as the value of export parity prices derived from the international market price forecasted for the year of 1995 by the World Bank.

The economic price for the import goods such as wheat and fertilizer were estimated as import substitution , based on the international market prices projected by the World Bank. The boarder prices of imported commodities including wheat and fertilizers were converted into the parity prices using the exchange rate of US$1.00 = £S 12.30 prevailing in the Sudan at present. The details of the calculation of the economic farm gate prices from those import goods are shown in Table 2.1.

(2) Non-trade Goods

Estimation of Ministry of Finance and Economic Planning (MOFEP) indicated that the shadow foreign exchange rate in the Sudan be about US$1.00 = £S 30.0. Considering the above, SCF of 0.41 is employed in this economic evaluation to convert current market or farm gate prices of non-trade goods into economic prices.

(3) Unskilled Labour

Most of the farm labour requirement are generally met by family labor at present. The economic labour wage was estimated using a shadow wage rate of 0.35 which was estimated in conformity with a guideline prepared by UNIDO and based on the results of the farm economic survey and interview to the farmers on the actual working days and financial labour wage.

Economic and financial prices of farm inputs and outputs used for the project evaluation are listed in Table 2.2.

2.3 Economic Project Costs

The financial Project cost estimated in ANNEX-G, PROJECT COST AND IMPLEMENTATION SCHEDULE is summarized as follows.

(Unit: £S 1,000)

Item	F.C.	L.C.	Total
A. Direct Costs	212,131	80,545	292,676
B. Indirect Cost	44,994	2,309	47,303
C. Physical Contingency	12,510	7,807	20,317
Total	269,635	90,661	360,296

Economic project costs were estimated by applying Standard Conversion Factors (SCF) to the local currency portion of the financial costs. The total economic construction cost amounts to £S 306.8 million and its annual disbursement is scheduled as shown in Table 2.3. These economic costs are summarized as shown below.

(Unit: £S 1,000)

Item	F.C.	L.C.	Total
A. Direct Costs	212,131	33,023	245,154
B. Indirect Cost	44,994	947	45,941
C. Physical Contingency	12,510	3,201	15,711
Total	269,635	37,171	306,806

The economic annual O&M costs for project facilities and pumps were estimated at £S 2,160 thousand and was assumed to be initially needed in 1994 when operation would start.

The useful life of the pumps, motors, gates and electrical facilities for the Project were estimated to be 25 years. Those equipment and facilities are expected to be replaced one times during the project life. The costs for replacement of these equipment and facilities were estimated at £S 68,047 thousand in total (see Table 2.4). Furthermore, the useful life of the O&M equipment was estimated to be 10 years so they would be replaced every 10 years. The cost for O&M equipment was estimated £S 4,072 thousand as shown Table 2.4.

Price contingency were excluded from the project economic costs. Since EIRR of the Project was evaluated at constant prices, provision of price contingency was excluded from the Project costs.

2.4 Economic Benefits

The Project benefit consists of a direct benefits. The direct benefits will accrue from increased cotton, wheat, sorghum and groundnuts production. Livestock production benefit which will accrue from fodder production was estimated in terms of sorghum production additionally.

The net return per feddan for each crop under the with and without project conditions was estimated as shown in Tables 2.5 and 2.6. By multiplying the net return per feddan for each crop to those harvested area, the total net return by crop production was calculated on both the future with and without project conditions.

The direct benefits, or agricultural benefits were estimated as the deference of the benefits under with and without project conditions, at £S 53,221 thousand, breakdown of which is tabulated below. Further, details are given in Table 2.7. The benefits would start earning in 1994, and would gradually increase up to the full benefit level in 1998. Negative benefits would never occur.

(Unit: £S 1,000)

Crops	Total Net Return		
	Without Project	With Project	Benefits
Agricultural Benefit			
Cotton	-	33,754	33,754
Wheat	-	6,352	6,352
Sorghum	369	2,187	1,818
Groundnuts	-	6,922	6,922
Fodder (sorghum)	-	4,375	4,375
Total	369	53589	53,221

2.5 Economic Evaluation

2.5.1 EIRR, B/C and B-C

In order to compute the EIRR, B/C and B-C, the annual economic costs and benefits flows were firstly prepared as shown in Table 2.8. In estimating B/C and B-C, in assumed discount rate 10% was .employed. The results of the economic evaluation are tabled below.

