7.5 Sensitivity Analysis of Storage Requirement

1. Introduction

The river runoff is estimated by Tank Model method, using the irrigation intake records for calibration of Tank coefficients and assuming the long-term runoff coefficient of around 50%, since there is no discharge record long enough for the study. There might be a possibility to overestimate or under-estimate the available runoff at the damsite and to estimate the storage requirement based on such runoff. In order to check the storage requirement under the different runoff condition, sensitivity analysis is made hereunder.

2. Case

Two cases are examined as follows;

Case 1	Evaporation rate	0.60
Case 2	Evaporation rate	0.70

3. Runoff

Runoff is estimated in each case by Tank Model method. The results are shown in Table 7.5.1 and 7.5.2 and the runoff coefficient are shown in Table 7.5.3 and summarized below together with the case of evaporation rate of 0.65.

Evapo-rate	Runoff coefficient
0.60	0.51
0.65	0.48
0.70	0.45

4. Storage requirement

The storage requirement of each case is estimated by the same way as the comparative study in the previous section. The annual maximum storage requirement and storage requirement at 80% dependable year are shown in Table 7.5.4 and 7.5.5, respectively, and summarized below;

Runoff coefficient	Storage requirement Kedungwarak Reservoir (MCM)	Storage requirement Ketandan Reservoir (MCM)
1. 0.51	2.6	10.6
2. 0.48	2.6	11.7
3. 0.45	2.7	13.0

The runoff coefficient of 0.51 nearly equals to that of the Widas river at Ngudikan weir as stated in ANNEX-2 Chapter 14.

When the runoff coefficient is 0.51, the storage requirements almost not change in Kedungwarak reservoir and in Ketandan reservoir. Conversely, when the runoff coefficient is 0.45, the storage requirements increase by 0.1 MCM and 1.3 MCM, respectively.

5. Sensitibility to dam volume

Due to the increase or the decrease of storage requirement, the high water level in the reservoir changes as follows;

Runoff coefficient	High water level (EL. M) Kedungwarak Reservoir	Ketandan Reservoir
0.51	154.6	133.2
0.48	154.6	134.0
0.45	154.7	135.1

As for the Kedungwarak reservoir, the change of the high water level is negligibly small. Thus the dam construction costs little change. In case of Ketandan reservoir, the dam embankment volume decreases by 17,000 m^3 in case of runoff-coefficient : 0.51 and increases by 24,000 m^3 in case of 0.45 according to the relation curve between elevation and dam volume shown in Fig. 7.5.1.

These decrease and increase of dam volume is only less than one precent of total construction cost and thus it can be judged that the cost increase or decrease due to the change of the runoff coefficient is not influenced to the project feasibility study.

Table 7.5.1

****
* ESTIMATED MONTHLY RUNOFF AT K.WARAK SITE
EVARATION RATE 0.6
****

UNIT;M^3/SEC

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1951	1.08	0.97	1.17	0.32	0.20	0.74	0.14	0.09	0.05	0.03	0.02	2.12	0.58
1952	1.98	1.50	3.15	1.78	0.52	0.28	0.34	0.19	0.13	0.10	1.13	2.75	1.15
1953	1.28	2.05	2.98	4.63	1.91	0.64	0.51	0.33	0.26	0.18	0.17	1.17	1.34
1954	3.19	1.67	2.02	1.07	0.64	0.32	0.30	0.20	0.15	0.10	1.61	3.26	1.21
1955	1.65	1.17	1.35	1.74	0.63	0.36	0.77	0.82	0.28	0.21	1.08	0.58	0.89
1956	0.80	1.05	1.72	0.50	0.30	0.57	0.32	0.21	0.14	0.10	0.15	0.75	0.55
1957	1.50	2.23	3.38	1.33	0.52	0.27	0.22	0.28	0.13	0.08	0.13	0.76	0.90
1958	1.34	2.08	1.28	6.24	1.10	0.50	0.30	0.25	0.20	0.13	0.49	0.95	1.24
1959	1.52	1.33	0.98	1.14	0.83	0.48	0.23	0.18	0.12	0.07	0.03	0.76	0.64
1960	1.91	1.34	2.97	1.31	0.85	0.36	0.48	0.20	0.14	0.09	0.26	0.63	0.88
1961	0.81	1.69	1.25	0.97	1.47	0.38	0.19	0.14	0.09	0.04	0.29	0.23	0.63
1962	2.03	1.19	1.56	1.54	1.07	0.40	0.21	0.16	0.10	0.05	1.02	1.19	0.88
1963	1.26	1.38	2.39	2.06	0.83	0.51	0.28	0.21	0.15	0.08	0.13	1.16	0.87
1964	1.06	1.64	2.06	0.83	1.18	0.53	0.25	0.18	0.13	1.10	0.64	0.52	0.84
1965	1.27	2.16	1.14	0.83	0.23	0.26	0.16	0.09	0.04	0.02	0.01	1.52	0.64
1966	1.49	1.98	2.51	1.51	1.15	0.77	0.28	0.22	0.16	0.14	0.17	2.11	1.04
1967	1.73	2.39	2.34	2.04	0.55	0.28	0.22	0.16	0.10	0.04	0.03	2.14	1.00
1968	1.19	1.41	2.46	2.89	1.13	1.13	1.51	0.55	0.33	0.26	0.64	1.75	1.27
1969	0.90	1.70	2.31	0.90	0.39	0.25	0.19	0.13	0.08	0.03	0.08	1.08	0.67
1970	1.41	2.96	2.19	0.97	1.00	0.39	0.25	0.20	0.14	0.09	0.33	1.74	0.97
1971	3.03	2.10	2.30	2.00	1.79	1.28	0.46	0.32	0.25	0.55	2.20	2.53	1.57
1972	1.64	0.92	1.79	0.72	1.04	0.27	0.20	0.14	0.08	0.03	0.13	1.55	0.71
1973	3.99	4.13	2.07	1.37	1.96	0.80	0.41	0.33	0.74	0.44	1.15	1.40	1.57
1974	0.97	2.06	1.27	2.39	1.34	0.44	0.29	0.31	0.28	0.51	0.60	3.16	1.14
1975	1.82	1.19	3.28	2.86	1.65	0.73	0.39	0.31	0.32	0.86	1.05	2.40	1.40
1976	1.03	0.47	0.98	0.66	0.26	0.18	0.13	0.08	0.03	0.02	0.57	0.74	0.43
1977	1.40	1.91	1.41	1.50	0.37	0.98	0.26	0.16	0.11	0.05	0.05	1.45	0.80
1978	2.16	2.06	1.15	0.57	0.38	0.88	0.83	0.27	0.18	0.13	0.09	1.17	0.82
1979	2.40	1.65	1.04	0.76	1.01	0.63	0.24	0.17	0.12	0.06	0.06	0.90	0.75
1980	1.45	1.24	0.67	0.63	0.40	0.18	0.15	0.21	0.06	0.02	0.77	3.19	0.75
1981	1.74	1.02	1.21	0.62	1.32	0.33	0.31	0.18	0.49	0.28	0.79	1.49	0.81
1982	1.95	3.08	5.62	1.81	0.69	0.35	0.34	0.23	0.16	0.09	0.04	2.26	1.38
1983	1.91	1.82	1.74	1.15	1.28	0.58	0.28	0.22	0.15	0.33	0.93	0.86	0.94
mean	1.66	1.74	1.99	1.56	0.91	0.52	0.35	0.23	0.18	0.19	0.51	1.52	0.95

****

Table 7.5.2 * ESTIMATED MONTHLY RUNOFF AT K.WARAK SITE

EVARATION RATE 0.7

****

UNIT;M^3/SEC

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1951	0.90	0.83	1.03	0.24	0.15	0.65	0.09	0.05	0.03	0.02	0.02	1.99	0.50
1952	1.86	1.37	3.00	1.68	0.45	0.25	0.29	0.15	0.09	0.05	0.97	2.54	1.06
1953	1.13	1.90	2.81	4.45	1.79	0.57	0.45	0.29	0.21	0.13	0.12	1.04	1.24
1954	2.98	1.54	1.88	0.95	0.54	0.26	0.25	0.16	0.10	0.05	1.42	3.06	1.10
1955	1.50	1.03	1.19	1.60	0.54	0.29	0.65	0.69	0.21	0.15	0.95	0.43	0.77
1956	0.64	0.88	1.54	0.40	0.20	0.45	0.22	0.14	0.08	0.04	0.09	0.61	0.44
1957	1.33	2.06	3.19	1.23	0.44	0.23	0.18	0.22	0.09	0.04	0.08	0.61	0.81
1958	1.19	1.89	1.13	6.05	1.01	0.42	0.26	0.21	0.15	0.09	0.38	0.79	1.13
1959	1.33	1.17	0.83	1.00	0.70	0.37	0.18	0.13	0.07	0.03	0.01	0.64	0.54
1960	1.76	1.20	2.81	1.19	0.76	0.31	0.41	0.16	0.10	0.04	0.20	0.53	0.79
1961	0.66	1.53	1.11	0.84	1.33	0.29	0.14	0.09	0.04	0.01	0.22	0.17	0.54
1962	1.87	1.07	1.42	1.39	0.97	0.32	0.16	0.11	0.06	0.02	0.90	1.05	0.78
1963	1.12	1.20	2.22	1.91	0.74	0.43	0.23	0.17	0.10	0.04	0.08	1.07	0.78
1964	0.93	1.50	1.90	0.73	1.07	0.43	0.20	0.14	0.08	0.95	0.51	0.42	0.74
1965	1.12	1.97	0.99	0.71	0.17	0.20	0.10	0.04	0.01	0.00	0.00	1.40	0.56
1966	1.35	1.84	2.36	1.37	1.03	0.68	0.24	0.18	0.11	0.08	0.09	1.93	0.94
1967	1.55	2.21	2.19	1.90	0.46	0.23	0.18	0.11	0.06	0.01	0.02	2.02	0.91
1968	1.08	1.26	2.30	2.73	1.01	1.01	1.37	0.48	0.28	0.21	0.52	1.53	1.15
1969	0.74	1.51	2.11	0.79	0.30	0.20	0.14	0.08	0.03	0.00	0.05	0.96	0.58
1970	1.27	2.77	2.04	0.87	0.89	0.32	0.21	0.15	0.09	0.04	0.23	1.54	0.87
1971	2.83	1.93	2.13	1.87	1.64	1.17	0.40	0.28	0.20	0.44	2.01	2.32	1.44
1972	1.47	0.80	1.60	0.61	0.93	0.21	0.15	0.09	0.04	0.01	0.10	1.45	0.62
1973	3.83	3.95	1.95	1.26	1.81	0.73	0.36	0.29	0.64	0.35	0.98	1.19	1.44
1974	0.81	1.87	1.12	2.21	1.22	0.36	0.23	0.24	0.21	0.41	0.46	2.95	1.01
1975	1.64	1.02	3.07	2.66	1.51	0.64	0.33	0.26	0.25	0.72	0.86	2.18	1.26
1976	0.88	0.36	0.81	0.52	0.19	0.13	0.08	0.03	0.01	0.01	0.50	0.63	0.34
1977	1.24	1.75	1.28	1.38	0.30	0.88	0.20	0.12	0.06	0.01	0.03	1.33	0.72
1978	1.99	1.92	1.03	0.48	0.31	0.76	0.71	0.21	0.13	0.08	0.03	1.07	0.73
1979	2.19	1.46	0.91	0.64	0.88	0.53	0.18	0.13	0.07	0.02	0.03	0.75	0.65
1980	1.29	1.10	0.56	0.51	0.31	0.13	0.11	0.14	0.02	0.00	0.63	2.99	0.65
1981	1.60	0.88	1.07	0.52	1.19	0.27	0.24	0.13	0.40	0.21	0.65	1.30	0.71
1982	1.77	2.90	5.43	1.68	0.61	0.30	0.28	0.18	0.11	0.05	0.01	2.11	1.28
1983	1.78	1.68	1.62	1.02	1.15	0.50	0.23	0.17	0.11	0.26	0.76	0.71	0.83
mean	1.50	1.59	1.84	1.44	0.81	0.44	0.29	0.18	0.13	0.14	0.42	1.37	0.85

ü

Table 7.5.3 RUNOFF COEFFICIENT OF K.WARAK RIVER .EVAPO RATE 0.60 (1/3)

YEAR	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
RUNOFF	1217	890	557	903	1230	640	889	627	882	874
RAINFALL	2176	1847	1468	1742	2172	1399	1724	1433	1901	1603
COEFFICIENT	55.96	48.21	37.98	51.85	56.65	45.76	51.60	43.78	46.44	54.53

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
RUNOFF	850	641	1043	1000	1280	670	966	1571	722	1557
RAINFALL	1854	1317	1966	1758	2384	1362	1947	2606	1418	2670
COEFFICIENT	45.85	48.69	53.05	56.89	53.70	49.26	49.63	60.31	50.93	58.34

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
RUNOFF	1136	1414	435	802	823	756	756	822	1384	939
RAINFALL	2099	2509	1068	1549	1837	1574	1719	1686	2142	1883
COEFFICIENT	54.12	56.39	40.79	51.81	44.81	48.06	44.00	48.75	64.64	49.88

MEAN 50.76

ü

Table 7.5.3 RUNOFF COEFFICIENT OF K.WARAK RIVER .EVAPO RATE 0.65 (2/3)

YEAR	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
RUNOFF	1158	830	500	852	1174	588	839	577	828	822
RAINFALL	2176	1847	1468	1742	2172	1399	1724	1433	1901	1603
COEFFICIENT	53.25	44.96	34.08	48.93	54.08	42.08	48.67	40.31	43.58	51.33

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
RUNOFF	794	597	989	952	1216	622	912	1504	674	1494
RAINFALL	1854	1317	1966	1758	2384	1362	1947	2606	1418	2670
COEFFICIENT	42.86	45.39	50.33	54.18	51.04	45.70	46.87	57.72	47.59	55.97

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
RUNOFF	1071	1343	391	755	772	701	704	767	1333	883
RAINFALL	2099	2509	1068	1549	1837	1574	1719	1686	2142	1883
COEFFICIENT	51.07	53.53	36.65	48.74	42.03	44.59	40.98	45.50	62.25	46.90

MEAN 47.70

ü

Table 7.5.3 RUNOFF COEFFICIENT OF K.WARAK RIVER .EVAPO RATE 0.70 (3/3)

YEAR	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
RUNOFF	1106	772	447	807	1123	540	797	536	783	779
RAINFALL	2176	1847	1468	1742	2172	1399	1724	1433	1901	1603
COEFFICIENT	50.86	41.81	30.51	46.38	51.71	38.66	46.25	37.46	41.18	48.65
YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
RUNOFF	745	558	941	909	1158	577	864	1439	631	1435
RAINFALL	1854	1317	1966	1758	2384	1362	1947	2606	1418	2670
COEFFICIENT	40.18	42.38	47.89	51.74	48.58	42.43	44.38	55.24	44.52	53.76
YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
RUNOFF	1009	1273	351	714	727	651	658	713	1286	832
RAINFALL	2099	2509	1068	1549	1837	1574	1719	1686	2142	1883
COEFFICIENT	48.08	50.75	32.88	46.12	39.61	41.40	38.31	42.31	60.05	44.22

MEAN 44.94

Table 7.5.4 ANNUAL MAXIMUM STORAGE REQUIREMENT IN EACH CASE

Unit : MCM

Year	Case 1 (Evapo.Rate 0.6)		Case 2 (Evapo. Rate 0.7)	
	Kedungwarak	Ketandan	Kedungwarak	Ketandan
1954	1.57	4.17	1.66	4.50
55	0.59	2.62	0.69	
56	1.71	6.47	1.97	8.16
57	2.58	11.40	2.77	12.33
58	1.82	6.38	1.95	7.20
59	2.15	8.54	2.34	9.10
60	1.61	12.10	1.89	
61	3.20		3.42	16.47
62	2.08		2.21	
63	2.57	9.65	2.63	10.59
64	1.44	5.44	1.58	
65	3.06	10.06	3.17	12.58
66	2.00	5.58	2.12	6.00
67	2.83	9.74	2.91	10.33
68	0.70	1.67	0.72	2.45
69	2.88	12.48	2.93	13.18
70	2.15	7.39	2.30	8.01
71	1.12	3.30	1.25	3.77
72	2.71	8.47	2.76	8.83
73	0.33	2.18	0.65	3.22
74	1.52	4.56	1.76	5.20
75	1.08	3.76	1.30	4.20
76	2.52	15.22	2.96	
77	1.93		1.98	18.01
78	1.53	3.65	1.59	
79	2.05		2.32	
80	2.27	13.46	2.41	16.82
81	1.54	5.68	1.68	
82	2.72	8.79	2.82	9.32
83	1.73	6.61	1.80	7.84

Table 7.5.5 PROBABLE STORAGE REQUIREMENT

(1) Case 1

I Kedungwarak

Xt=b+1/a*Yt
a = 1.56839055
b = 1.59710749
Sx= .709245374
Sy= 1.11237374

T	Yt	Xt
2	.3665	1.83
3	.9027	2.17
4	1.2459	2.39
5	1.4999	2.55
6	1.702	2.68
7	1.8698	2.79
8	2.0134	2.88
9	2.1389	2.96
10	2.2504	3.03
11	2.3506	3.1
12	2.4417	3.15
13	2.5252	3.21
14	2.6022	3.26
15	2.6738	3.3
16	2.7405	3.34
17	2.8031	3.38
18	2.8619	3.42
19	2.9175	3.46
20	2.9702	3.49

II Ketandan

Xt=b+1/a*Yt
a = .311462969
b = 5.8125518
Sx= 3.53344898
Sy= 1.10053851

T	Yt	Xt
2	.3665	6.99
3	.9027	8.71
4	1.2459	9.81
5	1.4999	10.63
6	1.702	11.28
7	1.8698	11.82
8	2.0134	12.28
9	2.1389	12.68
10	2.2504	13.04
11	2.3506	13.36
12	2.4417	13.65
13	2.5252	13.92
14	2.6022	14.17
15	2.6738	14.4
16	2.7405	14.61
17	2.8031	14.81
18	2.8619	15
19	2.9175	15.18
20	2.9702	15.35

(2) Case 2

III Kedungwarak

Xt=b+1/a*Yt
a = 1.54931581
b = 1.73856487
Sx= .717977403
Sy= 1.11237374

T	Yt	Xt
2	.3665	1.98
3	.9027	2.32
4	1.2459	2.54
5	1.4999	2.71
6	1.702	2.84
7	1.8698	2.95
8	2.0134	3.04
9	2.1389	3.12
10	2.2504	3.19
11	2.3506	3.26
12	2.4417	3.31
13	2.5252	3.37
14	2.6022	3.42
15	2.6738	3.46
16	2.7405	3.51
17	2.8031	3.55
18	2.8619	3.59
19	2.9175	3.62
20	2.9702	3.66

IV Ketandan

Xt=b+1/a*Yt
a = .244113875
b = 6.8293484
Sx= 4.40560924
Sy= 1.07547034

T	Yt	Xt
2	.3665	8.33
3	.9027	10.53
4	1.2459	11.93
5	1.4999	12.97
6	1.702	13.8
7	1.8698	14.49
8	2.0134	15.08
9	2.1389	15.59
10	2.2504	16.05
11	2.3506	16.46
12	2.4417	16.83
13	2.5252	17.17
14	2.6022	17.49
15	2.6738	17.78
16	2.7405	18.06
17	2.8031	18.31
18	2.8619	18.55
19	2.9175	18.78

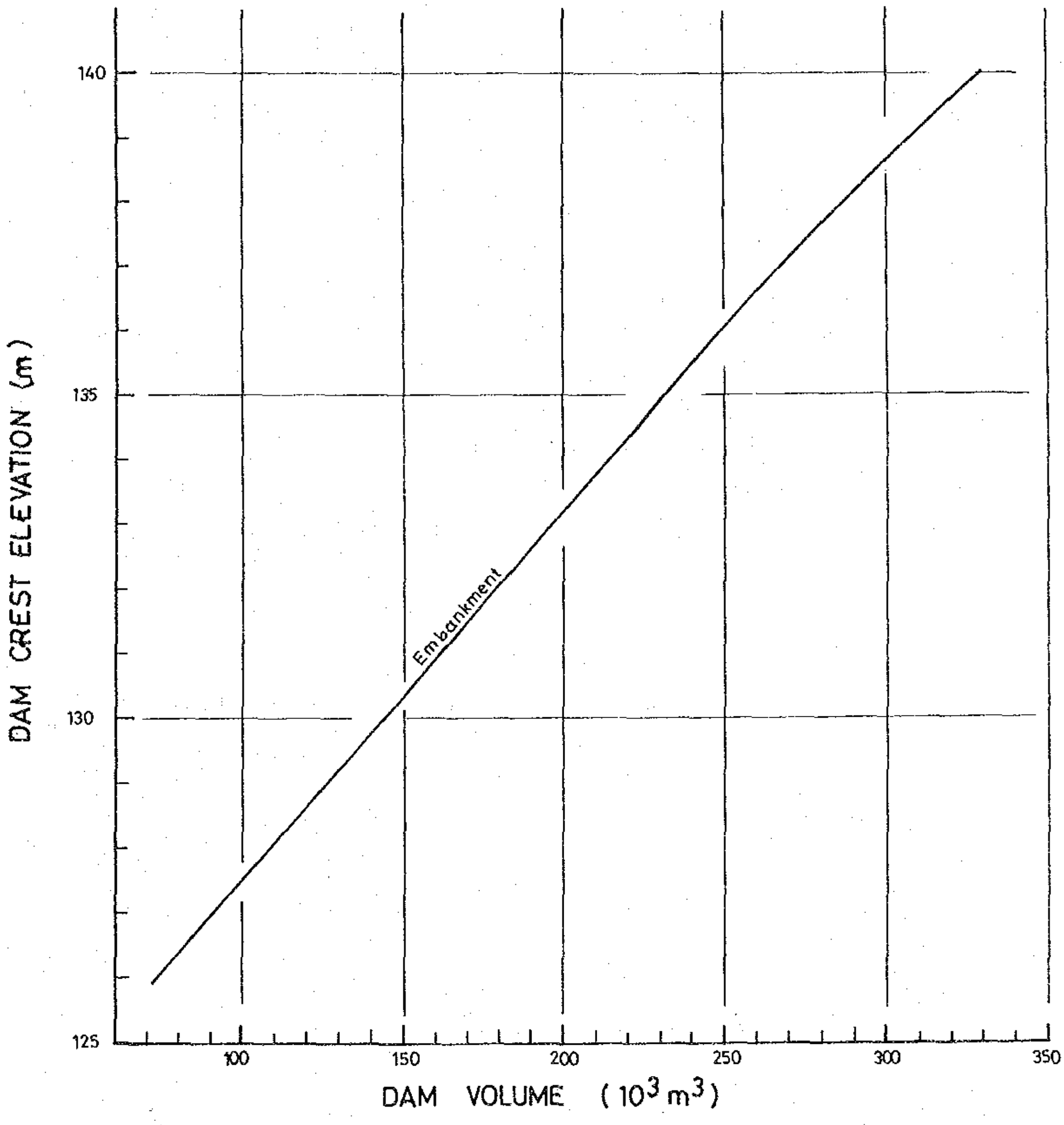


Fig. 7.5.1 RELATION BETWEEN ELEVATION AND WORK VOLUME

7.6 Stability Analysis of Kedungwarak Weir

1. Conditions and Requirements

The stability analysis of the weir against overturning, sliding and bearing capacity of the foundation are made under the following conditions.

