16.4 Storage Requirements

16.4.1 Methodology

The storage requirement is calculated as the balance between the irrigation requirement estimated from the unit irrigation requirement and cropped area and the available runoff of rivers.

Calculation procedure is explained as follows;

(1) To compare the irrigation requirement in tributaries' contribution area with the available runoff. If the irrigation requirement is larger than tributaries' available runoff, the difference shall be supplied from Kedungwarak and/or Ketandan river.

(2) To calculate the irrigation water supplied from the Kedungwarak and/or the Ketandan river by adding the irrigation requirement calculated in step (1) to the irrigation requirement in other area than the tributary contribution area.

(3) To compare the irrigation water requirement obtained in step (2) with the available runoff of Kedungwarak river and/or Ketandan river. If the former is larger than the latter, water stored in the reservoirs is released. On the contrary, when the former is less than the latter, difference between former and latter is stored in the reservoir and/or spilled out if reservoir becomes full.

(4) To deduct evaporation loss from the reservoir.

(5) The above calculation is repeated on 10-day basis for 30 years from 1954 to 1983.

(6) To assess the carry-over years and frequency and if not to meet the criteria, the balance calculation is repeated so as to meet the requirements.

(7) To pick up the annual maximum storage requirement and to estimate storage requirement for supply dependability of irrigation water of 80% by Gumbel method.

16.4.2 Data

(1) Unit irrigation requirement

Unit irrigation requirement for 30 years are compiled in Section 7.3, ANNEX-7.

(2) River runoff

Available runoff of Kedungwarak river and Ketandan river are shown in Tables 16.1 and 14.3.

(3) Tributaries' available runoff

As being mentioned in Section 16.1, intake discharges in four irrigation units in 1982 are taken as water resources of irrigation. The intake discharge records are shown in Section 7.1 of ANNEX-7.

16.4.3 Cropped areas and storage requirement

The cropped areas to be irrigated are determined through the water balance calculation by trial and error in accordance with the requirements of carry-over those and frequency. The results are as follows;

Crop	Alt. 1	Alt. 2
	ha	ha
Wet season paddy	2,680	2,800
Dry season paddy	269	269
Polowijo I	1,504	1,760
Polowijo II	130	606
Sugarcane	102	102
Total	4,685	5,537

The water storage requirement results are presented in Section 7.4, ANNEX-7 and summarized on Table 16.2. From the series of annual maximum storage requirement for 30 years, the 80% dependable storage requirement is estimated as follows (detail, see Table 16.3.);

Alt. 1	Kedungwarak dam	8.2 MCM
	Ketandan dam	4.9 MCM
Alt. 2	Kedungwarak weir	2.6 MCM
	Ketandan dam	11.7 MCM

16.5 Costs

The low water level of the reservoirs is determined assuming the sediment yield rate of 1 mm/km^2/year and the reservoir life time of 50 years, on the storage capacity curves shown in Fig.16.3 and 16.4. The high water level is set to secure the effective storage capacity according to the storage requirement above the low water level. The results are shown below;

		LWL (EL. in M)	HWL (EL. in M)
Alt. 1.	Kedungwarak	152.0	159.0
	Ketandan	110.0	125.0
Alt. 2.	Kedungwarak	150.0	154.0
	Ketandan	117.0	134.0

Based on the required high water level, the required facilities are preliminarily designed. The principal features are shown in Table 16.4.

The construction cost of each alternative is estimated as shown in Table 16.5 and summarized below;

Alt. 1.	Rp. 18,081.7 million
Alt. 2.	Rp. 17,800.6 million

16.6 Benefit

The incremental benefit of each alternative is estimated as shown in Table 16.6 and summarized below;

	Incremental Benefit (Rp. million/year)
Alternative 1	1,586.1
Alternative 2	1,814.8

16.7 Evaluation

From the results of cost and benefit estimates, the alternative 2; transbasin scheme is economically recommendable. Also, from the view point of regional development the alternative 2 is preferable to the alternative 1.

In case of the alternative 1, no returns are brought to the Nglugu area around the Kedungwarak reservoir. Furthermore, many houses are lost together with the paddy fields and villages are obliged to be isolately located. In case of the alternative 2, 122 ha of farm land around the reservoir can receive the returns from the reservoir by pumped-up irrigation.

Table 16.1 ESTIMATED MONTHLY RUNOFF AT K.WARAK SITE

AVAILABLE RUNOFF

UNIT: M^3/SEC

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1951	0.58	0.50	0.70	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	1.64	0.31
1952	1.51	1.03	2.67	1.33	0.09	0.00	0.00	0.00	0.00	0.00	0.65	2.24	0.79
1953	0.80	1.57	2.49	4.14	1.45	0.21	0.08	0.00	0.00	0.00	0.00	0.70	0.95
1954	2.67	1.20	1.55	0.61	0.19	0.00	0.00	0.00	0.00	0.00	1.11	2.76	0.84
1955	1.17	0.70	0.87	1.27	0.18	0.00	0.31	0.35	0.00	0.00	0.61	0.10	0.46
1956	0.32	0.56	1.23	0.05	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.27	0.21
1957	1.01	1.74	2.88	0.88	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.57
1958	0.86	1.58	0.80	5.74	0.65	0.06	0.00	0.00	0.00	0.00	0.03	0.47	0.85
1959	1.03	0.85	0.51	0.67	0.36	0.02	0.00	0.00	0.00	0.00	0.00	0.29	0.31
1960	1.42	0.86	2.49	0.85	0.41	0.00	0.05	0.00	0.00	0.00	0.00	0.17	0.52
1961	0.33	1.21	0.78	0.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
1962	1.54	0.73	1.09	1.06	0.62	0.00	0.00	0.00	0.00	0.00	0.55	0.71	0.52
1963	0.79	0.89	1.90	1.58	0.38	0.07	0.00	0.00	0.00	0.00	0.00	0.70	0.52
1964	0.59	1.16	1.57	0.38	0.72	0.08	0.00	0.00	0.00	0.62	0.18	0.07	0.45
1965	0.80	1.66	0.66	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.38
1966	1.02	1.50	2.03	1.04	0.69	0.33	0.00	0.00	0.00	0.00	0.00	1.61	0.68
1967	1.24	1.90	1.86	1.57	0.11	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.69
1968	0.73	0.93	1.97	2.41	0.67	0.67	1.04	0.11	0.00	0.00	0.18	1.24	0.83
1969	0.42	1.20	1.81	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.37
1970	0.94	2.46	1.71	0.52	0.54	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.61
1971	2.53	1.61	1.81	1.54	1.31	0.83	0.03	0.00	0.00	0.09	1.70	2.02	1.12
1972	1.15	0.46	1.29	0.26	0.58	0.00	0.00	0.00	0.00	0.00	0.00	1.09	0.40
1973	3.50	3.64	1.61	0.91	1.48	0.36	0.00	0.00	0.29	0.00	0.66	0.90	1.11
1974	0.49	1.57	0.80	1.90	0.88	0.00	0.00	0.00	0.00	0.06	0.13	2.65	0.70
1975	1.33	0.70	2.77	2.36	1.18	0.28	0.00	0.00	0.00	0.39	0.55	1.89	0.95
1976	0.56	0.01	0.49	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.28	0.14
1977	0.92	1.43	0.94	1.04	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.98	0.48
1978	1.66	1.58	0.69	0.13	0.00	0.42	0.36	0.00	0.00	0.00	0.00	0.72	0.46
1979	1.89	1.15	0.58	0.30	0.54	0.18	0.00	0.00	0.00	0.00	0.00	0.42	0.42
1980	0.96	0.77	0.21	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.30	2.69	0.42
1981	1.27	0.55	0.74	0.17	0.86	0.00	0.00	0.00	0.05	0.00	0.32	0.99	0.41
1982	1.46	2.59	5.12	1.34	0.25	0.00	0.00	0.00	0.00	0.00	0.00	1.77	1.04
1983	1.44	1.34	1.27	0.68	0.81	0.14	0.00	0.00	0.00	0.00	0.44	0.38	0.54
mean	1.18	1.26	1.51	1.10	0.48	0.14	0.05	0.01	0.01	0.03	0.23	1.05	0.59

Table 16.2 STORAGE REQUIREMENT OF EACH ALTERNATIVE

Unit MCM

Year	Alt. 1 Kedungwarak	Alt. 1 Ketandan	Alt. 2 Kedungwarak	Alt. 2 Ketandan
1954	3.61	1.94	1.62	4.35
55	3.36	1.36	0.51	3.46
56	5.89	3.61	1.79	7.2
57	8.18	4.25	2.69	11.9
58	5.24	2.12	1.89	6.81
59	6.01	3.56	2.26	8.84
60			1.69	
61			3.34	
62	10.16	7.29	2.16	14.49
63	6.76	3.15	2.62	10.18
64	5.03	1.47	1.50	6.52
65	8.16	5.19	3.13	10.49
66	4.88	2.03	2.07	5.80
67	6.99	3.79	2.88	10.06
68	2.03	0.45	0.72	1.83
69	7.69	6.24	2.90	12.88
70	6.34	2.24	2.24	7.72
71	3.47	0.65	1.18	3.55
72	6.57	3.31	2.74	8.62
73	2.30	1.02	0.61	2.50
74	4.86	1.49	1.65	4.87
75	4.05	1.13	1.20	3.98
76	11.91	7.07	2.68	16.44
77			1.96	
78	7.89		1.56	11.06
79			2.20	
80	10.26	6.66	2.34	15.34
81			1.62	
82	6.87	3.30	2.77	9.07
83	4.66	2.27	1.77	7.41

Table 16.3 STORAGE REQUIREMENT IN 80% DEPENDABILITY IN EACH ALTERNATIVE

Unit : MCM

		Alternative I		Alternative II	
		Kedungwarak Reservoir	Ketandan Reservoir	Kedungwarak Reservoir	Ketandan Reservoir
T	Yt	Xt	Xt	Xt	Xt
2	3665	5.69	2.85	1.9	7.5
3	9027	6.89	3.84	2.25	9.46
4	1.2459	7.67	4.47	2.47	10.72
5	1.4999	8.24	4.94	2.63	11.65
6	1.702	8.69	5.32	2.76	12.39
7	1.8698	9.07	5.63	2.87	13.01
8	2.0134	9.39	5.89	2.97	13.54
9	2.1389	9.68	6.13	3.05	14
10	2.2504	9.93	6.33	3.12	14.41
11	2.3506	10.15	6.52	3.19	14.77
12	2.4417	10.36	6.69	3.24	15.11
13	2.5252	10.54	6.84	3.3	15.41
14	2.6022	10.72	6.98	3.35	15.7
15	2.6738	10.88	7.11	3.39	15.96
16	2.7405	11.03	7.24	3.44	16.2
17	2.8031	11.17	7.35	3.48	16.43
18	2.8619	11.3	7.46	3.52	16.65
19	2.9175	11.43	7.57	3.55	16.85
20	2.9702	11.55	7.66	3.59	17.05

T : Return period

Xt : Storage requirement

Table 16.4 PRINCIPAL FEATURES OF EACH ALTERNATIVE

Alternative I

Irrigation Area	2,833 ha 1,505 ha from Kedungwarak dam 1,328 ha from Ketandan dam

Kedungwarak dam and reservoir

Reservoir

Flood water level	EL. 161.2 m
High water level	EL. 159.0 m
Low water level	EL. 152.0 m
Gross storage	9.8 million m^3
Effective storage capacity	8.2 million m^3
Reservoir area at FWL	230 ha

Dam

Type	Homogeneous earthfill
Crest elevation of dam	EL. 163.5 m
Dam height above river bed	21.5 m
Upstream slope	1 : 3
Downstream slope	1 : 2.5
Embankment volume	71,000 m^3

Spillway

Type	Side channel type
Design flood (200 yr x 1.2)	312 m^3/sec
Crest elevation	EL. 159.0 m
Crest width	45 m

Ketandan dam and reservoir

Reservoir

Flood water level	El. 127.1 m
High water level	EL. 125.0 m
Low water level	EL. 110.0 m
Gross storage	EL. 5.7 million m^3
Effective storage capacity	EL. 4.9 million m^3
Reservoir area at FWL	74 ha

Dam

Type	Homogeneous earthfill
Crest elevation of dam	EL. 129.5 m
Dam height above river bed	29 m
Upstream slope	1 : 3
Downstream slope	1 : 2.5
Embankment volume	135.000 m^3

Spillway

Type	Side channel spillway
Design flood (200 yr x 1.2)	264 m^3/sec
Crest elevation	EL. 185.0 m
Crest width	40 m

Irrigation facilities

Bangle headworks	Fixed overflow weir type
West and East Main Canal	6.5 km + 2 km = 8.5 km
Secondary and tertiary canals	49 km
On-farm canal density	50 m/ha

Alternative - II

Irrigation Area	2,995 ha
Kedungwarak reservoir	
Flood water level	EL. 157.0 m
High water level	EL. 154.6 m
Low water level	EL. 150.0 m
Gross storage	3.4 million m^3
Effective storage capacity	2.6 million m^3
Reservoir area at FWL	135 ha
Kedungwarak dam	
Type	Concrete weir in center with earthfill in both sides
Crest elevation of dam	EL. 158.0 m
Dam height above river bed	16 m
Crest elevation of weir	EL. 154.6 m
Design flood (200 yr x 1.2)	312 m^3/s
Transbasin tunnel	
Type	Circulation with concrete linning on 25 cm thickness
Length	1,500 m
Ketandan dam reservoir	
Flood water level	EL. 136.1 m
High water level	EL. 134.0m
Low water level	EL. 117.5 m
Gross storage	14.00 million m3
Effective storage	11.65 million m3
Reservoir area at F.W.L.	125 ha
Ketandan Dam	
Type	Homogeneous earthfill
Crest elevation	EL. 138.5 m
Dam height above river bed	38 m
Upstream slope	1 : 3.0
Downstream slope	1 : 2.5
Embankment volume	300,000
Ketandan dam spillway	
Type	Side channel type
Crest elevation	EL. 134.0 m
Crest width	40 m
Design flood (200 yr x 1.2)	264 m3/s
Irrigation Facilities	
Bangle headworks	Fixed overflow weir type, 2 m high
West and East Main Canal	6.6 km + 2.0 km = 8.6 km
Secondary and tertiary canal	60 km
On-farm canal density	50 m/ha

Table 16.5 CONSTRUCTION COST OF EACH ALTERNATIVES

Unit : Million Rp.

Work Item		Alternative I	Alternative II
1.	General Item	1,284.5	1,284.5
2.	Compensation works	230.0	230.0
3.	Kedungwarak Dam/weir		
	3-1. Diversion works	1,262.8	-
	3-2. Dam or weir	740.0	935.8
	3-3. Spillway	892.5	-
	3-4. Intake	150.0	-
	3-5. Relocation of road	880.0	-
	3-6. Miscellaneous works	161.0	-
	Sub-Total	4,186.3	935.8
4.	Transbasin Tunnel		1,550.5
5.	Ketandan Dam		
	5-1. Diversion works	642.8	655.3
	5-2. Dam	1,230.9	2,318.2
	5-3. Spillway	1,123.5	1,123.5
	5-4. Intake	150.0	225.0
	5-5. Miscellaneous works	150.0	218.1
	Sub-Total	3,317.2	4,538.1
6.	Bangle headworks	120.9	120.9
7.	Irrigation facilities	4,533.0	4,800.0
	Total of direct cost	13,671.9	13,459.8
8.	Engineering Service	1,367.2	1,346.0
9.	Administration	683.6	678.0
	Total of base cost	15,722.7	15,478.8
10.	Physical Contingency	2,358	2,321.8
11.	Grand Total	18,081.1	17,800.6

TABLE 16.6 INCREMANTAL BENEFIT IN EACH ALTERNATIVE

CASE NO ALTERNATIVE-I

KIND OF CROP	AREA HA	YIELD T/HA	ECONOMIIC PRICE RP.000/T	GROSS REVENUE RP.000/HA	PRODUCTION COST PR.000/HA	GROSS MARGIN RP.000/HA	GROSS MARGIN RP.MILLION
WITHOUT PROJECT							
WET PADDY	2597	3.91	225.3	880.92	277.9	603.02	1566.05
DRY PADDY	269	3.91	225.3	880.92	277.9	603.02	162.21
MAIZE IRRIGATED	0	4	173.5	694	249.3	444.7	0
MAIZE NON-IRRIGATED	730	2.23	173.5	386.91	139.3	247.6	180.75
SOYBEAN IRRIGATED	0	1.4	325.4	455.56	142.6	312.96	0
SOYBEAN NON-IRRIGATED	680	.68	325.4	221.27	151.2	70.07	47.65
SUGARCANE IRRIGATED	0	90	23.5	2115	1266.8	848.2	0
SUGARCANE NON-IRRIGTED	102	56.9	23.5	1337.15	827.8	509.35	51.95
TOTAL	4378	0	0	0	0	0	2008.62
WITH PROJECT							
WET PADDY	2680	5.5	225.3	1239.15	362.2	876.95	2350.23
DRY PADDY	269	5.5	225.3	1239.15	362.2	876.95	235.9
MAIZE IRRIGATED	817	4	173.5	694	249.3	444.7	363.32
MAIZE NON-IRRIGATED	954	2.23	173.5	386.91	139.3	247.6	236.22
SOYBEAN IRRIGATED	817	1.4	325.4	455.56	142.6	312.96	255.69
SOYBEAN NON-IRRIGATED	954	.68	325.4	221.27	151.2	70.07	66.85
SUGARCANE IRRIGATED	102	90	23.5	2115	1266.8	848.2	86.52
SUGARCANE NON-IRRIGTED	0	56.9	23.5	1337.15	827.8	509.35	0
TOTAL	6593	0	0	0	0	0	3594.71
INCREMENTAL BENEFIT ON FULL DEVELOPMANT							1586.1

CASE NO ALTERNATIVE-II

KIND OF CROP	AREA HA	YIELD T/HA	ECONOMIIC PRICE RP.000/T	GROSS REVENUE RP.000/HA	PRODUCTION COST PR.000/HA	GROSS MARGIN RP.000/HA	GROSS MARGIN RP.MILLION
WITHOUT PROJECT							
WET PADDY	2707	3.91	225.3	880.92	277.9	603.02	1632.38
DRY PADDY	269	3.91	225.3	880.92	277.9	603.02	162.21
MAIZE IRRIGATED	0	4	173.5	694	249.3	444.7	0
MAIZE NON-IRRIGATED	762	2.23	173.5	386.91	139.3	247.6	188.68
SOYBEAN IRRIGATED	0	1.4	325.4	455.56	142.6	312.96	0
SOYBEAN NON-IRRIGATED	709	.68	325.4	221.27	151.2	70.07	49.68
SUGARCANE IRRIGATED	0	90	23.5	2115	1266.8	848.2	0
SUGARCANE NON-IRRIGTED	102	56.9	23.5	1337.15	827.8	509.35	51.95
TOTAL	4549	0	0	0	0	0	2084.91
WITH PROJECT							
WET PADDY	2800	5.5	225.3	1239.15	362.2	876.95	2455.46
DRY PADDY	269	5.5	225.3	1239.15	362.2	876.95	235.9
MAIZE IRRIGATED	1183	4	173.5	694	249.3	444.7	526.08
MAIZE NON-IRRIGATED	710	2.23	173.5	386.91	139.3	247.6	175.8
SOYBEAN IRRIGATED	1183	1.4	325.4	455.56	142.6	312.96	370.23
SOYBEAN NON-IRRIGATED	710	.68	325.4	221.27	151.2	70.07	49.75
SUGARCANE IRRIGATED	102	90	23.5	2115	1266.8	848.2	86.52
SUGARCANE NON-IRRIGTED	0	56.9	23.5	1337.15	827.8	509.35	0
TOTAL	6957	0	0	0	0	0	3899.74
INCREMENTAL BENEFIT ON FULL DEVELOPMANT							1814.83