EIRR (%)	13.8
B/C	1.38
B-C (£S 10^3)	96,908

As shown in the above table, these results indicate that the Project is economically viable.

2.5.2 Sensitivity Analysis

Project sensitivity in terms of the EIRR was analyzed in respect of changes in Project costs and benefits (see Table 2.9). The results of analysis are summarized below.

(EIRR: %)

Cost Overrun	Case - 1 Benefit Reduction		Case - 2 Benefit Reduction	
	0%	-10%	0%	-10%
0%	13.8	12.5	12.3	11.2
10%	12.6	11.3	11.3	10.2
15%	12.1	10.8	10.8	9.8

Case - 1; In the case of on schedule completion of the Project.
Case - 2; In the case of delay of completion by one year

The result of sensitivity analysis demonstrate that if project costs increase by 15% and project benefits decrease by 10%, the feasibility of the Project become economically marginal.

3. FINANCIAL EVALUATION

3.1 General

Financial evaluation of the project was made by analysing the typical farm budgets. Farm budget analysis is conducted to assess whether the project will have sufficient incentive to the farmers in the project area and will bring about enough income in the farmer,s economy.

3.2 Farm Budget Analysis

Farm budget of the beneficiary tenants was estimated under the future without and with project conditions as follows:

(Unit: £S)

Item	Without Project		With Project
	Hurga	Nur El Din	
Farm Size (fd.)	15	15	15
1) Gross Income	(12,374)	(10,193)	(44,787)
Farm Income	821	0	41,607
Off-farm Income	11,553	10,193	3,180
2) Gross Outgoing	(17,988)	(16,165)	(31,564)
Production Cost	1,436	800	11,864
Living Expense	16,652	15,365	19,700
3) Net reserve/Capacity to Pay	-5614	-5972	13,224

As mentioned in detail in ANNEX-D, farm income of the beneficiary tenant is expected to increase significantly under the Project condition. The future annual income of the tenant would increase to 3.6-4.4 times of the present ones. Thus, living standard of the tenants in the Project area would be enhanced remarkably by implementation of the Project. The Project is thus justified from the view point of tenants' economy.

4. SOCIO-ECONOMIC IMPACTS OF THE PROJECT

In addition to the direct benefits counted in the economic evaluation, various secondary and intangible benefits and/or favorable socio-economic impacts are expected by the implementation of the Project. Principal socio-economic impacts are described hereunder.

(1) Increase of production of agricultural crops

The Project would greatly increase in agricultural production of cotton (4,146 ton), wheat (4,180 ton), sorghum (2,262 ton), groundnuts (2,714 ton) and fodder (6,786 ton), which would bring the considerable profit to the beneficiaries in the Project area. The anticipated production would reaches 16,388 ton in total. Thus the increase in crop production would improve self-sufficiency (wheat and sorghum) in the Project area as well as contribute to foreign exchange earnings (cotton and groundnuts) and would also enhance livestock production in the Project area.

(2) Expansion of the willingness to work

In contrast with low productivity of the current agricultural husbandry, the beneficiary tenants would find the satisfaction in improvement of the living standard through the increment of the crop production in the future condition. It would encourage them to expand the willingness to work, resulting in future improvement in agricultural production and living standard consequently.

(3) Women's activity

At present, women in the Project area are obliged to attend to farming and homework as well during a period that her husband is engaged temporary jobs outside the Project area. After implementation of the Project, family labour force working outside the Project area would return to their home and devote themselves to farming. Thus women would share farming with her family, then be able to have spare time to join a sort of culture school sponsored by Tenants' Union and other social activities.

(4) Increase of employment opportunity

The Project will generate considerable employment opportunities for unskilled labour during the construction period. Most of the manpower will be supplied by the farmers in and around the Project area. Furthermore, employees will be able to gain experience, technical know-how and skillfulness in the various working fields. These accumulations of experience would be very useful for operation and maintenance works for the tenants. In addition, the Project will create a demand for farm machinery run by the private sector, which will accrue from increased farming activities due to insentive use of land.