(1) Load

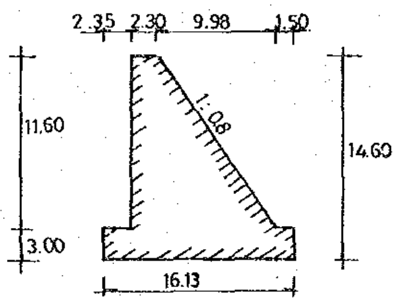
Self weight	:	concrete 2.3 ton/m3
Water pressure	:	1/2 H^2, where, H : water depth
Uplift		
Upstream end	:	water pressure at downstream end plus ones-third of difference between water pressure at upstream end and downstream end
Downstream end	:	water pressure at downstream end
Seismic force	:	$I = W \cdot Kd$

where, I ; seismic force
W ; self weight of weir
Kd ; seismic coefficient, 0.15 taken

Dynamic water pressure ; $pd = \frac{7}{12} Kd H^2$ $\quad Y = \frac{2}{5} H$

where, pd ; dynamic water pressure
Kd ; seismic coefficient
H ; water depth

(2) Dimensions of weir



(3) Requirements

Against overturning ; reluctant force shall be in middle-third section at normal time or middle two-third section at earthquake time

Against sliding ; resistant force against sliding shall satisfy the following equation

Rb = fv + o /o = 4 H

where, Rb ; resistant force against sliding
f ; coefficient of internal friction, 0,62
v ; vertical load
o; shearing strength, 50 ton/m2
ℓ o; shearing length
H ; horizontal force

Against bearing capacity; Load acting on the foundation shall be under or equal to 50 ton/m2 from the view of foundation

(4) Case of calculation

(a) Normal time

- Flood water level
- High water level
- Low water level

(b) Seismic time

- High water level, seismic load acting from upstream side

2. Results

Case	Safety Overturning	Factor Sliding	Excentricity (m)	Stress at edge Upstream (ton/m2)	Downstream (ton/m2)
Normal time					
High water level	2.9	9.1	0.21	15	18
Flood water level	2.3	6.9	0.90	11	17
Low water level	6.6	19.8	0.60	14	22
Seismic time					
High water level	2.2	5.7	1.55	7	26

7.7 Diversion Capacity Study of Transbasin Tunnel

Flood routing calculation is made to confirm the diversion capacity of the transbasin tunnel.

1. Condition

Flood runoff	:	Estimated by dimension less unit hydrograph method explained in Chapter 14, Main Report.
Storage capacity	:	Given by an equation converted from storage capacity curve of the Kedungwarak reservoir
Overflow through Kedungwarak weir	:	Overflow equation with a overflow coefficient of 2.1
Inflow to Ketandan through transbasin tunnel	:	Estimated by Manning formula with roughness coefficient of 0.014 but the ceiling discharge is limited to 7 m^3/sec which is a maximum discharge under free flow condition.

2. Calculation method

A flood routine calculation is made by the following basin equation.

$$\frac{1}{2}(I_i + I_{i+1}) \quad t = (S_{i+1} - S_i) + \frac{1}{2}(O_i + O_{i+1}) \quad t$$

$$= (S_{i+1} - \frac{Q_i}{2} \quad t) - (S_i - \frac{Q_t}{2} \quad t)$$

$$\emptyset = S + \frac{O}{2} \quad t, \quad Z = S - \frac{O}{2} \quad t$$

Then, $\emptyset_{i+1} = \frac{1}{2}(I_{i+1} + I_i) \quad t + Z_i$

Where, I : Inflow
O : Outflow
S : Storage
t : Routing period

3. Results

Results are shown in Table 7.7.1 and summarized below;

Initial W.Level in K.Warak Reservoir (m)	Rainfall (mm)	Inflow ($x10^3m^3$)	Loss = Overflow from K.Warak Weir (x 10^3 m^3)	Inflow Rate to Ketandan (%)
	–	–	–	–
152.5	100	1,028	0	100
153.0	70	605	0	100
	100	1,028	79	923
153.5	70	605	0	100
	100	1,028	243	76.4
154.0	70	605	49	91.9
	100	1,028	233	57.9

Table 7.7.1 DIVERSION CAPACITY OF TRANSBASIN TUNNEL (1/4)

INITIAL WL= 152.5 M
RAIN = 100 MM

TIME HOUR	INFLOW M3/SEC	TUNNEL M3/SEC	WEIR M3/SEC	W.L. EL M.	STORAGE 10^3 M3
.5	1.923	7	0	0	0
1	5.707	7	0	152.489	898.159
1.5	15.273	7	0	152.501	905.138
2	31.682	7	0	152.558	938.093
2.5	55.195	7	0	152.683	1010.97
3	73.217	7	0	152.87	1125.383
3.5	80.771	7	0	153.087	1265.371
4	74.91	7	0	153.296	1407.053
4.5	67.416	7	0	153.476	1535.38
5	59.516	7	0	153.629	1648.312
5.5	52.064	7	0	153.758	1745.891
6	46.025	7	0	153.865	1829.98
6.5	41.219	7	0	153.957	1903.224
7	37.108	7	0	154.037	1967.551
7.5	33.584	7	0	154.106	2024.243
8	30.48	7	0	154.166	2074.308
8.5	27.733	7	0	154.218	2118.521
9	25.3	7	0	154.264	2157.553
9.5	23.038	7	0	154.304	2191.891
10	20.948	7	0	154.339	2221.878
10.5	19.004	7	0	154.369	2247.83
11	17.251	7	0	154.394	2270.084
11.5	15.775	7	0	154.416	2289.11
12	14.45	7	0	154.434	2305.336
12.5	13.218	7	0	154.45	2319.005
13	12.091	7	0	154.463	2330.314
13.5	11.058	7	0	154.473	2339.462
14	10.121	7	0	154.481	2346.64
14.5	9.686	7	0	154.488	2352.447
15	9.725	7	0	154.494	2357.858
15.5	9.655	7	0	154.5	2363.238
16	9.923	7	0	154.506	2368.816
16.5	9.029	7	0	154.512	2373.768
17	6.906	7	0	154.514	2375.703
17.5	5.961	7	0	154.512	2374.571
18	5.454	7	0	154.51	2371.987
18.5	5.073	7	0	154.506	2368.514
19	4.761	7	0	154.501	2364.348
19.5	4.482	7	0	154.496	2359.591
20	4.223	7	0	154.49	2354.296
20.5	3.989	7	0	154.483	2348.509
21	3.777	7	0	154.476	2342.276
21.5	3.586	7	0	154.469	2335.638
22	3.413	7	0	154.461	2328.637
22.5	3.258	7	0	154.452	2321.309
23	3.119	7	0	154.444	2313.686
23.5	2.993	7	0	154.435	2305.798
24	2.877	7	0	154.426	2297.667

INITIAL WL= 153 M
RAIN = 100 MM

TIME HOUR	INFLOW M3/SEC	TUNNEL M3/SEC	WEIR M3/SEC	W.L. EL M.	STORAGE 10^3 M3
.5	1.923	7	0	0	0
1	5.707	7	0	152.99	1201.669
1.5	15.273	7	0	153.001	1208.648
2	31.682	7	0	153.051	1241.603
2.5	55.195	7	0	153.161	1314.48
3	73.217	7	0	153.327	1428.893
3.5	80.771	7	0	153.522	1568.881
4	74.91	7	0	153.712	1710.563
4.5	67.416	7	0	153.877	1838.89
5	59.516	7	0	154.018	1951.822
5.5	52.064	7	0	154.136	2049.401
6	46.025	7	0	154.236	2133.49
6.5	41.219	7	0	154.321	2206.734
7	37.108	7	0	154.396	2271.061
7.5	33.584	7	0	154.46	2327.753
8	30.48	7	0	154.516	2377.818
8.5	27.733	7	0	154.565	2422.031
9	25.3	7	.216	154.608	2460.956
9.5	23.038	7	1.17	154.644	2494.278
10	20.948	7	1.948	154.673	2521.057
10.5	19.004	7	2.569	154.697	2542.413
11	17.251	7	3.35	154.714	2558.829
11.5	15.775	7	3.959	154.727	2570.461
12	14.45	7	4.37	154.735	2578.257
12.5	13.218	7	4.614	154.74	2582.858
13	12.091	7	4.717	154.742	2584.765
13.5	11.059	7	4.703	154.742	2584.435
14	10.121	7	4.593	154.74	2582.271
14.5	9.686	7	4.426	154.736	2579.031
15	9.725	7	4.255	154.733	2575.759
15.5	9.655	7	4.101	154.73	2572.791
16	9.923	7	3.971	154.727	2570.31
16.5	9.029	7	3.823	154.724	2567.459
17	6.906	7	3.54	154.718	2561.964
17.5	5.961	7	3.134	154.71	2554.095
18	5.454	7	2.696	154.701	2545.664
18.5	5.073	7	2.43	154.691	2537.151
19	4.761	7	2.175	154.682	2528.387
19.5	4.482	7	1.919	154.672	2519.534
20	4.223	7	1.662	154.663	2510.658
20.5	3.989	7	1.406	154.653	2501.803
21	3.777	7	1.151	154.643	2493.014
21.5	3.586	7	.899	154.634	2484.328
22	3.413	7	.652	154.625	2475.778
22.5	3.258	7	.409	154.615	2467.392
23	3.119	7	.171	154.606	2459.192
23.5	2.993	7	0	154.598	2451.166
24	2.877	7	0	154.589	2443.121

Table 7.7.1 DIVERSION CAPACITY OF TRANSBASIN TUNNEL (2/4)

INITIAL WL= 153 M
RAIN = 70 MM

TIME HOUR	INFLOW M3/SEC	TUNNEL M3/SEC	WEIR M3/SEC	W.L. EL M.	STORAGE 10^3 M3
.5	1.89	7	0	0	0
1	1.919	7	0	152.984	1197.848
1.5	5.256	7	0	152.973	1191.024
2	13.546	7	0	152.981	1195.826
2.5	28.869	7	0	153.025	1224.242
3	40.878	7	0	153.109	1279.99
3.5	46.292	7	0	153.218	1353.16
4	43.351	7	0	153.327	1428.802
4.5	39.243	7	0	153.424	1497.396
5	34.706	7	0	153.507	1557.344
5.5	30.385	7	0	153.576	1608.435
6	26.895	7	0	153.634	1651.714
6.5	24.146	7	0	153.683	1688.755
7	21.806	7	0	153.725	1720.707
7.5	19.796	7	0	153.761	1748.309
8	18.031	7	0	153.792	1772.135
8.5	16.476	7	0	153.818	1792.642
9	15.116	7	0	153.84	1810.234
9.5	13.861	7	0	153.859	1825.211
10	12.675	7	0	153.875	1837.747
10.5	11.561	7	0	153.888	1847.983
11	10.565	7	0	153.899	1856.11
11.5	9.733	7	0	153.907	1862.408
12	8.989	7	0	153.912	1867.131
12.5	8.296	7	0	153.917	1870.416
13	7.662	7	0	153.919	1872.375
13.5	7.077	7	0	153.92	1873.114
14	6.546	7	0	153.919	1872.737
14.5	6.069	7	0	153.918	1871.352
15	6.008	7	0	153.915	1869.429
15.5	6.303	7	0	153.913	1867.74
16	6.601	7	0	153.912	1866.644
16.5	6.072	7	0	153.91	1865.317
17	4.769	7	0	153.906	1862.159
17.5	4.202	7	0	153.9	1857.13
18	3.907	7	0	153.892	1851.239
18.5	3.689	7	0	153.884	1844.835
19	3.513	7	0	153.876	1838.037
19.5	3.355	7	0	153.867	1830.905
20	3.21	7	0	153.857	1823.47
20.5	3.078	7	0	153.847	1815.757
21	2.958	7	0	153.837	1807.792
21.5	2.849	7	0	153.827	1799.599
22	2.752	7	0	153.816	1791.2
22.5	2.664	7	0	153.805	1782.616
23	2.586	7	0	153.794	1773.866
23.5	2.514	7	0	153.782	1764.966
24	2.449	7	0	153.771	1755.929

INITIAL WL= 153.5 M
RAIN = 100 MM

TIME HOUR	INFLOW M3/SEC	TUNNEL M3/SEC	WEIR M3/SEC	W.L. EL M.	STORAGE 10^3 M3
.5	1.923	7	0	0	0
1	5.707	7	0	153.491	1545.972
1.5	15.273	7	0	153.501	1552.951
2	31.682	7	0	153.546	1585.906
2.5	55.195	7	0	153.643	1658.784
3	73.217	7	0	153.793	1773.196
3.5	80.771	7	0	153.97	1913.185
4	74.91	7	0	154.143	2054.867
4.5	67.416	7	0	154.294	2183.193
5	59.516	7	0	154.424	2296.125
5.5	52.064	7	0	154.534	2393.705
6	46.025	7	.686	154.626	2477.45
6.5	41.219	7	2.75	154.702	2547.946
7	37.108	7	5.66	154.762	2604.287
7.5	33.584	7	8.004	154.808	2647.033
8	30.48	7	10.119	154.841	2678.859
8.5	27.733	7	11.608	154.865	2701.031
9	25.3	7	12.591	154.881	2715.611
9.5	23.038	7	13.16	154.89	2723.992
10	20.948	7	13.387	154.893	2727.261
10.5	19.004	7	13.336	154.893	2726.35
11	17.251	7	13.062	154.888	2722.095
11.5	15.775	7	12.621	154.881	2715.355
12	14.45	7	12.061	154.872	2706.839
12.5	13.218	7	11.412	154.862	2696.991
13	12.091	7	10.696	154.851	2686.158
13.5	11.058	7	9.936	154.839	2674.652
14	10.121	7	9.147	154.826	2662.733
14.5	9.686	7	8.372	154.814	2651.027
15	9.725	7	7.668	154.802	2640.434
15.5	9.655	7	7.144	154.792	2631.092
16	9.923	7	6.713	154.784	2622.86
16.5	9.029	7	6.294	154.775	2614.81
17	6.906	7	5.76700001	154.764	2604.631
17.5	5.961	7	5.141	154.751	2592.541
18	5.454	7	4.504	154.738	2580.307
18.5	5.073	7	3.887	154.725	2568.453
19	4.761	7	3.296	154.713	2557.117
19.5	4.482	7	2.735	154.702	2546.344
20	4.223	7	2.398	154.69	2536.028
20.5	3.989	7	2.1	154.679	2525.762
21	3.777	7	1.806	154.668	2515.624
21.5	3.586	7	1.518	154.657	2505.665
22	3.413	7	1.235	154.647	2495.914
22.5	3.258	7	.959	154.636	2486.394
23	3.119	7	.691	154.626	2477.125
23.5	2.993	7	.43	154.616	2468.12
24	2.877	7	.177	154.607	2459.386

Table 7.7.1 DIVERSION CAPACITY OF TRANSBASIN TUNNEL (3/4)

INITIAL WL= 153.5 M
RAIN = 70 MM

TIME HOUR	INFLOW M3/SEC	TUNNEL M3/SEC	WEIR M3/SEC	W.L. EL M.	STORAGE 10^3 M3
.5	1.89	7	0	0	0
1	1.919	7	0	153.486	1542.152
1.5	5.256	7	0	153.476	1535.327
2	13.546	7	0	153.483	1540.13
2.5	28.869	7	0	153.522	1568.545
3	40.878	7	0	153.598	1624.293
3.5	46.292	7	0	153.695	1697.463
4	43.351	7	0	153.793	1773.105
4.5	39.243	7	0	153.88	1841.699
5	34.706	7	0	153.955	1901.648
5.5	30.385	7	0	154.019	1952.738
6	26.895	7	0	154.072	1996.017
6.5	24.146	7	0	154.116	2033.058
7	21.806	7	0	154.155	2065.01
7.5	19.796	7	0	154.188	2092.612
8	18.031	7	0	154.216	2116.439
8.5	16.476	7	0	154.24	2136.945
9	15.116	7	0	154.261	2154.537
9.5	13.861	7	0	154.278	2169.515
10	12.675	7	0	154.293	2182.051
10.5	11.561	7	0	154.305	2192.287
11	10.565	7	0	154.314	2200.413
11.5	9.733	7	0	154.321	2206.712
12	8.989	7	0	154.327	2211.434
12.5	8.296	7	0	154.331	2214.72
13	7.662	7	0	154.333	2216.678
13.5	7.077	7	0	154.334	2217.418
14	6.546	7	0	154.333	2217.041
14.5	6.069	7	0	154.332	2215.655
15	6.008	7	0	154.33	2213.732
15.5	6.303	7	0	154.328	2212.044
16	6.601	7	0	154.326	2210.948
16.5	6.072	7	0	154.325	2209.621
17	4.769	7	0	154.321	2206.462
17.5	4.202	7	0	154.315	2201.433
18	3.907	7	0	154.309	2195.543
18.5	3.689	7	0	154.301	2189.138
19	3.513	7	0	154.293	2182.34
19.5	3.355	7	0	154.285	2175.208
20	3.21	7	0	154.276	2167.773
20.5	3.078	7	0	154.267	2160.061
21	2.958	7	0	154.258	2152.096
21.5	2.849	7	0	154.248	2143.903
22	2.752	7	0	154.238	2135.503
22.5	2.664	7	0	154.228	2126.919
23	2.586	7	0	154.218	2118.169
23.5	2.514	7	0	154.207	2109.27
24	2.449	7	0	154.197	2100.232

INITIAL WL= 154 M
RAIN = 100 MM

TIME HOUR	INFLOW M3/SEC	TUNNEL M3/SEC	WEIR M3/SEC	W.L. EL M.	STORAGE 10^3 M3
.5	1.923	7	0	0	0
1	5.707	7	0	153.992	1931.069
1.5	15.273	7	0	154.001	1938.049
2	31.682	7	0	154.041	1971.003
2.5	55.195	7	0	154.129	2043.881
3	73.217	7	0	154.265	2158.293
3.5	80.771	7	0	154.426	2298.282
4	74.91	7	0	154.585	2439.964
4.5	67.416	7	3.671	154.721	2566.455
5	59.516	7	9.247	154.828	2667.42
5.5	52.064	7	14.214	154.906	2741.234
6	46.025	7	18.198	154.959	2792.42
6.5	41.219	7	20.836	154.994	2825.957
7	37.108	7	22.586	155.016	2846.419
7.5	33.584	7	23.498	155.027	2856.609
8	30.48	7	23.741	155.029	2859.099
8.5	27.733	7	23.482	155.026	2855.838
9	25.3	7	22.854	155.019	2848.35
9.5	23.038	7	21.954	155.008	2837.744
10	20.948	7	20.89	154.995	2824.805
10.5	19.004	7	19.757	154.98	2810.077
11	17.251	7	18.521	154.963	2794.002
11.5	15.775	7	17.232	154.946	2777.248
12	14.45	7	15.926	154.929	2760.308
12.5	13.218	7	14.625	154.911	2743.428
13	12.091	7	13.402	154.894	2726.75
13.5	11.058	7	12.305	154.876	2710.255
14	10.121	7	11.222	154.859	2693.914
14.5	9.686	7	10.189	154.843	2678.334
15	9.725	7	9.259	154.828	2664.349
15.5	9.655	7	8.443	154.815	2652.083
16	9.923	7	7.741	154.804	2641.534
16.5	9.029	7	7.174	154.793	2631.639
17	6.906	7	6.56	154.78	2619.818
17.5	5.961	7	5.855	154.766	2606.226
18	5.454	7	5.148	154.751	2592.638
18.5	5.073	7	4.467	154.737	2579.564
19	4.761	7	3.819	154.724	2567.13
19.5	4.482	7	3.206	154.711	2555.366
20	4.223	7	2.639	154.699	2544.249
20.5	3.989	7	2.328	154.688	2533.622
21	3.777	7	2.021	154.676	2523.041
21.5	3.586	7	1.721	154.665	2512.665
22	3.413	7	1.427	154.654	2502.519
22.5	3.258	7	1.14	154.643	2492.627
23	3.119	7	.861	154.632	2483.007
23.5	2.993	7	.591	154.622	2473.671
24	2.877	7	.329	154.612	2464.625

Table 7.7.1 DIVERSION CAPACITY OF TRANSBASIN TUNNEL (4/4)

INITIAL WL= 154 M
RAIN = 70 MM

TIME HOUR	INFLOW M3/SEC	TUNNEL M3/SEC	WEIR M3/SEC	W.L. EL M.	STORAGE 10^3 M3
.5	1.89	7	0	0	0
1	1.919	7	0	153.987	1927.249
1.5	5.256	7	0	153.979	1920.424
2	13.546	7	0	153.985	1925.227
2.5	28.869	7	0	154.02	1953.642
3	40.878	7	0	154.088	2009.39
3.5	46.292	7	0	154.176	2082.56
4	43.351	7	0	154.265	2158.203
4.5	39.243	7	0	154.345	2226.796
5	34.706	7	0	154.413	2286.745
5.5	30.385	7	0	154.471	2337.835
6	26.895	7	0	154.52	2381.115
6.5	24.146	7	0	154.561	2418.155
7	21.806	7	0	154.596	2450.108
7.5	19.796	7	.684	154.626	2477.367
8	18.031	7	1.316	154.65	2499.168
8.5	16.476	7	1.819	154.668	2516.474
9	15.116	7	2.212	154.683	2529.979
9.5	13.861	7	2.509	154.694	2540.187
10	12.675	7	2.77	154.702	2547.425
10.5	11.561	7	3.002	154.707	2551.875
11	10.565	7	3.107	154.709	2553.829
11.5	9.733	7	3.111	154.709	2553.859
12	8.989	7	3.037	154.708	2552.394
12.5	8.296	7	2.899	154.705	2549.711
13	7.662	7	2.709	154.701	2546.035
13.5	7.077	7	2.555	154.696	2541.529
14	6.546	7	2.4	154.69	2536.197
14.5	6.069	7	2.226	154.684	2530.175
15	6.008	7	2.047	154.677	2523.976
15.5	6.303	7	1.884	154.671	2518.366
16	6.601	7	1.747	154.666	2513.652
16.5	6.072	7	1.611	154.661	2508.967
17	4.769	7	1.432	154.654	2502.744
17.5	4.202	7	1.209	154.646	2495.052
18	3.907	7	.976	154.637	2486.971
18.5	3.689	7	.74	154.628	2478.85
19	3.513	7	.507	154.619	2470.805
19.5	3.355	7	.278	154.61	2462.89
20	3.21	7	.053	154.602	2455.126
20.5	3.078	7	0	154.593	2447.446
21	2.958	7	0	154.585	2439.508
21.5	2.849	7	0	154.575	2431.315
22	2.752	7	0	154.566	2422.915
22.5	2.664	7	0	154.557	2414.331
23	2.586	7	0	154.547	2405.581
23.5	2.514	7	0	154.537	2396.681
24	2.449	7	0	154.527	2387.644

7.8 Comparative Study of Open Cut and Tunnel on Transbasin Tunnel

Comparative study of open cut and tunnel works is made for determining the locations of inlet and outlet of transbasin tunnel.