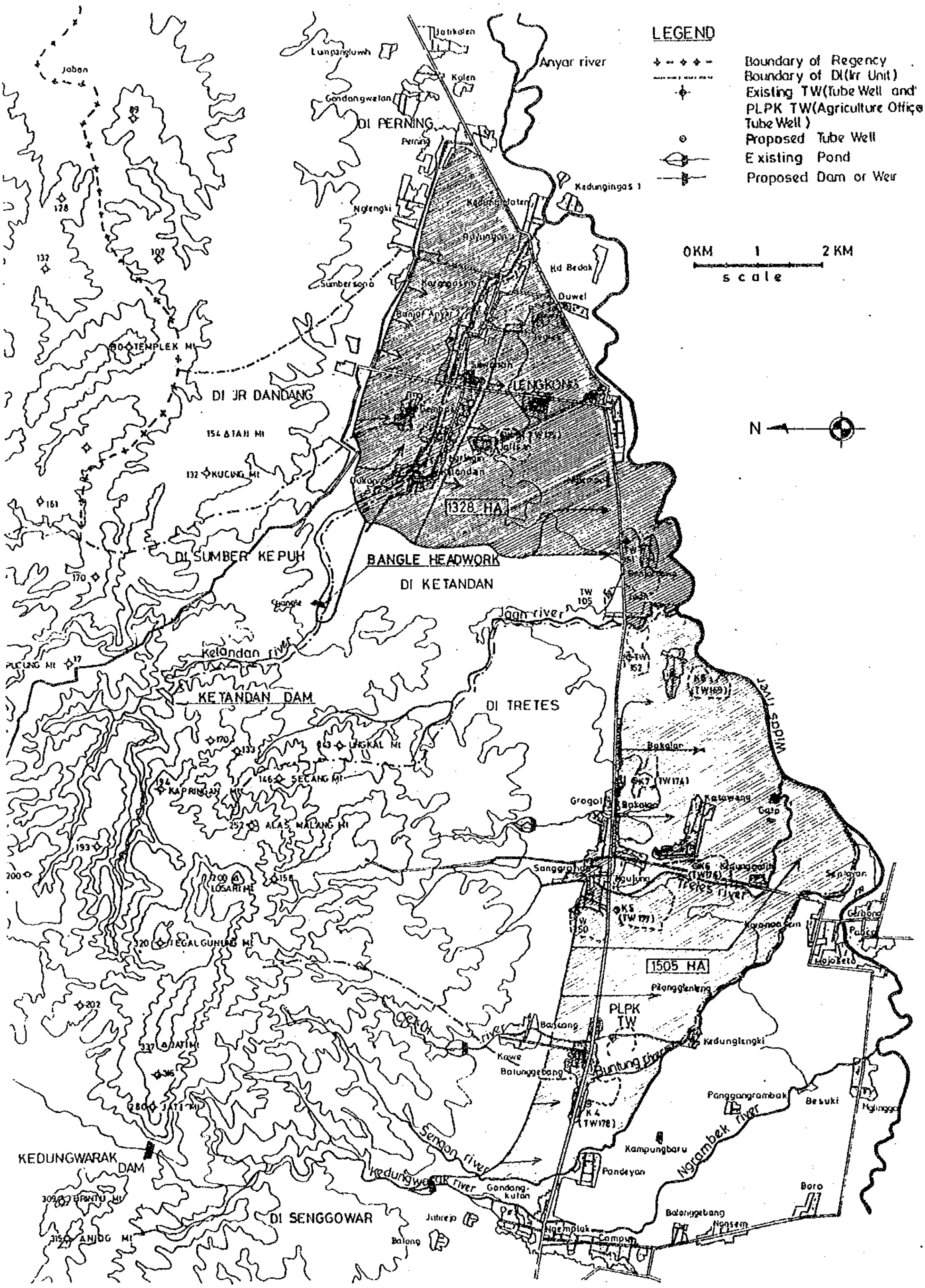


Fig. 16.1 GENERAL LAYOUT OF ALTERNATIVE I

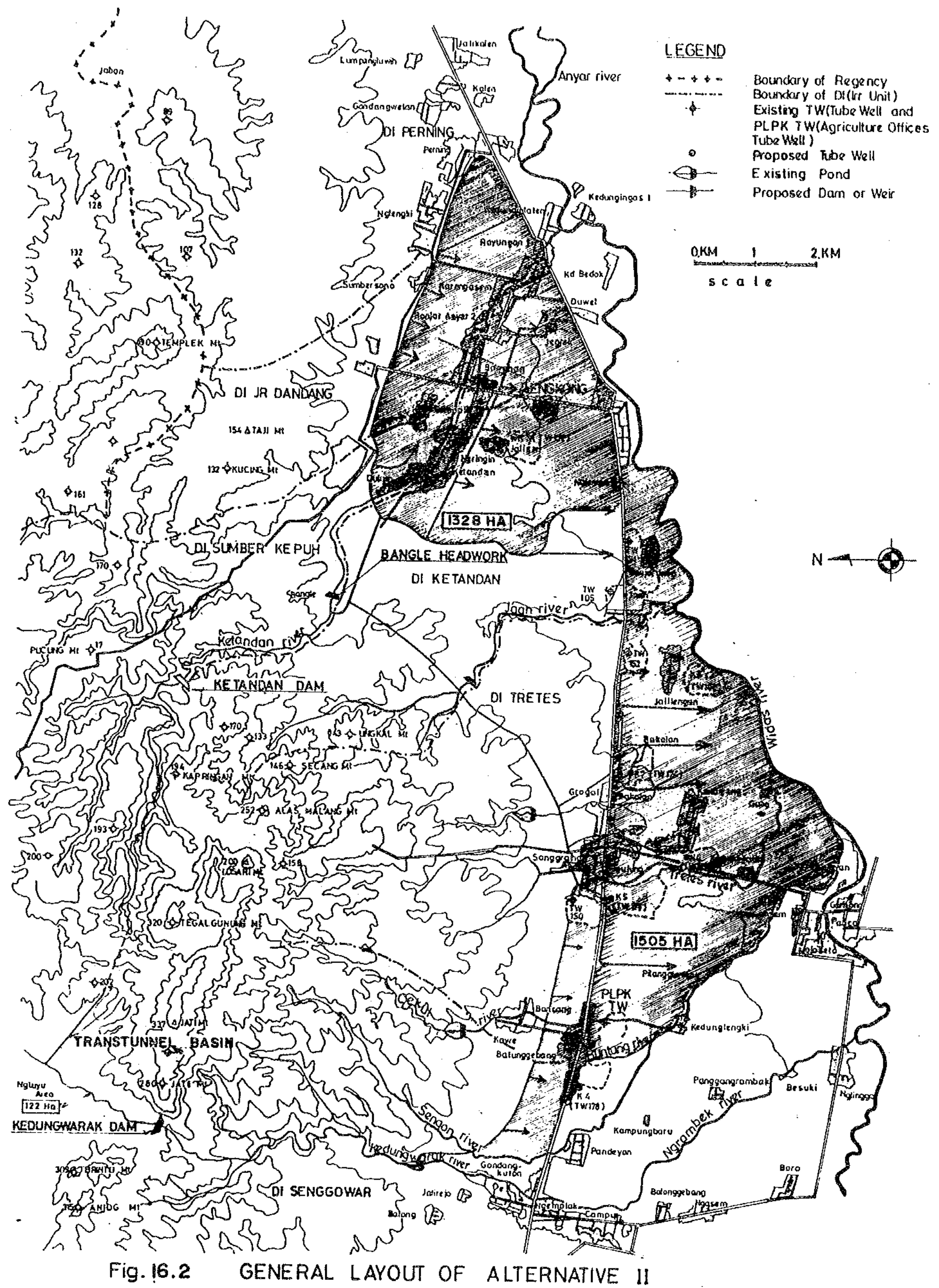


Fig. 16.2 GENERAL LAYOUT OF ALTERNATIVE II

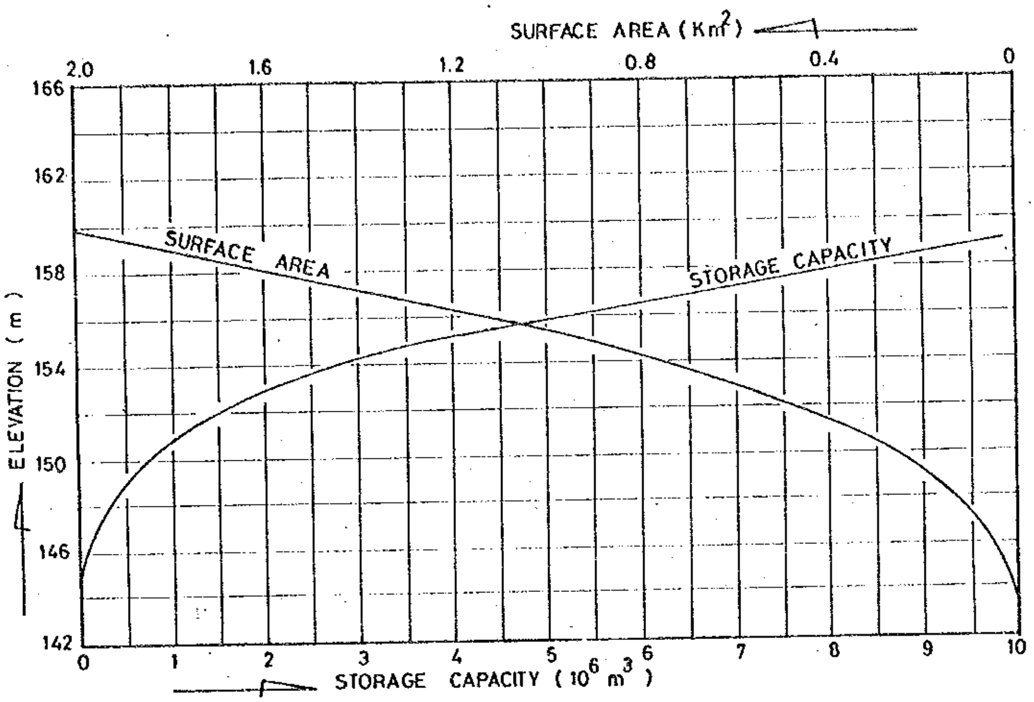


Fig. 16.3 STORAGE CAPACITY AND SURFACE AREA OF KEDUNGWARAK DAM

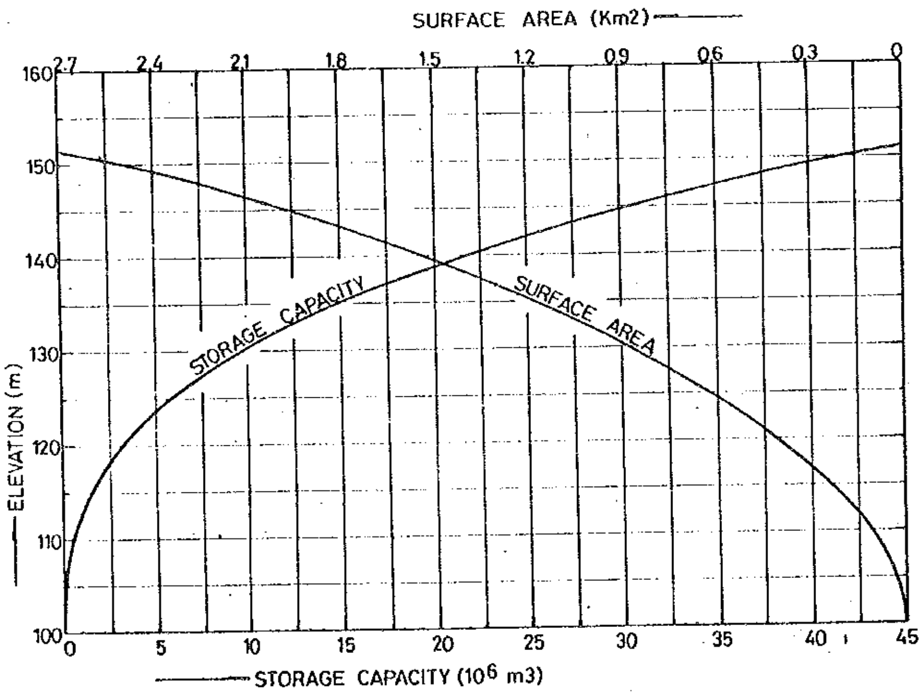
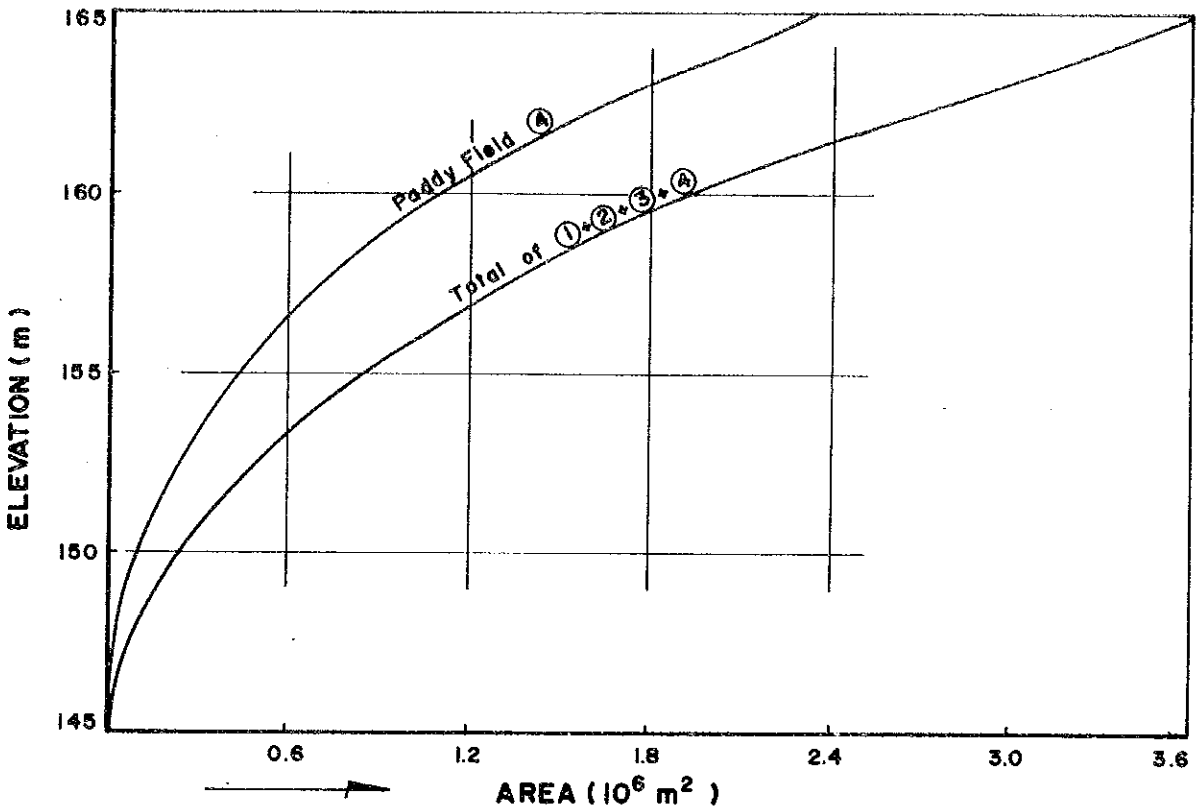


Fig.16.4 STORAGE CAPACITY AND SURFACE AREA OF KETANDAN DAM



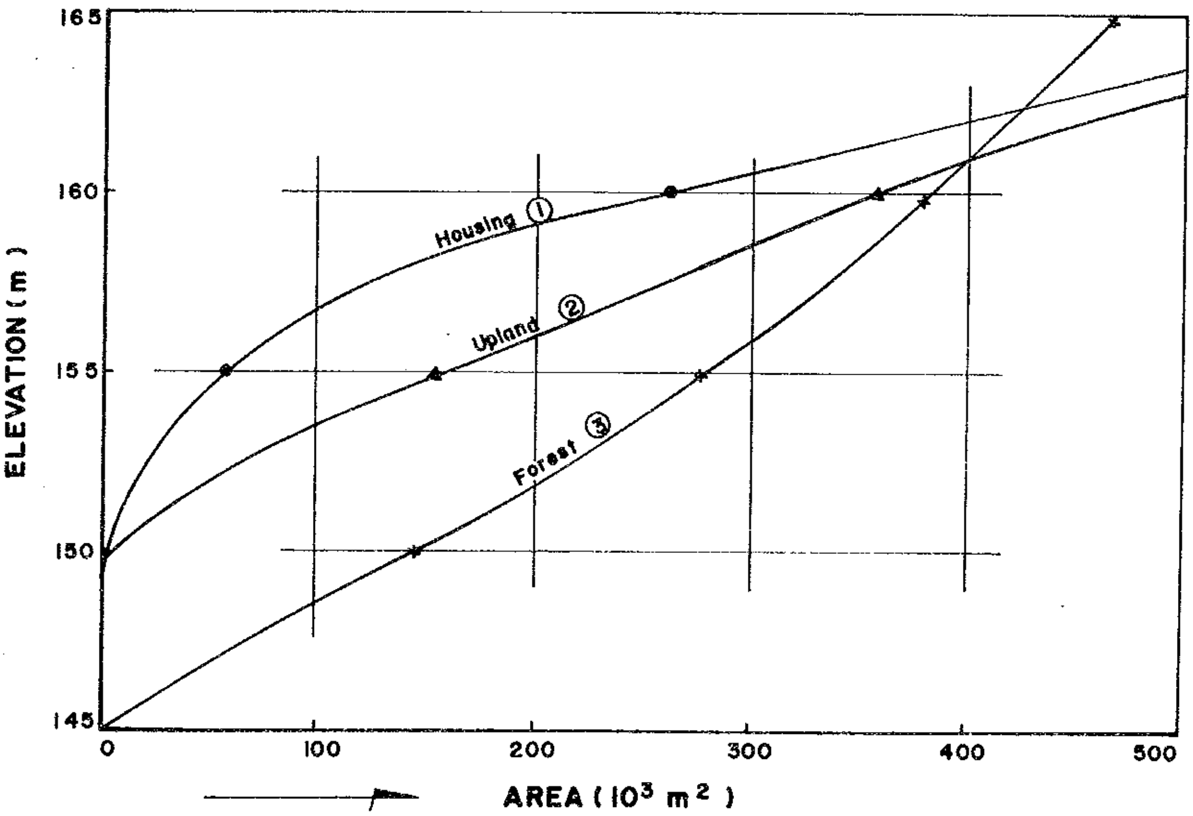


Fig. 16.5 RELATION BETWEEN LAND USE AND ALTITUDE IN KEDUNGWARAK RESERVOIR

CHAPTER 17 PROPOSED DAM AND IRRIGATION DEVELOPMENT PLAN

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17. PROPOSED DAM AND IRRIGATION DEVELOPMENT PLAN

17.1 Introduction

As the result of comparative study, the alternative 2 is selected as an optimum development plan. In this Chapter, according to the alternative 2, the proposed dam and irrigation development plan is formulated for the feasibility study. At first, the water distribution plan is explained and then the individual work is designed.

17.2 Water Distribution Plan

The irrigation area is divided into three areas such as Ngluyu area, Lengkong area and Tretes area. The Tretes area is further divided into two parts depending on the irrigation water source such as Tretes north covered by the Kedungwarak reservoir and Tretes south covered by the Ketandan reservoir. Net irrigation area after reducting the area occupied by irrigation facilities from total area of 3,109 ha is 2,955 ha in total and respective acreages are as follows.

Area	Net Irrigation Area in HA
Ngluyu	122
Lengkong	1,328
Tretes north	325
Tretes south	1,180

The runoff of the Kedungwarak river is stored after deducting 0.4 m^3/sec to guarantee for Senggowar irrigation are as previously explained. Ngluyu area is irrigated by pumping up the water stored in the Kedungwarak reservoir. For this irrigation, two small pumping stations are provided along the reservoir. Also, the Tretes north area; 325 ha is fed from the Kedungwarak reservoir through a existing headworks so-called Gondang weir. The most of the flood flows of the Kedungwarak river are transferred from the Kedungwarak reservoir to the Ketandan reservoir through a transbasin tunnel. The water stored in the Ketandan reservoir is used for irrigation of the Lengkong area and the Tretes south area. The water released from the Ketandan reservoir is caught by the proposed Bangle headworks and distributed to Lengkong and Tretes south areas through the East main canal and West main canal, respectively. In the each area, the water is distributed through secondary, tertiary and quarternary canals to fields. This water distribution plan is shown in Fig. 17.1.

17.3 Kedungwarak Weir

General

A primary objective of the Kedungwarak weir is to transfer the run-off of the Kedungwarak river to the Ketandan reservoir through a transbasin tunnel and to store the water for the irrigation of Ngluyu area, 122 ha and Tretes north area; 325 ha. The storage requirement is estimated at 2.6 MCM in Chapter 16.

17.3.1 Topography, geology and construction materials

The site forms a narrow gorge. The left bank slope is around 30° and right bank slope is 40°. The river width is around 15 m.

The geology at the Kedungwarak weir site consists of tufaceous sandstone overlying calcareous sandstone as shown on Figs. 17.2 and 17.3. Tufaceous sandstone has high permeability in the order of 3 x 10^{-3} to 5 x 10^{-2}cm/s, but calcareous sandstone has rather low permeability according to the test. Therefore, it will be necessary to carry out foundation treatment by curtain grout and blanket grout, up to the depth of calcareous sandstone since the standard penetration test value is in the order of 30, the allowable height of concrete structure will be limited to 20 m or so.

Earth materials suitable for dam embankment are found in borrow areas in the downstream of the weir site. Based on the laboratory test results, the design values of earth materials are determined as follows;

Dry density	1.55 t/m^3
Wet density	1.85 t/m^3
Saturated density	1.95 t/m^3
Cohesion	2.0 t/m^2
Internal friction angle	32°
Coefficient of permeability	5 x 10^{-5} cm/sec

There are no materials suitable for filter, fine and coarse aggregates, and rock riprap in the vicinity of the weir site. Materials for filter and fine aggregates will be taken from the Brantas river, and material for coarse aggregates and rock riprap will be taken from the Kuncir river.

17.3.2 Design of Kedungwarak Weir

Two types of dam are conceivable; fill type dam and concrete gravity type. The fill type dam requires a coffer and a diversion tunnel during construction and a spillway independent from the dam, while the concrete gravity type dam does not need the tunnel works, since the flood can be released through the concrete weir during the construction time. The concrete gravity type requires only the concrete volume of around 10,000 m^3, while the spillway concrete and tunnel concrete in case of the fill type dam is estimated to be nearly 9,000 m^3. Further, the excavation volume and embankment volume in the fill type larger than those in concrete type. Accordingly the concrete gravity type is judged to be more economical than the fill type dam. Since the foundation rock has the strength enough to bear such a low concrete dam, so-called, concrete weir. Thus, the concrete gravity type is selected in principal.

Accually the concrete gravity type weir is combined with earthfill in both sides. Fig. 17.4 shows the weir.

Storage requirement has been already estimated at 2.6 MCM in Chapter 16. Sediment loads are estimated on the assumption that the sediment deposit upto EL. 150.0 m which is the inlet channel bed elevation of the transbasin tunnel. From the storage capacity curve shown in Fig. 16.3, the gross storage requirement is 3.4 MCM and high water level of 154.6 m is obtained.

The Kedungwarak basin is well-developed and many inhabitants are living in the hilly area. Thus the crest length of the weir is tried to widen more than the river trail since means to reduce the reservoir area in only to widen the crest length of the overflow weir and to reduce the overflow depth. The crest length is decided to be 40 m considering the reservoir area, site topographic and geological conditions and a span of an inspection bridge to be provided on the weir.

The overflow depth is calculated based on the design flood discharge of 312 m^3/sec which is defined as 1.2 times the 200 year probable flood without retarding in the reservoir. Overflow depth on the weir is estimated by the following overflow equation assuming that the weir is standard type and overflow coefficient is 2.12.

$$Q = C\ B\ H^{3/2}$$

Where,
- Q : Overflow discharge
- C : Overflow coefficient
- B : Crest length of overflow weir
- H : Overflow depth

From the calculation above, the overflow depth of 2.4 m is obtained. Thus, the design flood water level is estimated to be EL. 157.0 m.

The weir crest elevation is decided to be EL. 158.0 m with a free-board of 1 m after checking the wave height by the following equation.

$$HW = 0.00086\ V^{1.1} F^{0.45}$$

Where,
- HW : Waveheight (m)
- V : Wind velocity (m/sec)
- F : Fetch (m)

The wind velocity is assumed to be 25 m/sec and the fetch is measured to be 1,600 m using the topographic map on a scale of 1 to 2,500. The wave height of 0.82 m is obtained.

Then, safety of dam against 10,000 year probable flood is checked using the overflow equation. The 10,000 year probable flood is estimated at 422 m^3/sec (refer to Chapter 14). The overflow depth of 2.9 m is obtained and the water level becomes EL. 157.5 m. Consequently, the weir is safe against the extraordinary flood.

The overflow weir shape is decided to be vertical in the upstream face and 1:0.8 in the downstream slope in accordance with the stability analysis against sliding, overturning and bearing capacity. The results are as follows. Calculation method and the calculation details are compiled in ANNEX 7, Section 7.6.

Case	Overturning	Sliding	Excentricity (m)	Bearing Capacity (t/m^2)
High Water Level				
Normal time	2.9 > 2.0	9.1 > 4	0.2	18 < 50
Seismic time	2.2 > 1.5	5.7 > 2.5	1.6	26 < 50
Flood Water Level				
Normal time	2.3 > 2.0	6.9 > 4	0.9	17 < 50

An outlet equipped with a gate is provided in the center bottom of the weir to release the water to the downstream.

The width of the downstream apron is decided to be 23 m so as to fit the downstream cross section of the river. The length is decided to be 40 m and the wall height, 8 m is assumed in accordance with the calculation of flood water depth by the Manning formula with the roughness coefficient of 0.10 and assuming that the river gradient is the same as hydraulic gradient, which is 1/145, and rectangular shape having a width of 23 m. The water depth of 6.7 m is obtained.

17.4 Transbasin Tunnel

The route of the transbasin tunnel is examined using the topographic maps on a scale of 1 to 2,500 and is selected as the shortest route to connect the Kedungwarak reservoir with the Ketandan basin along a ridge. The ridge geologically consists of marl. The trnsbasin tunnel is provided with an approach channel, an inlet structure and an outlet structure. Fig. 17.5 shows the transbasin tunnel and the related structures.

As for the flow condition in the tunnel, two alternatives are conceivable; pressure flow type and free flow type. The pressure flow condition requires a certain water depth above the ceiling of the tunnel inlet for making the stable flow. In case of the Kedungwarak reservoir, the pressure flow type tunnel requires a large amount of excavation in the approach channel to keep the stable pressure flow. Therefore, the free flow type is selected and the sill elevation of the tunnel inlet is set at EL. 147.7 m considering the topographic conditions and the longitudinal slope of the approach channel.

The tunnel slope is set at 1 to 450 taking into account the topographic profiles at both ends of the tunnel. The tunnel diamter is determined 2 m by taking account of the results of discharge capacity to divert flood runoff tentatively stored in the Kedungwarak reservoir to the Ketandon basin. The results are summarized as follows.

Details are presented in Section 7.7 in ANNEX-7.

Initial Water Level in K. Warak Reservoir	Rainfall	Inflow*	Loss=Overflow from K. Warak Weir	Inflow Rate to Ketandan
(m)	(mm)	($x10^3m^3$)	($x10^3m^3$)	(%)
152.5	100	1,028	0	
	100	1,208	0	100
153.0	70	605	0	100
	100	1,028	79	92.3
153.5	70	605	0	100
	100	1,028	243	76.4
154.0	70	605	49	91.9
	100	1,028	433	57.9

* During 24 hrs.

Note: Daily rainfall, 70 mm is equivalent to the rainfall caused two to four times a year.
Daily rainfall, 100 mm is nearly annual maximum.

From the above results, it is judged that when the water level of Kedungwarak reservoir is under 153.5 m almost all the runoffs can be diverted to the Ketandan basin throughout a year. At this water level, the effective storage in the reservoir is 1.7 MCM. It is quite enough to supplement the irrigation water for the rainy season irrigation of the Ngluyu area and the Tretes north area during the rainy season. Thus, there is no problem to keep the water level at EL. 153.5 m from the above points of view.

The locations of the inlet and outlet structures are decided based on the comparative study of the construciton cost between an open-cut channel and a tunnel. The result indicates that if the open cut depth is over 12 m, the tunnel works are more economical than the open channel. Therefore the locations of these structures are decided at the points where the cut depth in case of open channel is around 12 m. The estimate is presented in Section 7.8 in ANNEX-7.

According to the above result and the topographic conditions, the length of approach channel is determined to be 450 m and the downstream excavation of the outlet is estimated to be 500 m in the Jurang river, which is one of the tributaries of the Ketandan river, with a excavation depth less than 12 m.

The inlet structure is equipped with a roller gate and a screen. The hoist deck elevation is decided to be EL. 158.0 m, the same as that of the Kedungwarak weir. The gate leaf size is 4 m in width and 4 m in height.

17.5 Ketandan Dam

A primary objective of the Ketandan dam is to store the runoff of the Ketandan river and water coming from the Kedungwarak reservoir for the irrigation of Lengkong area of 1,328 ha and Tretes south area of 1,180 ha.