(5) Increase of farmer's income

The farmer's income would be expected to improve considerably due to production increase of crops. The net reserve would become about £S 13,113, which will function to provide motive power in improvement of living standard of the farmers as well as of the economic development in the Project area.

TABLES

Table 2.1 CALCULATION OF ECONOMIC FARM GATE PRICES (1/4)

Description	Unit	
Wheat		
1) Wheat (Canadian), St. Lawrence	US$/ton	160
Projected 1995 Price		
2) International Freight	US$/ton	20
3) Price c.i.f. Port Sudan	US$/ton	180
	£S/ton	2,220
4) Port Handling Charge	£S/ton	50
5) Storage Port Sudan	£S/ton	20
6) Price Ex-warehouse Port Sudan	£S/ton	2,289
7) Transport Port Sudan/Wad Medani	£S/ton	135
8) Loading, Unloading and Transport to Mill	£S/ton	52
9) Price Delivered at Mill	£S/ton	2,476
10) Transport and Marketing Costs	£S/ton	14
11) Farmgate Price	£S/ton	2,462

Description	Unit	
Urea		
1) FOB Europe	US$/ton	190
Projected 1995	US$/ton	
2) Freight and Insurance	US$/ton	36
3) c.i.f. Port Sudan	US$/ton	226
	£S/ton	2,778
4) Port Handling Charge		38
5) Transport and Handling Port Sudan/Wad Medani	£S/ton	135
6) Transport to Farm	£S/ton	14
7) Economic farm gate price	£S/ton	2,964
	£S/sack	148
TSP		
1) FOB US Gulf	US$/ton	168
2) Projected 1995	US$/ton	
3) Freight and Insurance	US$/ton	38
4) c.i.f. Port Sudan	US$/ton	206
	£S/ton	2,531
5) Port Handling Charge		34
6) Transport and Handling Port Sudan/Wad Medani	£S/ton	135
7) Transport to Farm	£S/ton	14
8) Economic farm gate price	£S/ton	2,714
	£S/sack	136

Source:

Price Prospects for Major Primary Comodities, WB, December 19, 1990
MOANR, ABS, SGB
Marketing Costs and Margines for Selected Agricultural Comodities in Sudan

Table 2.1 CALCULATION OF ECONOMIC FARM GATE PRICES (2/4)

Item	Unit	
Cotton Lint		
1) Cotton (c. i. f Europe)	US$/ton	1,752
Projected 1995 Price	US$/ton	
2) Quality adjustment (ELS premium)	US$/ton	2,277
3) Freight and insurance	US$/ton	202
4) CIF Port Surdan	US$/ton	2,075
	£S/ton	25,525
5) Export Commision	£S/ton	115
6) Quay Dues	£S/ton	57
7) Shipping Charge	£S/ton	40
8) Price Ex-store	£S/ton	25,313
9) C.P.C. Commission	£S/ton	228
10) Price Delivered Port Sudan	£S/ton	25,085
11) Transport and Handling (LS350/ton)	£S/ton	158
12) Ex-ginnery Price	£S/ton	24,928
Cotton Seed		
13) Ex-ginnery price	£S/ton	1,600
14) C.P.C. Commission	£S/ton	7
15) Sacks	£S/ton	25
16) Net Price	£S/ton	1,568
17) Return from lint (37%)	£S/ton	9,223
18) Return from seed (57%)	£S/ton	894
Total		10,117
19) Ginning Cost	£S/ton	99
20) transport (warehouse to Ginnery)	£S/ton	18
21) transport (from tenants)	£S/ton	18
22) Farm Gate Price Seed Cotton	£S/ton	9,983

Source:

Price Prospects for Major Primary Comodities, WB, December 19, 1990
MOANR, ABS, SGB
Marketing Costs and Margines for Selected Agricultural Comodities in Sudan
CPC,
Factors Affecting Cotton Yields in Gezira, Sudan

Table 2.1 CALCULATION OF ECONOMIC FARM GATE PRICES (3/4)