1. Condition

The dimensions of the open cut and tunnel is decided as follows for comparative study.

(1) Open cut

Type	:	Trapezoidal shaped channel
Bottom width	:	4 m
Side slope	:	1 : 0.7
Bern width	:	1 m
Height between berms	:	5 m

(2) Tunnel

Type	:	Circular,lined with concrete
Lining thickness	:	25 cm
Grouting	:	0.8 m3/m

The unit cost of each work is provisionally estimated.

2. Work Quantity and Cost

Based on the above design figures, the work quantities and costs are estimated as follows.

(1) Open cut

Cut Depth (m)	Work Q'ty (m3/100 m)		Unit Cost (Rp/m^3)		Cost (10^6 Rp)
	Rock	Earth	Rock	Earth	
12	9,100	5,600	7,000	4,000	6.7 + 22.4 = 86.1
10	6,100	4,700	7,000	4,000	42.7 + 18.8 = 61.5
8	3,600	3,900	7,000	4,000	25.2 + 15.6 = 40.8

Note: Top soil thickness is assumed to be 3 m

(2) Tunnel

Works	Work Q'ty (m3/100m)	Unit Cost (Rp/m3)	Cost (x 10^6 Rp)
Tunnel excavation	491	85,000	41.7
Lining concrete	177	150,000	26.6
Grouting	85	150,000	12.8
		Total	81.1

3. Result

From the above results, if open cut depth is more than or equal to 12 m, the tunnel works is more economical.

Based on this result, the locations of the inlet and outlet of the transbasin tunnel are decided at the points where the cut depth is around 12 m in case of open channel.

7.9 Design Calculation of Side Channel Portion of Spillway

1. Condition

To determine the required depth of the side channel, the following conditions are proposed considering the scale of design flood and topographic conditions.

Spillway channel type	:	Trapezoid
Side slope		
reservoir side	:	1 : 0.7 (overflow weir, downstream side slope)
fill side	:	1 : 0.2
Bottom width		
at upstream end	:	5 m
at downstream end	:	10 m
Channel length	:	40 m as same as overflow weir

2. Equation

Equations applied as follows.

$$Q_x = q.X$$

$$V = a.x^n$$

$$Y = \frac{n+1}{n} \cdot \frac{V^2}{2g}$$

$$d = (-b + b^2 + 2A (Z_1 + Z_2)) / (Z_1 + Z_2)$$

$$A = bd + \frac{1}{2} d^2 (Z_1 + Z_2)$$

$$Hf = \frac{n^2.V^2}{R^{3/4}} \cdot X$$

$$P = d + Y + Hf$$

where;

Q_x	:	Discharge at x-point
q	:	Unit overflow discharge
X	:	Distance from upstream end
a, n	:	Coefficient of velocity
Y	:	Distance between weir crest and water surface
A	:	Cross-sectional flow area
d	:	Depth of water at each section
Hf	:	Friction less head
Z_1, Z_2	:	Side slopes of the channel.

3. Calculation

The coefficient; a and n is examined by trial and error method so as to minimize the longitudinal sectional area of the side channel which means the most economic cost in the aboves conditions. As the results a of 0.44 and n of 0.64 are obtained.

Calculation results are shown in Fig. 7.9.1. The required depth at the downstream end is 7.7 m below the weir crest.

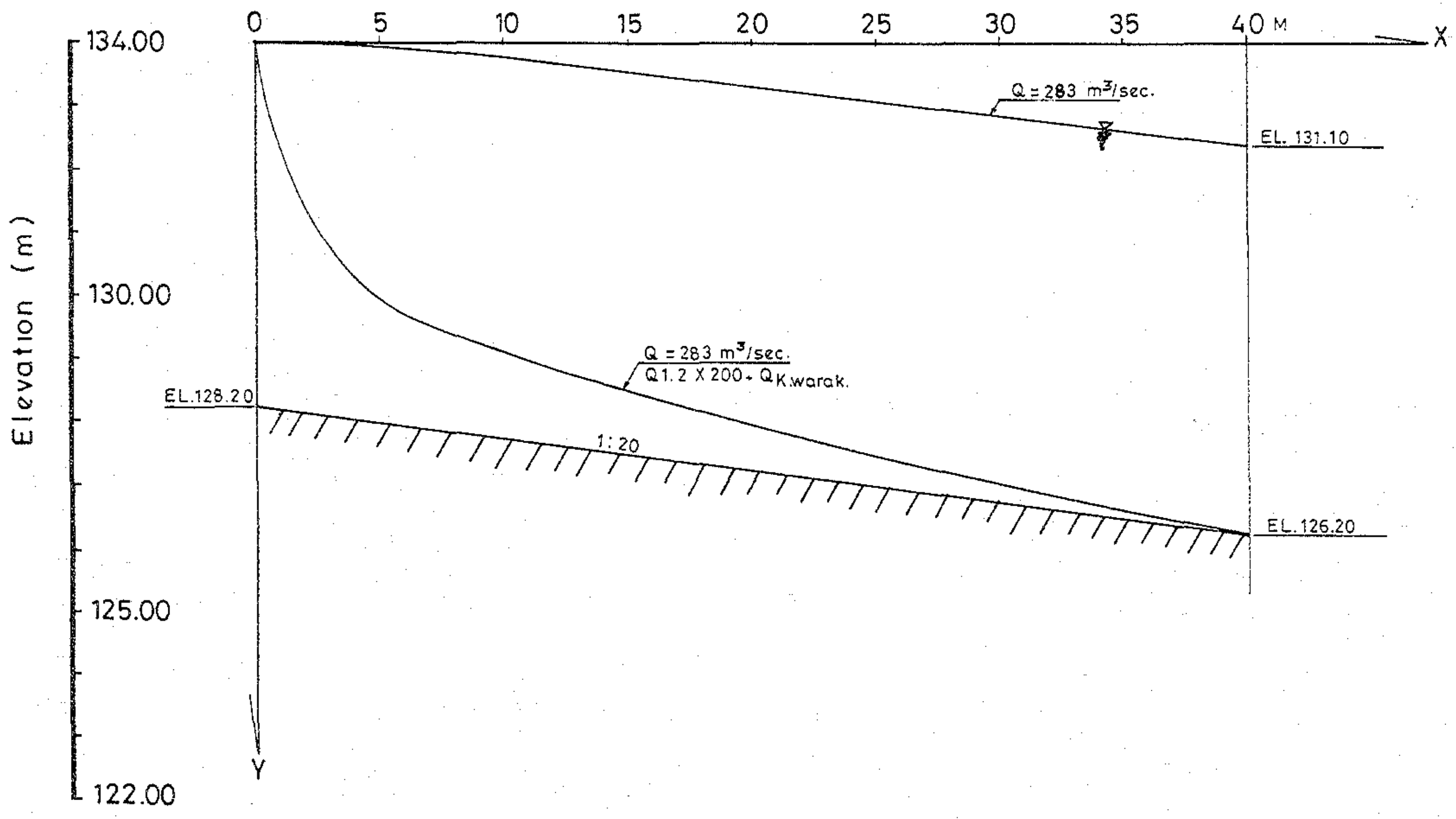


Fig. 7.9.1 LONG. SECTION OF SIDE WEIR CHANNEL

7.10 Slope Stability of Dam Embankment

Slope stability analysis are made by slice method for the following conditions ;

1. Calculation Case : High water level at normal time
   (Upstream and downstream slopes)
   High water level at seismic time
   (Upstream and downstream slopes)
   Empty in reservoir at normal time
   (Upstream slope)
   Empty in reservoir at seismic time
   (Upstream slope)

2. Design values applied :

   Seismic coefficient : 0.15

   Embankment material

   Wet density : 1.60 ton/m^3

   Saturated density : 1.75 ton/m^3

   Internal friction angle : 25°

   Cohesion : 4 ton/m^2

3. Calculation results

   Table 7.10.1 to 7.10.3 show the results of stability analysis of various sliding circles and Fig. 7.10.1 show the most dangerous sliding circles in each case. Safety factors in the most dangerous cases are as follows ;

Condition	At normal time	At seismic time
(1) Upstream slope		
High water level	3.07	1.32
Empty	2.46	1.53
(2) Downstream Slope		
High water level	2.04	1.24

Table 7.10.1 STABILITY ANALYSIS OF KETANDAN DAM

UPSTREAM SLOPE

At High Water Level

NUMBER	SLIPPE CIRCLE(M) XCOOR	Y-COOR	RADIUS	SAFETY FACTOR (NORMAL)	(SEISMIC)	MOMENT(T*M) RESISTANCE	SLIDING
1	70.0	160.0	60.0	2.861	1.659	86878	52358
2	70.0	160.0	55.0	3.416	1.501	35890	23910
3	70.0	160.0	50.0	4.044	1.783	22892	12838
4	70.0	160.0	45.0	5.337	2.418	13016	5382
5	70.0	170.0	70.0	3.065	1.707	111172	65123
6	70.0	170.0	65.0	2.798	1.669	75768	45394
7	70.0	170.0	60.0	3.689	1.688	31546	18693
8	70.0	170.0	55.0	4.981	2.274	18495	8135
9	70.0	180.0	80.0	3.239	1.737	135748	78147
10	70.0	180.0	75.0	2.912	1.690	95062	56256
11	70.0	180.0	70.0	3.387	1.602	41409	25854
12	70.0	180.0	65.0	4.516	2.126	25153	11830
13	80.0	160.0	60.0	3.073	1.324	59878	45221
14	80.0	160.0	55.0	3.126	1.402	42622	30392
15	80.0	160.0	50.0	3.406	1.565	28504	18214
16	80.0	160.0	45.0	4.202	1.929	17313	8974
17	80.0	160.0	40.0	6.404	2.938	8916	3035
18	80.0	170.0	70.0	4.077	1.915	118929	62110
19	80.0	170.0	65.0	3.099	1.384	55755	40289
20	80.0	170.0	60.0	3.215	1.507	38702	25679
21	80.0	170.0	55.0	3.725	1.796	24658	13728
22	80.0	170.0	50.0	5.574	2.659	13353	5021
23	80.0	180.0	80.0	4.495	1.987	144889	72908
24	80.0	180.0	75.0	3.248	1.406	69776	49619
25	80.0	180.0	70.0	3.215	1.492	49520	33182
26	80.0	180.0	65.0	3.518	1.722	32745	19011
27	80.0	180.0	60.0	4.837	2.426	18940	7806
28	90.0	160.0	60.0	3.762	1.443	67482	46776
29	90.0	160.0	55.0	3.427	1.437	48631	33831
30	90.0	160.0	50.0	3.303	1.495	33847	22634
31	90.0	160.0	45.0	3.464	1.659	22001	13262
32	90.0	160.0	40.0	4.227	2.095	12786	6104
33	90.0	170.0	70.0	4.270	1.519	86228	56757
34	90.0	170.0	65.0	3.772	1.494	63159	42274
35	90.0	170.0	60.0	3.484	1.520	44865	29518
36	90.0	170.0	55.0	3.433	1.632	30286	18558
37	90.0	170.0	50.0	3.854	1.958	18530	9464
38	90.0	180.0	80.0	4.910	1.603	106067	66187
39	90.0	180.0	75.0	4.251	1.570	78792	50189
40	90.0	180.0	70.0	3.810	1.575	56677	35980
41	90.0	180.0	65.0	3.622	1.661	39114	23546
42	90.0	180.0	60.0	3.799	1.916	24909	13001
43	90.0	180.0	55.0	5.223	2.847	13186	4632

Table 7.10.2 STABILITY ANALYSIS OF KETANDAN DAM

UPSTREAM SLOPE

At Reservoir Empty

NUMBER	SLIPPE CIRCLE(M) XCOOR	Y-COOR	RADIUS	SAFETY FACTOR (NORMAL)	(SEISMIC)	MOMENT(T*M) RESISTANCE	SLIDING
1	70.0	160.0	60.0	2.502	1.560	83970	53821
2	70.0	160.0	55.0	2.547	1.618	55121	34059
3	70.0	160.0	50.0	2.758	1.780	33428	18781
4	70.0	160.0	45.0	3.308	2.176	17380	7988
5	70.0	170.0	70.0	2.461	1.532	108493	70803
6	70.0	170.0	65.0	2.453	1.567	73269	46768
7	70.0	170.0	60.0	2.649	1.718	46033	26798
8	70.0	170.0	55.0	3.147	2.075	25025	12061
9	70.0	180.0	80.0	2.490	1.534	134420	87647
10	70.0	180.0	75.0	2.438	1.551	93220	60121
11	70.0	180.0	70.0	2.562	1.664	60157	36150
12	70.0	180.0	65.0	3.018	1.993	34153	17138
13	80.0	160.0	60.0	2.573	1.560	94384	60488
14	80.0	160.0	55.0	2.556	1.590	65306	41061
15	80.0	160.0	50.0	2.639	1.679	42107	25081
16	80.0	160.0	45.0	2.930	1.898	24267	12788
17	80.0	160.0	40.0	3.800	2.517	11361	4514
18	80.0	170.0	70.0	2.634	1.574	120277	76407
19	80.0	170.0	65.0	2.556	1.577	85115	53975
20	80.0	170.0	60.0	2.582	1.638	56807	34670
21	80.0	170.0	55.0	2.791	1.816	34329	18906
22	80.0	170.0	50.0	3.565	2.365	17136	7245
23	80.0	180.0	80.0	2.757	1.614	148035	91706
24	80.0	180.0	75.0	2.639	1.600	106214	66377
25	80.0	180.0	70.0	2.606	1.634	72431	44332
26	80.0	180.0	65.0	2.743	1.773	45350	25572
27	80.0	180.0	60.0	3.379	2.244	24203	10786
28	90.0	160.0	60.0	3.023	1.703	104285	61225
29	90.0	160.0	55.0	2.863	1.680	73981	44041
30	90.0	160.0	50.0	2.768	1.689	49777	29473
31	90.0	160.0	45.0	2.815	1.778	30947	17410
32	90.0	160.0	40.0	3.165	2.060	16885	8198
33	90.0	170.0	70.0	3.185	1.748	131631	75309
34	90.0	170.0	65.0	3.004	1.719	95328	55443
35	90.0	170.0	60.0	2.868	1.713	65774	38399
36	90.0	170.0	55.0	2.831	1.763	42364	24033
37	90.0	170.0	50.0	3.054	1.976	24306	12304
38	90.0	180.0	80.0	3.376	1.801	160278	89006
39	90.0	180.0	75.0	3.185	1.773	117816	66464
40	90.0	180.0	70.0	3.031	1.762	82765	46964
41	90.0	180.0	65.0	2.951	1.795	54523	30374
42	90.0	180.0	60.0	3.075	1.958	32488	16596
43	90.0	180.0	55.0	3.981	2.648	15634	5904

Table 7.10.3 STABILITY ANALYSIS OF KETANDAN DAM
DOWNSTREAM SLOPE
At High Water Level

NUMBER	SLIPPE CIRCLE(M)			SAFETY FACTOR		MOMENT(T*M)	
	XCOOR	Y-COOR	RADIUS	(NORMAL)	(SEISMIC)	RESISTANCE	SLIDING
1	160.0	160.0	60.0	2.133	1.251	82196	-65707
2	160.0	160.0	55.0	2.191	1.326	61958	-46711
3	160.0	160.0	50.0	2.481	1.498	43789	-29224
4	160.0	160.0	45.0	2.459	1.591	29468	-18523
5	160.0	160.0	40.0	2.683	1.814	16847	-9286
6	160.0	170.0	70.0	2.180	1.255	102058	-81349
7	160.0	170.0	65.0	2.241	1.325	77839	-58724
8	160.0	170.0	60.0	2.686	1.529	55025	-35991
9	160.0	170.0	55.0	2.638	1.625	38681	-23810
10	160.0	170.0	50.0	2.724	1.799	23972	-13323
11	160.0	170.0	45.0	3.404	2.363	11394	-4821
12	160.0	180.0	80.0	2.240	1.266	122973	-97121
13	160.0	180.0	75.0	2.308	1.336	94616	-70808
14	160.0	180.0	70.0	2.404	1.432	70193	-49013
15	160.0	180.0	65.0	2.853	1.667	47824	-28695
16	160.0	180.0	60.0	2.918	1.846	31097	-16843
17	160.0	180.0	55.0	3.368	2.284	16078	-7039
18	160.0	190.0	90.0	2.303	1.281	144750	-113002
19	160.0	190.0	85.0	2.381	1.352	112117	-82956
20	160.0	190.0	80.0	2.489	1.448	83833	-57880
21	160.0	190.0	75.0	2.653	1.594	59709	-37458
22	160.0	190.0	70.0	3.153	1.904	38225	-20078
23	160.0	190.0	65.0	3.465	2.275	20931	-9199
24	170.0	160.0	60.0	2.171	1.325	80044	-60406
25	170.0	160.0	55.0	2.141	1.377	59099	-42912
26	170.0	160.0	50.0	2.242	1.492	40065	-26856
27	170.0	160.0	45.0	2.468	1.685	23534	-13968
28	170.0	160.0	40.0	3.242	2.264	11015	-4866
29	170.0	170.0	70.0	2.010	1.247	100300	-80456
30	170.0	170.0	65.0	2.237	1.383	73725	-53304
31	170.0	170.0	60.0	2.240	1.461	52422	-35887
32	170.0	170.0	55.0	2.400	1.626	33068	-20343
33	170.0	170.0	50.0	2.980	2.081	17057	-8197
34	170.0	180.0	80.0	2.042	1.244	120305	-96747
35	170.0	180.0	75.0	2.110	1.320	91111	-69015
36	170.0	180.0	70.0	2.349	1.477	64567	-43720
37	170.0	180.0	65.0	2.426	1.611	42992	-26690
38	170.0	180.0	60.0	2.817	1.947	23615	-12132
39	170.0	190.0	90.0	2.086	1.249	141248	-113095
40	170.0	190.0	85.0	2.157	1.323	107807	-81498
41	170.0	190.0	80.0	2.479	1.498	76506	-51058
42	170.0	190.0	75.0	2.541	1.633	52758	-32314
43	170.0	190.0	70.0	2.802	1.903	30909	-16239
44	180.0	160.0	60.0	2.033	1.340	76311	-56965
45	180.0	160.0	55.0	2.151	1.443	51725	-35845
46	180.0	160.0	50.0	2.355	1.605	31100	-19374
47	180.0	160.0	45.0	2.904	2.019	15736	-7794
48	180.0	170.0	70.0	2.016	1.304	94906	-72769
49	180.0	170.0	65.0	2.078	1.389	67865	-48845
50	180.0	170.0	60.0	2.245	1.533	43176	-28169

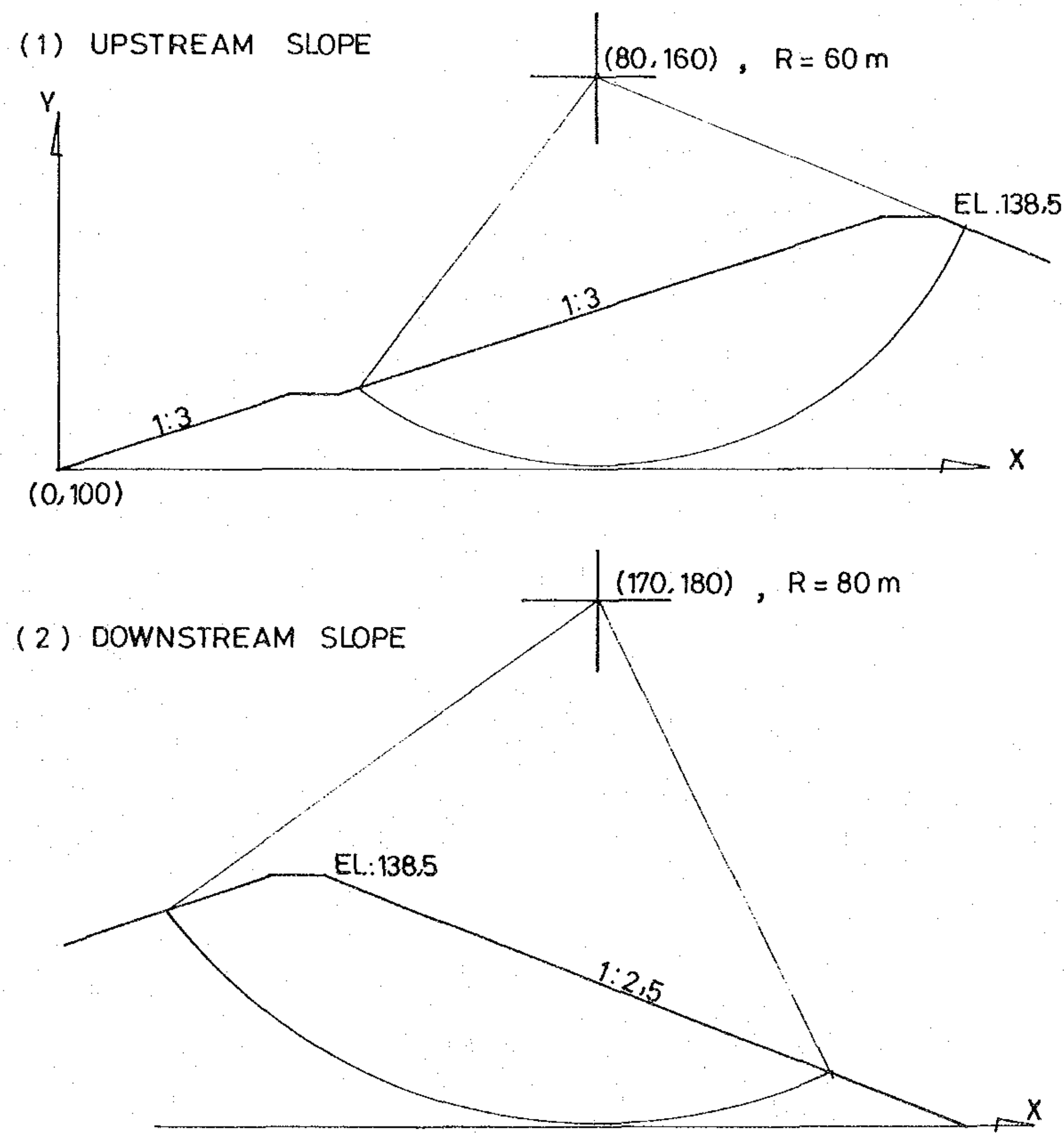


Fig: 7.10.1 MOST DANGEROUS SLIDING CIRCLE

7.11 Diversion Tunnel Diameter

To decide the tunnel diameter and the crest elevation of a cofferdam, flood routine analysis are made by changing the diameter of the tunnel such as diameter of 2.0 m, 2.9 m and 4.0 m.