17.5.1 Topography, geology and construction materials

The dam site is selected at a gorge. The river width at the site is about 15 m. The side slope is as steep as 30 to 40 degrees. The area is covered with teak forest. The forest of poor teak trees covers the whole reservoir area. In the reservoir area, about 10 small huts are found.

The geological profiles are as shown on Figs. 17.7 and 17.6. As shown on these figures the geology at the Ketandan dam site is composed of calcareous sandstone and marl which are classified by quality of rock as CH, CM and D classes. The calcareous sandstones of CL and D classes are strongly to moderately weathered, friable and fractured, partly altered into clay. These weathered sandstone layer reaches 25 m in thickness at the left abutment. It's lower part may correspond to the land sliding clay seam. Under this weathered layer, the fresh sandstones are found. The fresh sandstones are fairly hard and stiff, and classified as CM to CH. From these observation, the removal of all the weathered sandstone is recommended. Marl occurs in contact with the overlying calcareous sandstone at the dam axis and dips south-east.

According to the permeability test, the calcareous sandstones shows high permeability ($K = 3 \times 10^{-3}$ cm/sec - 3×10^{-4} cm^3/sec) even fresh and the marl shows low permeability ($K < 3 \times 10^{-4}$ cm/sec) High permeability of calcareous sandstone is due to large porosity and weakly cemented condition. It is very difficult for those kind of rock to get higher water tightness by cement grouting. The recommended method to control seepage through the foundation rock is overall blanket over the upstream side of the abutments and the riverbed.

The Ketandan dam is designed as homogeneous earthfill type dam. The required earth materials are to be obtained in borrow areas in the downstream of the damsite. Based on the results of the laboratory test, design values of earth materials in the borrow areas are determined as follows;

Wet density	1.60 ton/m^3
Saturated density	1.75 t/m^3
Cohesion	4.0 t/m^2
Angle of internal friction	25°
Coefficient of permeability	5×20^{-5}

Materials for filter drain and fine aggregate shall be taken from the Brantas river and materials for coarse aggregate and rock riprap shall be taken from the Kuncir river, since there are no suitable materials in the vicinity of the dam site.

17.5.2 Design of dam

Fig. 17.8 shows the primary features of the Ketandan dam and the related structures. A homogeneous earthfill type dam is proposed based on the topographic and geological features of the damsite and the available construction materials.

In Chapter 16, the storage requirement has been already estimated at 11.7 MCM through water balance calculation between available runoff and irrigation requirement. The storage requirement of 11.7 MCM already causes three times of carry-over in the simulated period from 1954 to 1982. It is therefore judged to be the maximum limit from the view point of water resources.

The low water level of the reservoir is estimated at EL. 117.5 m on the storage capacity curve shown in Fig. 16.4, according to the sediment space of 2.3 MCM estimated on the assumption that the annual yield rate is 1 $mm/km^2/year$ and the reservoir life time is 50 years. Thus, the gross storage becomes 14.0 MCM. From the storage capacity curve, the high water level of E.L. 134 m is obtained.

Design flood discharge, which is defined as 1.2 times the 200-year probable flood without retarding in the reservoir, is estimated at 283 m^3/sec by adding the discharge of 19 m^3/sec coming from the Kedungwarak basin through the transbasin tunnel with the flood discharge of the Ketandan river which is estimated at 264 m^3/sec. The estimation method and calculation of probable floods are shown in Chapter 14.

As for the spillway, considering the steep slope topographic condition in the both banks, side overflow channel type spillway is adopted and the spillway site is selected at the right bank of the dam, since the spillway chute length is able to be shortened compared with the case of left bank.

The spillway crest elevation is set at EL. 134.0 m the same as the high water level of the reservoir. The crest length is decided to be 40 m considering the design flood discharge and the dam scale. The overflow depth is estimated by overflow equation assuming that the weir is standard type and overflow coefficient is 2.18. The overflow depth of 2.2 m is obtained. Thus, the design flood water level becomes EL. 136.2 m. The side channel of the spillway is designed so as to keep completed overflow condition at the design flood time (See ANNEX-7, Section 7.9). Then the chute way is set so as to meet the topographic condition. The length is 150 m. At the end, a sky-jump type energy dessipator is adopted the same as the Bening dam spillway.

The dam crest elevation is decided to be EL. 138.6 m, 2.4 m above the design flood water level after checking the wave height and taking account of the additional foreboard of 1 m for earthfill dam. The wave height is estimated by the Saville method in accordance with the following conditions and assumptions.

Wind velocity	: 25 m/sec
Fetch	: 950 m measured on the 1/2,500 Map
Upstream slope of dam	: Rock riprap 1 : 3

The wave height of 0.36 m is obtained.

As recommended by the geological study, the strongly or moderately weathered sandstone layer in the left abutment is planned to be removed by cutting the abutment with slope of 1 in vertical and 2.75 in horizontal to the river direction, in order to attain higher safety of dam embankment. Besides the left abutment, the foundation excavation is assumed to be 2 to 3 m only.

Also according to the geological investigation, sandstone layers having a high permeability of 1×10^{-4} cm/sec are found in both abutments. To control the seepage through these layers, the blanket is proposed to be continuously extended from the dam embankment to both upstream sides to cover the sandstone layers exposed to the air. In the left side, the blanket is extended around 100 m and in the right, around 150 m.

The dam upstream slope and downstream slope are examined by stability analysis and decided to be 1 : 3 and 1 : 2.5 respectively (See ANNEX-7, Section 7.10).

The upstream slope of the dam is covered with rock riprap of 1.5 m as thick as Bening dam and the downstream slope is provided with sod-facing. Chimney drain consisting of sand is provided along the immediate downstream of the dam axis.

As for the diversion tunnel and coffer dam, three cases are examined to decide the diameter of the diversion tunnel and the crest elevation of the coffer dam against the 20 year probable flood. The analysis are presented in Section 7.11 in ANNEX-7.

The results are shown below;

	Tunnel Dia (m)	Maximum Flood W.L. (m)	Required Coffer Dam (m^3)
Case 1	2.0	112.6	45,000
Case 2	2.9	110.6	26,000
Case 3	4.0	107.8	12,000

In every cases, the coffer dam can be easily constructed in one dry season. The coffer dam embankment is mostly incorporated into the main dam as a part of it. Thus, the construction cost of dam embankment is not so different among the above cases. The cost difference mainly depends on the scale of the diversion tunnel. Based on the above consideration, tunnel diameter of 2 m is adopted for the diversion works. The diameter is the same as that of the transbasin tunnel. Thus the tunnel machine and tools can be commonly used since the diversion tunnel will be constructed in early construction stage and the transbasin tunnel will be done in mid to late construction stage. The coffer dam crest elevation is set at EL. 114.5 m. The length of the diversion tunnel and the longitudinal slope are 400 m and 1/180.

After completion of the dam and spillway, the diversion tunnel is modified to be used for intake and outlet structure to release the irrigation water. For this puspose, the diversion tunnel is plugged with concrete at the inlet and an intake tower is built at just downstream of it. The intake tower is equipped with a screen and a bulk head gate so as to meet the low water level of the reservoir. The gate size is around 1.5 m in diameter. The diversion tunnel is also plugged with concrete at the middle point on the way and a steel pipe line is installed through the plug concrete to the outlet. At the outlet end of the steel pipe, a hollow jet valve is installed. The diameter of the steel pipe is decided to be 0.8 m.

In order to cope with accident of hollow jet valve, it is necessary to install a stand-by unit. Alternatively, there is a possibility to install a mini hydropower. From the parallel duration curves of sum of irrigation release and spillout from the reservoir a maximum discharge is tentatively set at 1.2 m^3/sec. Setting a rated head at 28.5 m, a possible installed capacity is calculated at 270 kW. Calculation is presented in Section 7.12 in ANNEX-7. By this provision, an average annual energy output is calculated at 1,101 MWh. Since the variation of discharge is large, suitable turbine type is cross flow type turbine, which is cheaper than other type and easy to maintain. Suitable generator type is inducting generator from the view points of cost and maintenance.

17.6 Irrigation and Drainage Facilities

17.6.1 Canal layout

1. Irrigation canals

Irrigation canals are divided into four classes by the function of canals as follows.

Main canal	:	To deliver irrigation water to secondary canals. The commanding area is more than 1,000 ha.
Secondary canal	:	To deliver water to tertiary canals. The commanding area is more than 100 ha with some exceptions.

Tertiary canal : To deliver water to quaternary canals. The commanding area is less than 100 ha and more than 12 ha at the end in general.

Quaternary canal : To deliver water to fields. The commanding area is around 6 ha.

The commanding area of each of secondary canal, tertiary canal and quaternary canals is set at the smaller area than the standard in Indonesia so as to use the limited water effectively.

Taking the above functions into account, the canal layout is made based on the following criteria.

- Irrigation canals are to be situated on elevated fields so as to feed the irrigation area by gravity system as much as possible.

- All the canals avoid passing through villages and public utilities as much as possible

- Alignment of main canals is made to keep the route as straight as possible, however, the high embankment and deep excavation is avoided. The West main canal is laid out to convey water to existing Sumberagung pond which can be used as a regulation pond.

- Secondary canals and tertiary canals are also laid out as straight as possible. If existing canals can be used, they are employed. The tertiary canals are provided so that the quaternary canals' length is around 600 m in principal.

- Quaternary canals are laid along the paddy ridge so as to use the ridge as a canal bank of one side and not to disturb the present paddy plot layout. The interval between quaternary canals is 100 m to 150 m in conformity with the results of distribution canal study stated in ANNEX-7, Section 7.2.

According to the above criteria, the irrigation canal layout is made as shown in ANNEX-7, Section 7.14. Each of irrigation canals up to tertiary canals is presented in Table 17.1 and summarized below;

	Main Canal	Secondary Canal	Tertiary Canal	Quaternary Canal	Total
Lengkong area	2.1	14.9	31.3	106.2	154.5
Tretes area	6.3	18.4	28.5	120.4	173.6
Ngluyu area	-	-	4.6	9.4	14.0
Total	8.4	33.3	64.4	236.0	342.1

2. Drainage canals

At present, the area located along the Widas river is often inundated with the flooding water coming from the Widas river. After completion of flood control works, the flooding water is protected not to intrude the present inundated area with the provision of flood protection dikes along the Widas river. Excess rain water tentatively standing in the ill-drained paddy field along the Widas river is smoothly drained by drainage canals to be provided along the inside of the flood protection dikes and drainage culverts provided across the flood protection dikes.

In the areas other than the ill-drained field along the Widas river, flood is not so severe problem. According to the interview survey, flood does not or little occures in those areas in the rainy season. Paddy which is durable plant against deep water standing is planted at present and forecasted not to be replaced with upland crops in the rainy season in near future. The mechanized farming will not be introduced in near future since the ample cheap labour force is available. Therefore, necessity of small drainage networks is little.

Taking the above situations into account, drainage canals are provided or improved only to drain the excess water coming from the high elevated fields of outside the project area. Those length of drainage canals is planned to be 14 km consisting of 6.9 km in Lengkong area and 7.1 km in Tretes area except the drain to be provided with flood dikes. The canal layout is shown in ANNEX 7, Section 7.14.

17.6.2 Design discharge

1. Irrigation canals

As for the main canal to tertiary canals the design discharge of irrigation canals is estimated as a product of the irrigation area, maximum unit irrigation requirement and pemali distribution factor. The unit irrigation requirement is decided to be 1.4 ℓ/s/ha according to the peak irrigation requirement of 1.389 ℓ/s/ha. Fig. 17.9 shows the flow diagram.

As for quaternary canals, the design discharge is decided to be 40 ℓ/s considering the intermittent irrigation.

Detailed explanation is made in ANNEX-7, Section 7.13.

2. Drainage canals

The drainage requirement for the design of drain and the related structures is estimated dividing into two areas such as paddy fields and elevated land.

According to the Indonesian criteria, probable rainfalls of three consecutive days with the return period of 5 years and 20 years are adopted to estimate the drainage requirement. The five years probable rainfall is for design of drainage canals and the 20 years is for the drainage structures.

In the result, the drainage requirement for drainage canals is 5.6 ℓ/s/ha and 8.0 ℓ/s/ha for structures.

Drainage requirement in elevated land is estimated by Rational method. The result is 5.3 $m^3/sec/km^2$ for 5-year probable rainfall and 7.4 $m^3/sec/km^2$ for 20-year probable rainfall.

Details are referred to in ANNEX-7, Section 7.13.

17.6.3 Bangle headworks

1. General

Direct supply from the Ketandan dam to canals requires large cost and so is not economically justified. The headworks is provided for taking the water released from the Ketandan reservoir and distribute the water to the Lengkong area of 1,328 ha and the Tretes area of 1,180 ha through the East and West main Canals, respectively. The headworks consists of an overflow fixed weir, an intake and sand trap ponds. Fig. 7.10 shows the features of Bangle headworks.

2. Site

(1) Location

The site is selected on the Ketandan river at the upstream of Desa Bangle about 3.5 km downstream from the Ketandan dam by taking the following into account;

(a) Water head should be maintained to irrigate the objective area as much as possible in the extent that can be economically justified. The required head at the Bangle is around EL. 64 m.

(b) Back-water effect caused by the provision of weir to the upstream area is minimized.

(c) Foundation of the headworks is strong enough to be stable.

(2) Topography and geology

The Ketandan river is straight at the site and the altitude is around EL. 61 m in the river bed. The both sides of the rivers are almost 5 to 6 m higher than the riverbed. The right bank side is covered with sparse teak forest and the left bank side with the poor plantation. No inhabitants are living in the upstream stretch.

According to the site inspection, original rock is exposed to the riverbed and according to the boring investigation, tuff having white color covers upto around 2 m below the riverbed and bluish sandstone is found beneath the tuff zone (refer to ANNEX-3). This sandstone is well-bedded and judged to be enough to bear against the reluctant force acting on the foundation.

3. Design of headworks

(1) Weir

According to the geological information, the foundation of the weir is set at 2 m below the riverbed.

A fixed overflow weir is to be provided to keep the water level required to distribute main canals, since this type of weir requires no operation to release flood to downstream.

The crest elevation of the weir is decided to be EL. 64.2 m considering the water head to distribute irrigation water by gravity systems to the project area. The weir height required becomes 4.2 m above downstream apron.

The weir crest length is decided to be 40 m so that the design flood discharge can be safely drained to the downstream with no injurious backwater effects to the both sides of the upstream stretch.

A 100-year probable flood is taken as the design flood discharge. It is 207 m^3/sec. The estimation method and calculations are shown in ANNEX-2 Hydrology.

The overflow depth and design flood water level are calculated by overflow equation with the overflow coefficient of 2.1 based on the design flood discharge and the weir crest width. These results are as follows.

Overflow depth	:	2.21 m
Design flood water level	:	EL. 66.41 m

A sand flushing sluice equipped with a gate having a gate leaf size of 2.0 m in width x 3.5 m in height is provided in front of the intake structure.

A rear apron is provided to protect the riverbed against erosion and to increase the creep length. The length is set at 21 m.

(2) Intake

The intake structure consists of an intake, a sand-trap pond, a sand flushing channel and a diversion to East and West Main Canals.

The intake water level is set at EL. 64.20 m. The design intake discharge is 3.5 m^3/sec. The intake is equipped with two slide gates having a gate leaf dimension of 1.5 m x 1.5 m.

The sand trap pond is designed so as to catch sand of which practical size is 0.2 mm. The dimensions are as follows.

Section	:	Trapezoid
Side slope	:	1 : 1
Length	:	50 m
Bottom width	:	5 m

At the end of the sand trap pond, the channel is divided into two ways; East and West main canals. In those inlets, a slide gate of which size is 1.5 m x 1.5 m is provided each with a discharge measuring weir.

17.6.4 Irrigation canal and the related structures

1. Irrigation Canals

(1) Design Criteria

Irrigation canals are designed as trapezoidal cross - section open canals with a side slope of 1 to 1. Main canals and secondary canals are lined with wet stone masonry and concrete block panels, respectively. Tertiary and quaternary canals are earth canals.

Hydraulic calculation is approximately made by the Manning formula with a roughness coefficient of 0.020 for lining canals or 0.030 for earth canals. Head losses at structures are assumed as follows;

Check	:	5 cm minimum
Culvert	:	10 cm "
Syphon	:	30 cm "
Drop	:	Variable
Bridge	:	5 cm
Turnout	:	20 cm
Division box	:	5 cm

A freeboard of canals is decided in accordance with the criteria of U.S.B.R.

(2) Main Canal

Figs. 17.11 and 17.12 show the plan and profiles of East and West main canals.

The west main canal is obliged to pass through deep excavation section of which depth reaches 5 to 6 m. The area collects drain water. Then in case of the open channel, the excavation section will be much eroded owing to the drain water and weak soil and then the main canal will suffer from the heavy sedimentation. Therefore, in this section of 350 m in length, a buried pipeline is proposed. The pipeline has two lanes of concrete pipes, a diameter of 1 m supported by masonry foundation. Primary features of these canals are as follows;

		East Main Canal	West Main Canal
Type	:	Trapezoidal lining canal with masonry	
Design discharge	:	1.86 m^3/sec	1.65 m^3/sec
Canal legnth	:	6.3 km	2.1 km
Canal gradient	:	1/1,500	1/3,000
Canal height	:	1.50 m	1.60 m
Bottom width	:	1.2m	1.2 m
Side slope	:	1:1	1:1

(3) Secondary Canals

Plan and profiles are shown in ANNEX-7, Section 7.14. Primary features of secondary canals are summarized below.

Type	: Trapezoidal lining canal with concrete block panel	
Design discharge	: 0.18 m^3/sec	- 1.25 m^3/sec
Canal height	: 0.70 m	- 1.40 m
Canal bottom width	: 0.5 m	- 1.0 m
Side slop	: 1:1	

(4) Tertiary Canals

Design discharge of tertiary canals ranges from 0.08 m^3/sec to 0.25 m^3/sec and the canal gradient ranges from 1 to 150 to 1 to 2,000. Based on these data, hydraulic calculation is made and then the canal is classified into three grades in the cross sectional scale. The results are as follows;

Clase	Canal Bed Width (m)	Canal Height (m)	Minimum Freeboard (m)	Canal Bank Width (m)	Total Length (km)
I	0.6	0.9	0.3	0.6	4.1
II	0.5	0.8	0.3	0.6	40.0
III	0.5	0.6	0.3	0.5	20.7

(5) Quaternary Canals

Design discharge of quaternary canals is 40 ℓ/sec as previously stated. The average gradient of the Project area is around 1 to 500 and the most of the area is more than 1/750. Based on these informations the canal dimensions are decided as follows;

Canal height	:0.5 m
Canal bed width	:0.3 m
Canal bank width	:0.4 m

2. Related Structures

Structures designed for use in this feasibility study include; turnouts, checks, drops, syphons, bridges, culverts cross drainage culverts, and division box. Typical drawings of these structures are compiled in ANNEX-7, Section 7.14.

A short description of some of the design features of these structures is given below.

(1) Turnout

Five types of turnouts are prepared according to the design discharges. These turnouts are equipped with a slide gate and a measuring device. If the turnout is laid across a road, the throat portion is lengthened so as to meet the width of the road. Number of turnouts is 51.

(2) Checks

Checks are provided to maintain design water levels in the canals. At the most points of turnouts, the checks are provided. Four types of checks are designed in accordance with the design discharge of canals. Number of checks is 33.

(3) Drop

A drop is provided on the canal where the excess energy of water head is needed to be dissipated. Four types of drops are presented in this study in accordance with the design discharge. The number of drops is 25.

(4) Syphon

Syphons are provided for crossing of rivers having a design flood discharge more than 9 m^3/sec. These syphons are designed with precast concrete pipes wrapped with wet masonry. The riverbed at the crossing point of syphons is protected with masonry ripraps. The principal features of syphons are presented below.

Canal Name	No. of Syphon	Design Discharge (m^3/sec)	Length of Syphon (m)	Barrel Size & Nos of Lanes	Name of River Crossing
WMC	No.1	1.65	140	ø1.0 x 2	Small stream
	No.2	1.65	40	ø1.0 x 2	Small stream
	No.3	1.65	130	ø1.0 x 2	Jaan
ESC-1	No.1			ø0.8 x 1	Ketandan
	No.2			ø0.8 x 1	Small stream from Sumber-Kepuh pond
WSC-2	No.1			ø0.80 x 1	Tretes

(5) Bridge

Bridges are provided as roadway crossings for main canals. One lane bridge having a width of 4.5 m is planned considering the small traffic amount. The superstructure is made by reinforced concrete slab. The substructure is made by masonry.

The number of the bridges are only three; one is on West Main Canal and two are on East Main Canal.

(6) Culvert

Culverts are used to convey irrigation water under roadways or drainage channels where the drainage channel is situated in higher elevation than the irrigation canal. Five types of culverts are prepared depending on the design discharge. Type A is provided on the West Main Canal. Types B to D are provided on secondary canals and Type E is on the tertiary canals.

The number of culverts is 109 units.

(7) Cross - Drain Culvert

Cross-drain culverts are provided to convey drainage flow across irrigation canals or roadway.

Three types are prepared depending on the drainage discharge. Total number of them is 14.

(8) Division Box

Division box are provided on tertiary canals to divert the irrigation water to quaternary canals. The division box is equipped with two simple slide gates of which gate leaf sizes are 0.3 x 0.3 m and 0.4 x 0.4 m in each.

The gate of 0.3 m is turnout gate and the gate of 0.4 m is check gate. Just after the turnout gate, a culvert barrel having the diameter of 0.3 m and the length of 3 m is provided as easy crossing means. The total number of box is estimated to be 334.

17.6.5 Drainage canals and the related structures

1. Drainage canal

The drainage canals are designed as an earthen canal with a side slope of 1 to 1.5. The primary features are as follows.

Name of Drain	Canal Length (km)	Catchment Area (km^2)		Design Flood (m^3/sec)	Gradient	Canal Bed Width (m)	Canal Depth (m)
		Hill	Paddy Field				
ED-1	3.2	0.8	3.2	6.0	1/400	2.0	1.2
ED-2	3.7	0.7	0.3	3.9	1/300	1.5	1.0
WD-1	4.2	2.5	3.0	15.0	1/750	4.0	1.8
WD-2	2.9	3.2	2.4	18.3	1/1,000	5.0	1.9

2. Related structures

For road crossing points, bridges are provided. All the bridges are single concrete slab bridge with masonry made abutments. The clear span is the same as the bed width of each of the drainage canals.

Necessary numbers of the bridge are as follows;

ED-1	2 nos
ED-2	2 nos
WD-1	3 nos
WD-2	2 nos

17.6.6 Small pump station

Two pump stations are installed along the Kedungwarak reservoir to irrigate Ngluyu area of 122 ha in total. One pump station has the irrigation area of 41 ha. The design discharge is 0.058 m^3/sec and net head is 24 m. The discharge pipeline length is 600 m. Another pump station has the irrigation area of 81 ha. The design discharge is 0.114 m^3/sec. Net head is 25 m. The discharge pipeline length is 1,100 m.

Based on these data, the total head loss is approximately estimated by Manning formula with a roughness coefficient of 0.013 for various diameter of pipelines. Then, the diameter of the pipeline is decided to be 250 mm and 350 mm for respective pump stations. In these cases total loss becomes around 8 m.

The discharge largely vary in accordance with the variation of irrigation requirement. Thus, two pumps are planned to be provided in each of pump stations. (one is playing a role as stand-by at off-peak). A single suction solute pump (50 Hz, 4 pole) is selected.

For operating these pumps, a diesel generator is installed for each station. The output required are estimated at 30 kW and 60 kW, respectively.

The space of the pump stations is estimated to be 36 m^2 in both pump stations.

Inlet channels are required about 70 m and 80 m, respectively. The pipelines are connected with respective tertiary canals at the upstream ends.

17.6.7 Inspection road

An inspection road is provided along the main canals and the secondary canals excluding area where the existing road is running along these canals.

Total length of the inspection road is 25 km consisting of the inspection road 6.2 km for the west main canal and 18.8 km for the secondary canals.

The width of the inspeciton road is 5 m for main canal inspection road or 3.5 m for the secondary canal inspection road. The main inspection road is provided with gravel metaling having width of 3.0 m and thickness of 0.2 m. All the inspection road side slopes are protected by sod-facing.

17.6.8 Water supply to Senggowar Area in rainy season

1. General

As explained in Chapter 17, the runoff in the Kedungwarak river is used for irrigation in the downstream area (Senggowar irrigation area) together with the water conveyed through the Widas existing main canal. According to the past 7 years intake records, the maximum intake discharge was 1.33 m^3/s in the rainy season, although it is unknown whether this amount was actually needed or not. In order to make it possible to use the water in the Kedungwarak river for the Widas Extension Area, it is necessary to guarantee the amount of 1.33 m^3/s to the Senggowar irrigation area.