Item	Unit	
Groundnuts		
1) Groundnuts (CIF Rotterdam)	US$/ton	633
Projected 1995	US$/ton	
2) Extract Ratio (0.72)	US$/ton	456
3) Freight and insurance	US$/ton	35
4) CIF Port Sudan	US$/ton	421
Quality Premium (15%)	US$/ton	484
	£S/ton	5,955
5) Handling and Port Charges	£S/ton	80
6) Impurities	£S/ton	27
7) Oil Deficit	£S/ton	27
8) Administration Expences	£S/ton	134
9) Transport Port Sudan/Wad Medani	£S/ton	135
	£S/ton	5,552
10) Local Dealer Margin	£S/ton	125
11) Loading	£S/ton	14
12) Transport to Farm	£S/ton	23
13) Farmgate Price (Shelled)	£S/ton	5,391
14) Farmgate Price (Un-shelled)*1	£S/ton	3,774

Source:

Price Prospects for Major Primary Comodities, WB, December 19, 1990
MOANR, ABS, SGB
Marketing Costs and Margines for Selected Agricultural Comodities in Sudan
SOC

Remarks:

Assume unshelled nuts are 70% shelled equivalent.

Table 2.1 CALCULATION OF ECONOMIC FARM GATE PRICES (4/4)

Item	Unit	
Sorghum		
1) Sorghum FOB US Gulf ports	US$/ton	93
2) Projected 1995	US$/ton	
3) Freight and insurance	US$/ton	20
4) FOB Port Sudan (Premium Price)	US$/ton	145
	£S/ton	1,789
5) Port handling, storage and opelation	£S/ton	48
6) Clearing and Storage	£S/ton	24
7) Lossess	£S/ton	8
8) Commission to traders	£S/ton	16
9) Transport Port Sudan/Wad Medani	£S/ton	135
10) Price Delivered Wad Medani	£S/ton	1,558
11) Merchant's Margin	£S/ton	21
12) Transport to farm	£S/ton	14
13) Farmgate Price	£S/ton	1,523

Source:

Price Prospects for Major Primary Comodities, WB, December 19, 1990
MOANR, ABS, SGB
Marketing Costs and Margines for Selected Agricultural Comodities in Sudan

Table 2.2 ECONOMIC PRICE OF FARM INPUT AND OUTPUT

Description	Unit	Price (£S)
1. Farm Outputs		
1) Cotton	(100kg)	998
2) Wheat	(100kg)	246
3) Sorghum	(100kg)	152
4) Groundnuts	(100kg)	377
2. Farm Inputs		
1) Seeds		
Cotton	(kg)	1.4
Wheat	(kg)	1.4
Sorghum	(kg)	1.3
Groundnuts	(kg)	2.7
2) Fertilizer		
Urea	(50kg)	148
TSP	(50kg)	136
3) Agrochemical Apprication		
Insecticides	(times)	30.2
Herbicides	(times)	16.2
4) Hired Labor	(man/day)	8.8
5) Hired Machinery		
Tractor	(hr)	90.0
Harvestor	(hr)	135.0
Thresher	(hr)	54.0
6) Empty Sack	(piece)	3.2

Table 2.3 ANNUAL DISBURSEMENT SCHEDULE OF ECONOMIC COST

(Unit: £S1,000)