1. Condition and assumption

The conditions and the assumption for this analysis are as follows.

Design flood	: 20 years probable flood (refer to ANNEX-2)
Tunnel	
Type	: Circular lined with concrete
Longitudinal slope	: 1/180
Length	: 360 m
Upstream bed elevation	: 101.0 m
Downstream bed elevation	: 99.o m
Roughness coefficient	: 0.014
Baseflow	: 0.0 m^3/sec.

2. Calculation method

A flood routing calculation is carried out by using Ekdahe's method. The equation is as follows.

$$\frac{1}{2}(Ii + Ii + 1) \quad t = (S_{i+1} - S_i) + \frac{1}{2}(Q_i + O_{i+1}) \quad t$$

$$= (S_{i+1} + \frac{Oi}{2} \quad t) - (S_i - \frac{Oi}{2} \quad t)$$

$$\emptyset = S + \frac{O}{2} \quad t, \qquad Z = S - \frac{O}{2} \quad t$$

Then, $\emptyset_{i+1} = \frac{1}{2}(I_{i+1} + I_i) \quad t \pm Z_i$

where,
- I : Inflow
- O : Outflow
- S ; Storage
- t : Routing period

The inflow discharge is estimated by the dimension less method (details, refer to Hydrology).

The outflow depends on the capacity of the diversion tunnel. The capacity is calculated by Manning formula. Fig. 7.11.1 shows the capacity of the diversion tunnel. The storage volume is estimated by the elevation storage relation curve. The routing period is set at 0.5 hr.

3. Results

Results are shown in Table 7.11.1 and summarized below.

Diameter (m)	Peak water level (m)
2.0	112.6
2.9	110.6
4.0	207.8

The crest elevations of coffer dam on the above cases are 114.5 m, 112.1 m and 109.3 m, respectively. The embankment volume is as small as 45,000 m^3 to 12,000 m^3. In every cases, the coffer dam can be easily constructed in the dry season. The most of the coffer dam embankment is incoperated into the main dam, thus, the construction cost is not so different among the above cases. The cost difference mainly depends on the tunnel works. Also if the tunnel diameter is same as that of the transbasin tunnel, tunnel machine and tools can be commonly used and the construction period can be adjusted so as not to overlap between the transbasin tunnel and the diversion tunnel.

Taking the above considerartion into account, the tunnel diameter is decided to be 2 m.

TABLE 7.11.1 CALCULATION RESULTS OF FLOOD ROUTING FOR KETANDAN DIVERSION TUNNEL

TIME	DIA.=2.0 M INFLOW (M3)	DIA.=2.0 M OUTFLOW (M3)	DIA.=2.0 M W.LEVEL (M)	DIA.=2.9 M INFLOW (M3)	DIA.=2.9 M OUTFLOW (M3)	DIA.=2.9 M W.LEVEL (M)	DIA.=4.0 M INFLOW (M3)	DIA.=4.0 M OUTFLOW (M3)	DIA.=4.0 M W.LEVEL (M)
.5	20.35	2.25	101.81	20.35	2.92	101.78	20.35	3.26	101.76
1	52.06	14.16	104.33	52.06	25.8	103.75	52.06	29.83	103.53
1.5	87.15	16.7	106.16	87.15	38.72	105.58	87.15	64.22	105.15
2	140.73	18.91	108.21	140.73	44.5	107.39	140.73	82.24	106.17
2.5	135.56	20.78	110.11	135.56	49.48	108.95	135.56	94.84	107.41
3	100.23	21.66	111.07	100.23	51.12	110.05	100.23	97.22	107.8
3.5	75.53	22.23	111.73	75.53	51.92	110.41	75.53	96.39	107.65
4	56.25	22.63	112.17	56.25	52.22	110.55	56.25	91.85	107.03
4.5	42.21	22.84	112.43	42.21	52.16	110.52	42.21	81.27	106.09
5	32.72	22.95	112.57	32.72	51.84	110.38	32.72	65.19	105.2
5.5	25.37	23	112.62	25.37	51.34	110.15	25.37	35.8	103.8
6	19.96	23	112.62	19.96	50.49	109.78	19.96	22.96	103.2
6.5	17.16	22.96	112.58	17.16	49.24	109.26	17.16	18.75	102.99
7	10.36	22.9	112.5	10.36	47.79	108.68	10.36	14.45	102.74
7.5	8.02	22.79	112.36	8.02	46.23	108.05	8.02	10.01	102.46
8	6.08	22.66	112.21	6.08	44.46	107.37	6.08	7.98	102.29
8.5	4.57	22.53	112.03	4.57	41.86	106.43	4.57	6.15	102.13
9	3.38	22.35	111.85	3.38	38.5	105.52	3.38	4.66	102
9.5	2.4	22.15	111.65	2.4	29.36	104.1	2.4	3.9	101.87
10	1.42	21.96	111.45	1.42	9.35	102.53	1.42	3.07	101.73
10.5	1.33	21.8	111.25	1.33	4.41	102.04	1.33	2.37	101.61
11	1.26	21.63	111.04	1.26	3.1	101.82	1.26	1.92	101.53
11.5	1.25	21.44	110.84	1.25	2.42	101.68	1.25	1.66	101.49
12	1.25	21.24	110.64	1.25	1.99	101.59	1.25	1.55	101.45
12.5	1.24	21.05	110.44	1.24	1.71	101.54	1.24	1.47	101.43

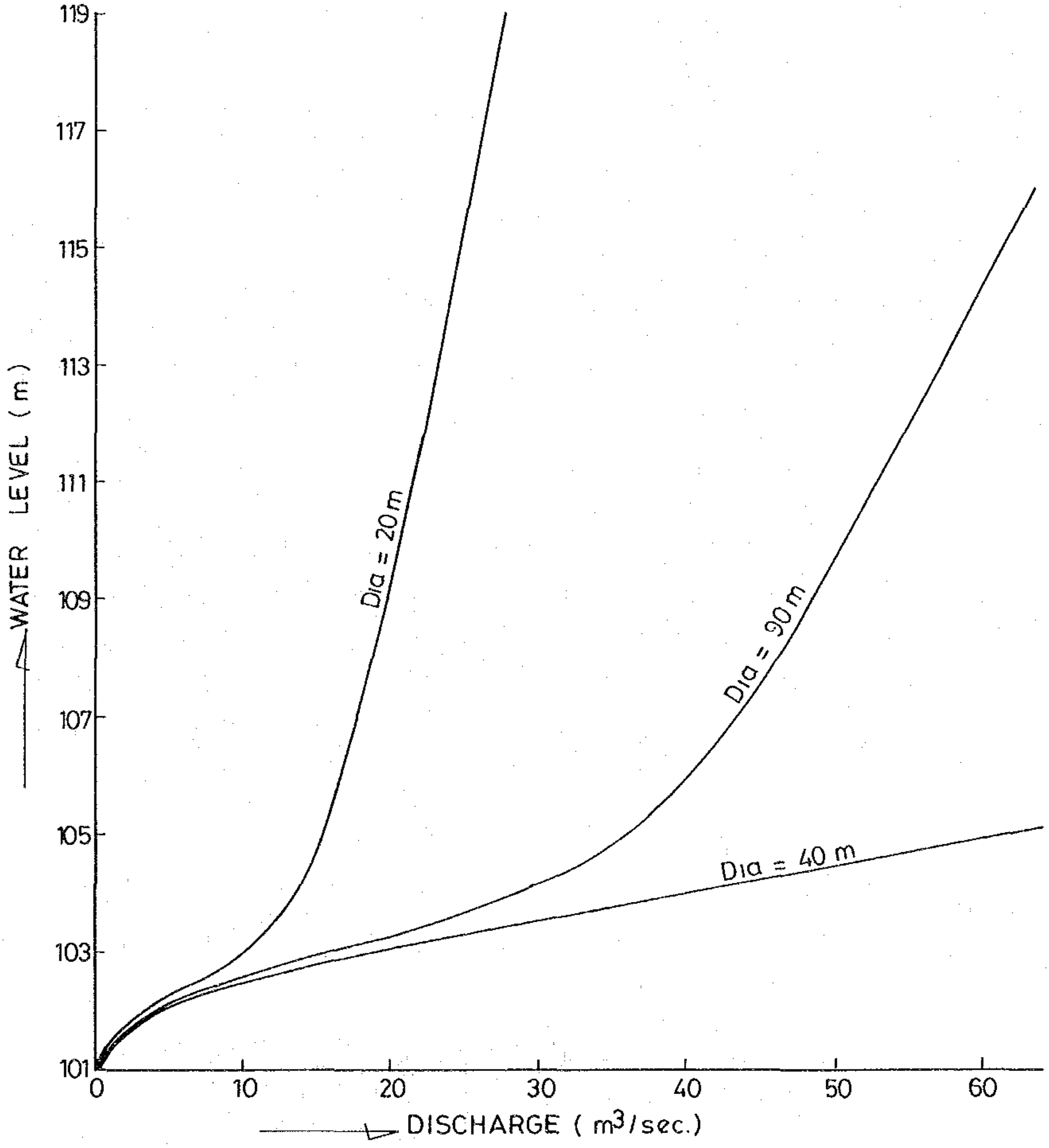


Fig: 7.II.1 CAPACITY CURVE OF DIV., TUNNEL OF KETANDAN DAM

7.12 Mini-Hydro Power

1. Turbine output and generator output

(1) Condition

The following conditions are considered for estimate the turbine output and the generator output.

Reservoir water level	HWL	EL. 134.0 m
	LWL	EL. 117.5 m
Turbine elevation		EL. 100.0 m
Tail water level		EL. 97.4 m

(2) Estimate

Sums of irrigation release and the spill-out from the Ketandan reservoir are available source for hydro-power generator. The sums are listed in Table 7.12.1. According to these sums, the parallel duration curves are made as shown in Fig. 7.12.1. Then, maximum discharge is set at 1.2 m^3/sec from the duration curves.

The turbine output is estimated by the following equation.

$$Pt = 9.8 \times Q \times H \times \eta t$$

where, Pt : turbine output
Q : discharge
H : rated head
ηt : turbine efficiency

The rated head is estimated at 28.5 m on assumption that the reservoir water level is 128.5 m on an average, the loss head in the water way is 5% of static head and the suction effect is 1.4 m. The turbine efficiency is set at 0.8. Then, a possible installed capacity is calculated at 270 kw by the above equation.

The generator output is estimated by the following equation.

$$Pg = Pt \times \eta a \times \eta g /$$

where; Pg : generator output (kvA)
Pt : turbine output (kw)
a : efficiency of accelarator
g ; generator efficiency 0.93
:

The generator output becomes 300 kvA.

Based on the above equations and the available water sources, the 10-day energy output and the annual total are estimated in Table 7.12.2. An average annual energy output is estimated at 1,101 MWh.

2. Connection line

Fig. 7.12.1 shows the connection diagram of generating system.

3. Power station

The power station is shown in section 7.14.

Table 7.12.1 ESTIMATED TEN-DAY RUNOFF (1/4)

OUTFLOW FROM KETANDAN DAM

Month		1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
JAN	1	4.42	0.63	0.09	0.00	0.20	0.15	0.08	0.17	0.42	0.88
	2	3.57	0.68	0.80	0.00	2.09	0.00	1.02	0.77	0.00	1.41
	3	4.17	2.27	1.08	0.00	1.79	0.00	0.62	1.22	0.40	0.00
FEB	1	1.03	1.48	0.00	0.32	0.00	0.00	0.98	0.00	2.30	0.00
	2	1.20	1.62	1.70	1.16	0.00	0.00	0.00	0.00	1.14	0.16
	3	3.64	2.19	0.00	0.66	0.86	0.00	0.57	2.10	0.00	0.00
MAR	1	2.74	0.21	0.00	6.16	0.00	0.69	0.00	0.59	0.23	0.05
	2	2.27	0.83	1.81	3.64	0.00	1.08	4.36	0.00	1.55	0.08
	3	1.81	0.78	0.84	3.50	0.00	0.48	1.47	0.50	0.01	1.00
APR	1	0.59	2.08	0.26	2.00	0.00	1.02	0.95	0.11	0.18	2.68
	2	1.76	2.34	0.20	1.57	16.86	1.50	1.27	0.13	0.00	1.98
	3	0.66	1.56	0.29	0.59	3.90	0.74	1.86	0.06	0.01	2.73
MAY	1	0.31	0.64	0.45	0.44	1.52	0.56	1.71	0.16	0.50	1.15
	2	0.59	0.44	0.27	0.55	1.04	0.43	0.45	0.33	0.64	0.64
	3	0.21	0.36	0.00	0.84	0.72	0.78	0.22	0.41	0.84	0.21
JUN	1	0.14	0.48	0.00	1.03	1.03	0.88	1.03	0.90	0.04	0.69
	2	0.52	0.55	0.94	1.15	1.15	1.15	0.46	1.15	1.04	1.15
	3	1.22	1.07	1.13	1.22	1.16	1.13	0.86	1.22	1.22	1.22
JUL	1	0.46	0.43	1.18	1.02	1.18	0.68	0.82	1.18	1.18	1.18
	2	0.83	0.25	0.37	0.83	0.65	0.83	0.83	0.83	0.83	0.83
	3	0.47	0.00	0.26	0.19	0.11	0.25	0.47	0.47	0.47	0.47
AUG	1	0.05	0.13	0.15	0.01	0.14	0.15	0.15	0.15	0.15	0.15
	2	0.00	0.03	0.00	0.03	0.02	0.03	0.03	0.03	0.03	0.03
	3	0.06	0.16	0.00	0.06	0.03	0.06	0.06	0.06	0.06	0.06
SEP	1	0.14	0.14	0.12	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	2	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.22	0.24
	3	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
OCT	1	0.45	0.45	0.43	0.45	0.12	0.32	0.45	0.45	0.45	0.45
	2	0.52	0.29	0.00	0.52	0.26	0.52	0.52	0.52	0.52	0.52
	3	0.10	0.28	0.51	0.56	0.56	0.56	0.49	0.56	0.33	0.56
NOV	1	0.00	0.00	0.29	0.42	0.25	0.44	0.04	0.29	0.00	0.44
	2	0.04	0.86	0.33	0.12	0.15	0.33	0.12	0.00	0.19	0.33
	3	0.03	0.20	0.01	0.02	0.16	0.03	0.02	0.23	0.19	0.22
DEC	1	5.05	1.56	0.45	0.63	1.16	0.53	1.66	1.09	1.50	1.17
	2	5.23	0.85	0.63	0.32	0.94	0.33	1.46	1.41	1.00	0.71
	3	1.79	0.39	1.63	1.82	0.47	2.29	2.38	2.79	0.93	0.64
TOL		1.30	0.74	0.47	0.90	1.09	0.52	0.78	0.57	0.53	0.68

Table 7.12.1 ***************************
* ESTIMATED TEN-DAY RUNOFF * (2/4)
****

OUTFLOW FROM KETANDAN DAM

Month		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
JAN	1	2.04	0.23	0.98	0.12	1.11	1.25	1.84	1.06	0.12	0.65
	2	1.14	2.47	0.00	0.48	0.53	0.00	0.35	0.00	0.00	2.14
	3	0.00	0.00	0.47	0.00	0.80	0.15	0.00	2.92	2.85	3.18
FEB	1	0.00	0.30	2.58	1.94	0.00	1.20	0.00	2.32	2.41	2.61
	2	1.67	0.00	0.00	1.47	2.16	0.06	1.42	1.40	1.22	8.78
	3	1.15	2.01	0.00	3.45	1.31	3.47	0.44	3.92	3.04	5.05
MAR	1	0.00	1.61	0.97	1.77	0.00	2.25	0.00	2.16	0.75	3.74
	2	0.31	0.44	2.09	0.87	0.28	2.47	2.21	1.73	0.05	1.80
	3	0.00	0.65	1.20	5.19	0.16	3.51	1.21	3.94	0.00	1.58
APR	1	0.39	0.06	2.05	4.84	6.07	1.13	1.01	2.35	0.53	1.26
	2	0.12	0.21	0.84	1.59	2.95	0.69	0.90	3.80	0.53	1.34
	3	0.34	0.36	2.05	0.83	2.06	0.41	0.64	1.02	0.29	1.76
MAY	1	1.90	0.47	1.70	0.55	1.10	0.28	1.11	1.77	1.56	2.96
	2	0.55	0.31	0.59	0.64	1.04	0.64	1.30	1.57	1.26	1.86
	3	0.59	0.58	1.01	0.84	1.10	0.05	0.62	2.77	0.84	2.14
JUN	1	0.00	1.03	1.39	1.03	1.00	1.03	0.92	2.38	1.03	0.85
	2	0.66	0.90	1.15	1.15	1.60	1.15	0.56	1.15	1.15	1.15
	3	1.22	1.22	1.22	1.22	0.61	1.22	1.14	0.83	1.22	0.82
JUL	1	1.18	1.18	1.18	1.18	2.23	1.10	1.18	1.09	1.18	0.70
	2	0.83	0.83	0.83	0.83	1.12	0.83	0.83	0.83	0.83	0.20
	3	0.40	0.47	0.47	0.47	1.25	0.47	0.30	0.42	0.47	0.47
AUG	1	0.15	0.15	0.15	0.15	0.47	0.15	0.15	0.15	0.15	0.14
	2	0.02	0.03	0.03	0.03	0.25	0.03	0.03	0.03	0.03	0.03
	3	0.06	0.06	0.06	0.06	0.13	0.06	0.06	0.06	0.06	0.06
SEP	1	0.14	0.14	0.14	0.14	0.14	0.14	0.11	0.14	0.14	0.14
	2	0.24	0.24	0.24	0.24	0.09	0.24	0.07	0.24	0.24	0.07
	3	0.19	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.16
OCT	1	0.00	0.45	0.28	0.45	0.18	0.45	0.45	0.38	0.45	0.45
	2	0.09	0.52	0.08	0.52	0.52	0.52	0.46	0.52	0.52	0.52
	3	0.54	0.56	0.56	0.56	0.56	0.38	0.41	0.01	0.56	0.36
NOV	1	0.00	0.44	0.44	0.39	0.13	0.30	0.29	0.07	0.44	0.35
	2	0.22	0.33	0.11	0.27	0.10	0.33	0.00	0.00	0.33	0.10
	3	0.03	0.05	0.08	0.20	0.16	0.03	0.12	3.58	0.02	0.15
DEC	1	1.67	1.14	0.42	0.75	1.33	1.22	1.51	3.53	0.62	1.08
	2	2.34	0.41	1.53	1.69	1.30	1.17	1.09	4.00	0.54	1.46
	3	0.54	0.33	2.20	0.49	2.11	2.34	0.71	2.82	0.55	2.04
TOL		0.57	0.57	0.82	1.02	1.01	0.86	0.66	1.54	0.73	1.45