To guarantee this amount of water, water resources of the Wengkol river, the Jintel river and the Musir river which are not fully used after the Bening reservoir and the main canal were completed, are proposed to be used for the irrigation of the Senggowar area. These rivers are located in the west adjacent to the Kedungwarak basin. These catchment area is 33 km^2 in total to meet the catchment area of the Kedungwarak river of 31.5 km^2. The Widas main canal can be used to transfer the water by provision of connection canals and related structures.

On the Jintel and the Wengkol rivers, intakes are existing and the canals originating these intakes are crossing over the Widas main canals. Therefore the water can be easily taken to the main canal with provision of control structures and rehabilitation of existing canals. As for the Musir river, an intake and a connection channel have to be newly constructed. The main canal has enough capacity as explained in the succeeding section.

2. Design

The canal length from the intake to the Widas main canal is as follows.

Jintel river	1.5 km (existing)
Wengkol river	0.8 km (existing)
Musir river	1.0 km (proposed)

The existing canals are earthen canals except the upstream reach, about 0.4 m of the Wengkol canal and 0.3 km of the Jintel canal. These lining portions are well maintained and have enough capacity compared with the required cross section mentioned below. The earth section is only to be rehabilitated with provision of concrete panel lining. Besides a small aqueduct existing on the Jintel canal is completely ruined. Thus, one aqueduct is newly constructed.

As for the Musir river, an intake and a connection canal to the Widas main canal are proposed to be newly provided with lining.

As shown in ANNEX-2, the maximum intake discharge of the Senggowar area is 1.33 m^3/sec for past 7 years. Thus the canal capacity, 0.5 m^3/sec each is enough to function well. The required cross section of the canal are as follows, estimated by the Manning formula with a roughness coefficient of 0.020 and the hydraulic gradient of 1/500.

Bed width	0.6 m
Canal height	0.8 m
Side slope	1 : 1

Control structures such as an intake and an inlet to the Widas main canal are equipped with a small gate, 0.5 x 0.5 m.

The Widas main canal flow capacity is checked by the Manning formula.

The present conditions are as follows.

Canal bed width	:	3 m
Canal height	:	1.6 m
Side slope	:	1:1.5
Lining	:	in both slopes
Canal gradient	:	1/2,500

The flow capacity under above conditions is estimated at 2.8 m^3/sec keeping the freeboard of 0.6 m assuming the roughness coefficient of 0.025. The capacity is quite enough compared with the past maximum intake record of 1.33 m^3/sec.

Table 17.1 PROPOSED IRRIGATION CANAL LENGTH

Canal Name	Irrigation Area (ha)	Canal Existing (m)	Length New Canal (m)	Total Length (m)
(1) LENGKONG AREA				
East Main Canal	1,328	-	2,060	2,060
Secondary Canal				
ESC-1	433	1,300	3,515	4,815
ESC-2	895	1,100	4,720	5,820
ESC-2-1	(275)	715	3,500	4,215
Total Secondary Canal		3,115	11,735	14,850
Tertiary Canal				
ETC-1-1	39	1,500	210	1,710
ETC-1-2	60	1,220	-	1,220
ETC-1-3	170	1,900	800	2,700
ETC-1-3-1	(44)	1,250	300	1,550
ETC-1-4	40	-	1,150	1,150
ETC-1-5	58	-	1,520	1,520
ETC-1-5-1	(28)	-	770	770
		5,870	4,750	10,620
ETC-2-1	41	-	350	350
ETC-2-2	59	1,370	420	1,790
ETC-2-3	31	-	300	300
ETC-2-4	95	1,990	800	2,790
ETC-2-5	63	370	1,200	1,570
ETC-2-6	106	0	2,950	2,950
ETC-2-6-1	(40)	-	830	830
ETC-2-6-2	(29)	-	590	590
ETC-2-7	40	-	750	750
ETC-2-8	38	740	-	740
ETC-2-9	29	360	-	360
ETC-2-10	100	1,390	390	1,780
ETC-2-10-1	(55)	730	300	1,030
ETC-2-10-2	(26)	-	660	660

- to be continued -

Canal Name	Irrigation Area (ha)	Canal Existing (m)	Length New canal (m)	Total Length (m)
ETC-2-1-1	58	-	600	600
ETC-2-1-2	25	-	460	460
ETC-2-1-3	80	1,500	-	1,500
ETC-2-1-4	43	1,100	-	1,100
ETC-2-1-5	35	-	500	500
		9,550	11,100	20,650
Total Tertiary Canal		15,420	15,850	31,270
(2) TRETES AREA				
West Main Canal	1,180	-	6,280	6,280
Secondary Canal				
WSC-1	319	-	2,560	2,560
WSC-2	861	-	6,750	6,750
WSC-2-1	169	-	1,035	1,035
WSC-3	251	325	3,175	3,500
WSC-4	325	1,000	3,600	4,600
Total Secondary Canal		1,325	17,120	18,445
Tertiary Canal				
WTC-1	102	2,000	-	2,000
WTC-1-2	47	-	750	750
WTC-1-3	51	-	1,300	1,300
WTC-1-4	33	-	2,400	2,400
WTC-1-5	86	700	900	1,600
		2,700	5,350	8,050
WTC-2-1	49	-	600	600
WTC-2-2	54	450	350	800
WTC-2-3	79	-	1,200	1,200
WTC-2-4	34	-	530	530
WTC-2-5	44	-	600	600
WTC-2-6-1	94	1,300	-	1,300
WTC-2-6-2	63	-	1,100	1,100
WTC-2-1-1	128	-	1,600	1,600
WTC-2-1-2	36	-	800	800
		1,750	7,080	8,830

- to be continued -

Canal Name	Irrigation Area (ha)	Canal Existing (m)	Length New Canal (m)	Total Length (m)
WTC-3-1	24	-	1,740	1,740
WTC-3-2	29	600	500	1,100
WTC-3-3	60	-	950	950
WTC-3-4	57	760	240	1,000
WTC-3-5	47	-	800	800
WTC-3-6	58	-	1,400	1,400
		1,360	5,630	6,990
WTC-4-1	42	-	300	300
WTC-4-2	67	-	700	700
WTC-4-3	46	-	750	750
WTC-4-4	40	-	350	350
WTC-4-5	74	900	-	900
WTC-4-6	56	-	1,650	1,650
		900	3,750	4,650
Total Tertiary Canal		6,710	21,810	28,520
(3) NGLUYU AREA				
NTC-1	41	-	71,300	1,300
NTC-2		-	1,500	1,500
NTC-2-1		-	400	400
NTC-3	81	-	700	700
NTC-3-1		-	700	700
			4,600	4,600
GRAND TOTAL		26,570	79,455	106,025

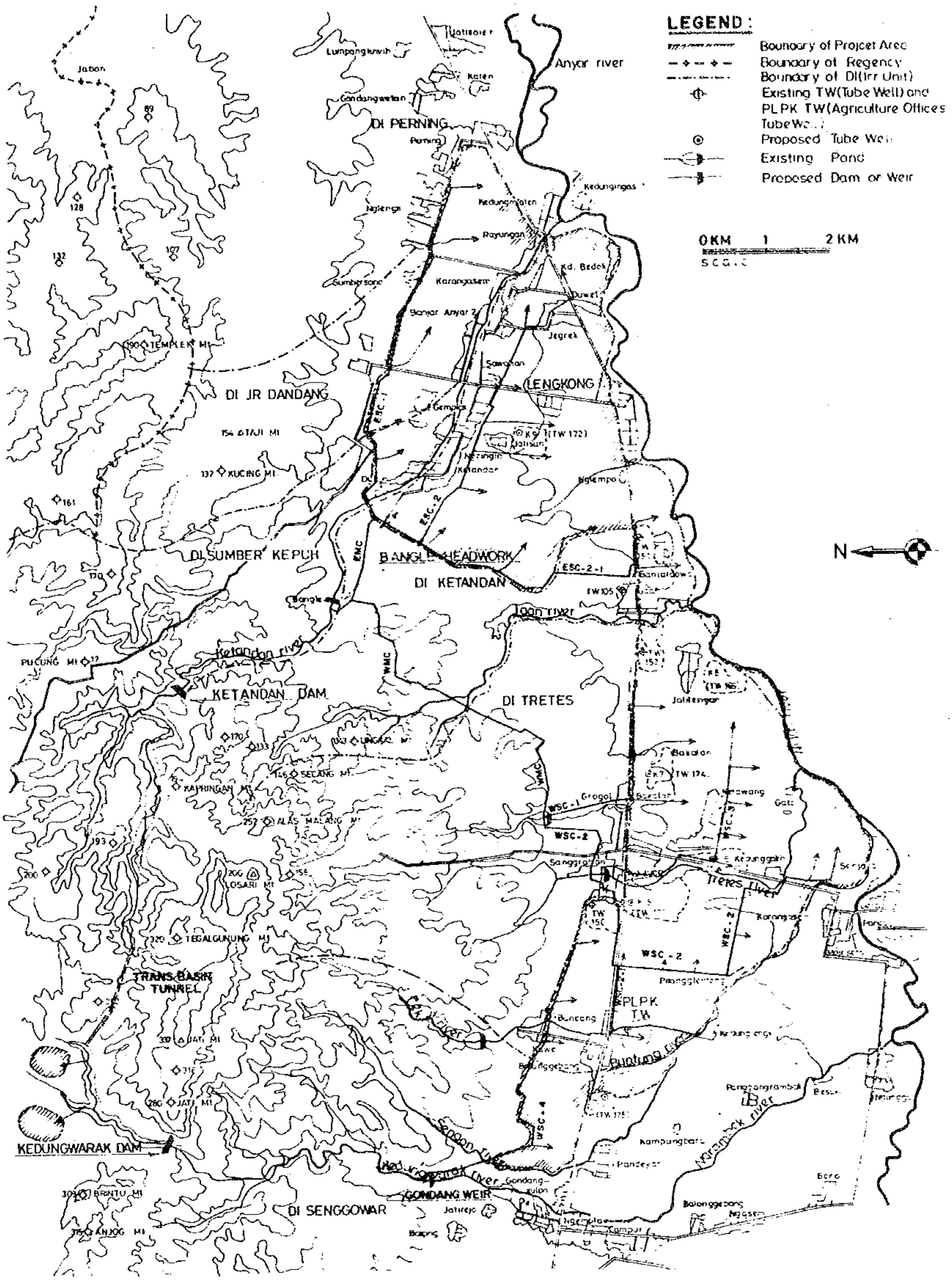


Fig. 17.1 DAM AND IRRIGATION DEVELOPMENT PLAN

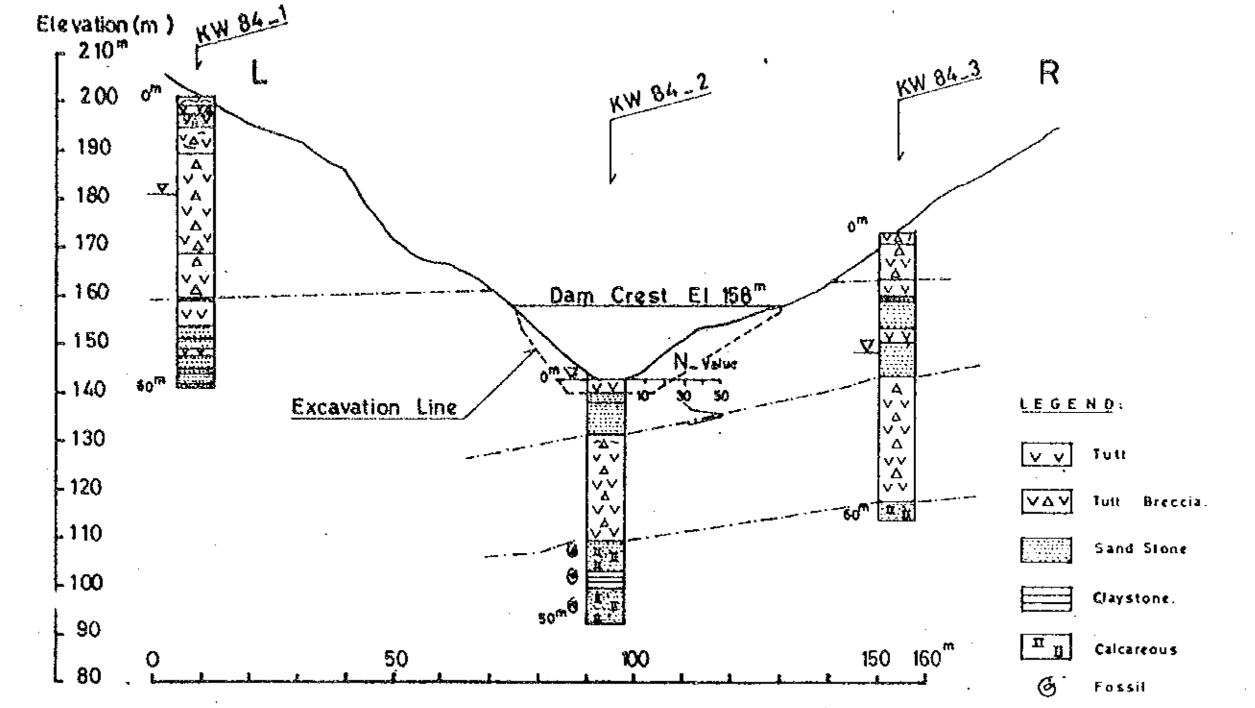


Fig. 17.2 GEOLOGIC PROFILE OF KEDUNGWARAK WEIR SITE

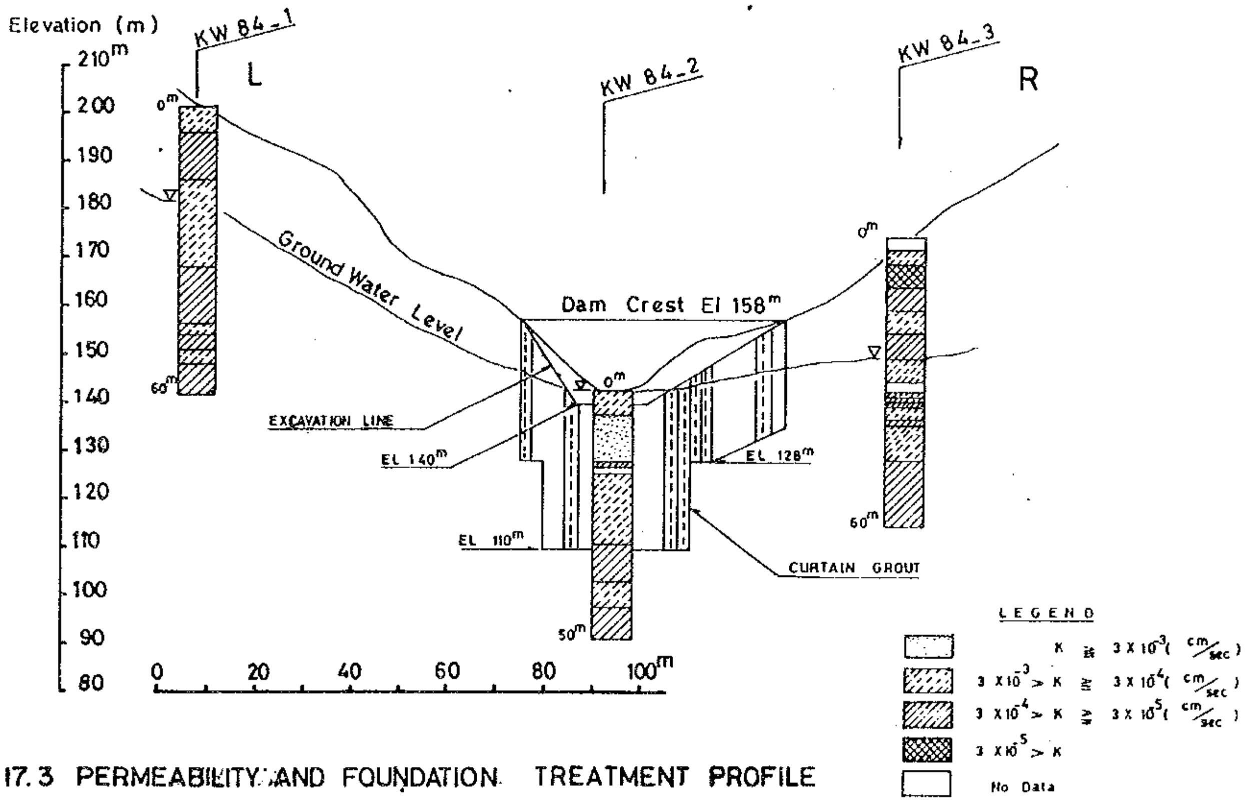
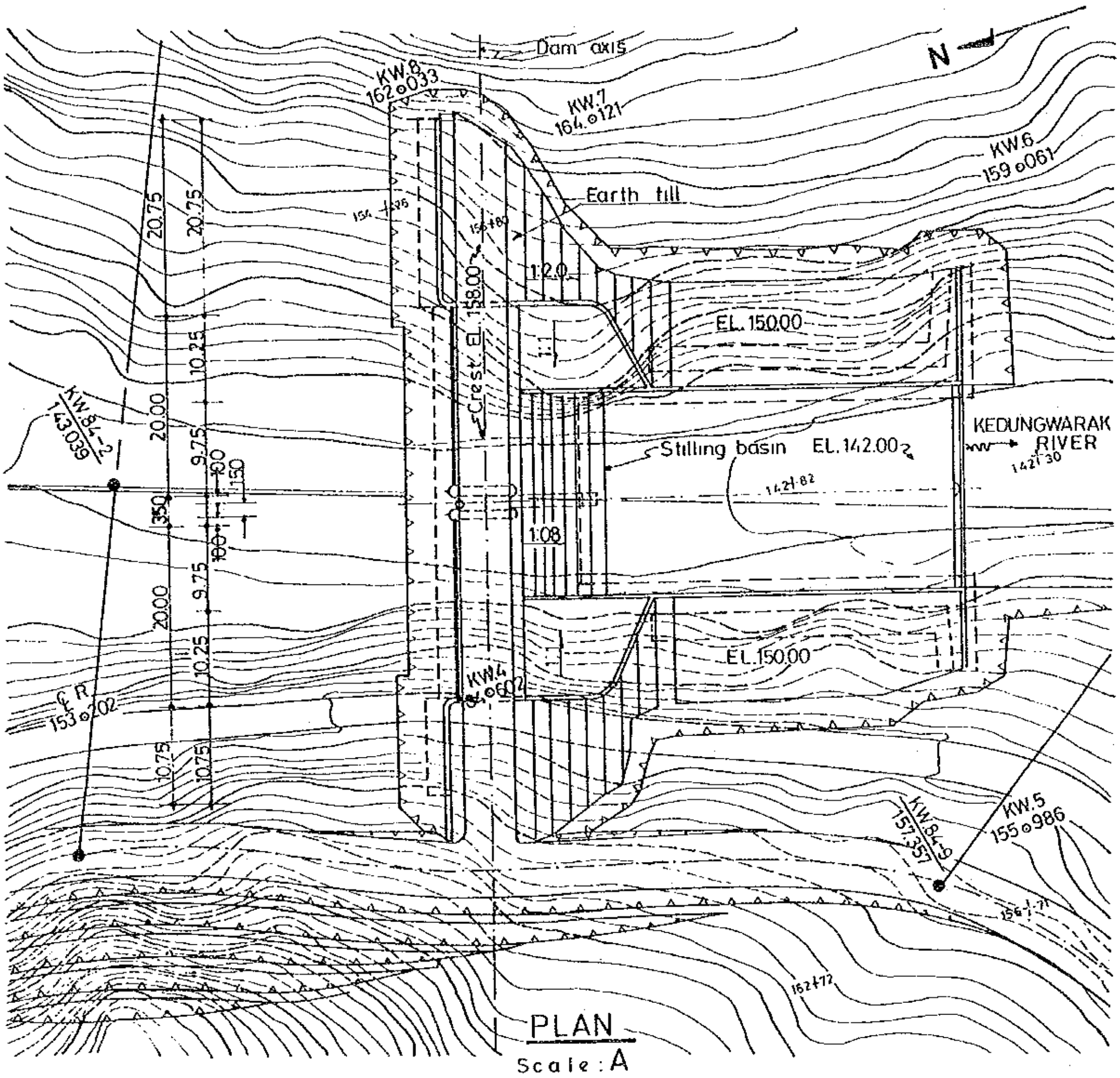