Description	1st			2nd			3rd			4th		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
A. Direct Cost												
I Civil Work												
1. Preparatory Work	11,373	2,910	14,283	0	0	0	5,687	1,455	7,142	5,687	1,548	7,235	0	0	0
2. Pumping Station	14,821	3,332	18,153	0	0	0	0	0	0	13,339	2,999	16,338	1,482	333	1,815
3. Canal System (New)	10,278	1,774	12,052	0	0	0	0	0	0	10,278	1,629	11,907	0	0	0
4. Hurga Canal System	52,365	14,054	66,419	0	0	0	0	0	0	36,656	11,608	48,264	15,710	4,216	19,926
5. Nur El Din Canal System	27,333	7,572	34,905	0	0	0	0	0	0	17,766	4,874	22,640	9,567	2,650	12,217
6. Drainage System	5,330	556	5,886	0	0	0	0	0	0	5,330	571	5,901	0	0	0
7. O & M Facility	0	1,339	1,339	0	0	0	0	0	0	0	670	670	0	670	670
8. O & M Equipment	3,600	472	4,072	0	0	0	0	0	0	3,600	472	4,072	0	0	0
II Mechanical & Electrical Works												
1. Pumping Equipment	84,124	925	85,049	0	0	0	33,650	370	34,020	42,062	462	42,524	8,412	93	8,505
2. Power Supply System	2,907	89	2,996	0	0	0	1,163	36	1,199	1,454	45	1,499	291	9	300
Sub total	212,131	33,023	245,154	0	0	0	40,500	1,861	42,361	136,172	24,877	161,049	35,462	7,971	43,433
B. Indirect Cost												
1. Engineering Services	44,994	0	44,994	4,499	0	4,499	13,498	0	13,498	20,247	0	20,247	6,749	0	6,749
2. Administration Expenses	0	947	947	0	47	47	0	284	284	0	474	474	0	142	142
Sub total	257,125	33,970	291,095	4,499	47	4,546	53,998	2,145	56,143	156,419	25,350	181,769	42,211	8,113	50,324
C. Physical Contingency	12,510	3,201	15,711	0	0	0	569	146	714	9,266	2,437	11,703	2,676	787	3,463
Total	269,635	37,171	306,806	4,499	47	4,546	54,567	2,290	56,857	165,685	27,787	193,472	44,887	8,900	53,787

Table 2.4 ECONOMIC ANNUAL OPERATION, MAINTENANCE COST AND REPLACEMENT COST

(Unit: £S)

Item	Amount
Annual Operation and Maintenance Cost	
1. Salary and Wages	166,460
2. Operation Cost	1,353,000
3. Office Expenses	41,000
4. Repair and Maintenance Cost	599,830
Total	2,160,290

(Unit: £S 1,000)

Item	F/C	L/C	Total
I. Replacement Cost			
1. Pump	23,652	255	23,907
2. Electric Equipment and Motor	27,234	310	27,544
3. Transmission Lines	2,907	89	2,996
4. Irrigation Facilities, Gates and Pipes	9,707	3,892	13,599
Totral	63,500	4,547	68,047
II. O & M Equipment	3,600	472	4,072

Table 2.5 ECONOMIC NET RETURN UNDER WITHOUT PROJECT CONDITION

Description	Unit	Unit Price (£S)	Hurga Amount /fd	Hurga £S /fd	Nur El Din Amount /fd	Nur El Din £S /fd
1 Gross Production Value						
1) Unit Yield	(kg/fd)		240		130	
2) Unit Price	(£S/100kg)			152		152
3) Unit Value	(£S/fd)			365		198
2 Production Cost						
1) Seed*1	(kg)		3.1	4	3.5	5
2) Fertilizers						
Urea	(kg)	3.0	0	0	0	0
T.S.P.	(kg)	2.7	0	0	0	0
3) Agro-chemicals						
Insecticides	(times)	30.2	0	0	0	0
Herbicides	(times)	16.2	0	0	0	0
4) Labor	(man-day)					
Land Preparation		8.8	1.3	11	2.2	19
Seedling		8.8	1.5	13	2.2	19
Fertilizing		8.8	0.0	0	0.0	0
Weeding		8.8	5.0	44	0.0	0
Spraying		8.8	0.0	0	0.0	0
Canal Maintenance		8.8	1.0	9	1.0	9
Harvesting		8.8	6.5	57	4.9	43
Threshing/Drying/		8.8	0.6	5	1.3	11
Post Harvest		8.8	0.0	0	0.0	0
Transporting		8.8	0.0	0	0.0	0
Water Management		8.8	1.5	13	2.0	18
Total			17.4	153	13.6	120
5) Hired Machineries	(machine-hr)					
- Plowing		90	0.25	23	0.25	23
- Harrowing		90	0.00	0	0.00	0
- Ridging		90	0.00	0	0.00	0
- Raising of		90	0.00	0	0.00	0
Field Cannals		90	0.00	0	0.00	0
- Levelling		90	0.00	0	0.00	0
- Fertilizer/seedling		90	0.00	0	0.00	0
application				0		0
- Harvesting		135	0.00	0	0.00	0
- Threshing		54	0.40	22	0.00	0
Total			0.65	44	0.25	23
6) Land and Water Charge				0		0
7) Others (10% of (1)-(5))				20		15
Unit Production Cost				221		161
3 Net Income (per fd)				143		36