Table 7.12.1

****
* ESTIMATED TEN-DAY RUNOFF * (3/4)
****

OUTFLOW FROM KETANDAN DAM

Month		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
JAN	1	1.05	1.61	0.16	0.07	0.13	2.62	2.25	0.33	1.39	0.06
	2	1.24	2.08	1.60	0.39	0.93	1.36	0.00	1.66	0.50	0.25
	3	0.38	0.66	2.16	0.50	1.12	1.71	0.03	0.00	0.04	1.87
FEB	1	1.62	1.16	0.90	0.00	0.00	1.51	1.18	0.94	4.08	0.12
	2	2.09	2.10	1.61	0.82	0.00	1.38	0.73	0.91	3.74	1.47
	3	0.46	0.87	0.83	1.94	0.00	2.30	0.00	0.70	2.22	1.35
MAR	1	1.81	3.05	0.00	1.74	0.95	0.80	1.95	0.00	5.59	2.09
	2	1.23	4.09	1.01	0.08	0.41	1.14	0.79	1.46	11.57	3.19
	3	0.59	4.19	0.00	0.00	0.00	0.47	0.17	0.44	6.11	0.72
APR	1	1.14	1.78	0.21	0.24	0.19	0.42	0.32	0.20	2.55	1.61
	2	4.93	4.52	0.13	0.12	0.15	0.20	0.01	0.13	1.99	1.05
	3	2.52	4.56	0.30	0.05	0.36	0.93	0.30	0.27	1.75	0.67
MAY	1	0.70	2.56	0.45	0.45	0.09	1.19	0.20	0.04	0.82	2.43
	2	2.83	1.75	0.64	0.64	0.00	0.53	0.64	0.04	0.64	0.81
	3	0.80	1.32	0.84	0.73	0.10	1.00	0.12	0.84	0.84	0.77
JUN	1	1.03	1.03	1.03	0.04	0.13	0.69	1.03	1.03	1.03	0.81
	2	1.15	1.15	1.15	1.08	0.36	1.15	1.15	1.15	1.15	1.15
	3	1.00	1.22	1.22	0.85	0.30	1.22	1.14	1.22	1.22	1.22
JUL	1	1.18	1.18	1.18	1.18	0.07	1.18	1.18	1.10	1.18	1.18
	2	0.77	0.80	0.83	0.83	0.52	0.77	0.83	0.24	0.74	0.83
	3	0.41	0.47	0.47	0.47	0.47	0.47	0.00	0.47	0.47	0.47
AUG	1	0.05	0.15	0.15	0.15	0.12	0.15	0.05	0.15	0.15	0.15
	2	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03
	3	0.02	0.06	0.06	0.06	0.06	0.06	0.06	0.03	0.06	0.06
SEP	1	0.04	0.04	0.14	0.14	0.07	0.14	0.12	0.10	0.14	0.14
	2	0.03	0.07	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
	3	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.00	0.36	0.36
OCT	1	0.16	0.00	0.45	0.45	0.19	0.45	0.45	0.45	0.45	0.45
	2	0.31	0.33	0.23	0.52	0.52	0.52	0.40	0.52	0.52	0.32
	3	0.19	0.00	0.10	0.56	0.49	0.41	0.31	0.47	0.56	0.39
NOV	1	0.25	0.17	0.16	0.44	0.00	0.35	0.21	0.27	0.44	0.17
	2	0.00	0.08	0.12	0.33	0.17	0.05	0.17	0.02	0.31	0.00
	3	0.06	0.02	0.12	0.14	0.22	0.11	0.01	0.02	0.29	0.02
DEC	1	0.57	2.80	1.23	1.15	0.99	1.37	0.25	0.72	0.86	1.11
	2	4.53	2.30	1.63	1.27	0.58	0.68	1.66	1.01	0.51	1.92
	3	2.28	2.22	1.75	1.02	0.18	0.87	1.37	0.56	0.62	0.99
TOL		1.05	1.41	0.65	0.53	0.29	0.80	0.55	0.49	1.53	0.85

PR#0

Table 7.12.1 * ESTIMATED TEN-DAY RUNOFF * (4/4)

OUTFLOW FROM KETANDAN DAM

Month		mean
JAN	1	0.87
	2	0.91
	3	1.01
FEB	1	1.03
	2	1.33
	3	1.48
MAR	1	1.40
	2	1.76
	3	1.35
APR	1	1.27
	2	1.79
	3	1.13
MAY	1	0.99
	2	0.79
	3	0.75
JUN	1	0.83
	2	1.02
	3	1.09
JUL	1	1.07
	2	0.74
	3	0.42
AUG	1	0.15
	2	0.03
	3	0.06
SEP	1	0.13
	2	0.21
	3	0.34
OCT	1	0.37
	2	0.42
	3	0.42
NOV	1	0.25
	2	0.18
	3	0.22
DEC	1	1.30
	2	1.48
	3	1.37
TOL		0.83

Table 7.12.2

****
* ENERGY OUTPUT (MWH)   * (1/3)
****

Month		1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
JAN	1	64.35	33.84	0.00	0.00	0.00	0.00	0.00	0.00	22.52	47.26
	2	64.35	36.72	43.33	0.00	64.35	0.00	55.14	41.33	0.00	64.35
	3	70.78	70.78	63.70	0.00	70.78	0.00	36.92	70.78	23.71	0.00
FEB	1	55.34	64.35	0.00	17.21	0.00	0.00	53.02	0.00	64.35	0.00
	2	64.35	64.35	64.35	62.72	0.00	0.00	0.00	0.00	61.20	0.00
	3	51.48	51.48	0.00	28.41	37.31	0.00	27.71	51.48	0.00	0.00
MAR	1	64.35	0.00	0.00	64.35	0.00	37.25	0.00	31.69	0.00	0.00
	2	64.35	44.73	64.35	64.35	0.00	58.29	64.35	0.00	64.35	0.00
	3	70.78	46.06	49.72	70.78	0.00	28.33	70.78	30.07	0.00	59.49
APR	1	31.81	64.35	14.09	64.35	0.00	54.81	51.32	0.00	0.00	64.35
	2	64.35	64.35	0.00	64.35	64.35	64.35	64.35	0.00	0.00	64.35
	3	35.92	64.35	15.74	31.66	64.35	40.04	64.35	0.00	0.00	64.35
MAY	1	16.73	34.69	24.33	23.85	64.35	30.42	64.35	0.00	27.29	62.04
	2	31.97	23.86	14.73	30.02	56.03	23.33	24.58	18.19	34.61	34.61
	3	0.00	21.61	0.00	49.99	42.67	46.12	0.00	24.54	49.99	0.00
JUN	1	0.00	25.90	0.00	55.67	55.67	47.71	55.67	48.36	0.00	37.15
	2	28.30	29.64	50.70	62.08	62.08	62.08	24.95	62.08	56.24	62.08
	3	64.35	57.38	60.63	64.35	62.59	60.63	46.51	64.35	64.35	64.35
JUL	1	25.01	23.29	63.48	54.91	63.48	36.76	44.22	63.48	63.48	63.48
	2	44.83	13.88	20.05	44.83	35.03	44.83	44.83	44.83	44.83	44.83
	3	28.20	0.00	15.68	0.00	0.00	15.07	28.20	28.20	28.20	28.20
AUG	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	13.13	13.13	13.13	13.13	13.13	13.13	13.13	13.13	0.00	13.13
	3	19.58	19.58	19.58	19.58	19.58	19.58	19.58	19.58	19.58	19.58
OCT	1	24.16	24.16	23.06	24.16	0.00	17.38	24.16	24.16	24.16	24.16
	2	28.25	15.73	0.00	28.25	14.01	28.25	28.25	28.25	28.25	28.25
	3	0.00	16.62	30.57	33.22	33.22	33.22	29.38	33.22	19.58	33.22
NOV	1	0.00	0.00	15.61	22.70	13.79	23.86	0.00	15.66	0.00	23.86
	2	0.00	46.12	17.96	0.00	0.00	17.96	0.00	0.00	0.00	17.96
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DEC	1	64.35	64.35	24.15	34.25	62.26	28.93	64.35	58.74	64.35	62.92
	2	64.35	45.86	33.86	17.16	50.85	18.00	64.35	64.35	53.87	38.15
	3	70.78	23.39	70.78	70.78	28.28	70.78	70.78	70.78	55.40	38.03
TOL		1226.28	1104.66	813.70	1117.21	978.25	921.23	1135.31	907.34	870.39	1060.24

Table 7.12.2 ***************************
* ENERGY OUTPUT (MWH) * (2/3)
****

Month		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
JAN	1	64.35	0.00	53.01	0.00	59.93	64.35	64.35	56.98	0.00	35.02
	2	61.47	64.35	0.00	25.85	28.70	0.00	19.21	0.00	0.00	64.35
	3	0.00	0.00	27.88	0.00	47.76	0.00	0.00	70.78	70.78	70.78
FEB	1	0.00	16.39	64.35	64.35	0.00	64.35	0.00	64.35	64.35	64.35
	2	64.35	0.00	0.00	64.35	64.35	0.00	64.35	64.35	64.35	64.35
	3	55.80	51.48	0.00	51.48	57.91	51.48	19.29	51.48	57.91	51.48
MAR	1	0.00	64.35	52.28	64.35	0.00	64.35	0.00	64.35	40.63	64.35
	2	16.83	23.59	64.35	46.73	15.20	64.35	64.35	64.35	0.00	64.35
	3	0.00	38.59	70.78	70.78	0.00	70.78	70.78	70.78	0.00	70.78
APR	1	20.96	0.00	64.35	64.35	64.35	60.67	54.65	64.35	28.69	64.35
	2	0.00	0.00	45.55	64.35	64.35	37.00	48.27	64.35	28.71	64.35
	3	18.35	19.81	64.35	45.01	64.35	22.23	34.43	54.97	16.03	64.35
MAY	1	64.35	25.50	64.35	29.90	59.17	15.51	59.76	64.35	64.35	64.35
	2	29.79	17.03	32.03	34.61	56.06	34.61	64.35	64.35	64.35	64.35
	3	34.86	34.38	59.74	49.99	64.90	0.00	36.82	70.78	49.99	70.78
JUN	1	0.00	55.67	64.35	55.67	53.95	55.67	49.34	64.35	55.67	45.94
	2	35.78	48.45	62.08	62.08	64.35	62.08	30.41	62.08	62.08	62.08
	3	64.35	64.35	64.35	64.35	33.02	64.35	61.13	44.91	64.35	44.39
JUL	1	63.48	63.48	63.48	63.48	64.35	59.19	63.48	58.49	63.48	37.80
	2	44.83	44.83	44.83	44.83	60.33	44.83	44.83	44.83	44.83	0.00
	3	23.97	28.20	28.20	28.20	70.78	28.20	18.26	25.36	28.20	28.20
AUG	1	0.00	0.00	0.00	0.00	25.49	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	13.75	0.00	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	13.13	13.13	13.13	13.13	0.00	13.13	0.00	13.13	13.13	0.00
	3	0.00	19.58	19.58	19.58	19.58	19.58	19.58	19.58	19.58	0.00
OCT	1	0.00	24.16	15.11	24.16	0.00	24.16	24.16	20.50	24.16	24.16
	2	0.00	28.25	0.00	28.25	28.25	28.25	25.13	28.25	28.25	28.25
	3	32.13	33.22	33.22	33.22	33.22	22.88	24.72	0.00	33.22	21.26
NOV	1	0.00	23.86	23.86	21.27	0.00	16.19	15.91	0.00	23.86	19.20
	2	0.00	17.96	0.00	14.94	0.00	17.96	0.00	0.00	17.96	0.00
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.35	0.00	0.00
DEC	1	64.35	61.36	22.88	40.25	64.35	64.35	64.35	64.35	33.43	58.05
	2	64.35	22.34	64.35	64.35	64.35	63.14	58.69	64.35	29.03	64.35
	3	32.03	19.98	70.78	29.35	70.78	70.78	42.03	70.78	32.83	70.78
TOL		869.58	924.39	1253.31	1283.31	1313.67	1204.51	1142.75	1535.96	1124.30	1446.87

Table 7.12.2

****
* ENERGY OUTPUT (MWH) * (3/3)
****

Month		1974	1975	1976	1977	1978	1979	1980	1981	1982	mean
JAN	1	56.70	64.35	0.00	0.00	0.00	64.35	64.35	18.23	64.35	30.97
	2	64.35	64.35	64.35	21.03	50.13	64.35	0.00	64.35	27.00	36.32
	3	23.00	39.49	70.78	29.58	66.10	70.78	0.00	0.00	0.00	34.31
FEB	1	64.35	62.33	48.57	0.00	0.00	64.35	63.63	50.75	64.35	37.07
	2	64.35	64.35	64.35	44.32	0.00	64.35	39.20	49.30	64.35	42.13
	3	19.91	37.41	40.50	51.48	0.00	51.48	0.00	30.03	51.48	33.74
MAR	1	64.35	64.35	0.00	64.35	51.38	43.00	64.35	0.00	64.35	35.46
	2	64.35	64.35	54.31	0.00	22.23	61.62	42.62	64.35	64.35	44.38
	3	35.36	70.78	0.00	0.00	0.00	28.11	0.00	26.21	70.78	38.64
APR	1	61.38	64.35	0.00	12.88	0.00	22.92	17.68	0.00	64.35	37.08
	2	64.35	64.35	0.00	0.00	0.00	0.00	0.00	0.00	64.35	36.56
	3	64.35	64.35	16.61	0.00	19.81	50.18	16.61	14.57	64.35	37.77
MAY	1	37.86	64.35	24.33	24.33	0.00	64.12	0.00	0.00	44.11	38.58
	2	64.35	64.35	34.61	34.61	0.00	28.51	34.61	0.00	34.61	36.18
	3	47.55	70.78	49.99	43.16	0.00	59.50	0.00	49.99	49.99	37.18
JUN	1	55.67	55.67	55.67	0.00	0.00	37.22	55.67	55.67	55.67	41.31
	2	62.08	62.08	62.08	58.19	19.46	62.08	62.08	62.08	62.08	53.93
	3	53.82	64.35	64.35	46.01	16.61	64.35	61.62	64.35	64.35	57.89
JUL	1	63.48	63.48	63.48	63.48	0.00	63.48	63.48	59.19	63.48	55.38
	2	41.74	43.25	44.83	44.83	28.40	41.36	44.83	13.39	40.04	39.46
	3	24.35	28.20	28.20	28.20	28.20	28.20	0.00	28.20	28.20	24.17
AUG	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEP	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	13.13	13.13	13.13	13.13	13.13	13.13	13.13	10.41
	3	19.58	19.58	19.58	19.58	19.58	19.58	19.58	0.00	19.58	17.55
OCT	1	0.00	0.00	24.16	24.16	0.00	24.16	24.16	24.16	24.16	18.45
	2	17.13	17.98	0.00	28.25	28.25	28.25	21.88	28.25	28.25	22.36
	3	0.00	0.00	0.00	33.22	29.38	24.72	18.33	27.93	33.22	24.01
NOV	1	13.88	0.00	0.00	23.86	0.00	18.91	0.00	14.83	23.86	12.24
	2	0.00	0.00	0.00	17.96	0.00	0.00	0.00	0.00	17.08	7.03
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.56	2.75
DEC	1	31.02	64.35	64.35	61.71	53.17	64.35	13.48	39.11	46.33	51.87
	2	64.35	64.35	64.35	64.35	31.11	36.83	64.35	54.19	27.58	51.09
	3	70.78	70.78	70.78	60.33	0.00	51.67	70.78	33.27	36.62	53.27
TOL		1314.53	1478.42	1043.44	913.11	477.00	1316.02	876.51	885.61	1392.06	1101.03

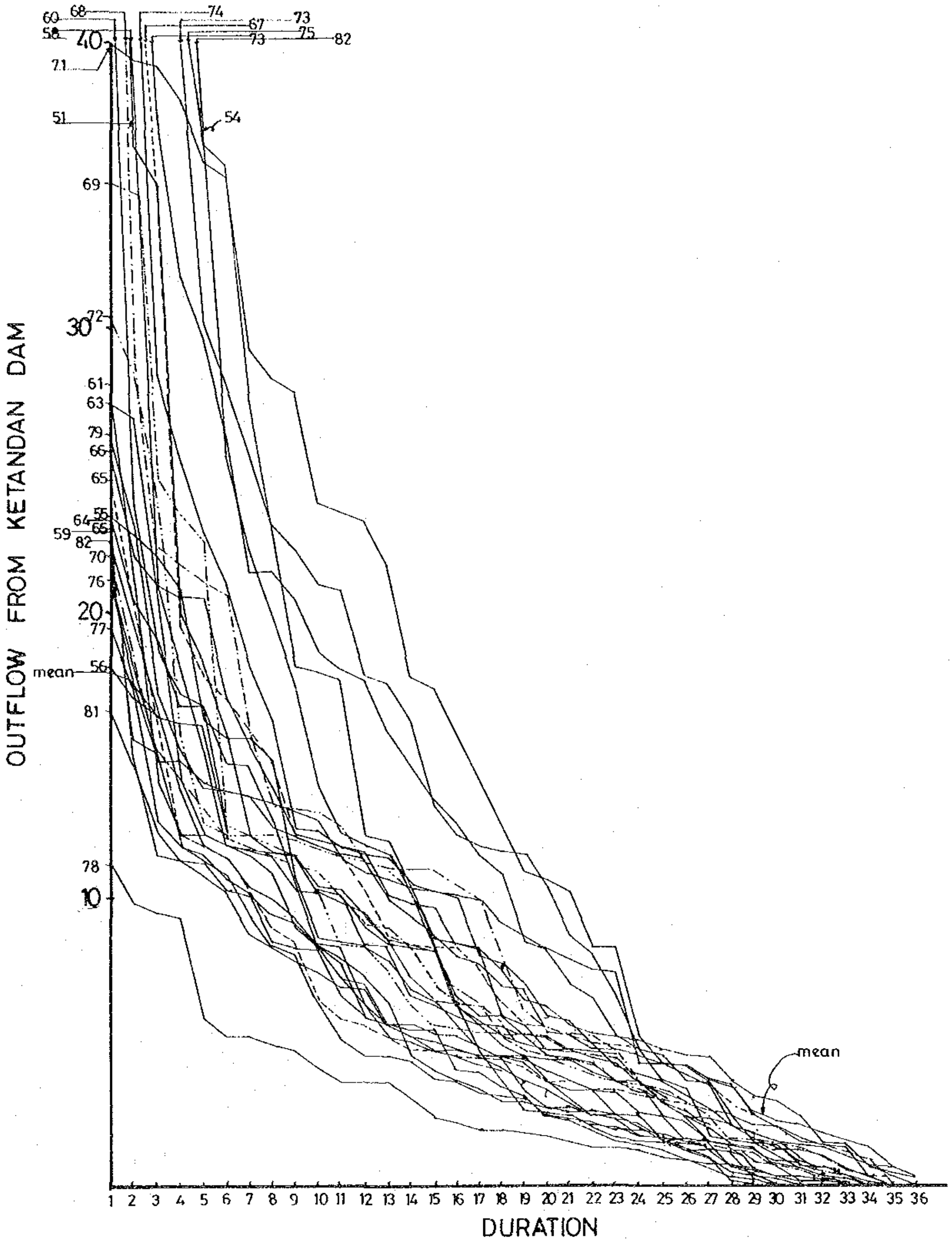


Fig: 7.12.1 DURATION CURVE OF OUTFLOW FROM KETANDAN DAM.

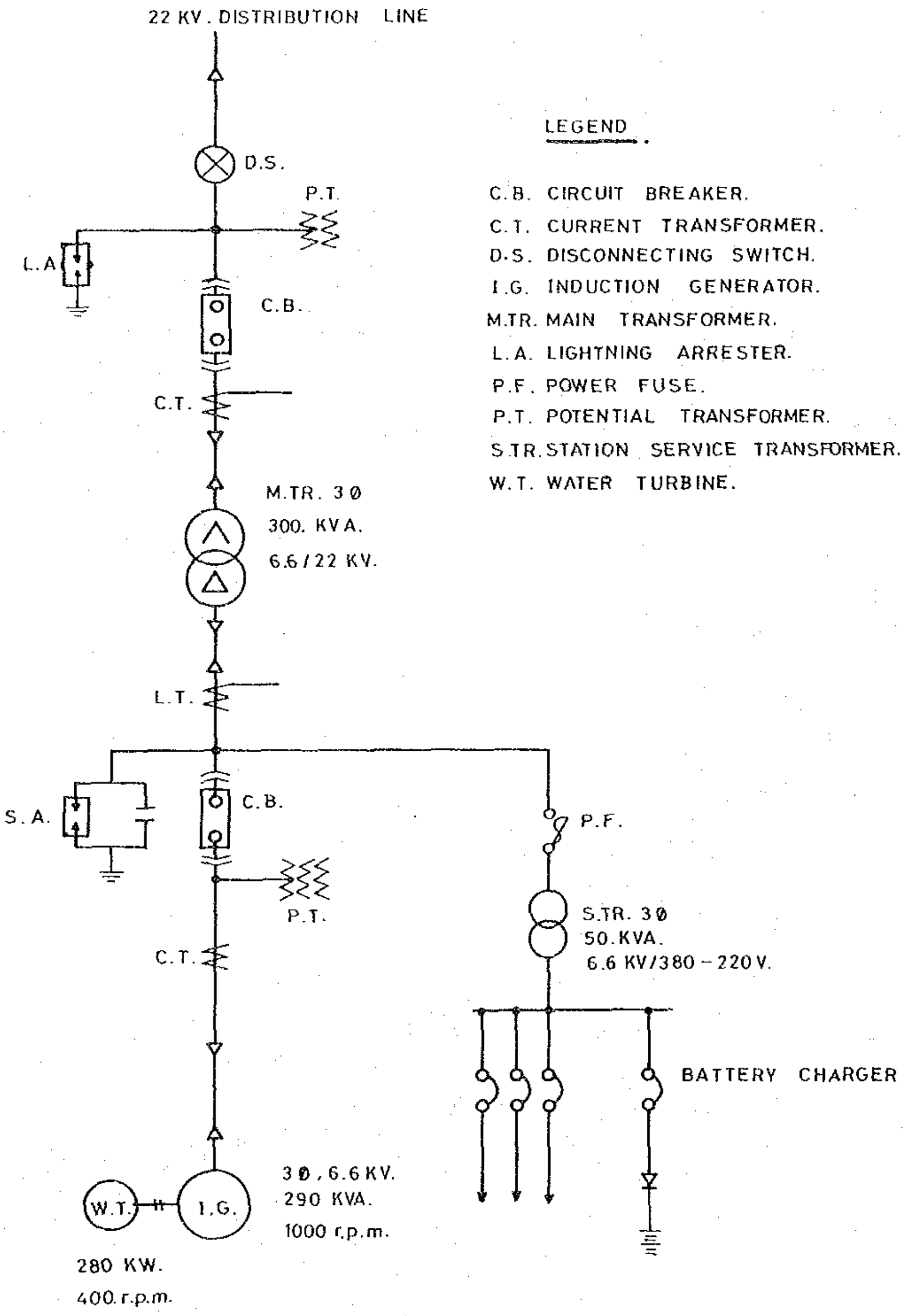


Fig. 7.12.2 SINGLE LINE CONNECTION DIAGRAM.