Fig. 17.3 PERMEABILITY AND FOUNDATION TREATMENT PROFILE OF KEDUNGWARAK WEIR SITE



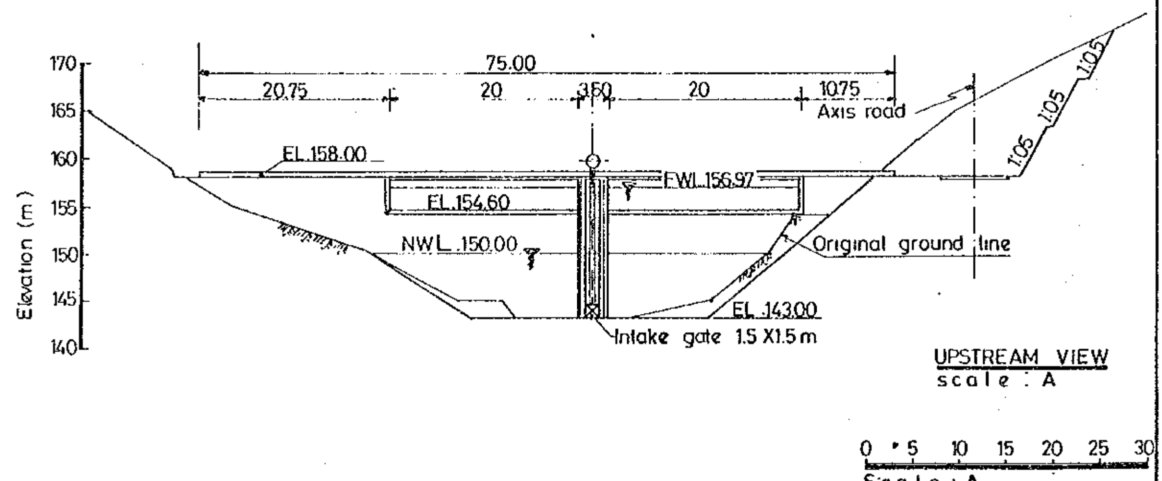


Fig. 17.4. KEDUNGWARAK WEIR

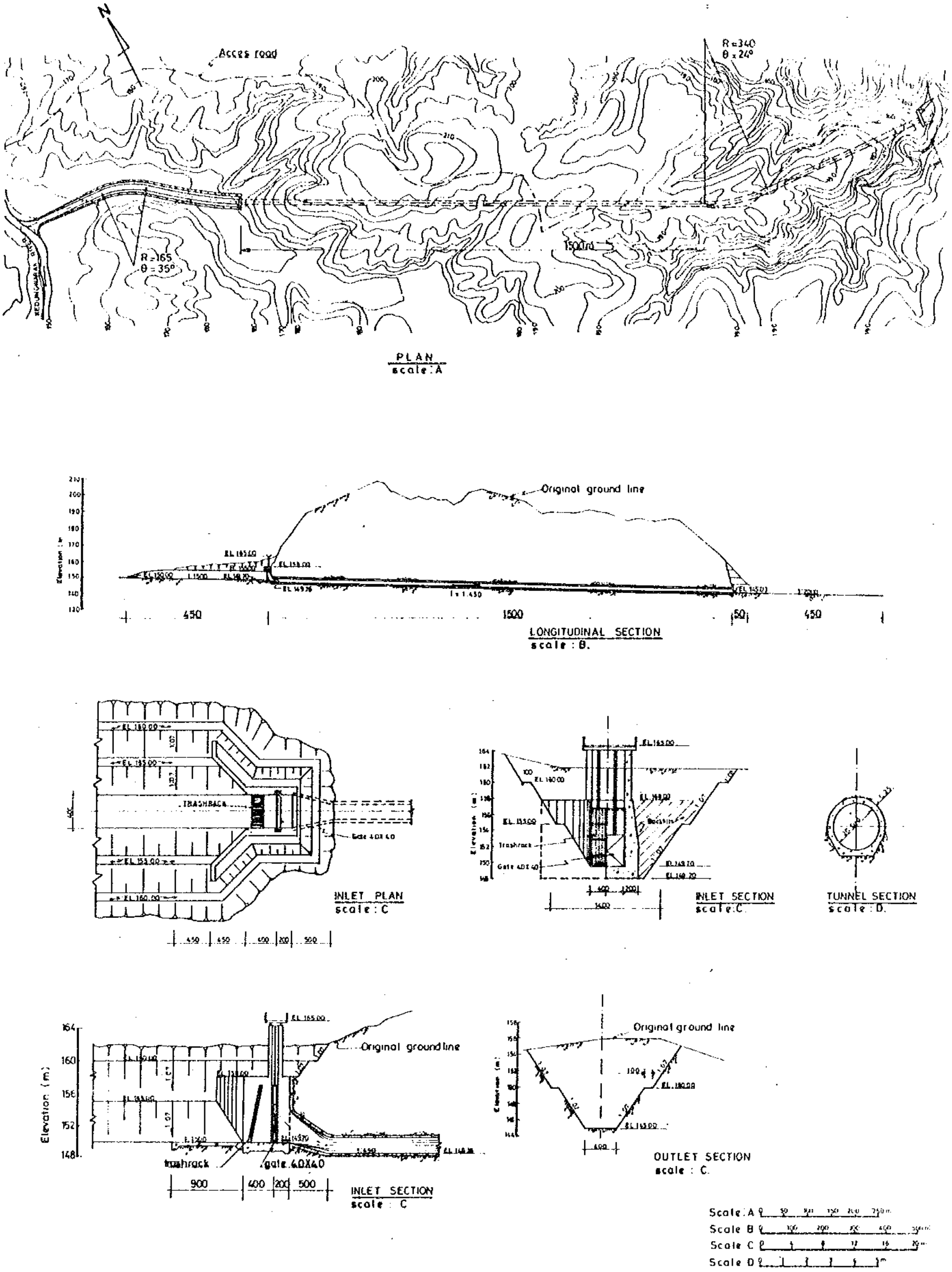


Fig. 17.5 TRANS BASIN TUNNEL

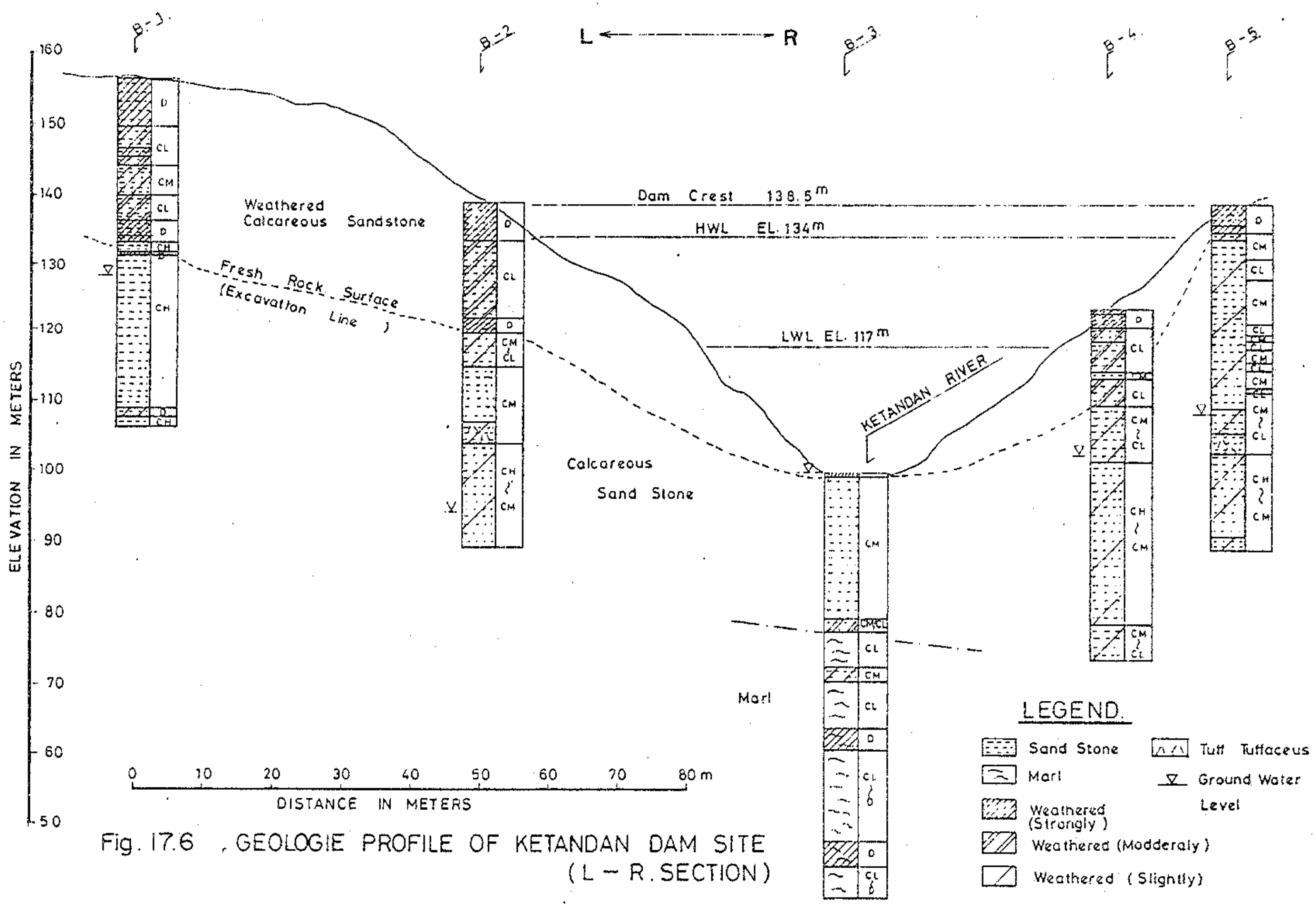


Fig. 17.6 . GEOLOGIE PROFILE OF KETANDAN DAM SITE (L – R. SECTION)

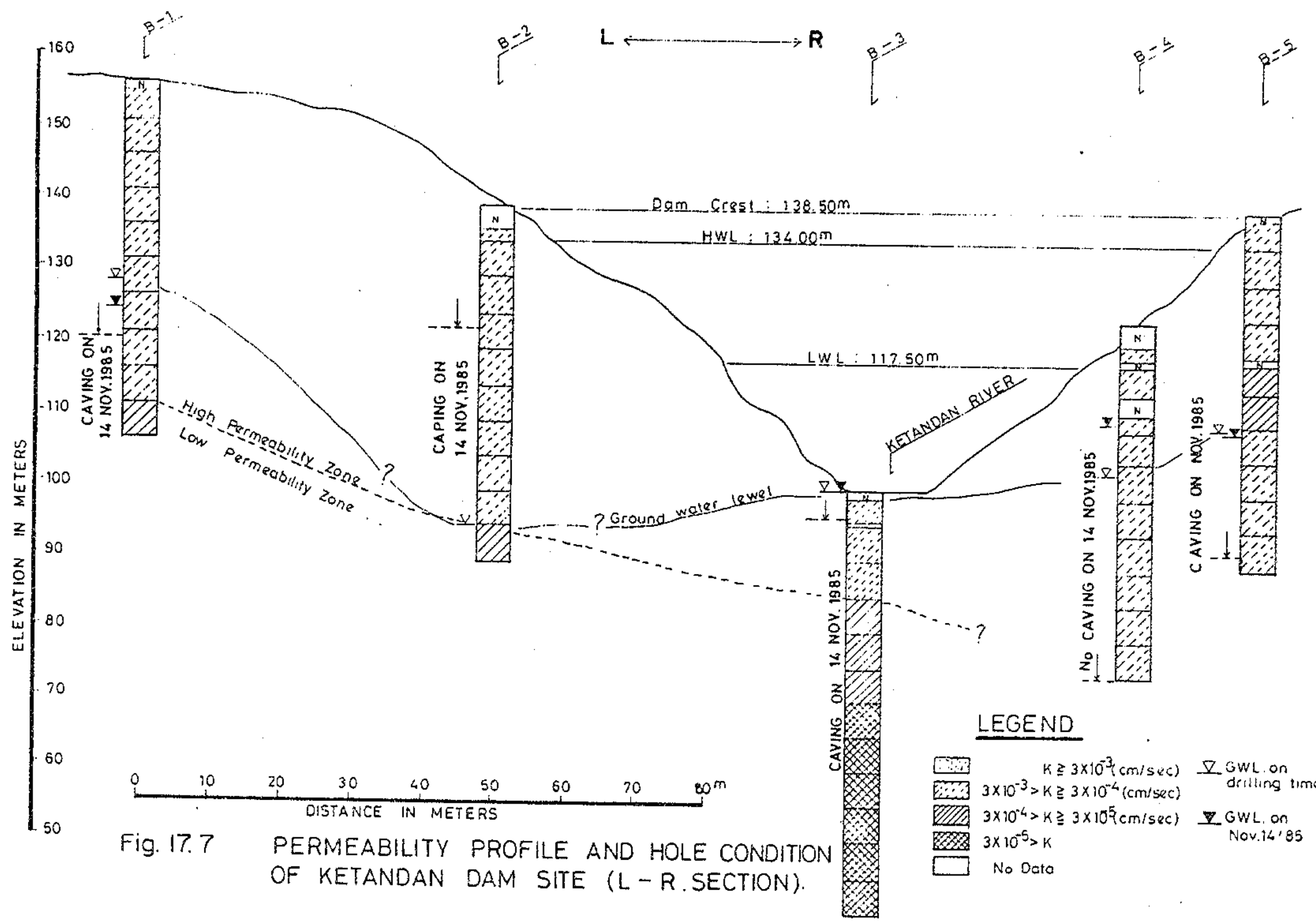


Fig. 17.7 PERMEABILITY PROFILE AND HOLE CONDITION OF KETANDAN DAM SITE (L-R.SECTION).

Fig. 17.8 PLAN OF KETANDAN DAM

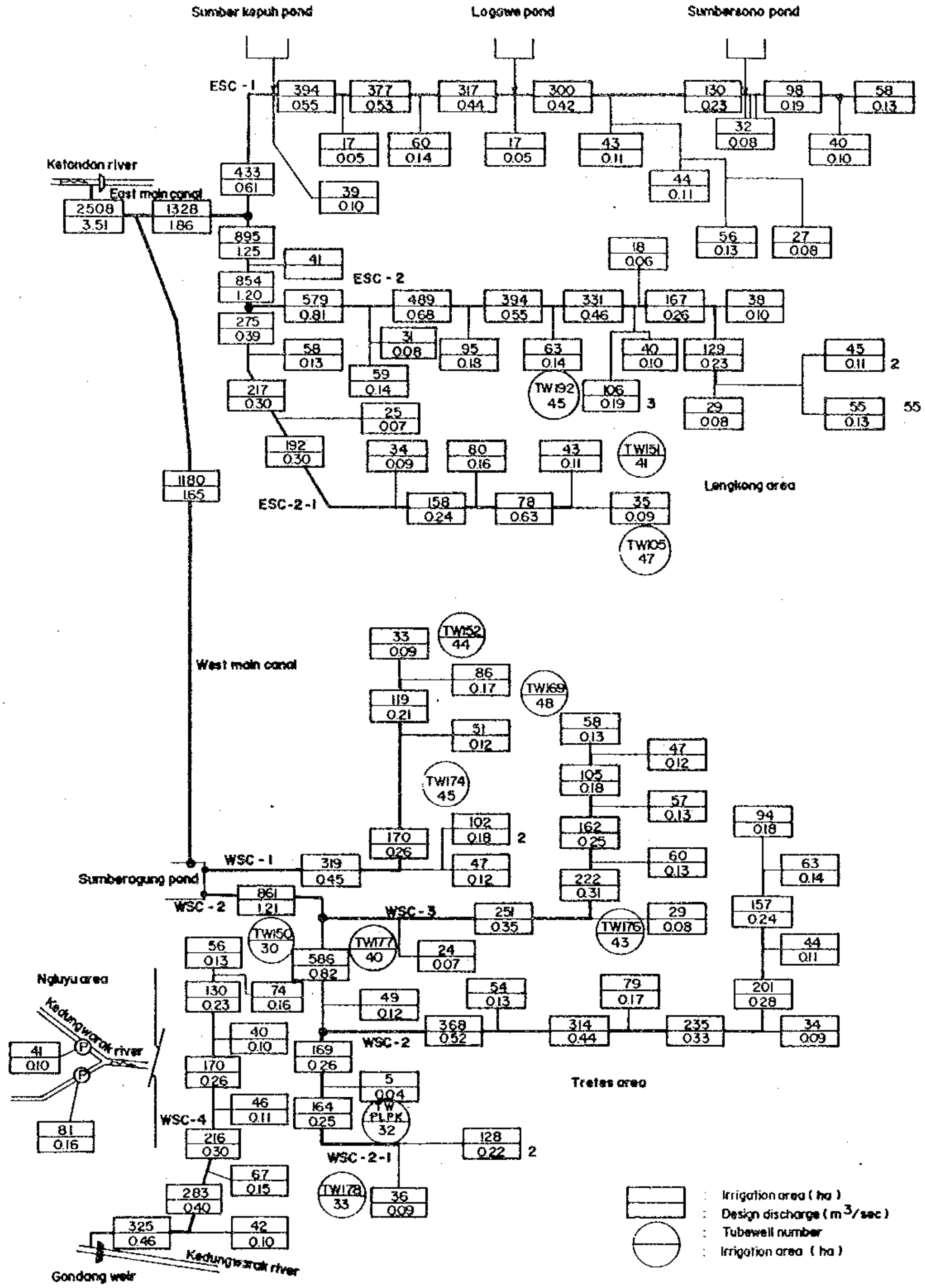


Fig. 17.9. PROPOSED IRRIGATION NETWORKS

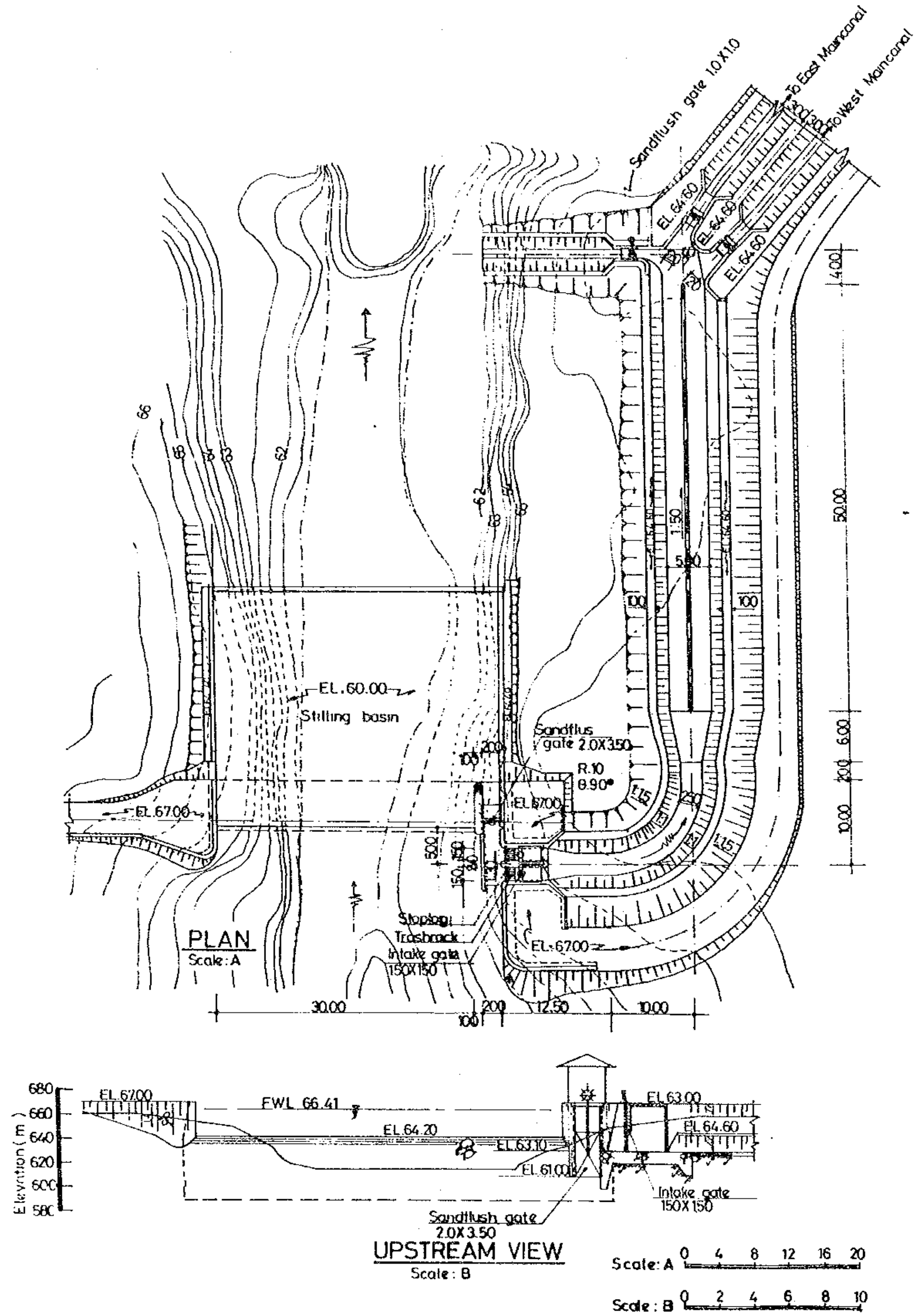
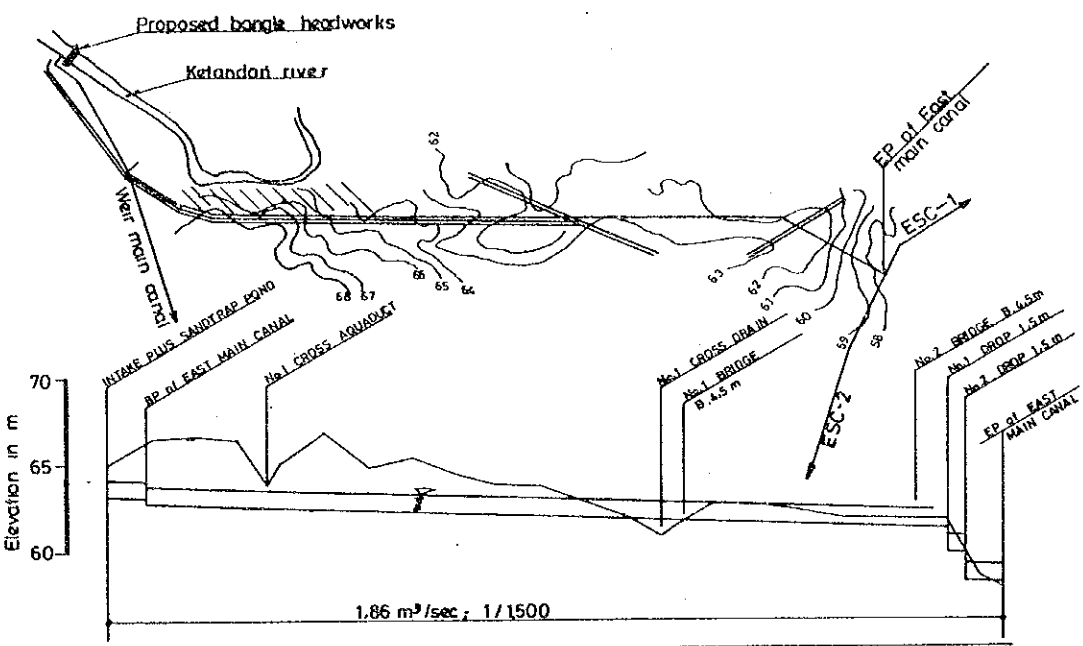


Fig. 17.10. BANGLE HEADWORK.



Canal base Elevation	63.10	62.77			61.93 / 61.88		61.52 / 61.47	61.42 / 59.92	59.89 / 58.39	58.33
Water surface Elevation	64.10	64.10 / 63.80			62.92 / 82.87		62.51 / 62.46	62.41 / 60.81	60.88 / 59.38	59.32
Distance	0	86.20	5.000	1.000	1.275 / 1.325	1.500	1.855	1.930	2.020	2.060

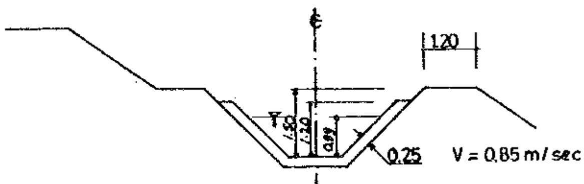
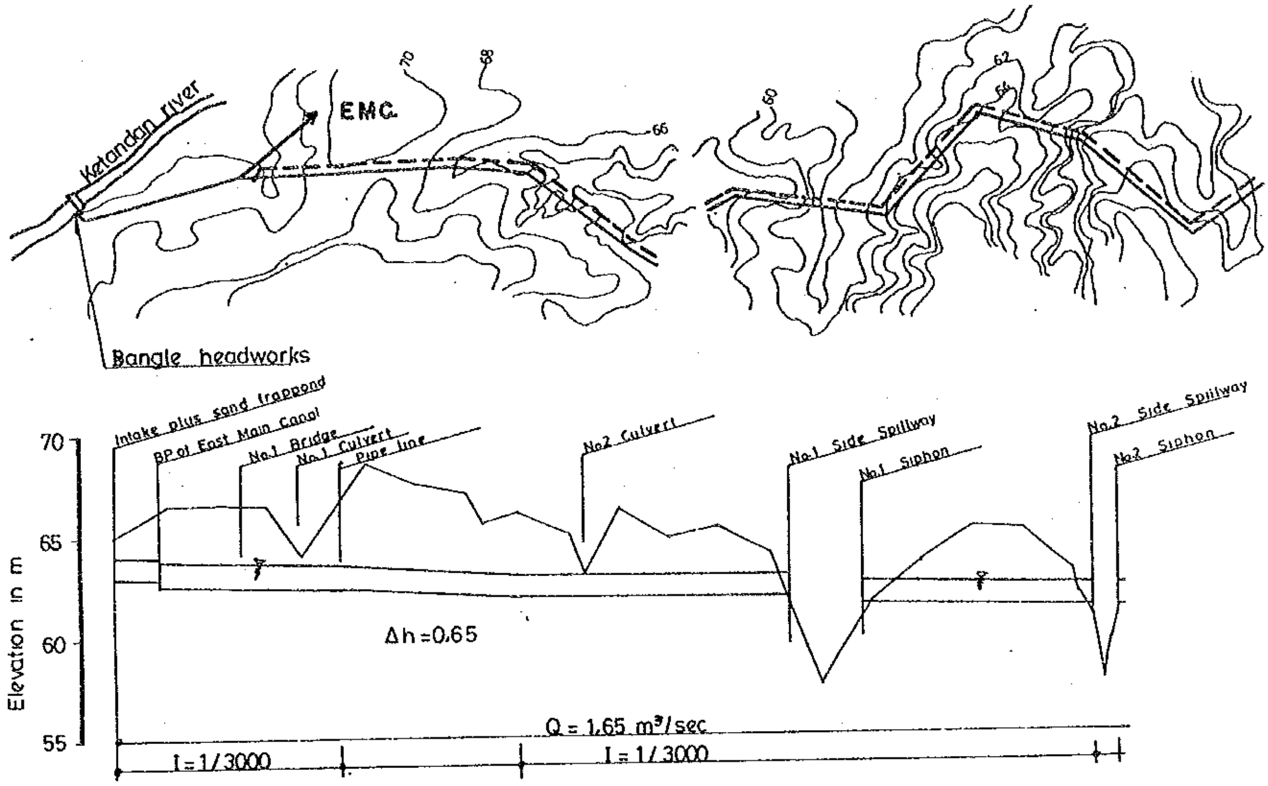
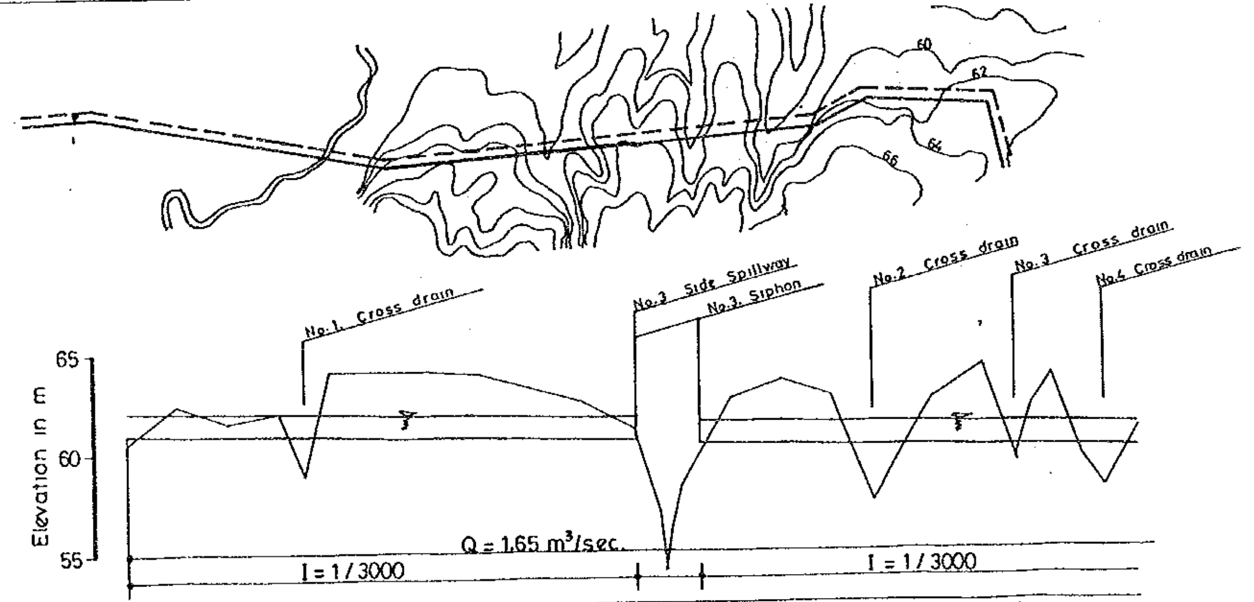