*1 Unit Price of Seed (Unit: £S/kg)

Sorghum	1.3

Table 2.6 CROP BUDGET OF MAJOR CROPS UNDER WITH PROJECT CONDITION

Description	Unit	Unit Price (£S)	Cotton Amount /fd	Cotton £S /fd	Wheat Amount /fd	Wheat £S /fd	Sorghum Amount /fd	Sorghum £S /fd	Groundnuts Amount /fd	Groundnuts £S /fd	Fodder Amount /fd	Fodder £S /fd
1 Gross Production Value												
1) Unit Yield	(kg/fd)		900		920		1000		1000		1000	
2) Unit Price	(£S/100kg)			998		246		152		377		152
3) Unit Value	(£S/fd)			8,982		2,263		1,520		3,770		1,520
2 Production Cost												
1) Seed*1	(kg)		12	16.9	60	81	5	6.5	30	81	5	6.5
2) Fertilizers												
Urea	(kg)	3.0	120	355	80	237	40	118	0	0	40	118
T.S.P.	(kg)	2.7	0	0	40	109	0	0	0	0	0	0
3) Agro-chemicals												
Insecticides	(times)	30.2	5	151	1.0	30	0	0	0	0	0	0
Herbicides	(times)	16.2	1	16	0	0	0	0	1	16	0	0
4) Labor	(man-day)											
Land Preparation		8.8	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Seedling		8.8	1.8	16	0.0	0	2.4	21	2.4	21	2.4	21
Fertilizing		8.8	2.4	21	1.6	14	0.8	7	0.0	0	0.8	7
Weeding		8.8	1.8	16	0.0	0	3.2	28	14.0	123	3.2	28
Spraying		8.8	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Canal Maintenance		8.8	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Harvesting		8.8	42.0	370	0.0	0	3.0	26	5.6	49	3.0	26
Threshing/Drying/		8.8	0.0	0	0.0	0	1.8	16	10.0	88	1.8	16
Post Harvest		8.8	5.0	44	1.0	9	5.0	44	5.0	44	5.0	44
Transporting		8.8	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Water Management		8.8	6.8	60	3.6	32	3.6	32	3.2	28	3.6	32
Total			59.8	526	6.2	55	19.8	174	40.2	354	19.8	174
5) Hired Machineries	(machine-hr)											
- Plowing		90	1.00	90	0.40	36	0.40	36	0.54	49	0.40	36
- Harrowing		90	0.20	18	0.20	18	0.20	18	0.20	18	0.20	18
- Ridging		90	0.60	54		0	0.40	36	0.40	36	0.40	36
- Raising of		90	0.30	27	0.30	27	0.50	45	0.50	45	0.50	45
Field Cannals		90		0		0		0		0		0
- Levelling		90	0.44	40	0.40	36		0		0		0
- Fertilizer/seedling		90	0.20	18	0.44	40		0		0		0
application				0		0		0		0		0
- Harvesting		135		0	0.40	54		0		0		0
- Threshing		54					0.40	22			0.40	22
Total			2.74	247	2.14	211	1.50	157	1.64	148	1.50	157
6) Land and Water Charge				71		59		47		47		47
7) Others (10% of (1)-(5))				138		78		50		65		50
Unit Production Cost				1,521		859		553		710		553
3 Net Income (per fd)				7,461		1,404		967		3,060		967

*1 Unit Price of Seed (Unit: £S/kg)

Cotton	1.4
Wheat	1.4
Sorghum	1.3
Groundnuts	2.7
Fodder	1.3

Table 2.7 PROJECT BENEFITS

Item	Area (fd)	Net Return (£S/fd)	Total Value (£S 1,000)
1. With Project Conditions			
1) Cotton	4,524	7,461	33,754
2) Wheat	4,524	1,404	6,352
3) Sorghum	2,262	967	2,187
4) Groundnuts	2,262	3,060	6,922
5) Fodder	4,524	967	4,375
Total			53,589
2. Without Project Conditions			
1) Sorghum			
Hurga	2,260	143	323
Nur El Din	1,260	36	45
Total			369
Benefit			53,221