7.13 Design Discharge

7.13.1 Irrigation discharge

1. Main canals, secondary canals and tertiary canals

Design discharge of irrigation canals is determined based on the following equation.

$$Q = P \times A \times I$$

Where;
- Q : Design discharge
- P : Pemali factor
- A : Irrigation area
- I : Peak irrigation requirement

The Pemali distribution factor is shown in Table 7.13.1 . The peak irrigation requirement is found to be 1,389 l/s/ha (See ANNEX Table 7.3.5). Thus, the unit irrigation requirement is decided to be 1.4 l/s/ha.

Table 7.13.1 PEMALI FACTORS USED IN DESIGN

Net Irrigation Area (ha)	Pemali Multiplication Factor
10 - 20	2.28
20 - 30	2.04
30 - 40	1.87
40 - 50	1.76
50 - 60	1.66
60 - 70	1.57
70 - 80	1.50
80 - 90	1.43
90 - 100	1.38
100 - 150	1.25
150 - 200	1.10
More than 200	1.00

2. Quaternary canals

The discharge of quaternary canals satisfies the irrigation demand for paddy cultivation and upland crops. For upland crops, an itermittent irrigation is usually practice for saving water. In this case, the irrigation discharge is usually larger than that for paddy. Thus, the design discharge is decided in consideration of the itermittent irrigation for upland crops taking into account the root zone depth, soil water extraction pattern and available moisture.

The root zone depth is estimated at 60 cm and standard soil moisture extraction pattern is applied as shown in Fig.7.13.1.The available moisture is the difference between field capacity and temporary wilting point. From Fig. 7.13.1 , the available moistures in upper layer (0 to 30 cm deep) and in lower layer (30 - 60 cm deep) are 10% and 9% in volume, respectively. Accordingly, the available moisture is 15 mm for first or second layer or 13.5 mm for third or fourth layer in the standard extraction pattern. Among layers, the first layer is confined - layer in which the soil moisture content firstly reaches the temporary wilting point. Therefore, the total readily available moisture of 37.5 mm is obtained. In the other words, net irrigation requirement is 37.5 mm. The area of one quaternary block is around 6 ha and the irrigation interval is 6 days at peak demand. Considering the aboves and the number of quarternary blocks in one tertiary block, one day irrigation for one quaternary block is reasonable from the practice. Thus, the design discharge of the quaternary canals is decided to be 40 l/sec considering the irrigation efficiency of 0.64.

$$Q = 37 \times 10^{-3} \times 6 \times 10^{4} / 86,400 / 0.64 = 0.040 \text{ m}^3/\text{sec.}$$

7.13.2 Drainage requirement

The drainage requirement is estimated for elevated land and paddy field.

1. Design rainfall

(1) Probable rainfall to be adopted for design of drainage canals is three consecutive day rainfall with a return period of five years.

(2) The design of drainage structures is made based on three consecutive day rainfall with a return period of 20 years.

(3) Drain structure crossing irrigation canals for draining excess water from the elevated land outside the project area is designed using Rational formula based on the probable rainfall of a return period of 20 years.

In order to calculate these probable rainfalls of above item (1) and (2) the average rainfall at two stations such as Tretes and Lengkong stations is used. For item (3), the probable rainfall at Bangle station is adopted since the cross drains are mainly situated along main canals which is located along hilly area. The probable rainfalls are estimated by the Gumbel method. The results are shown below.

Probable Maximum Continuous Three Days Rainfall

Return Period	5	10	20	50
Rainfall (mm)				
Tretes	144	163	181	205
Lengkong	148	167	185	209
Average	146	165	183	207

Probable Maximum Daily Rainfall (Bangle)

Return period (yr)	5	10	20	50
Rainfall (mm)	114	128	141	158

2. Drainage requirement

(1) For project area

The design discharge of drainage canals is estimated by the following equation.

$$Qd = D3 \times A / 8.64 \times 3$$

Where, Qd : Drainage discharge
D3 : Probable three consecutive rainfall with return period of 5 years for canals or with return period of 20 years for structures
A : Catchment area

The drainage requirements of 5.6 l/s/ha and 8.0 l/s/ha is obtained for canals and drain structures, respectively.

(2) For elevated land

The Rational formula is used for estimating the runoff from the elevated land; outside the project area.

$$Q = f.Rt. A / 3.6$$

where; Q : Peak runoff (m^3/s)
f : Runoff coefficient (See Fig. 3.6.2 of ANNEX Hydrology)
Rt : Rainfall intensity (mm/hr) during flood arival time
The flood arival time is assumed to be 1 hr.

$$Rt = \frac{R24}{24} (24)^{2/3}$$

A : Catchment area (km^2)

According to the aboves, the specific peak runoff of 7.4 $m^3/sec/km^2$ is obtained as 20 years probable flood and 5.3 $m^3/sec/km^2$ as 5 years probable flood.

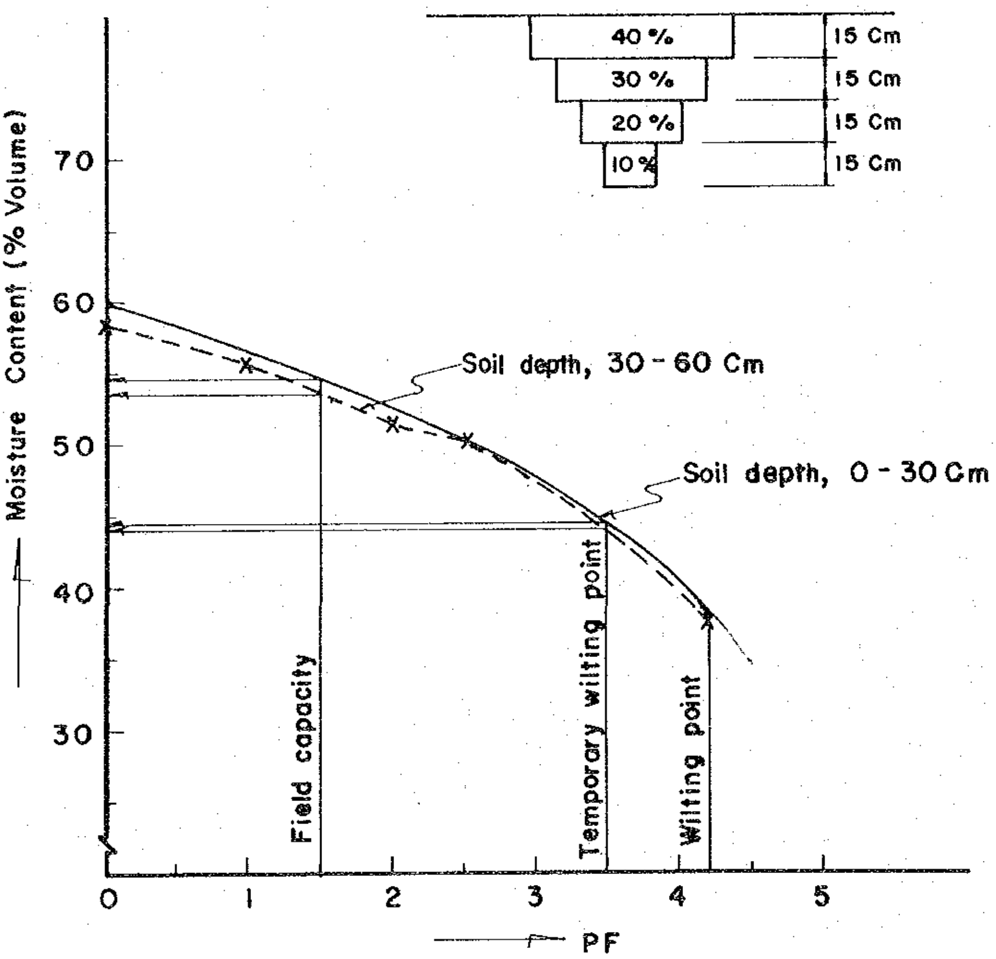


Fig. 7.13.1 RELATION BETWEEN MOISTURE CONTENT AND PF

7.14 Drawings

In this section, drawings of feasibility design concerning to the Dam and Irrigation Scheme are compiled as follows.

7.14.1 Kedungwarak Regulation Pond
7.14.2 Kedungwarak weir
7.14.3 Transbasin Tunnel
7.14.4 Reservoir area of Ketandan Dam
7.14.5 Plan of Ketandan dam
7.14.6 Earthfill of Ketandan Dam
7.14.7 Spillway of Ketandan Dam
7.14.8 Diversion Tunnel, Irrigation Intake and Power Facilities
7.14.9 Proposed Canal Layout on The Widas Extension Area
7.14.10 Proposed Canal Layout in Ngluyu Area
7.14.11 Bangle Headworks
7.14.12 Plan and Profile of East Main Canal
7.14.13 Plan and Profile of West Main Canal
7.14.14 Plan and Profile of ESC-1
7.14.15 Plan and Profile of ESC-2
7.14.16 Plan and Profile of ESC-2-1
7.14.17 Plan and Profile of WSC-1
7.14.18 Plan and Profile of WSC-2
7.14.19 Plan and Profile of WSC-2-1
7.14.20 Plan and Profile of WSC-3
7.14.21 Plan and Profile of WSC-4
7.14.22 Check and Turnout type
7.14.23 Syphon Structure
7.14.24 Culvert Type
7.14.25 Drop Type
7.14.26 Bridge
7.14.27 Cross Drain Type
7.14.28 Tertiary Box

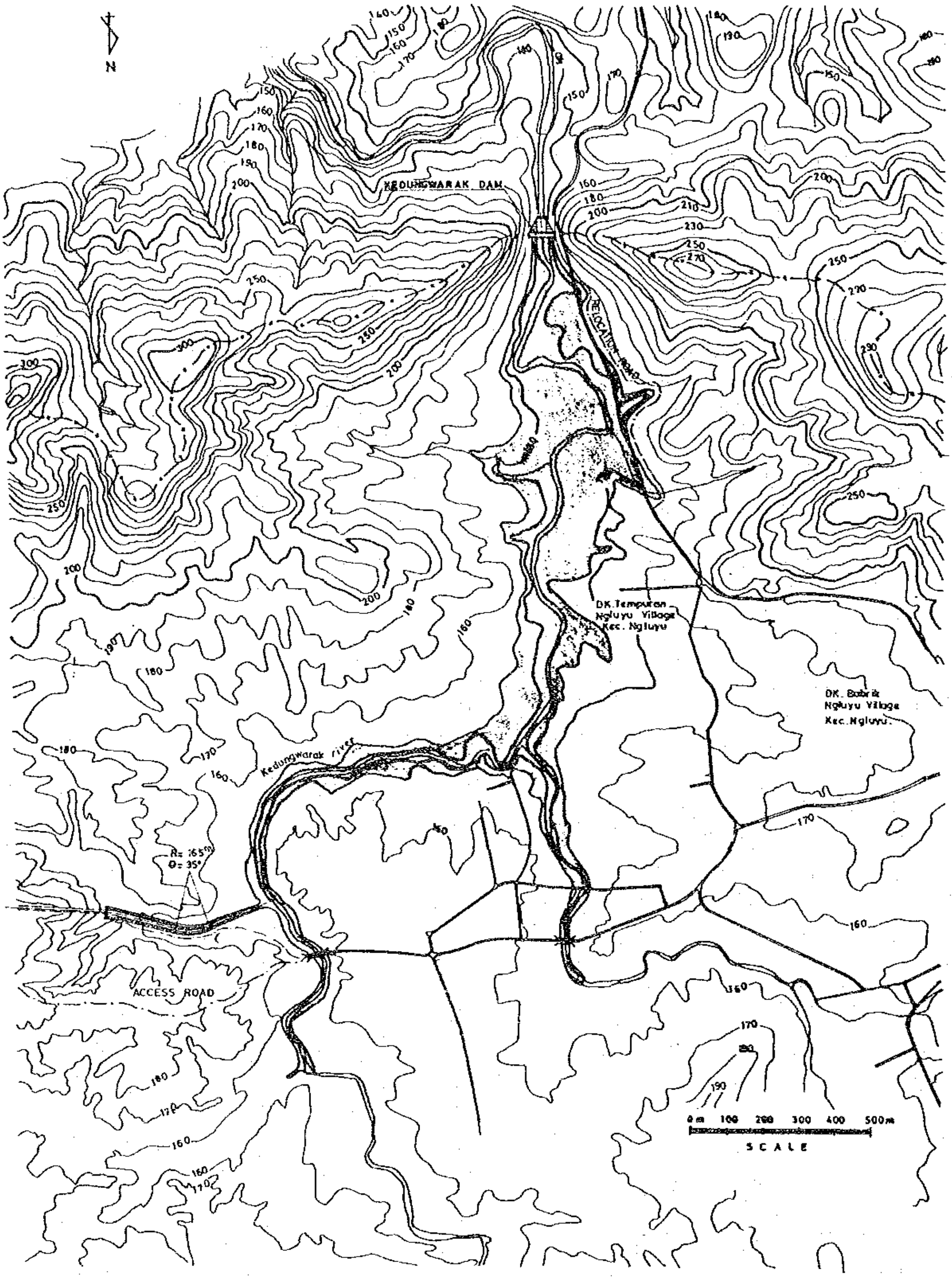


Fig: 7.14.1 **KEDUNGWARAK** REGULATION POND

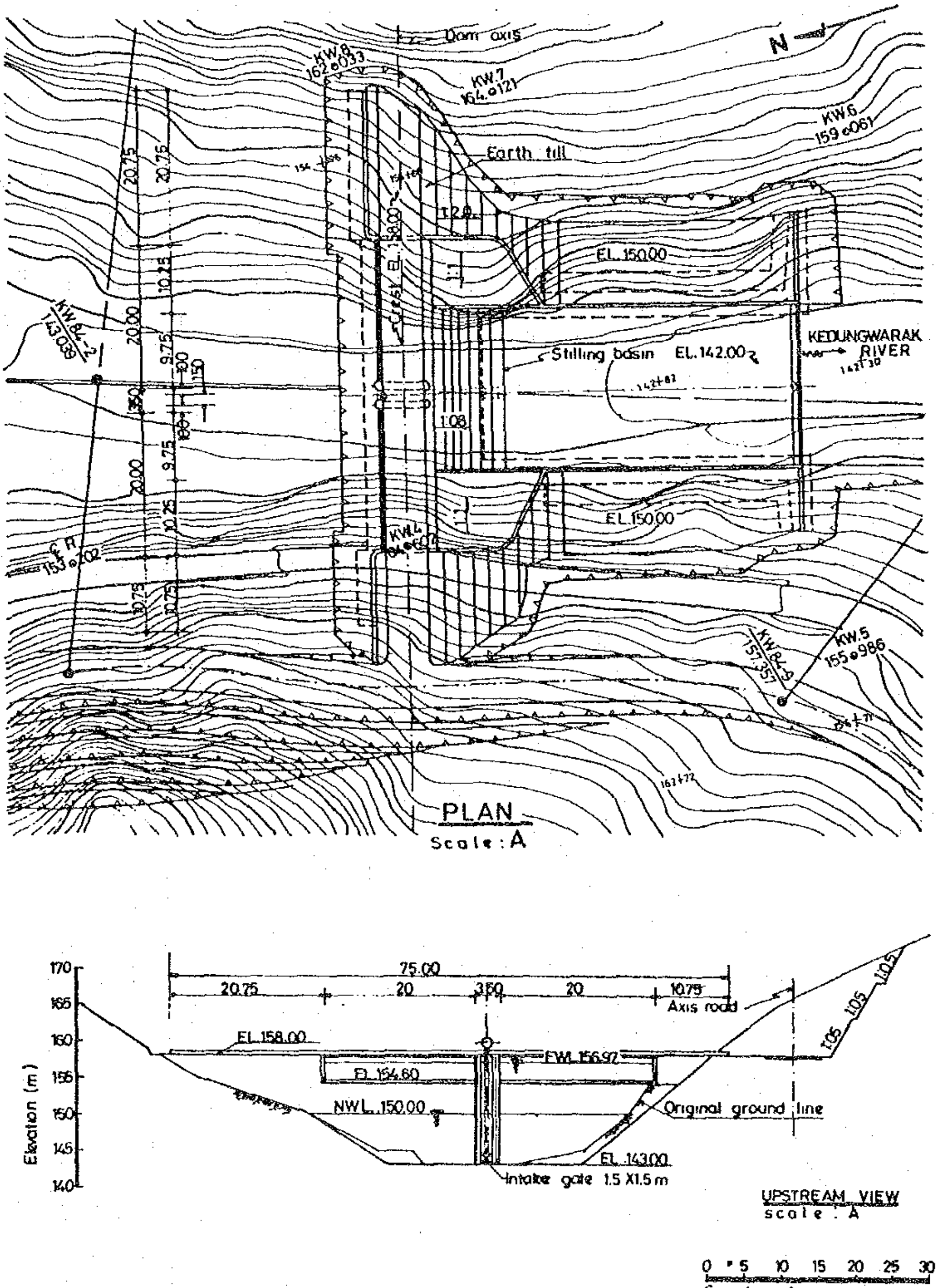


Fig.7.14.2 KEDUNGWARAK WEIR (1/3)

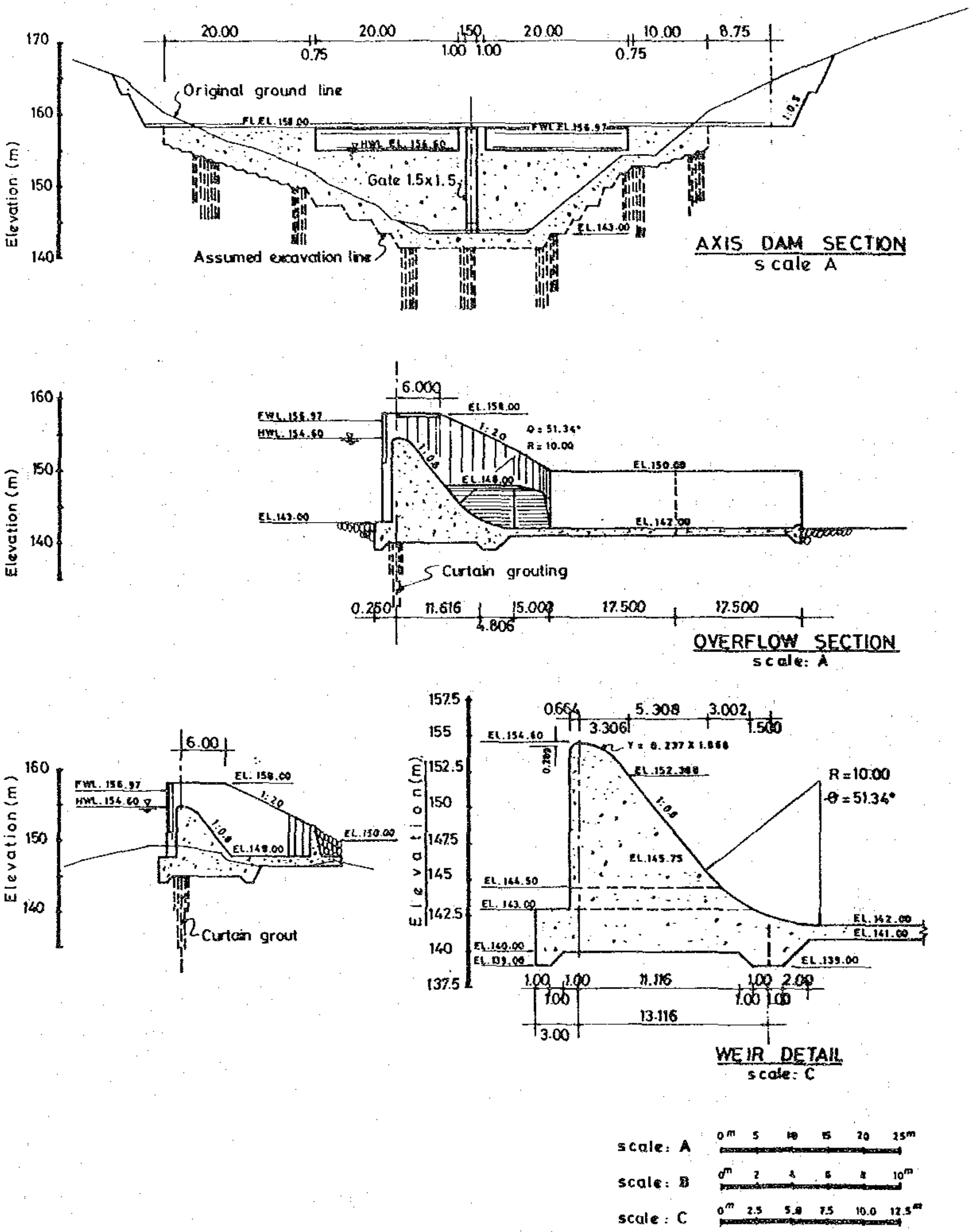


Fig: 7.14.2 KEDUNGWARAK WEIR (2/3)