Fig. 17.11. PLAN AND PROFILE OF EAST MAIN CANAL



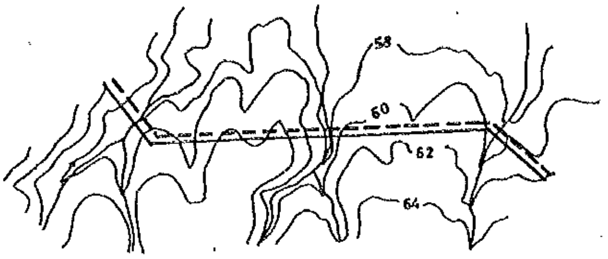
CANAL BASE ELEVATION	63.10	62.69	62.64	62.47		61.87	61.83		61.69	61.39		61.18	60.88	
WATER SURFACE ELEVATION	64.20	63.80	63.75	63.58		62.98	62.94		62.80	62.40		62.59	61.99	
DISTANCE	0	86.20	250	450	500	800	930	1,000	1340	1480	1500	1940	1980	2000

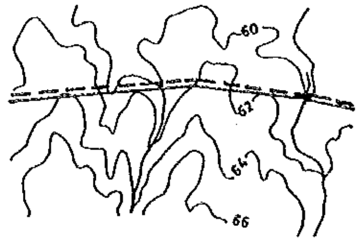


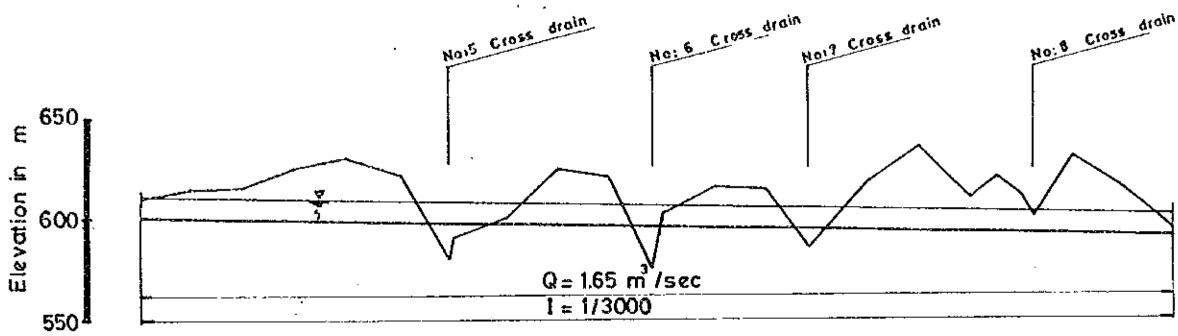
CANAL BASE ELEVATION			60.79		60.58		60.28	60.17		60.08	60.00
WATER SURFACE ELEVATION			61.90		61.69		61.39	61.28		61.19	61.11
DISTANCE	2000	2030	2350	2500	3000	3010	3160	3480	3500	3760	4000

NOTE : Location of this route (Refer to Fig. 7.14.9 of ANNEX 7)

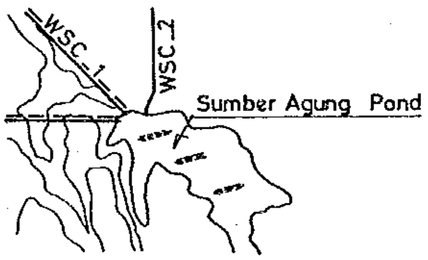
Fig: 17.12. PLAN AND PROFILE OF WEST MAIN CANAL (1/2)

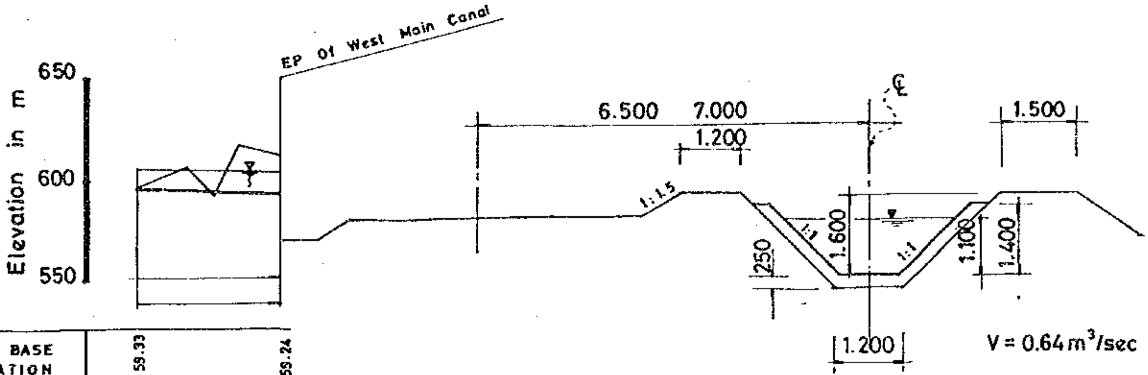






CANAL BASE ELEVATION	60.00		59.80	59.67	59.57		59.43	59.33
WATER SURFACE ELEVATION	61.11		60.91	60.78	60.68		60.54	60.44
DISTANCE	4.000	4.500	4.590	4.980	5.280	5.500	5.720	6.000





CANAL BASE ELEVATION	59.33	59.24
WATER SURFACE ELEVATION	60.44	60.33
DISTANCE	6.000	6.280

NOTE : Location of this route (Refer to Fig. 7.14.9 of ANNEX 7)

Fig. 17.12. PLAN AND PROFILE OF WEST MAIN CANAL (2/2)

CHAPTER 18 CONSTRUCTION PLAN AND COST ESTIMATE

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LIST OF TABLES

LIST OF FIGURES

18.1 Construction Plan

18.1.1 General

This section describes a construction plan and implementation schedule of the dam and irrigation development scheme.

The scheme aims to irrigate the Widas north area of about 3,000 ha with water to be stored in the Kedungwarak and Ketandan reservoirs by the gravity system. The scheme comprises the construction of a combined type weir of concrete and earthfill, circular sectioned transbasin tunnel, homogeneous earthfill dam, fixed type intake weir, trapezoidal cross sectioned canals and pumping stations.

A construction method is explained briefly hereinafter on the major works mentioned above including execution system, preparatory works and time schedule.

18.1.2 Mode of construction

The contract system will be applied for execution of construction works upon international and/or local tender divided into the following three (3) packages.

Package I	:	Kedungwarak weir
Package II	:	Ketandan dam and trans basin tunnel
Package III	:	Bangle headworks and canals with related structures.

The fund required for the execution of construction works will be allocated from the Government national budget and a loan from a donor country/international financing agency.

The construction works will be supervised, and administrated by BRBEDEO, DOR of DGWRD in association with a consultant.

18.1.3 Major work items and quantity

The major work items and quantities (approximately) are tabulated below.

Kedungwarak weir;

- Foundation excavation	:	20,300	m^3
- Foundation treatment	:	1,000	m
- Concrete	:	9,000	m^3
- Earthfill	:	1,600	"
- Metal works	:	1.5	ton

Transbasin tunnel

- Excavation, open	:	53,000	m^3
- Excavation tunnel	:	7,000	"
- Concrete tunnel	:	2,650	"

Ketandan dam

- Exca. diversion tunnel	:	2,000 m^3
- Concrete, diversion tunnel	:	750 "
- Foundation exca. main dam	:	355,000 "
- Embankment	:	423,000 "
- Concrete spillway	:	10,100 "
- Metal works	:	L.S.

Bangle headworks

- Excavation	:	7,800 m^3
- Masonry	:	2,200 "
- Gate	:	6 sets

Canals with related structures

- Excavation	:	450,000 m^3
- Embankment	:	400,000 "
- Masonry	:	20,000 m^2

Ngluye pumping Irrigation

- Earth work	:	L.S
- Pumping station, No.1	:	Q = 0.058 m^3/s, H = 24 m
- Pumping station, No.2	:	Q = 0.114 " , H = 24 m

18.1.4 Construction method

Kedungwarak weir

The weir is a combined type of concrete and earthfill. The proposed site is located at about 6 km point of Northern part of Gondang village. An existing roads in asphalted 3 m width is available as access road upon improvement of bridges. Tuffaceous sand stone with high permeability are distributed at the weir site. Curtain and blanket grout with 15 m to 30 m depth are recommended. The weir will be constructed in two (2) stages by partial coffering method of the river using earth materials. Construction works are assumed to take two (2) years.

No blasting method will be required for foundation excavation. A combination of buldozer with ripper, tractor shovel, dump trunk, grount pump and mixer will be used for the foundation excavation and treatment.

Portable type concrete mixer will be used for the concrete works.

Earthfill material will be obtained at downstream of the proposed weir site. Fine and coarse aggregate are planned to be taken from the sand borrow areas in K. Brantas and K. Kuncir, with hauling distances of about 20 km and 25 km respectively.

Transbasin tunnel

A free flow type of water tunnel having 2 m in diameter and 1,500 m in length is constructed to connect between the Kedungwarak pondage and K. Jurang.

General geology in the tunnel route is the marl formation, and surface is composed of stiff and compact marl.

The following method will be applied for the tunnel construction from the geology, technical and economical viewpoints.

Driven	: Bench cut & blasting method by air leg hammer and rail system.
Support	: Steel arch, half section rib with gunnite
Concrete	: Separation system after driven the whole length by concrete pump.
Form	: Steel form.

Backfill grout work will be carried out.

Two (2) work adits will be provided at up and downstream portal of the tunnel. The daily progress for tunnel excavation is estimated at 3 m at each adit. Ventilation facilities are to be provided at the both adits.

Excavated tunnel muck will be hauled to the spoil bank by muck car with rail.

Ketandan dam

The homogeneous earthfill dam is planned to be constructed at about 8 km point in linear distance in north-west from Lengkong town. An existing road runs nearby the proposed dam site from Lengkong through Bangle village, and the width varies 2 to 8 m with macadam or asphalt pavement. This road is utilized as a main access to the site after its widening to 3 to 4 m and constructing bridges. New access road is necessary to be constructed from the existing road to the site for about 1.5 km.

Geologic profile of the dam is a sandstone ridge overlying marl.

A diversion tunnel of about 500 m length and 2.0 m diameter will be constructed at left side by the same method for construction of trans basin tunnel.

Consequently, up and downstream cofferdams are constructed. River diversion will be carried out after completion of cofferdams.

Foundation excavation will be carried out from the both abutments towards the riverbed using bulldozer equipped with rippers, tractor shovels and dump trucks. Excavated earth will not be used for dam embankment materials due to the quality.

Foundation treatment will be carred out after foundation excavation.

The embankment work of main dam will be carried out by combination of wheel loader, dump truck, bulldozer, tire roller and vibration roller.

Embankment earth material will be scheduled to be obtained from the borrow area located at left side of the river and about one (1) km in hauling distance. The spillway construction is to be carried out in parallel with the dam embankment works using concreting equipment such as concrete plant, concrete pump, agistator truck and concrete vibrator.

Coarse aggregate and rock riprap material are scheduled to be taken from the Ketandan quarry site where located at right bank of the river and about 3 km south from the dam site. One (1) crushing plant will be provided in the dam site.

The filter, drain and fine aggregate materials are scheduled to be hauled from the Brantas sand borrow areas, since these materials are not available in the vicinity of the dam site.

The dam will be constructed in three (3) years including preparatory works.

Bangle headworks

A fixed type masonry weir equipped with a sandflush and intake gates will be constructed in the Ketandan river located at bangle village and about 3.5 km downstream of the proposed Ketandan dam site, for diversion of irrigation water to east and west main canals.

Geology of the site is composed of tuff and tuffaceous sandstone.

The same method as those for the construction of Kedungwarak weir will be applied for this weir construction. A temporary bridge will be constructed across the Ketandan river for transportation of construction materials.

Equipment for earthwork will be bulldozer equipped with ripper, tractor shovel, back hoe, vibration roller and dump truck. Portable type concrete mixers will be used for concrete production. Concrete aggregates are scheduled to be obtained from Ketandan quarry sites and Brantas sand borrow areas.

The Bangle headworks are planned in two (2) years construction period including two (2) dry seasons.

Canals

The canal length of proposed irrigation system is as follows for both Tretes area of 1,505 ha and Lengkong area of 1,328 ha.

Main canal : 8.4 km approx.
Secondary canal: 33.3 km "

These canals are all designed with trapezoids cross section all excluding 350 m of concrete pipe section of west main canal.

Major related structures are siphons, bridges, cross drains and culverts.

Construction of main canals will be carried out mainly by equipment, and the other canals and related structures will be done by manpower supported by small type of equipment.

Exvacated soils are to be used for the embankment of the canals. It is considered based on the site reconnaisance that the black clay exists in the proposed canal routes. According to the technical information from Wonogiri Irrigation Project in Central Jawa, this type of soil trends to form numerous and deep cracks as a result of remarkable shrinkage after desiccation. The following attention will be paid for the construction of canal embankment, in case of utilizing the black clay.

a) To desiccate black clay prior to embankment in order to reduce dry shrinkage after construction.

b) To protect embankment surface with sod facing immediately after shaping channel section since black clay is readily dried.

c) Shaping of channel slope before rainy season in order to reduce dry shrinkage as far as possible.

At the detailed design stage, more investigation will be needed.

At the construction of main canals, light class and swamp type of bulldozer, back hoe and dump truck will be used, and portable concrete mixer will be used for the concrete works. Required materials of concrete aggregates and masonry stones will be transported from Brantas sand borrow areas and Kuncir river deposits.

Three (3) years construction period will be required for the construction works of irrigation stystem including preparatory works.

Ngluyu Pumping Station

Two (2) pumping stations will be constructed for the supply of irrigation water of 122 ha at Ngluyu village.

Basic design condition is as follows;

Discharge	Head	Length discharge pipe
0.058 m^3/sec	24 m	600 m
0.114 "	25 "	1,100 "

Four (4) sets of single suction volute pump will be installed including the stand-by unit. The construction period is assumed at one (1) year work period. Civil works including buildings are carried out in advance of the installation works.

18.1.5 Preparatory works

Prior to the commencement of civil works construction, preparatory works should be carried out. Major preparatory works on the scheme are as follows. Fig. 18.1 shows general layout of temporary facilities.

(a) Access and construction road

An existing road running through Lengkong town, Bangle village, nearby the proposed Ketandan dam site, Lengkong village, Ngluyu village and Gondang village will be utilized as a main access of this project after improvement. Betterment works required are widening and pavement.

New access and construction roads are required to branch from the main access road mentioned above as follows.

Area	Distance, Approximately
Inlet of T.B Tunnel	0.5 km
Outlet of T.B tunnel	1.0 km
Ketandan dam	1.5 km
Ketandan dam, Borrow area	1.0 km
Ketandan dam, Quarry site	3.0 km
East & West main canal route	8.0 km
Total	15.0 km

(b) Power supply

Required electric power is planned to be supplied by diesel generators at each site. The capacity is estimated as follows on the assumption that demand and load factor are 70% and 50% respectively to the sum of capacities of all the facilities such as plant, repair shop, pump, compressor, lighting and etc., at each site.

Site	Capacity
Kedungwarak weir	50 kVA x 1 unit
Trans Basin Tunnel, inlet & outlet	50 kVA x 2 units
Ketandan dam	100 kVA x 2 units
Bangle Headworks	50 kVA x 1 unit
Canal & Related Structures	30 kVA x 2 units

(c) Water supply

The water required for the construction works will be taken from the river by a system with a well, head tank, distribution pipe and pumping station.

For control of optimum moisture contents, movable water tankers will be also provided at the embankment sites of Kedungwarak, Ketandan dam and canals.

(d) Air supply

Single suction multiblade fan having 50 m^3/min in capacity will be provided at the outlet and inlet of the transbasin tunnel for the ventilation. Portable type air compressors will be provied for the compressed air supply for pneumatic equipment.

(e) Communication system

A wireless communication system will be provided between the dam office and BRBDEO Malang. Dial-in telephone set will be provided for the dam site offices.

(f) Temporary buildings

The following are the estimated area required for temporary buildings at each site.

	K'warak	T.B. Tunnel	Dam	Bangle	Canals
Offices, owner	-	-	500 m^2	100 m^2	-
Quarters, owner	-	-	1,000 "	-	-
Contractor's camp	200 m^2	100 m^2	1,000 "	200 "	500 m^2
Laboratories	50 "	50 "	100 "	50 "	50 "
Warehouses	300 "	200 "	500 "	300 "	300 "
Repair shop	150 "	150 "	500 "	150 "	300 "
Motor pool	500 "	300 "	2,000 "	500 "	500 "
Magazine	-	30 "	50 "	-	-
Clinic	-	-	100 "	100 "	-
Total	1,200 m^2	830 m^2	5,750 m^2	1,400 m^2	1,650 m^2

(g) Construction plant

Crushing plant

The crushing plant which will produce aggregate for concrete, metalling and others is planned to be provided at the Ketandan dam site. Required aggregates for the construction of Kedungwarak weir, trans basin tunnel and dam will be supplied by this plant. The capacity is planned to be 30 tons/hr including processing losses.

No crushing plant is planned for Bangle headworks and canals construction because of the small quantity at many sites.

Required aggregate for these works will be purchased from villagers.

Concrete plant

The concrete volume required is estimated at about 15,000 m^3 for the transbasin tunnel and Ketandan dam. A concrete plant will be installed at the right above. The capacity is presumed to be 10 m^3/hr by a single 0.5 m^3/hr mixer concrete plant.

At the site of Bangle headworks and canals with related structures, portable type concrete mixer are planned to be provided.

(h) Clinics and first aid facility

Two (2) clinics will be provided one each at the dam site and Bangle village.

18.1.6 Construction time schedule

The construction time schedule of the dam and irrigation project is shown in Fig. 18.2. The summary is given as follows.

1985 - 1988	:	Pre-construction activities - Survey & investigation - Detailed design - Financial arrangement
1989	:	Tender and award of contract
1989 - 1992	:	Construction - Kedungwarak weir (2 years) - Transbasin tunnel (3 years) - Ketandan dam (3 years) - Bangle heaworks (2 years) - Canals & structures (3 years) - Ngluyu pumping station (1 year)

The construction works of earth and concrete works should be concentrated in dry season usually from May to October.

The construction of Kedungwarak weir is scheduled for two (2) years works period.

Excavation of transbasin tunnel will be commenced after completion of the diversion tunnel of Ketandan dam. It is scheduled at 14 months for excavation and 10 months for lining concrete works of the tunnel.

The construction period of Ketandan dam is scheduled for three (3) years as further callsified below.

Diversion tunnel construction	:	6 months
Foundation excavation	:	12 "
Embankment	:	18 "

Bangle headworks are planned to be completed in two (2) years starting from 1989.

The construction of canals with related structures will be commenced at the same time of the commencement of the dam construction, and be completed in three (3) years.

The irrigation water for the proposed area will become available in and around 1992.

18.1.7 Basic conditions

In preparing the construction plan and time schedule, the following conditions and assumptions are taken into account.

(a) Workable days and hours

Yearly workable days and hours are estimated as follows based on the rainfall records in last ten (10) years at Tempuran and Sawahan guaging station, labour regulations and other datas.

	Days	Hours
Dam embankment	157	1,100 (1 shift)
Excavation, tunnel	250	2,500 (2 ")
Excavation, open	215	1,500 (1 ")
Concrete, tunnel	250	2,500 (2 ")
Concrete, open	215	1,500 (1 ")

(b) Hourly production rate of equipment

Hourly production of major equipment is presumed by conventional method for each equipment.

(c) Transfer of BRBDEO's equipment

It is planned that BRBDEO's existing equipment will not be used since the project is to be implemented by the contract system.

18.2 Construction Cost Estimate

18.2.1 Conditions of cost estimate

The same conditions and assumptions as those adopted to the Flood Control and drainage component are applied for the finacial cost estimation of the dam and irrigation component.

18.2.2 Construction cost

The total construction cost is estimated at Rp. 24955.3 x 10^6 Rp. equivalent as brokendown below.

Foreign currency portion	:	US$ 12,572.4 x 10^3
Domestic currency portion	:	Rp. 11,125.7 x 10^6
Total equivalent	:	Rp. 24,955.3 x 10^6

The summary of construction cost is shown in Table 18.1.

Bill of quantities and estimated unit cost are shown in ANNEX-8.

18.2.3 Disbursement schedule

The construction period is scheduled to be three (3) years including preparatory works. The annual disbursement schedule of the Project, excluding interest during construction period, is assumed as shown in Table 18.2.

Table 18.1 DAM & IRRIGATION SCHEME

Work Item	Foreign 10^3 US$	Domestic 10^6 Rp.	Total 10^6 Rp.
1. Direct Construction Cost	9,300.6	4,730.1	14,960.6
(1) Kedungwarak Weir	1,022.0	687.4	1,811.4
(2) Trans-basin Tunnel	985.1	330.6	1,414.0
(3) Ketandan Dam	4,861.0	2,263.3	7,610.4
(a) Preparatory works	413.7	294.0	760.1
(b) Diversion works	227.6	52.3	302.7
(c) Main dam	2,610.0	1,119.2	3,990.3
(d) Spillway	1,040.4	609.8	1,754.1
(e) Intake structure	253.2	131.7	410.2
(f) Micro-power	306.1	56.3	393.0
(4) Bangle Headworks	82.2	70.9	161.3
(5) Irrigation Networks	2,216.7	1,325.1	3,763.5
(a) Preparatory works	24.6	23.0	50.1
(b) Main and secondary	895.2	406.5	1,391.2
(c) Tertiary and quartery	1,090.3	642.8	1,842.1
(d) Inspection road	206.6	252.8	480.1
(6) Ngluyu Pumping Station	133.6	52.8	199.8
2. Land Aquisition	-	3,000.0	3,000.0
3. Administrative Expenses /1	-	1,496.0	1,496.0
4. Engineering Services /2	1,632.0	448.7	2,244.0
Base Cost	10,932.5	9,674.5	21,700.3
5. Physical Contingency /3	1,639.9	1,451.8	3,255.0
6. Price Contingency /4	2,457.8	3,354.4	6,058.2
Total	15,030.3	14,481.0	31,013.8

Notes: /1 10% of direct construction cost

/2 15% of direct construction cost

/3 15% of base cost

/4 Foreign component 3% per annum

Domestic component 5% per annum

Table 18.2 DISBURSEMENT SCHEDULE OF DAM AND IRRIGATION DEVELOPMENT

Unit: FC 10^3 US$
DC 10^6 Rp

	Total			1988			1989		
	F	D	T	F	D	T	F	D	T
1. Direct Construction Cost									
Kendungwarak Weir	1,022.0	687.4	1,811.4						
Trans-basin Tunnel	985.1	330.6	1,414.0				325.1	109.1	466.6
Ketandam Dam									
Preparatory Works	423.7	294.0	760.1				423.7	294.0	760.1
Diversion works	227.6	52.3	302.7				227.6	52.3	302.7
Main Dam	2,610.0	1,119.2	3,990.2						
Spillway	1,040.4	609.8	1,754.2						
Intake Structure	253.2	131.7	410.2						
Micro Power	306.1	56.3	393.0						
Bangle Headworks	82.2	70.9	161.3						
Irrigation Facilities									
Preparatory Works	24.6	23.0	50.1						
Main & Secondary Canal	895.2	406.5	1,386.8						
Tertiary & Quartery Canal	1,090.3	642.8	1,842.3						
Inspection Road	206.6	252.8	480.0						
Ngluyu Pumping Station	133.6	52.8	199.8						
Sub-Total	9,300.6	4,730.1	14,960.6				976.4	455.4	1,529.4
2. Land Acquisition	-	3,000.0	3,000.0		1,500.0	1,500.0		1,500.0	1,500.0
3. Administration Expenses	-	1,496.0	1,496.0		149.6	149.6		374.0	374.0
4. Engineering Services	1,632.0	448.7	2,244.0				489.6	134.6	673.2
Base Cost	10,932.5	9,674.5	21,700.3		1,649.6	1,649.6	1,466.0	2,464.0	4,076.6
5. Physical Contingency	1,639.9	1,451.8	3,255.0		247.4	247.4	219.9	369.6	611.5
Base Cost + Physical Contingency	12,572.4	11,105.7	24,955.4		1,897.0	1,897.0	1,685.9	2,833.6	4,688.1
6. Price Contingency	2,457.8	3,354.4	6,058.2		353.3	353.3	239.8	695.7	959.5
Total	15,030.3	14,481.0	31,013.8		2,250.3	2,250.3	1,925.7	3,529.3	5,647.6

Note:
F; Foreign currency component in US$1,000
L; Domestic currency component in Rp. 10^6
T; Total in Rp. 10^6
L1 Escalation rate for Foreign currency component is assumed as 3% per annum
L2 Escalation rate for domestic currency component is assumed as 5% per annum
Escalation is started from 1986.