Table 2.8 PROJECT COSTS AND BENEFITS FLOWS

(Unit: £S1,000)

No	Year	Costs				Gross Benefit	Balance
		Capital	O&M	Replacement	Total (C)	(B)	(B-C)
1	1991 / 1992	4,546	0		4,546	0	-4,546
2	1992 / 1993	56,857	0		56,857	0	-56,857
3	1993 / 1994	193,472	0		193,472	0	-193,472
4	1994 / 1995	53,787	2,160		55,947	26,426	-29,521
5	1995 / 1996		2,160		2,160	33,124	30,964
6	1996 / 1997		2,160		2,160	39,823	37,663
7	1997 / 1998		2,160		2,160	43,842	41,682
8	1998 / 1999		2,160		2,160	53,221	51,061
9	1999 / 2000		2,160		2,160	53,221	51,061
10	2000 / 2001		2,160		2,160	53,221	51,061
11	2001 / 2002		2,160		2,160	53,221	51,061
12	2002 / 2003		2,160		2,160	53,221	51,061
13	2003 / 2004		2,160		2,160	53,221	51,061
14	2004 / 2005		2,160	4,072	6,232	53,221	46,989
15	2005 / 2006		2,160		2,160	53,221	51,061
16	2006 / 2007		2,160		2,160	53,221	51,061
17	2007 / 2008		2,160		2,160	53,221	51,061
18	2008 / 2009		2,160		2,160	53,221	51,061
19	2009 / 2010		2,160		2,160	53,221	51,061
20	2010 / 2011		2,160		2,160	53,221	51,061
21	2011 / 2012		2,160		2,160	53,221	51,061
22	2012 / 2013		2,160		2,160	53,221	51,061
23	2013 / 2014		2,160		2,160	53,221	51,061
24	2014 / 2015		2,160	4,072	6,232	53,221	46,989
25	2015 / 2016		2,160		2,160	53,221	51,061
26	2016 / 2017		2,160		2,160	53,221	51,061
27	2017 / 2018		2,160		2,160	53,221	51,061
28	2018 / 2019		2,160		2,160	53,221	51,061
29	2019 / 2020		2,160	68,047	70,207	53,221	-16,986
30	2020 / 2021		2,160		2,160	53,221	51,061
31	2021 / 2022		2,160		2,160	53,221	51,061
32	2022 / 2023		2,160		2,160	53,221	51,061
33	2023 / 2024		2,160		2,160	53,221	51,061
34	2024 / 2025		2,160	4,072	6,232	53,221	46,989
35	2025 / 2026		2,160		2,160	53,221	51,061
36	2026 / 2027		2,160		2,160	53,221	51,061
37	2027 / 2028		2,160		2,160	53,221	51,061
38	2028 / 2029		2,160		2,160	53,221	51,061
39	2029 / 2030		2,160		2,160	53,221	51,061
40	2030 / 2031		2,160		2,160	53,221	51,061
41	2031 / 2032		2,160		2,160	53,221	51,061
42	2032 / 2033		2,160		2,160	53,221	51,061
43	2033 / 2034		2,160		2,160	53,221	51,061
44	2034 / 2035		2,160	4,072	6,232	53,221	46,989
45	2035 / 2036		2,160		2,160	53,221	51,061
46	2036 / 2037		2,160		2,160	53,221	51,061
47	2037 / 2038		2,160		2,160	53,221	51,061
48	2038 / 2039		2,160		2,160	53,221	51,061
49	2039 / 2040		2,160		2,160	53,221	51,061
50	2040 / 2041		2,160		2,160	53,221	51,061
	NPV(10%) =				255,260	352,168	96,908

Sensitivity data:

ITEM	(%)	Cost up (%)	Benefit Down (%)		
			-10	0	10
Cost UP	0	-10	16.7%	15.3%	13.8%
		-5	15.9%	14.5%	13.1%
Benefit DOWN	0	0	15.1%	13.8%	12.5%
		5	14.4%	13.2%	11.9%
		10	13.8%	12.6%	11.3%
EIRR	13.8%	15	13.2%	12.1%	10.8%

Table 2.9 PROJECT COSTS AND BENEFITS FLOWS
(DALAY OF COMPLETION BY ONE YEAR)