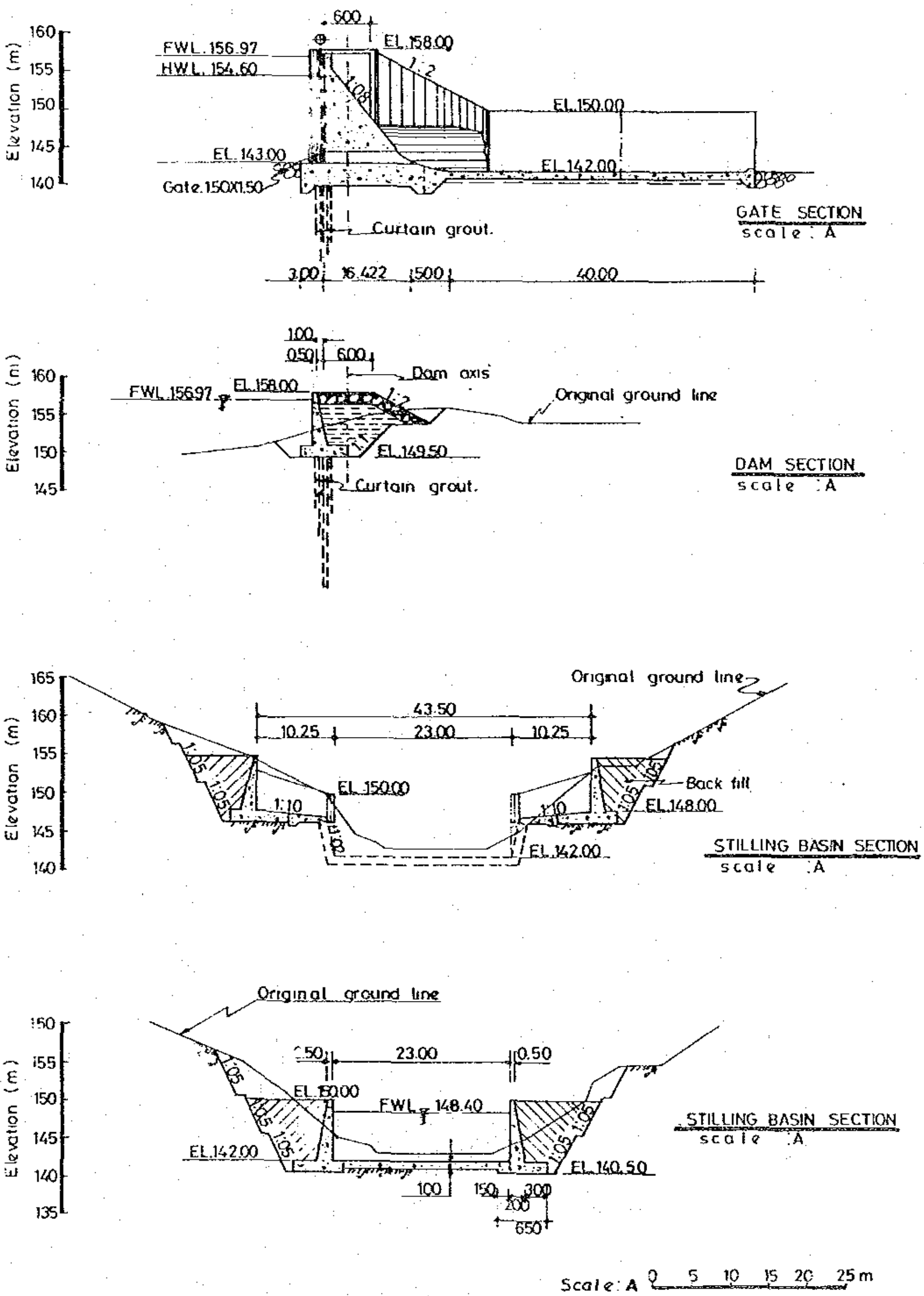


Fig: 7.14.2 KEDUNGWARAK WEIR (3/3)

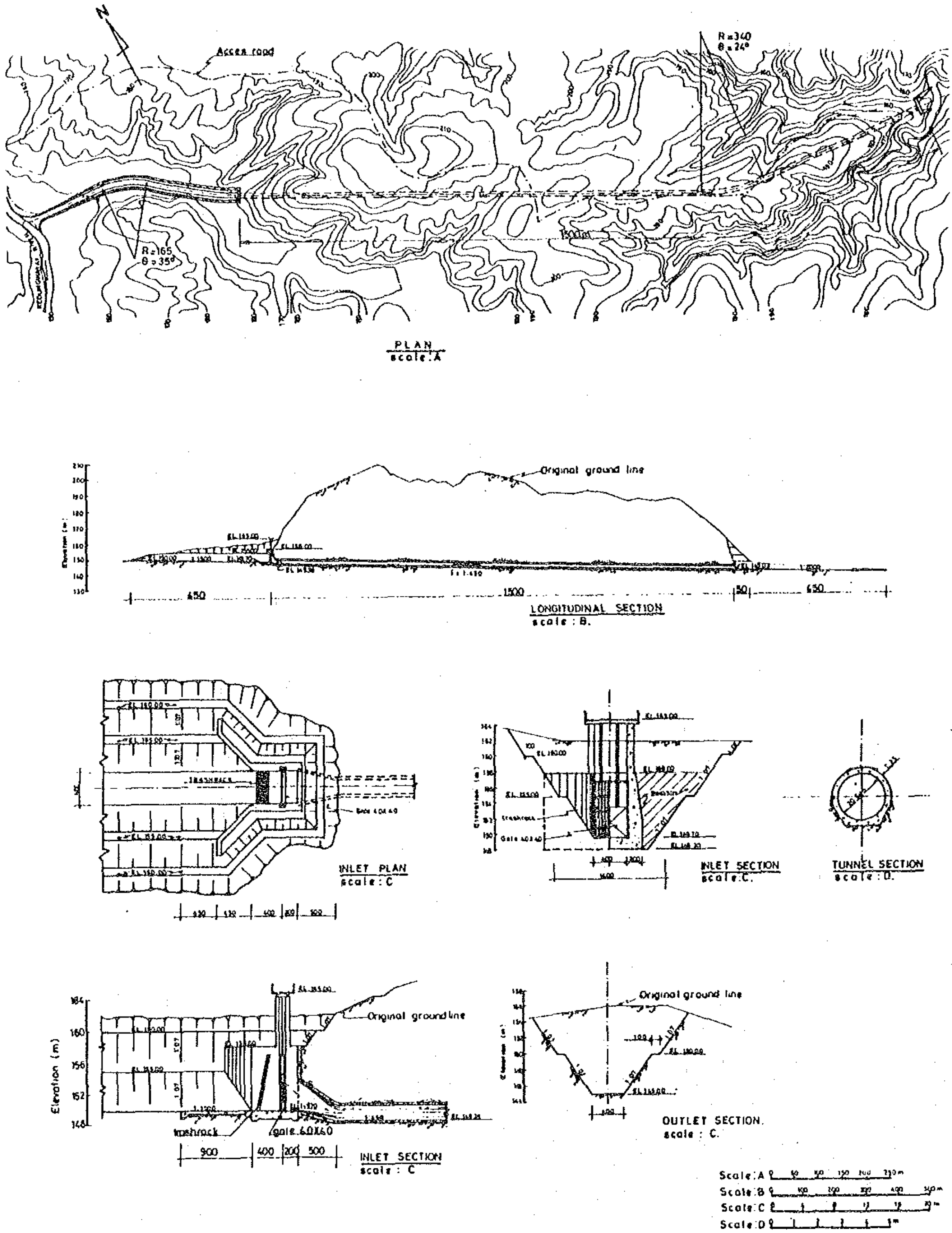


Fig. 7.14.3 **TRANS BASIN TUNNEL**

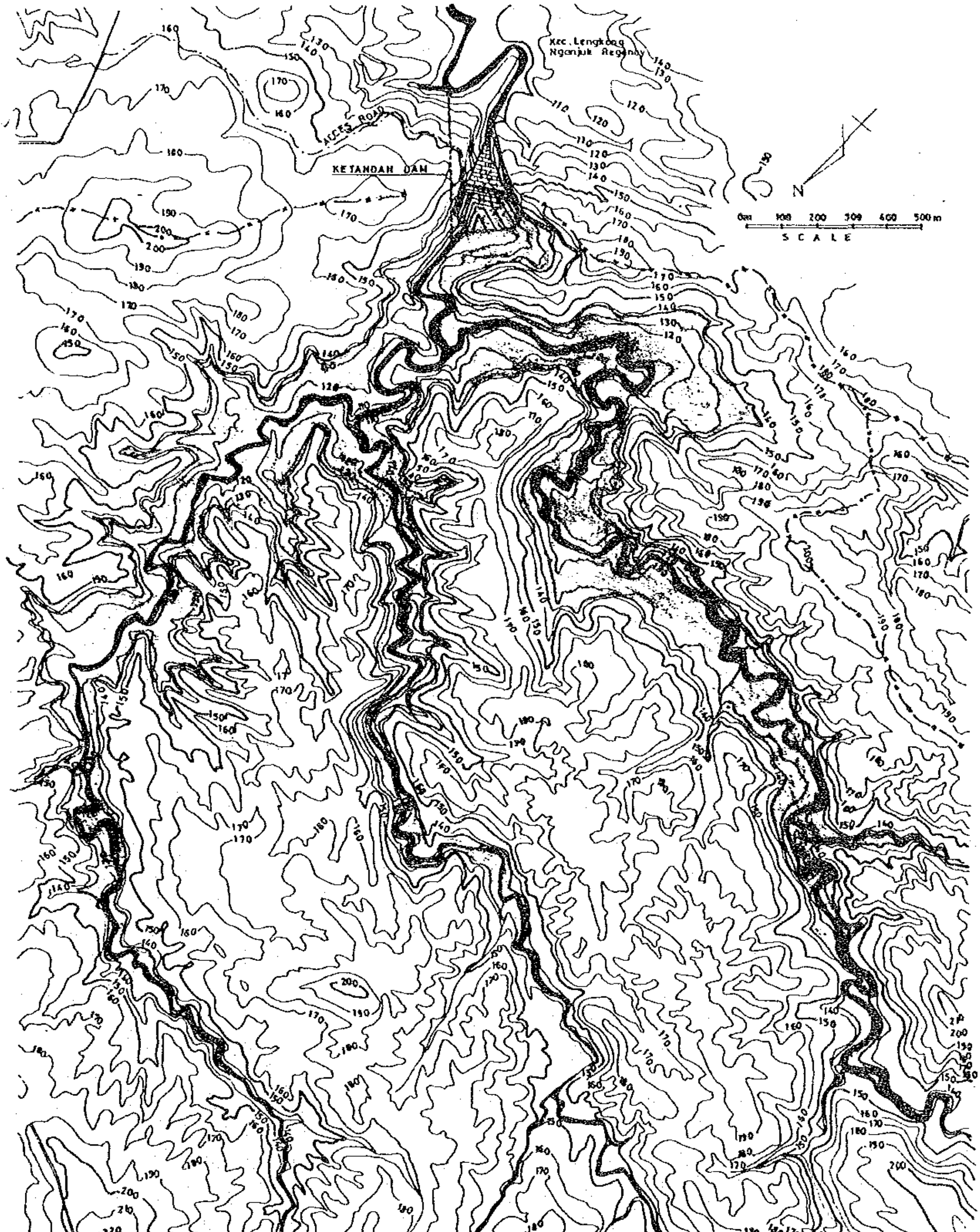


Fig. 7.14.4 RESERVOIR AREA OF KETANDAN DAM

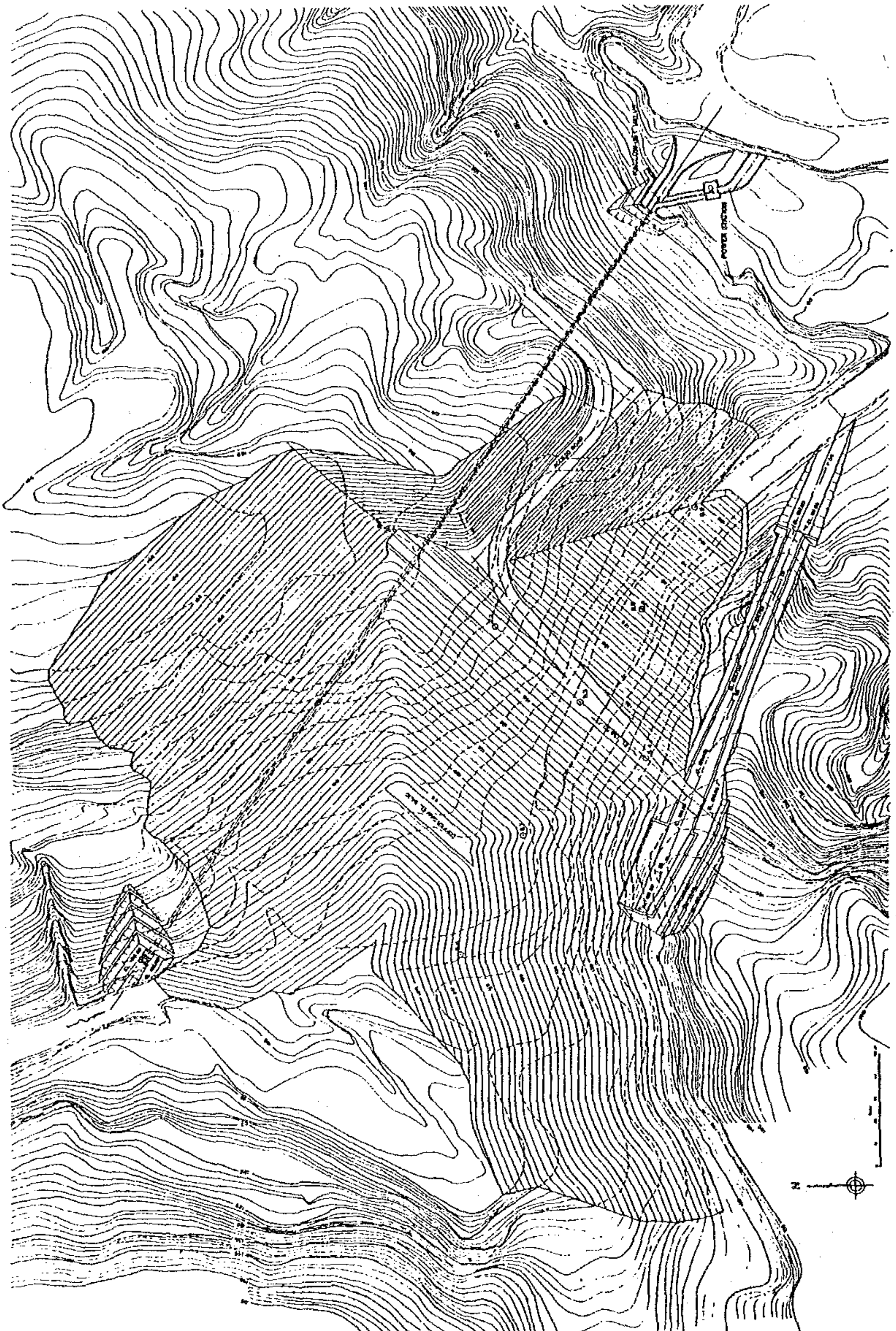


Fig. 7.14.5 **PLAN OF KETANDAN DAM**

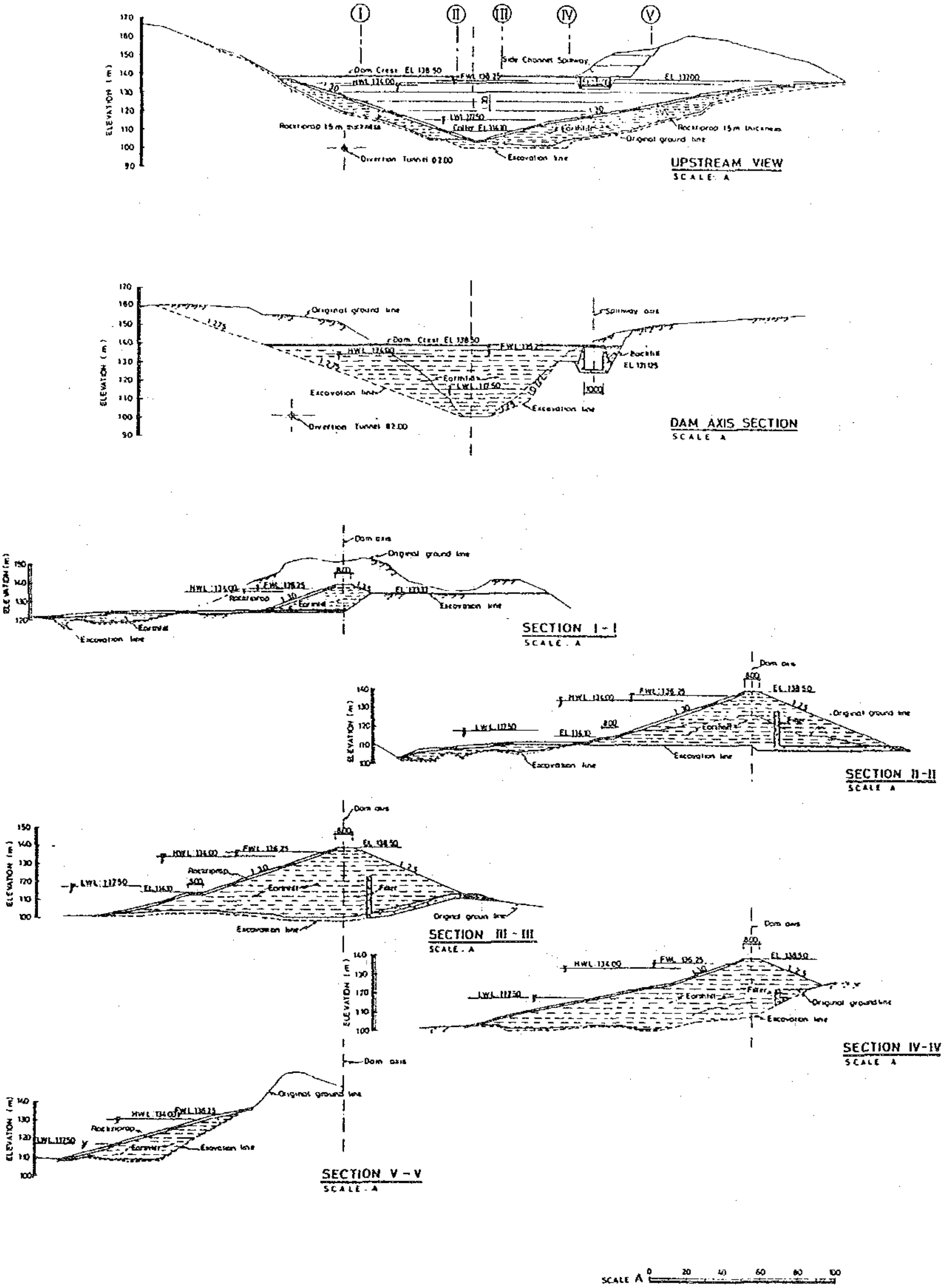


Fig.7.14.6 EARTHFILL OF KETANDAN DAM.