Table 18.2 DISBURSEMENT SCHEDULE

Unit: FC 10^3 US$
DC 10^6 Rp

	1990			1991			1992		
	F	D	T	F	D	T	F	D	T
1. Direct Construction Cost									
Kedung warak weir	511.0	343.7	905.7	511.0	343.7	905.7			
Trans-basin Tunnel	334.9	112.4	480.8	325.1	109.1	466.6			
Ketandan Dam									
Preparatory Works									
Diversion Works									
Main Dam	1,044.0	447.7	1,596.1	1,044.0	447.7	1,596.1	522.0	223.8	798.0
Spillway	520.2	304.9	877.1	520.2	304.9	877.1			
Intake Structure				253.2	131.7	410.2			
Micro Power				306.1	56.3	393.0			
Bangle Headworks				82.2	70.9	161.3			
Irrigation Facilities									
Preparatory Works	24.6	23.0	50.1						
Main & Secondary Canal	358.1	162.6	556.5	358.1	162.6	556.5	179.0	81.3	278.2
Tertiary & Quartery Canal	436.1	257.1	736.9	436.1	257.1	736.9	218.1	128.6	368.5
Inspection Road							206.6	252.8	480.1
Ngluyu Pumping Station							133.6	52.8	199.8
Sub-Total	3,228.9	1,651.4	5,203.2	3,836.0	1,884.0	6,103.4	1,259.3	739.2	2,124.6
2. Land Acquisition									
3. Administrative Expense		374.0	374.0		374.0	374.0		224.4	224.4
4. Engineering Service	489.6	134.6	673.2	408.0	112.2	561.0	244.8	67.3	336.6
Base Cost	3,718.5	2,159.9	6,250.2	4,243.9	2,370.0	7,038.4	1,504.1	1,031.0	2,685.5
5. Physical Contingency	557.8	324.6	937.5	636.6	355.5	1,055.8	225.6	154.7	402.8
Base Cost + Physical Contingency	4,276.3	2,483.9	7,187.8	4,880.5	2,725.5	8,094.1	1,729.7	1,185.7	3,088.4
6. Price Contingency	754.9	764.5	1,594.9	1,033.8	1,017.0	2,154.4	429.3	523.9	996.1
Total	5,031.2	3,249.1	8,782.8	5,914.4	3,742.7	10,248.6	2,159.0	1,709.6	4,084.5

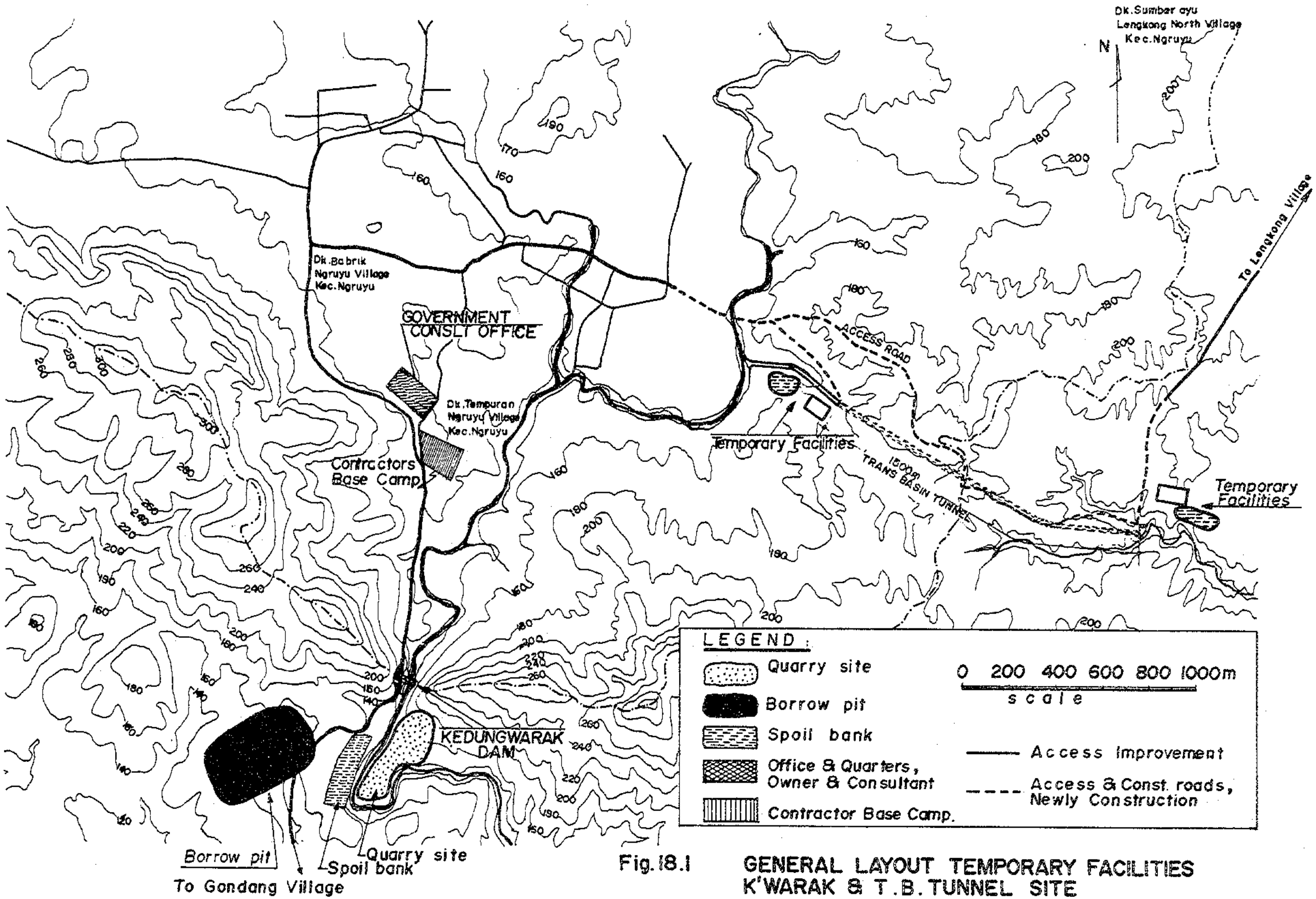


Fig.18.1 GENERAL LAYOUT TEMPORARY FACILITIES
K'WARAK & T.B.TUNNEL SITE

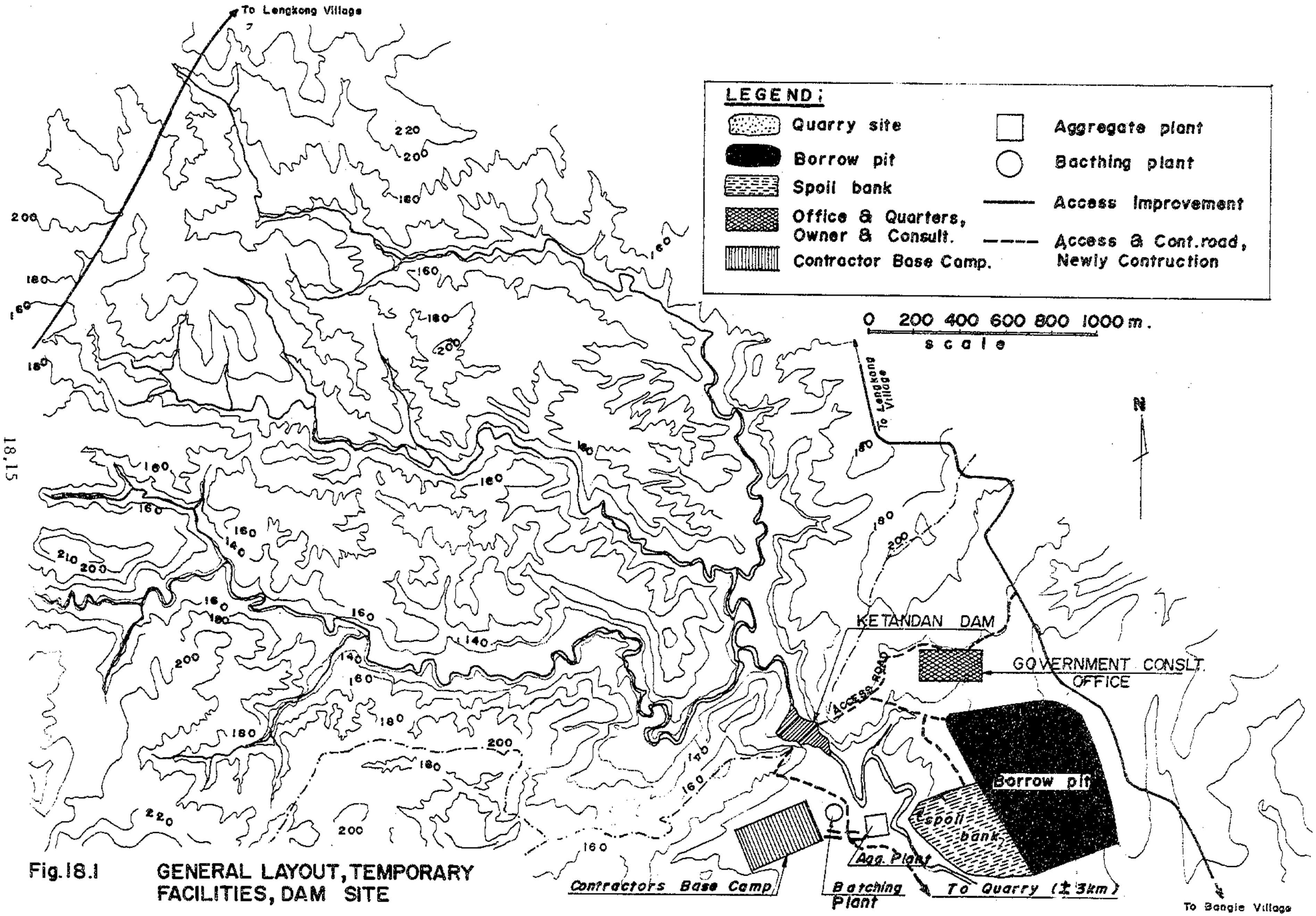
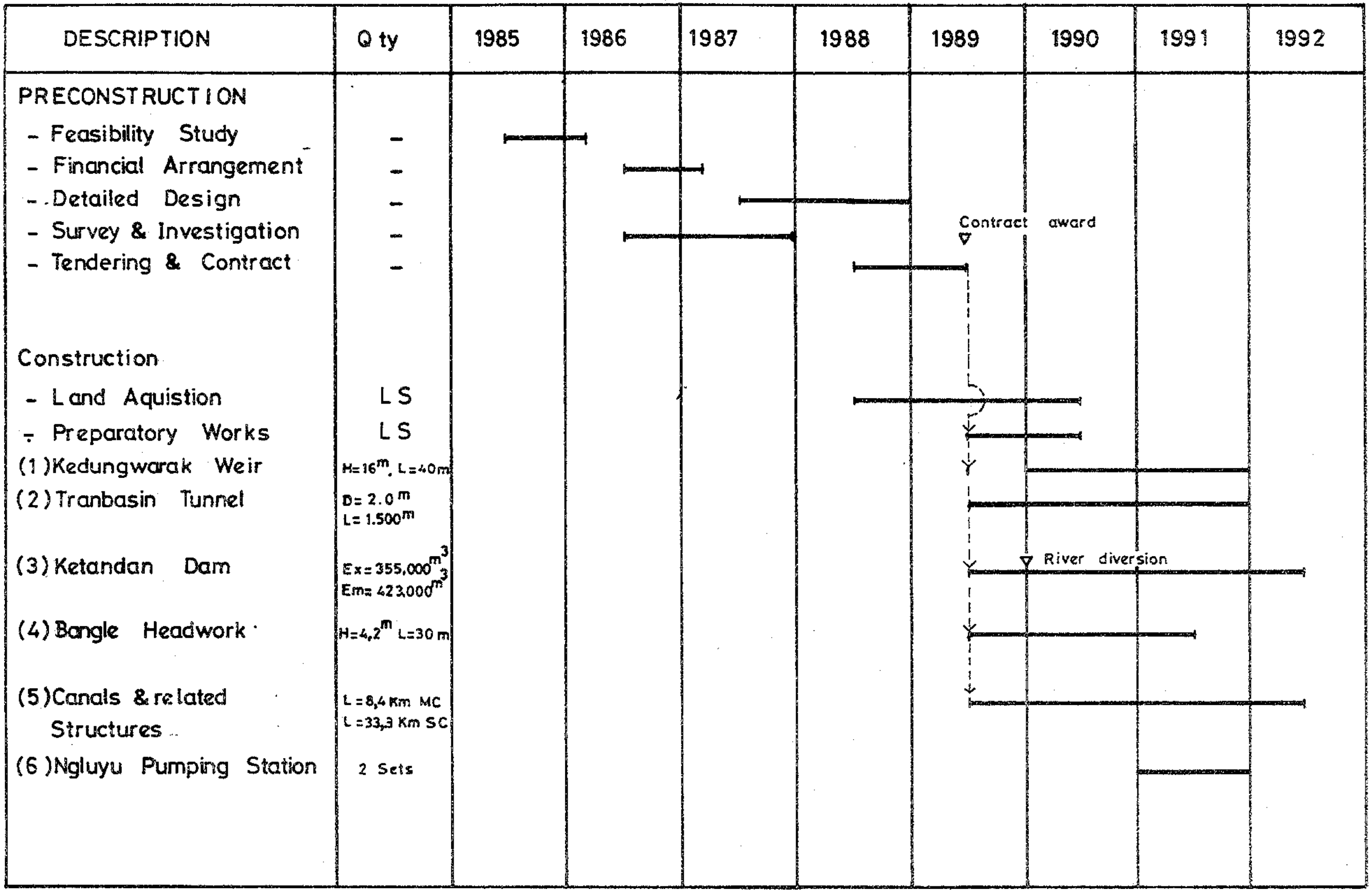


Fig.18.1 GENERAL LAYOUT, TEMPORARY FACILITIES, DAM SITE

Fig: 18.2 CONSTRUCTION TIME SCHEDULE FOR DAM & IRR. SCHEME



CHAPTER 19 EVALUATION OF PROPOSED PLAN

LIST OF TABLES

19. EVALUATION OF PROPOSED PLAN

19.1 General

In this Chapter, the proposed plan of dam and irrigation component of the Project is evaluated from economic point of view. Since financial analysis is made by comparing present farm budget with future farm budget in Chapter 13, the principal objective of this chapter is to calculate Economic Internal Rete of Return (EIRR) based on economic cost and benefit. This proposed plan consists of irrigation and power benefit which are discussed in Chapter 13 and 17 respectively. In this chapter therefore, the summary of benefit items and the procedure of calculating economic cost are presented.

19.2 Benefit

Irrigation benefit is defined as incremental benefit between with and without project condition. Annual irrigation benefit in the project area is estimated to be 2,766.4 x 10^6Rp at 1985 constant price. Concerning power benefit, energy benefit is taken up with the following conditions.

- Energy value per KWH is estimated to be 0.05 cent (55 Rp) KWH by referring to Electric Power Development in PART I STUDY

- Energy output is estimated at 1,101 MWA.

As a result, total energy benefit is calculatd at 60.5 x 10^6 Rp. Based on irrigation and energy benefit specified above, the benefit is expected to be 2826.9 x 10^6 at full development stage.

19.3 Economic Cost

The procedure of calculating economic cost is derived from explanation of economic cost discussed in Chapter 10. Economic cost of land acquisition cost is regarded as production foregone which will be caused by completion of the project. In this case, production foregone is forest and agricultural production. The detailed results are shown in Table 19.1.

19.4 Evaluation

Having adjusted financial cost to economic cost, the disbursement schedule of the economic cost is shown in Table 19.2. In case of land acquisition cost, the production value of crops foregone by this Project is expected to occur in 1993 because farm land will be submerged under the reservoir after completion of the Project.

Table 19.3 shows cash flow of the proposed plan. In the bebefit stream, negative benefit (economic cost of land acquisition) is substracted from total benefit. The benefit will be expected to increase linearly year by year and reach the full benefit in 1995, 2 years after the completion of the Project. EIRR is calculated at 10.6% based on economic cost and benefit. Sensitivity analyses are also made with the following conditions. The results of EIRR are presented by each condition below:

Sensitivity analyses	EIRR
- Cost up 10%	9.75 %
- Cost up 20%	9.02 %
- Benefit down 10%	9.67 %
- Benefit down 20%	8.67 %
- Cost up 10% Benefit down 10%	8.86 %

19.5 Environmental Assessment of Dam and Irrigation Project

The methodology and procedures of environmental assessment, and other assumptions are the same as explained in Chapter 10.

1. Division into Eco-system Region

Areas of the dam and irrigation development are divided into the following eco-system region.

	Physical works Area	Benefited Area	Surrounding Area
Kedungwarak	weir site, reservoir borrow and quarry area	irrigation area (farm land around the reservoir)	catchment
Ketandan	dam site, reservoir borrow and quarry area access road	irrigation area (Widas Extension Area)	catchment
Trans basin tunnel	transbasin tunnel Access road	-	-

2. Estimation and Evaluation

1. Kedungwarak weir and Reservoir weir site, reservoir, borrow and quarry area, canal, pump station

(1) Eco-system Area : Area of Physical Works (Kedungwarak) (RRM : ANNEX - 9)

a. Non-renewable resources

During construction and operation there will be no changes in geology, and there are no mineral resources in the area of physical works. Topography will be changed in the borrow and quarry areas and in the reservoir area after impoundment, however it will be neutral change. During construction there will be changes in the soil of the borrow and quarry area as the cover is stripped off. But it is planned that restoration be made in these areas after use. However such restoration may not totally restore the original condition. Soil in the other portion which will be inundated will have no effect on the eco-system. There is no serious sedimentation in K. Kedungwarak, and it is considered to be almost no effect both during construction and operation. There will be no possibilities for a reservoir of such small size to have any effect upon the climate. There are no archaeology and historical remains in the area of physical works.

b. Renewable Resources

During construction dust from the borrow and quarry area and weir site during dry season, might affect the people around the area of physical works. It is expected to consider some pertinent counterplans to control dust. After construction, these areas will be reforested, there will be no effect on the air. During construction, water flowing out of the physical works area will be turbid, however it may be relatively small effect because it will be limited downstream close to the weir site. There will be no change in total quantity of water in the physical works area. Construction of the reservoir will change the distribution of water to regulate supply of water a whole year and will bring great benefit to the irrigated area. However such change of the distribution of water will not mean direct effect upon the eco-system in the area of physical works, so it is evaluated to be neutral.

As for aquatic weeds, the size of the reservior is not so large that it should be controlled and the probability of generation of aquatic weeds is considered to be low.

The inundated area will involve approximately 160 ha. which consists of paddy land (51%), up land crop land (18%), housing and home garden land (9%) and forest (22%) submerged by impoundment. However such change is evaluted to be neutral from the stand point of land use. the borrow area and quarry site are covered by younger reforeasted teak forest, which will be cleared during construction. Forest area reduction for the project during construction will be approximately 110 ha in total, of which about 80 ha will be taken for borrow area and quarry sites and about 30 ha will be inundated. However these forest areas are relatively small, and may have small hydrological function. Further during operation the reservoir may have benefit for water conservation and make a contribution to the hydrological function around it. Then, reduction of the forest area is evaluated to be negative and small during construction, and neutral and small during operation.

There is no native flora and native fauna in the area of physical works. However after impoundment there is possibilities to generate new aquatic eco-system in the reservoir and to use the reservoir for inland fisheries. But these possibilities are judged relatively small from the small size of the reservoir.

As for public works facilities, existing roads and foot pathes in the reservoir area will be lost after impoundment, however instead of them new connection road, local roads and new bridge over the reservoir are planned to be constructed. New public work facilities will be maintained after construction.

c. Technology

The projects will use well-established technology during construction and will be implemented with safety care. Therefore the projects will not involve any direct development of new technology or technological spinoff to any other sectors.

d. Human Environment

Implementation of the project will bring forth job opportunities to many labours during construction.

During construction period many workers and staff will come to the project area, however construction time is not so long and workers will not bring their families to the site, so demography will not change around the area. To fill the needs of workers and staff during construction, small scale trade and services will be simulated and will receive benefits, however this effect will be temporary and will be limited to the construction period. There are no industries around the area.

Approximately 160 ha. of land in the reservoir area will have to be acquired. Peoples of approximately 70 households in hamlet Tempuran, Semanding and Ngluyu whose land is to be acquired shall be compensated with due care by the Project Executing Agency.

There exists about 108 ha. farmland which involves paddy field, upland field in the area of physical works, and the food production will be decreased by use of the land by the Project. Similarly other agricultural production (tobacco), which is very small, will be lost. However, such reduction can be compensated by increase in crop production by irrigation. Furthermore two pump stations and canals to irrigate 122 ha of farm land around the reservoir are planned in addition to the original plan. Then after impoundment, farmers of irrigated area will get benefit.

As for helath, there will be no problem during construction, and neither problem after impoundment because there is no experience of water-associated desease at any of the other reservoirs in the Brantas river basin.

After impoundment, Tempuran village and social infrastructures around it will be divided into two parts by the reservior, namely the area as it is, and the other to be affected. Though the above problem will be solved by the construction of a new bridgre over the reservoir and new roads, people living around the reservoir might feel troublesome to some extent.

The project is not expected to have any effects upon anthropology and culture.

(2) Eco-system Area : Benefited area; farm land around the reservoir (RRM : ANNEX-9)

a. Non-renewable Resources

There will be no effect upon non-renewable resources. Small canals will be constructed in the irrigation area.

b. Renewable Resources

After completion of dam and irrigation facilities, water of the reservoir will be used for irrigation during dry season. The quantity of available water will increase and distribution will be improved. However water quality may have possibility to be polluted by intensive agricultural activities in the project area.

There will be no effect upon the other sectors of renewable resources.

c. Technology

There will be no change in technology because the agricultural technology with the project will be similar to existing irrigation technology.

d. Human Environment

Agriculture will be endowed with benefits of irrigation by the increase food production. There may be possibility of negative effect because of the possibility of water polution, mentioned above. There will be no effect upon the other sectors of human environment.

(3) Eco-system Area : Surrounding Area (Kedungwarak)
Catchment area of K.Kedungwarak, downstream
(RRM : ANNEX-9)

There will be no effect of the project upon the surrounding area, catchment area of K. Kedungwarak, except beneficial effect upon distribution of water through all the year in the downstream during operation.

2. Ketandan Dam and Reservoir; dam site, reservoir, borrow and quarry area, access road.

(1) Eco-system Area : Area of Physical Works
(RRM : ANNEX-9)

a. Non-renewable Resources

During construction and operation there will be no change in geology, and there are no mineral resources in the area of physical works.

As for topography and soil, the arguments are the same as those discussed in Kedungwarak Dam; Area of Physical Works may be applicable. Restoration may not totally restore the original conditions. However this will be relatively small effect. There is no serious sedimentation in K. Ketandan, and it is considered to be almost no effect both during construction and operation. There are no possibilities for a reservoir of such small size to have any effects upon the climate. There are no archaeology and historical remains in the area of physical works.

b. Renewable Resources

During construction dust from the borrow and quarry area or dam site may be dispersed into the air during dry season. However people living in the area of physical works will be removed before construction, so this is no problem.