(Unit: £S1,000)

No	Year	Costs				Gross Benefit	Balance
		Capital	O&M	Replacement	Total (C)	(B)	(B-C)
1	1991 / 1992	4,546	0		4,546	0	-4,546
2	1992 / 1993	56,857	0		56,857	0	-56,857
3	1993 / 1994	193,472	0		193,472	0	-193,472
4	1994 / 1995	53,787	2,160		55,947	0	-55,947
5	1995 / 1996		2,160		2,160	26,426	24,266
6	1996 / 1997		2,160		2,160	33,124	30,964
7	1997 / 1998		2,160		2,160	39,823	37,663
8	1998 / 1999		2,160		2,160	43,842	41,682
9	1999 / 2000		2,160		2,160	53,221	51,061
10	2000 / 2001		2,160		2,160	53,221	51,061
11	2001 / 2002		2,160		2,160	53,221	51,061
12	2002 / 2003		2,160		2,160	53,221	51,061
13	2003 / 2004		2,160		2,160	53,221	51,061
14	2004 / 2005		2,160	4,072	6,232	53,221	46,989
15	2005 / 2006		2,160		2,160	53,221	51,061
16	2006 / 2007		2,160		2,160	53,221	51,061
17	2007 / 2008		2,160		2,160	53,221	51,061
18	2008 / 2009		2,160		2,160	53,221	51,061
19	2009 / 2010		2,160		2,160	53,221	51,061
20	2010 / 2011		2,160		2,160	53,221	51,061
21	2011 / 2012		2,160		2,160	53,221	51,061
22	2012 / 2013		2,160		2,160	53,221	51,061
23	2013 / 2014		2,160		2,160	53,221	51,061
24	2014 / 2015		2,160	4,072	6,232	53,221	46,989
25	2015 / 2016		2,160		2,160	53,221	51,061
26	2016 / 2017		2,160		2,160	53,221	51,061
27	2017 / 2018		2,160		2,160	53,221	51,061
28	2018 / 2019		2,160		2,160	53,221	51,061
29	2019 / 2020		2,160	68,047	70,207	53,221	-16,986
30	2020 / 2021		2,160		2,160	53,221	51,061
31	2021 / 2022		2,160		2,160	53,221	51,061
32	2022 / 2023		2,160		2,160	53,221	51,061
33	2023 / 2024		2,160		2,160	53,221	51,061
34	2024 / 2025		2,160	4,072	6,232	53,221	46,989
35	2025 / 2026		2,160		2,160	53,221	51,061
36	2026 / 2027		2,160		2,160	53,221	51,061
37	2027 / 2028		2,160		2,160	53,221	51,061
38	2028 / 2029		2,160		2,160	53,221	51,061
39	2029 / 2030		2,160		2,160	53,221	51,061
40	2030 / 2031		2,160		2,160	53,221	51,061
41	2031 / 2032		2,160		2,160	53,221	51,061
42	2032 / 2033		2,160		2,160	53,221	51,061
43	2033 / 2034		2,160		2,160	53,221	51,061
44	2034 / 2035		2,160	4,072	6,232	53,221	46,989
45	2035 / 2036		2,160		2,160	53,221	51,061
46	2036 / 2037		2,160		2,160	53,221	51,061
47	2037 / 2038		2,160		2,160	53,221	51,061
48	2038 / 2039		2,160		2,160	53,221	51,061
49	2039 / 2040		2,160		2,160	53,221	51,061
50	2040 / 2041		2,160		2,160	53,221	51,061
				NPV(10%) =	255,260	319,740	64,480

Sensitivity data:

ITEM	(%)
Cost UP	0
Benefit DOWN	0
EIRR	12.3%

Cost up (%)	Benefit Down (%)		
	-10	0	10
-10	14.7%	13.5%	12.3%
-5	14.0%	12.9%	11.7%
0	13.4%	12.3%	11.2%
5	12.8%	11.8%	10.7%
10	12.3%	11.3%	10.2%
15	11.8%	10.8%	9.8%

APPENDIX

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PE - 007	The Four Year Salvation Recovery & Development Programme1988/89-1991/92, Vol. 1 and 2, Ministry of Finance and Economic Planning, 1988
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