The effect upon water quality by physical works during construction will be limited to the downstream close to the dam site, and it is evaluated relatively small effect. As for quantity of water and aquatic weeds in the reservoir, the arguments are the same as those discussed in Kedungwarak Dam : Area of Physcial Works may be applicable.

In the area of physical works of Ketandan, land use consists mostly of teak forest. Teak trees in the physical works area will be cut during construction and the area will be inundated after construction. Such changes are supposed to have some effects upon the eco-system around the physical works area. the borrow and quarry area will be reforested and the role of hydrological function of reservoir may be attained enough. There are no native flora and fauna in the area of physical works. After impoundment, it will be possible to generate a new aquatic eco-system in the reservoir and to make use of the reservoir and to make use of the reservoir for inland fisheries.

As for public works facilities, there are none in the area of physical works, however new access road will be constructed from the existing road to the dam site.

c. Technology

There will be no effect upon the technology for treatment of marl, which is distributed around the dam site, prudent and proper consideration of technology shall be prepared.

d. Human Environment

Implementation of the project will bring forth job opportunities to many labours during construction.

As for demography, there are no hamlets around the area of physical works and workers and staff will not bring their families to the site.

Among economic activities, only small-scale trade and services will be stimulated and will receive benefits around the area to fill the needs of workers and staff during construction. However this effect will be temporary and be limited to the construction period.

People of about ten households in the area of physical works will be removed, and they shall be compensated by Project Executing Agency with due care.

Since the most of physical works area consists of teak forest, there will be no effect upon food production, other agriculural production, other social infrastructure and antropology and culture. With regard to health, there will be no problem during construction. After impoundment there will be no problem to health because there is no experience of water-associated desease at any of the other reservoirs in the Brantas.

(2) Eco-system Area : Benefited Area, Widas Extension Area (RRM : ANNEX-9)

a. Non-renewable Resources

There will be no non-renewable resources caused by the implementation of the project in the benefited area (Widas extension area). Only about 5% of total project area will be occupied by irrigation facilities including inspection roads.

b. Renewable Resources

After completion of dam and irrigation projects, water will be stored in the reservoir in rainy season and will be used for irrigation in the Widas Extension Area in dry season. The quantity of available water will increase and distribution will be improved. However water quality may have a possibility to be polluted by intensive agricultural activities in the project area.

There will be no effect upon land use patterns because the patterns in the benefited area is already fixed and will not be changed by irrigation.

There are no forest, native flora and fauna in the area of physical works and there will be no change in public works facilities.

c. Technology

There will be no changes in technology because the agricultural technology prepared for the project will be existing irrigation technology. And labour intensive construction way will be applied to the irrigation facilities construction. During operation water supply will be well controlled by new facilities.

d. Human Environment

There will be no change in demography and there are no conspicuous industry in the Widas Extension Area. After implementation of irrigation it is expected that income from agricultural production will increase and improvement of the human environment will realize in the Widas Extension Area.

(3) Eco-system Area : Surrounding Area, Catchment area of K. Ketandan (RRM : ANNEX-9)

There will be no effect of the project upon the surrounding area, catchment area of K. Ketandan.

3. Transbasin Tunnel

(1) Eco-system Area : Area of Physical Works (RRM : ANNEX-9)

a. Non-renewable Resources

Construction works of transbasin tunnel is to excavate through hills extending in between K. Kedungwarak and K. Ketandan. Judging from the contents and location of construction works, there will be no effect upon geological features. there are no mineral resources in the area of physical works.

The tunnel will bring only small change to the topography and it is evaluated neutral effect.

The excavated materials, which will be put near the inlet and the outlet of the tunnel, will be not so large amount and it is considered not to affect the environment.

There will be no problem about sedimentation, climate and archaeology and historical remains.

b. Renewable Resources

There will be no effect upon air, water quality and qcquatic weeks.

Construction of transbasin tunnel may have a possibility to cut the ground water flow, it will not affect the production on the hills, since the hills are covered by teak forest.

The tunnel will not change the land use and the loss of forest by construction of access road will be so small that there will be no effect upon the hydrological function. there are no native flora and fauna.

c. Technology

There will be no change in technology, because the project will use well - established technology and will not involve any direct development of new technology or technological spinoff to any other sectors. Further for treatment of marl which composes the hills, prudent and proper consideration of technology shall be prepared.

d. Human Environment

Concerning human environment, the Project Executing Agency should pay attention to health of workers in the tunnel construction and to consider a pertinent counterplan.

Table 19.1 BREAKDOWN OF ECONOMIC COST

1. Direct Cost

Unit 10^6 Rp.

	F.C.	D.C.	Total
Kedungwarak weir	1,124.2	687.4	1,811.6
Transbasin Tunnel	1,083.6	330.6	1,414.2
Ketandan Dam	5,347.1	2,263.3	7,610.4
Bangle Head Works	90.4	70.9	161.3
Irrigation Networks	2,438.2	1,325.1	3,763.5
Ngluyu Pumping Stations	147.0	52.8	199.8
Financial cost	10,230.7	4,730.1	14,960.8
Economic cost	8,455.1	3,907.1	12,357.6
Conversion rate	82.6 %	82.6 %	82.6 %

2. Land Acquisition

Houses	5.07 x 10^6 Rp.
Forest	42.47 x 10^6 Rp.
Agriculture	55.1 x 10^6 Rp.
Farm land	86 ha
Wet season paddy	75 ha
Maize	21 ha
Soybean	19.6 ha

* Crop area is calculated by cropping intensity of Widas extension area.

Unit yield :

Paddy	3.91 ton/ha
Maize	2.23 ton/ha
Soybean	0.68 ton/ha

Table 19.2 DISBURSEMENT SCHEDULE (ECONOMIC COST)

Unit: 10^6 Rp.

Year	Direct Cost		Land Acquisition (House, Forest, Agriculture)		Government Administration		Engineering Service		Physical Contingency		O & M Costs		Replacement Costs		Total
	FC	DC	FC	DC	FC	DC	FC	DC	FC	DC	FC	DC	FC	DC	
1988				1.69		149.6				22.7					174.0
1989	887.2	376.2		15.8		374.0	538.6	134.6	213.9	135.1					2,675.4
1990	2,933.7	1,364.1		30.0		374.0	538.6	134.6	520.8	285.4					6,181.2
1991	3,485.4	1,556.2		42.5		374.0	448.8	112.2	590.1	312.7					6,921.9
1992	1,144.2	610.6		97.6		224.4	269.3	67.3	212.0	150.0					2,775.4
1993				97.6								123.6			221.2
2016				97.6								123.6		900.0	1,121.2
2041				97.6								123.6			221.2

Remarks: O & M Cost is 1% of Direct Cost

Replacement Cost of Machinery and Electric Facility is estimated at 900 x 10^6 Rp. by considering its salvage value 10%.

Table 19.3 CASH FLOW AND IRR

Unit: 10^6 Rp.

No.	Year	Capital Cost	Replacement Cost	O&M Cost	Total Cost	Benefit
1	1988	174	0	0	174	0
2	1989	2,675.4	0	0	2,675.4	0
3	1990	6,181.2	0	0	6,181.2	0
4	1991	6,921.9	0	0	6,121.9	0
5	1992	2,775.4	0	0	2,775.4	0
6	1993	0	0	123.6	123.6	885.1
7	1994	0	0	123.6	123.6	1,807.2
8-28	1995-2015	0	0	123.6	123.6	2,729.3
29	2016	0	900	123.6	1,023.6	2,729.3
30-55	2017-2042	0	0	123.6	123.6	2,729.3

IRR = 10.63%

CHAPTER 20 OPERATION AND MAINTENANCE

20. OPERATION AND MAINTENANCE

20.1 General

As mentioned in Chapter 16, the water resources for the Widas Extension Area is so limited that the second pre polowijo crops planted in the late dry season can not be irrigated even if the Kedungwarak and Katandan rivers are developed.

Under such situations, a proper water management will have a key role to make the agricultural and irrigation development successful and to enhance Widas Extension Area.

Based on what is mentioned above, water management system conceived so far is explained in succeeding sections by putting an emphasis on the water distribution. The detail water management study is expected in coming stage.

20.2 Operation

20.2.1 Irrigation schedule

To use water efficiently, the irrigation schedule has to be made clear. There are various degrees of irrigation schedule by the objective period such as long-term, middle term and short term schedule and also by the scale of irrigation block ranging from whole irrigation to a quaternary block schedule.

Long-term schedule is usually annual schedule. It is made for whole irrigation area based on the past records of cropping, rainfall and reservoir storage and cropping plan. In the annual schedule, some alternatives should be presented against drought year, normal year and water-abundant year. The annual schedule should be made in September or October and explained to Desa groups and relevant agencies.

Usually three croppings a year are carried out. Thus the seasonal schedule should be made three times a year, based on the cropping schedule. Water is limited and so firstly the water availability should be forecasted and cropping planned accordingly. This seasonal schedule should be prepared in secondary canal level.

The seasonal schedule should be modified monthly to work out monthly schedule. The monthly schedule should be prepared in secondary block level based on the analysis of the coming irrigation demand, present reservoir storage volume and forecasting rainfall and also prepared for tertiary block. This tertiary block schedule is rotation schedule for upland crops among quaternary blocks.

Based on these irrigation schedules, irrigation water is to be distributed.

20.2.2 Operation rule

Herein, detail rules are not discussed. Only general but specific matters in this Project is suggested.

Effective use of rainfall can save water supply and saved water can be used in the dry season irrigation by storing it in the reservoirs. Accordingly, effective use of rainfall is of importance to maintain the dry season irrigation as planned especially in a drought year.

As the results of the Study of plot-to-plot irrigation method through ridges (See ANNEX-7 Section 7.2), water supply is proposed to be adjusted on 5-day interval.

Water supply should be adjusted by measuring the standing water depth of paddy field or based on the past 5 days amount of rainfall for polowijo crops. Also, when heavy rainfall, i.e. over 60 mm is coming, the irrigation supply should be stopped until coming adjustment time of water supply.

For polowijo crops and sugarcane, rotational irrigation should be adopted and much amount of water should be applied at one time because the irrigation water supply becomes extremely small in case of the continuous flow system and so the irrigation water can not or little reach to the last point of the field and sometimes water logging occurs locally especially around the inlet to fields.

Considering the time lag of water conveyance, gate operation is generally made from upstream to downstream ends. In case of Tretes south area, Sumberagung pond functions as regulation pond. Storage capacity of this pond is around 0.5 MCM. Thus at least 4 days, this pond can supply water to all the commanding area of 1,180 ha with no supply from the Bangle headworks. Conversely speaking, this pond should be given regulation space always to solve the time lag between water supply from the Bangle headworks and water distribution to the irrigation area and, to use the water effectively. Under provision of the regulation space, the head gates of secondary canals originating from this pond can be operated independently from the water supply of the West main canal. The west main canal discharge should be kept less than the irrigation water demand until the Sumberagung pond water level lower a certain limit of point which will be established through the simulation analysis of water balance.

In case of the D.I. Sumberkepuh and D.I. Jurang Dandang, irrigation should be made firstly by use of water stored in the existing pond such as Sumberkepuh pond, Logawe pond and Sumbersoko pond. Water supply from the Bangle headworks are limitted at the time when these ponds water levels lowers to a certain limit.

Kedungwarak reservoir water level should be maintained under a certain water level so as to divert runoff to the Ketandan basin with no loss of water resources until last rainy season.

As for the existing tubewells, combined-use with surface water should be considered in each of tertiary blocks where the irrigation networks are combined. Allocation between surface water and groundwater should be clearly decided in the irrigation schedule of the tertiary block.

20.3 Maintenance

Maintenance works are divided into two; one is periodical maintenance and another is emergency repair. Periodical maintenance works are;

Weed control, sediment control
Minor repair of canal lining, embankment, etc.
Painting of metal works
Oiling of gates, etc.

To keep the canal discharge capacity, canals have to be free from weeds, sedimentation and other obstacles. Cutting weeds and removal of deposit on canals should be made once a year.

The repair of canal lining or embankment should be executed as soon as possible. If no repair is executed or repair is delayed, the deterioraion is extending around the broken portion. Thus the quick repair action is most important in these works. On tertiary and quaternary canals, the sliding and leakage sometimes occur. These are caused by a certain animal behaviour, water flows, human-being behaviour and other matters for example cattle/human-being trace temporarily. Compared with weeds and rubbish, the leakage influence is more severe. Much irrigation water is lost obviously. Thus the maintenance works against the leakage should be executed by farmer's group supervised by Irrigation Service Staff. Also intensive innovation of farmer's group is needed. Outflow from the canal caused by slope sliding is rare but the most severe case. Thus, the sliding portion must be repaired as soon as possible.

Painting of metal works and oiling of gates etc., should be periodically executed so as to keep the function well.

20.4 Organization

Modification of organizatioin structure of Irrigation Service is required so as to meet the new irrigation distribution system. Farmer's group is also needed to be reorganized. Hereinafter the recommendations are presented.

The irrigation system drastically changes by the project. At present, the irrigation system is a group of small irrigation systems consisting of K. Sengon system, K. Tretes system and K. Sumberagung system in Tretes area and K. Ketandan system is DI Ketandan, K. Sumber-Kepuh system in DI Sumber Kepuh and K. Logawe system and K. Sumbersono system in DI Jurang Dandang. But after completion of the Project, comprehensive irrigation networks are realized and water released from the Kedungwarak and the Ketandan reservoirs contributes to the Widas Extension Area together with existing water sources.

As explained in Chapter 17, structure distributing water to the major areas except Ngluyu area and Tretes north area becomes the Bangle headworks. Accordingly, a headquarter is recommended to be founded at the Bangle site under the Irrigation Service Office Nganjuk. Instead of the headquarter, the Cabang Seksi Lengkong Office is released from the present roles to the project area.

D.I. Tretes office should be separated from the Cabang Seksi Gondang Office. In this case, the Widas north area where will be served from the existing Gondang weir should be separated from the control of the D.I. Tretes office and entrusted to the DI Senggowar office under the Cabang Seksi Gondang Office.

The D.I. Tretes Office should be located at the Sumberagung pond and sub-office should be located at the existing Dam Tretes.

As for the D.I. Sumberkepuh and the D.I. Jurang Dandang, one office should be founded between the Bangle head quarter and these two offices because the management area of both D.I.s will be served by one secondary canal so-called ESC-1 and so the water management of the secondary system by one office is preferable considering the proposed layout of canals.

As for the Kedungwarak weir and the Ketandan dam, branch offices of the Bangle headquater are recommended to be founded near the sites.

If tubewells are existing and pumped up water is used together with surface water, one farmer's group unified in the tertiary block should manage tubewells.

The actual functions of each office are conceived as follows;

Head Quarter

To review the irrigation water use monthly, seasonally and annualy based on the actual amount of water use, actual cropping data and rainfall data.

To check the irrigation requirement of the area based on the cropping hectare, the crop growing stage and rainfall in each of secondary canal level.

To issue monthly irrigation schedule for next month.

To release irrigation water considering the irrigation requirement and actual effective storage volume of the Ketandan reservoir.

To maintain Bangle headworks, main canals and the related structures.

ESC-1 office and the sub-office

To release irrigation water from Sumberkepuh pond, Logawe pond and Sumbersono pond according to the irrigation requirement.

To request the headquater to release the irrigation water if the above pond water resources are not enough and to distribute water from the secondary canal to tertiary canals.

To maintain the ponds, the intakes, secondary canal; ESC-1 and the related structures.

D.I. Ketandan Office

To inform the headquater of the irrigation requirement.

To control all the gates on Secondary Canals, ESC-2 and ESC-2-1 and tertiary canal heads.

To maintain secondary canals and the related structures.

D.I. Tretes and the sub-office

To release irrigation water from Sumberagung pond.

To request the irrigation water required to supplement the Sumberagung pond.

To control all the gates on secondary canals; WSC-1, WSC-2, WSC-2-1 and WSC-3.

To maintain the Sumberagung pond, existing dam Tretes, the secondary canals and the related structures.

Kedungwarak office

To control the released discharge to the downstream.

To control the reservoir water level by regulating the inlet gate of the transbasin tunnel so as to divert the water to the Ketandan reservoir by preventing loss of the runoff.

To operate small pumps for the irrigation of Ngluyu area according to the irrigation requirement.

To measure the inflow discharge, the reservoir water level and to record the open degree of the transbasin inlet gate and the K. Warak weir gate.

To maintain the K. Warak weir, transbasin tunnel, small pump stations and their related structures.

Ketandan dam office

To control the released discharge according to the instruction from the Headquater.

To maintain the Ketandan dam and reservoir together with the related structures.

Farmer's group

To operate division box gates according to the irrigation schedule and instruction of Irrigation Service staff.

To maintain the tertiary and quaternary canals.

To manage tubewells.

PART IV CONCLUSION AND RECOMMENDATION

CHAPTER 21 CONCLUSION AND RECOMMENDATION

21. CONCLUSION AND RECOMMENDATION

21.1 Flood Control and Drainage Improvement Project

1. Technical Feasibility

The proposed flood control and drainage improvement project is composed of conventional engineering works, such as dredging, excavation and embankment. There will be no serious technical difficulty in the construction stage.

In the operation and maintenance stage, cares should be taken of operation of drainage sluice gates in the retarding basins and gates of the irrigation headworks in order to avoid artificial floodings.

As a whole, it can be said that the Project is technically feasible.

2. Economic Feasibility

The economic cost of the Project is estimated including all the conceivable costs and the physical contingency of 15% of the direct construction cost. The economic benefit is estimated including flood control benefits, land enhancement benefit and negative benefit. The economic internal rate of return is estimated at 9.8% in the 1985 development level and at 14.1% in case of future development level. Since the basin economy is assumed to grow continuously in the future, economic feasibility of proposed plan has to be assessed by future development level. In this respect, the Projects EIRR is 14.1%.

As a whole, it can be said that the Project is economically viable.

3. Social Desirableness

The Widas river basin has suffered from serious flooding since long years ago. Flooding has caused not only losses of property values but also unhealthy living conditions. Removal of flooding is strongly desired. Due to the allowable maximum outflow from the Widas river basin into the main Brantas determinated from the viewpoint of the entire Brantas basin, it is necessitated to keep three areas as controllable retarding basins. However, frequency and duration of inundation in the retarding basins will be much reduced.

As a whole, the Project is socially desirable.

4. Recommendation

In view of the above, implementation of the Flood Control and Drainage Improvement in the Widas river basin is strongly recommended. In order to proceed to the project implementation, the followings are recommended.

This feasibility design on river channel improvement works of the Widas flood control and drainage project was made under such limited data as topo maps (1/5,000 to 1/10,000), surveyed river cross-sections (500 to 1,000 m internval) and data obtained from site reconnaissance and interview to local people, etc. In controllable retarding basins, proposed dimensions of control facilities such as fixed side overflow dike and drainage sluice were determined throughout preliminary hydraulic calculation against flood hydrograph and other hydraulic conditions assuming some hydraulic coefficients. Furthermore, proposed controllable retarding basin scheme still involves some political/social matters in view of governmental administration.

Many related river structures are associated with this plan. Flood control facilities were proposed to be newly constructed/reconstructed from the viewpoint of flood control and drainage plan in the basin. The other structures such as irrigation headworks and bridges were proposed to be improved/replaced by focusing on at least those existing structural function. Base foundation of structures were designed assuming geological condition at each site from typical soil and geological profile of the basin.

This feasibility study has been made under the limited data and based on the some technical assumptions.

From the above, it is recommendable to conduct or adjust the following matters for the further stage of this project.

Further investigation and study items are as follows.

(1) Topography survey, investigation and hydraulic model test

- Topographic maps covering areas of proposed river channel and retarding basin including 30 m outside of each proposed dike or boundary line : Scale 1 : 500, with 1 m contour interval.

- Topographic maps at major flood control and major related structures : 1/300 (Diversion weir, drainage sluice in retarding basin, irrigation headworks)

- River cross-section with an interval of 100 m covering 30 m outside area of each proposed dike

  Scale : Horizontal 1 : 500
  Vertical 1 : 100

- Soil and geological investigation at major structure sites and along river course

  Major structures : core boring and its laboratory test
  River cource : sounding test

- Hydraulic model test of controllable retarding basin focusing on test under various hydraulic conditions for the design of side overflow dike and adjacent river channel.

(2) Controllable retarding basin

In this plan, no surrounding dike in the proposed controllable retarding basin has been technically employed with due consideration of local drainage, social and political aspects such as compensation for land and house in the basin, and merit and demerit due to construction of surrounding dike.

Apart from the above technical decision, the following countermeasures would be taken up for governmental administration of the retarding basin in view of another technical viewpoint although that involves some social and political problems.

For delineation of controllable retarding basin

- Construction of low-height surrounding dike as inspection road
- Construction of drainage channel as boundary line
- Construction of boundary line pile

For administration of controllable retarding basin

- To provide control house/administration office
- To prepare operation manual
- To prohibit new construction of private house in proposed area
- To study necessity of compensation against inhabitants and its method
- To organize flood fighting team

The above countermeasures and matters involve some problem to be politically and socially resettled. Therefore, it is strongly recommended that such political and social matters on controllable retarding basin is fully discussed among authorities concerned including inhabitants.

(3) Adjustment and consultation among authorities concerned

There exist many related river structures such as irrigation headworks and bridges in the proposed river channel. For such structures, synthesis/discontinuation of their existing services are considered especially against irrigation headworks. Such consultation and adjustment between BRBDEO and other authorities concerned with this project are required prior to further stage.

21.2 Dam and Irrigation Development

1. Technical Feasibility

The Kedungwarak weir, trans-basin tunnel and Ketandan dam are designed based on the geo-technical informations available so far. Among them, the geological conditions in the Ketandan damsite is still certain. Extension of the strongly to moderately weathered zone in the left abutment and extension of the boundary zone between sandstone and marl are not clearly confirmed yet. Design of the Ketandan dam includes those uncertainties and large cutting in the left abutment and wide earth blanket.

The proposed dam and irrigation development project is composed of conventional engineering works. If there is technical difficulties, it may be treatment of marl during excavation. But this problem can be solved by quick covering after excavation.

In the operation and maintenance stage, efficient and effective water management including reservoir operation and irrigation water distribution is required, since loss of water resources available to the Widas Extension Area is not allowable.

Realization of the proposed agricultural development will not have serious difficulties, since the farmers have ample basic knowledges and are eager to attain higher production through improved farming practices.

2. Economic Feasibility

The economic cost of the Project is estimated including all the conceivable cost and the physical contingency of 15% of the direct construction cost. Owing to the unfavourable geological conditions in the Ketandan damsite and the irrigation facilities in the tobacco planted areas where no benefit is accounted for, the economic cost of the Project is relatively high.

The inputs and outputs are evaluated based on the world market prices forecasted by IBRD. The recent world market situation is not favourable to the agricultural commodities. Therefore, the feasibility of the Project is marginal.

3. Social Desirableness

The Widas Extension Area is less developed area owning to lack of stable watter sources. From the viewpoint of equitable development, the Project is socially desirable.

4. Recommendation

Although the Project is technically still uncertain and economically marginal, implementation of the Project is supported in the light of social desirability.

To proceeed to the project implementation, the following are recommended;

(1) Topographic survey and investigation

- Discharge measurement at the Kedungwarak weir site and Ketandan dam site.

- Topographic map covering the areas of the Kedungwarak weir, transbasin tunnel, Ketandan dam and Bangle headworks; scale 1 : 500 with 1 m contour interval.

- Topographic map, profile and cross-section of the major irrigation canal routes

- Geological investigation at the structure sites, especially at the Ketandan damsite.

- In site rock test at the Kedungwarak weir site

- Seismic exploration

(2) Coordination with other authorities concerned

(a) Teak Forest

The Kedungwarak reservoir is covered partly by teak forest and the Ketandan reservoir is fully covered by teak forest. The west main canal runs through teak forest. The teak forests belong to the Department of Forest. Settlement of teak forest problem is needed.

(b) East Java Irrigation Rehabilitation Project

In order to avoid double investment to the irrigation facilities, close contact and coordination are needed.

(c) East Java Groundwater Project

For efficient use of the surface water, combined use of the surface water and groundwater is recommended. In order to make combined use possible, it is necessary to introduce a system to share the operation and maintenance cost of pump evenly among all beneficiaries concerned.

(d) Agricultural Supporting Services

In order to realize the proposed agricultural development in the Widas Extension Area, strengthening of agricultural supporting services is needed.