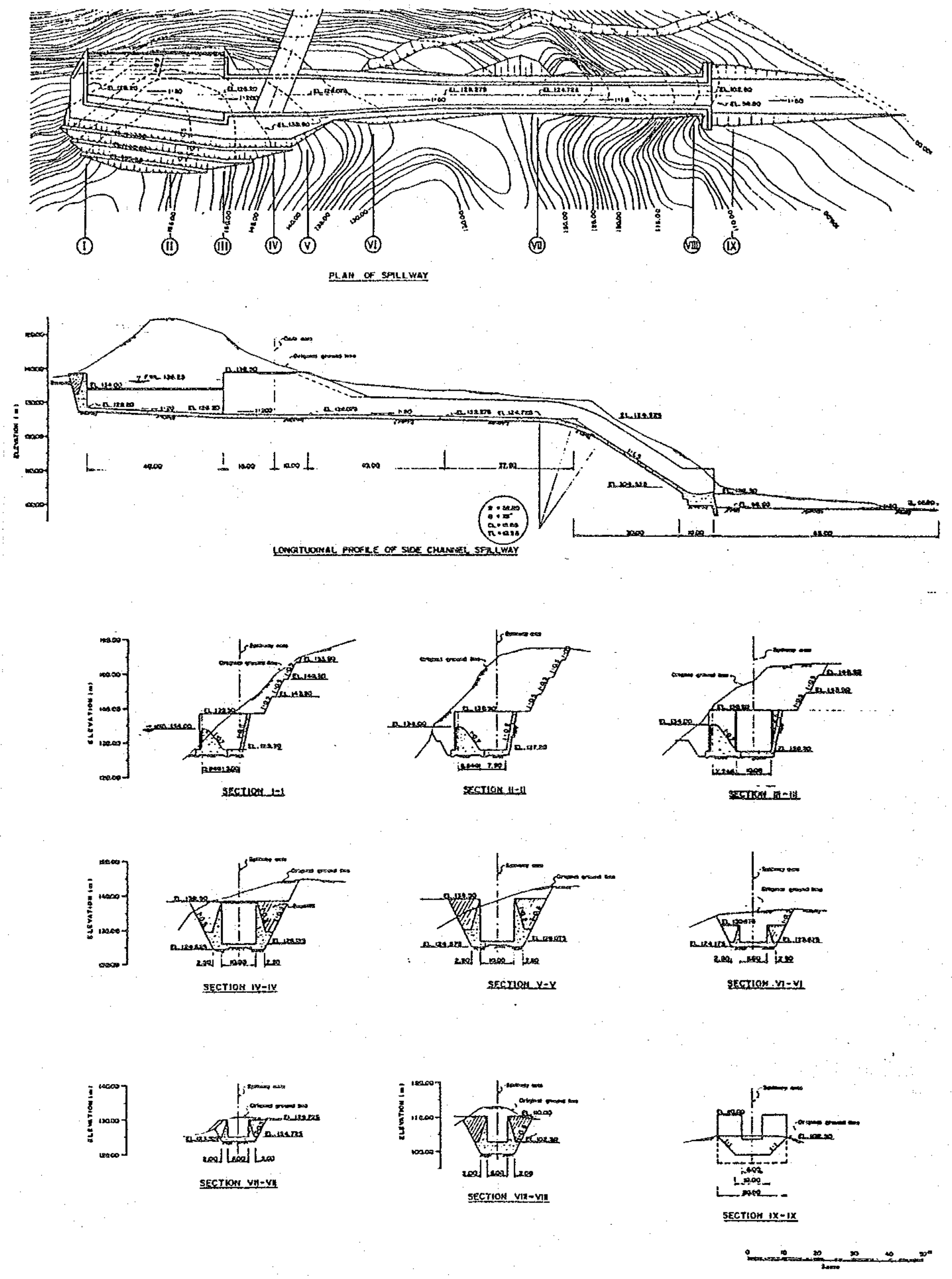


Fig.7.14.7 SPILLWAY OF KETANDAN DAM

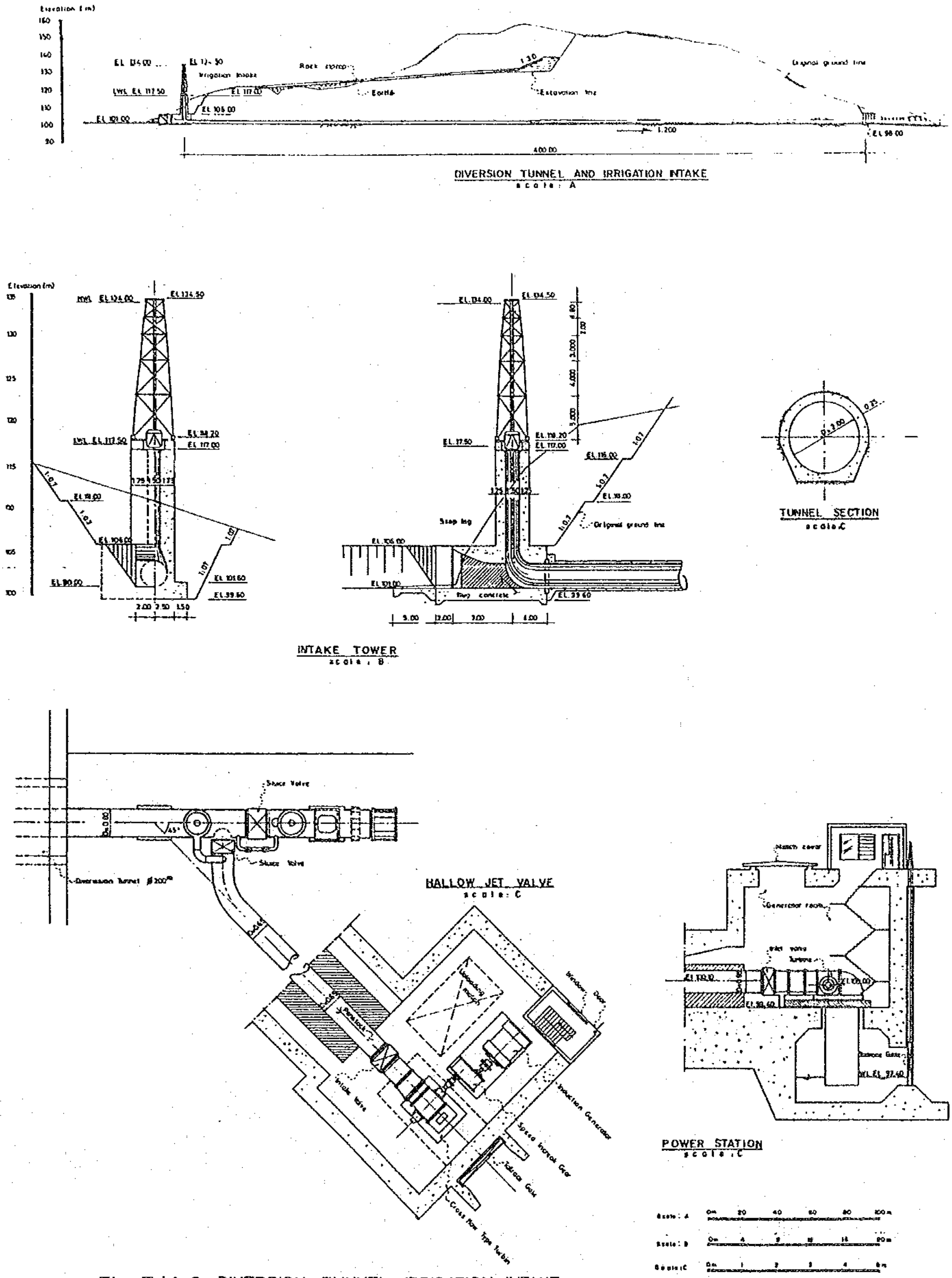


Fig. 7.14.8 DIVERSION TUNNEL, IRRIGATION INTAKE AND POWER FACILITIES

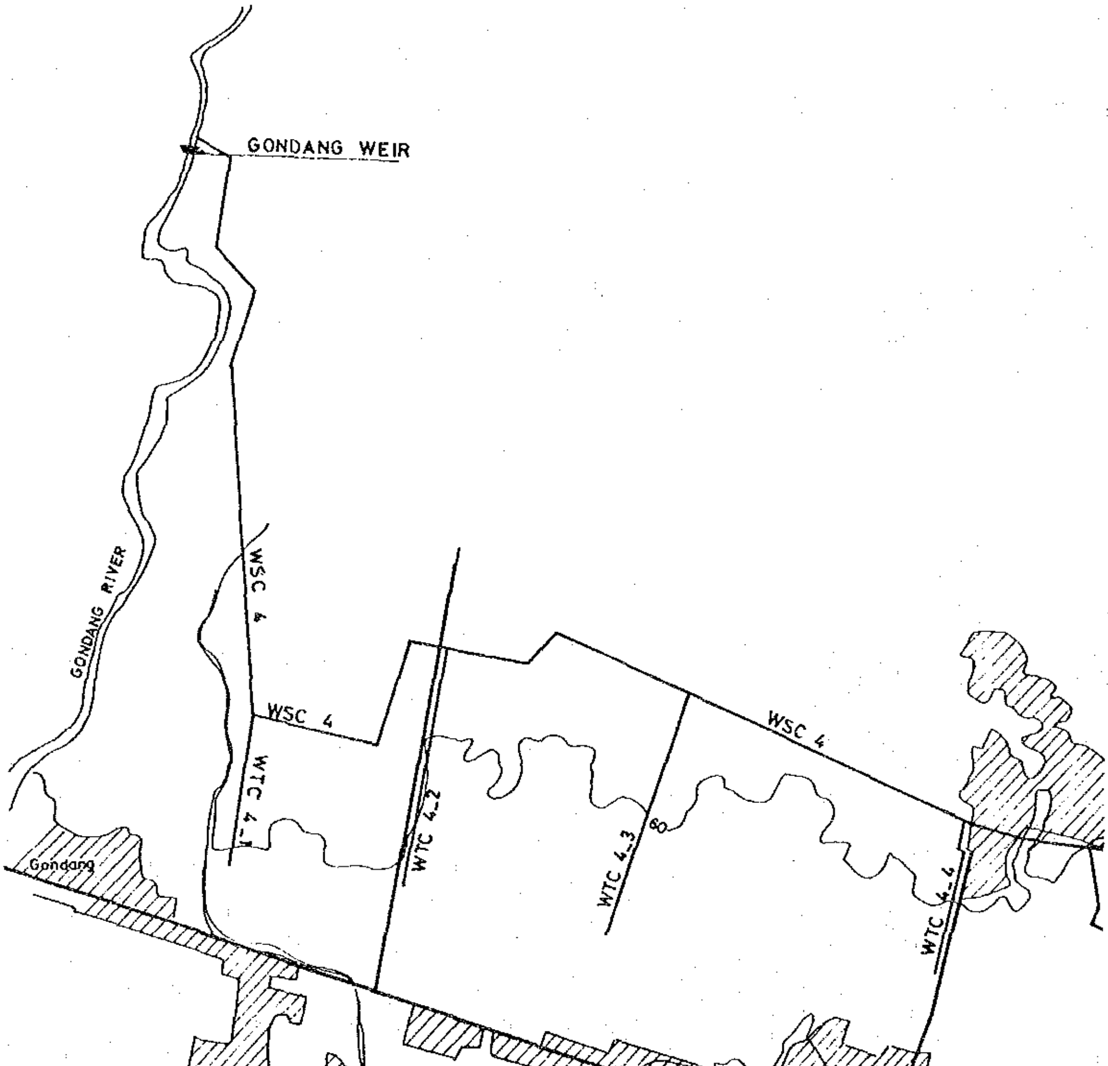


Fig. 7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (1/10)

1	2	3	4	5
6	7	8	9	10

0 200 400 600 800 1000m

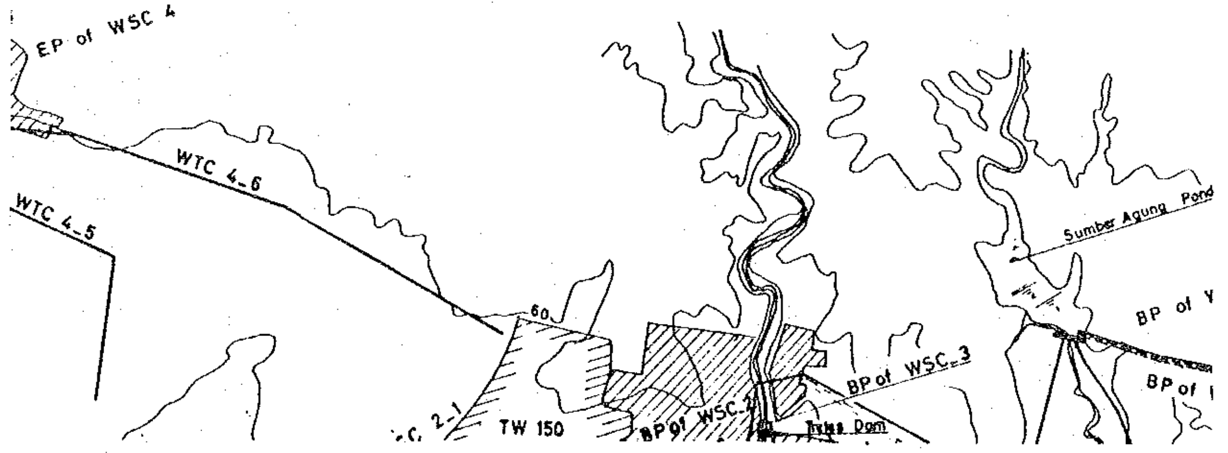
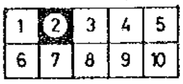
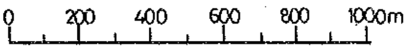


Fig. 7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (2/10)





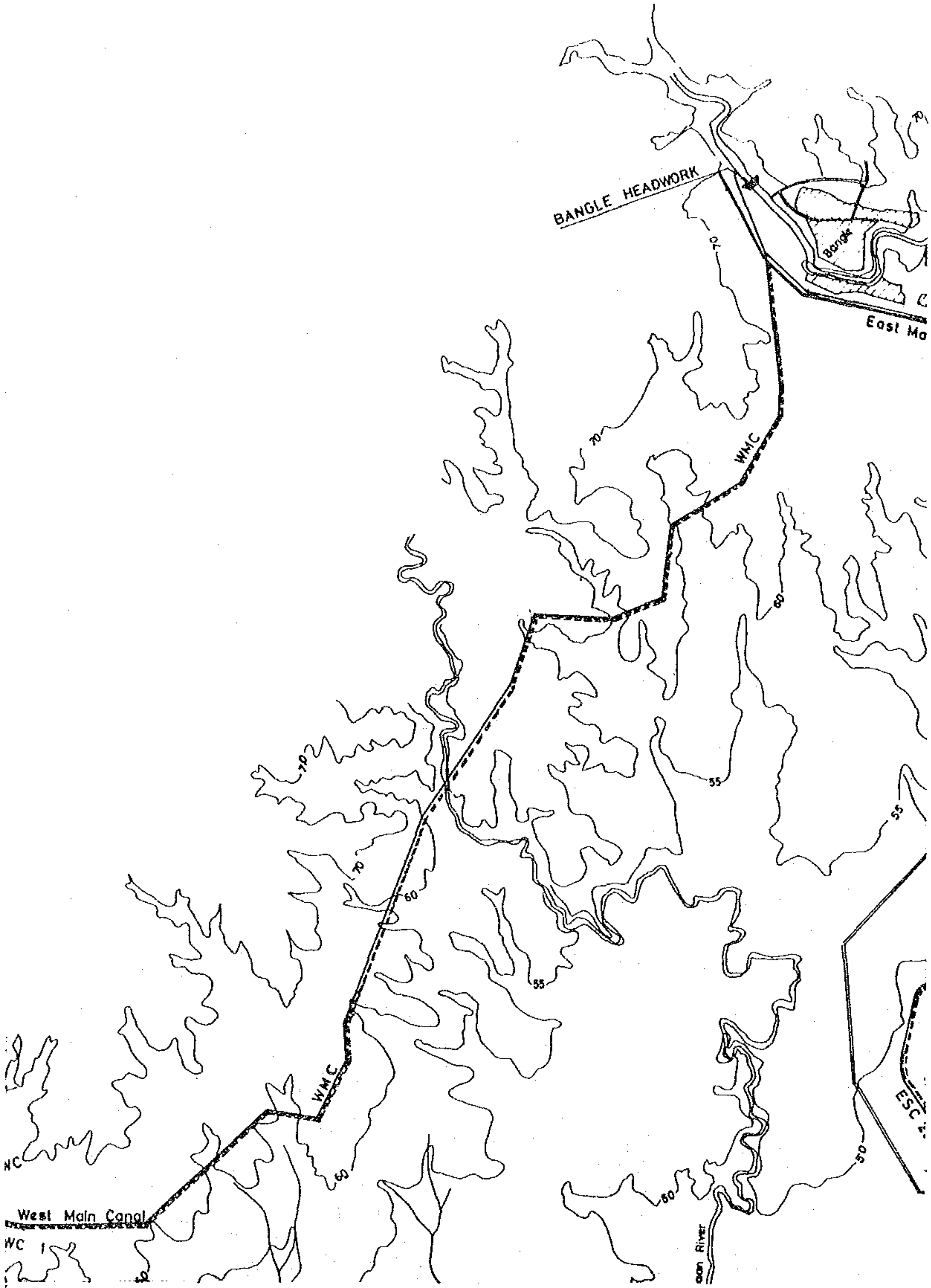


Fig. 7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (3/10)

1	2	3	4	5
6	7	8	9	10

0 200 400 600 800 1000m

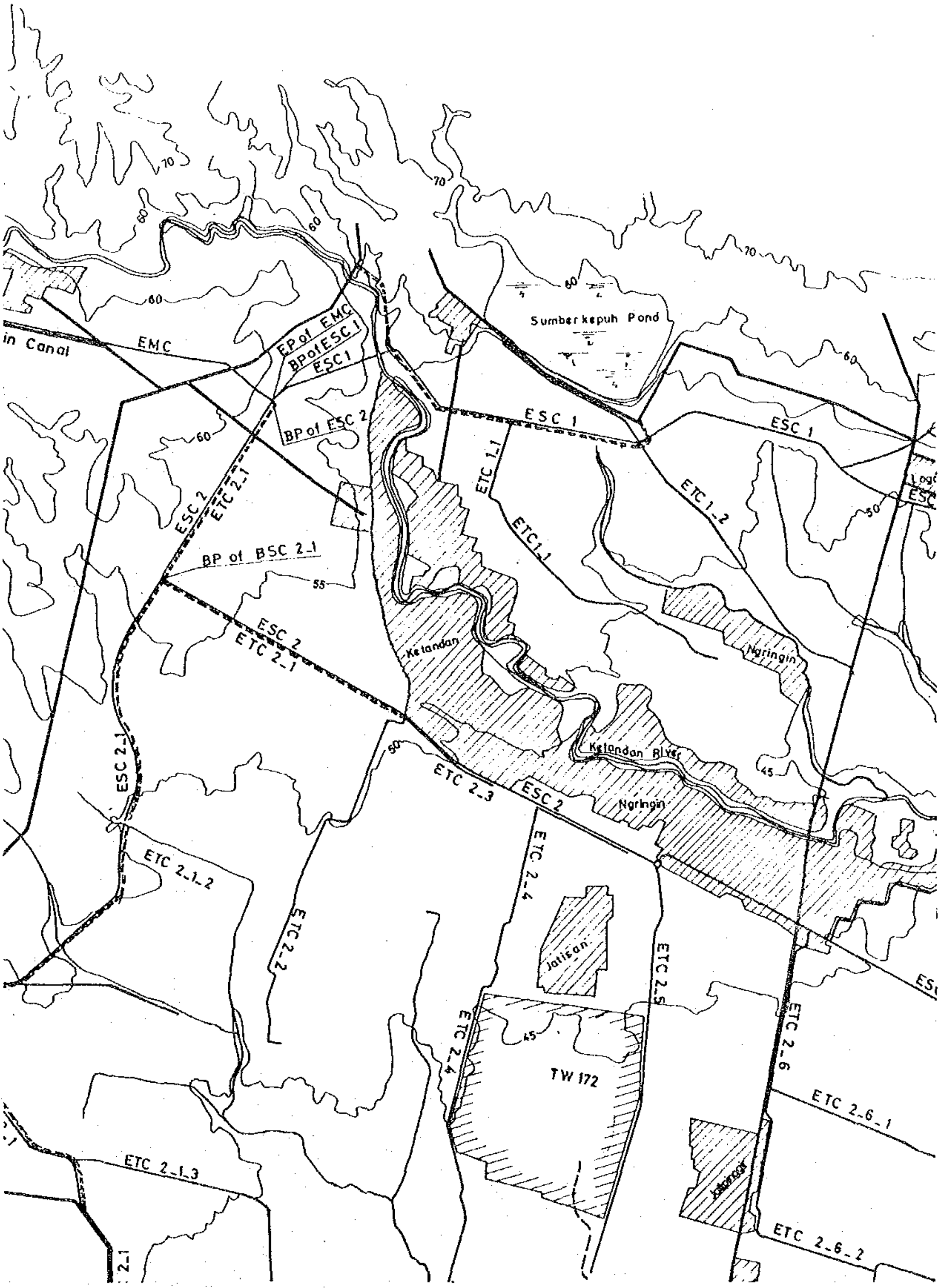
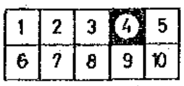
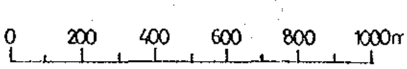


Fig. 7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (4/10)





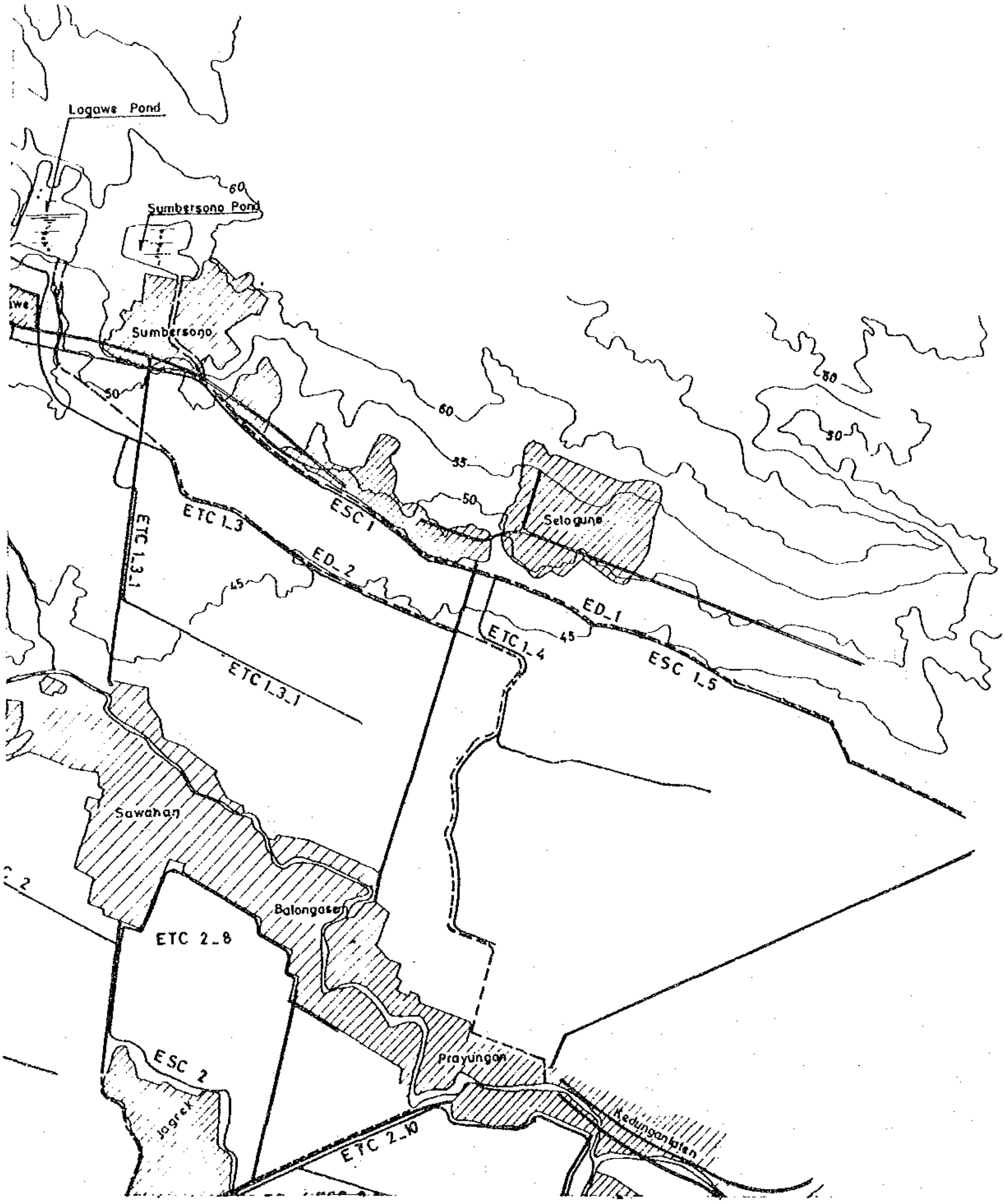
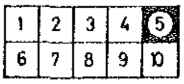
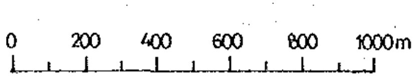


Fig. 7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (5/10)





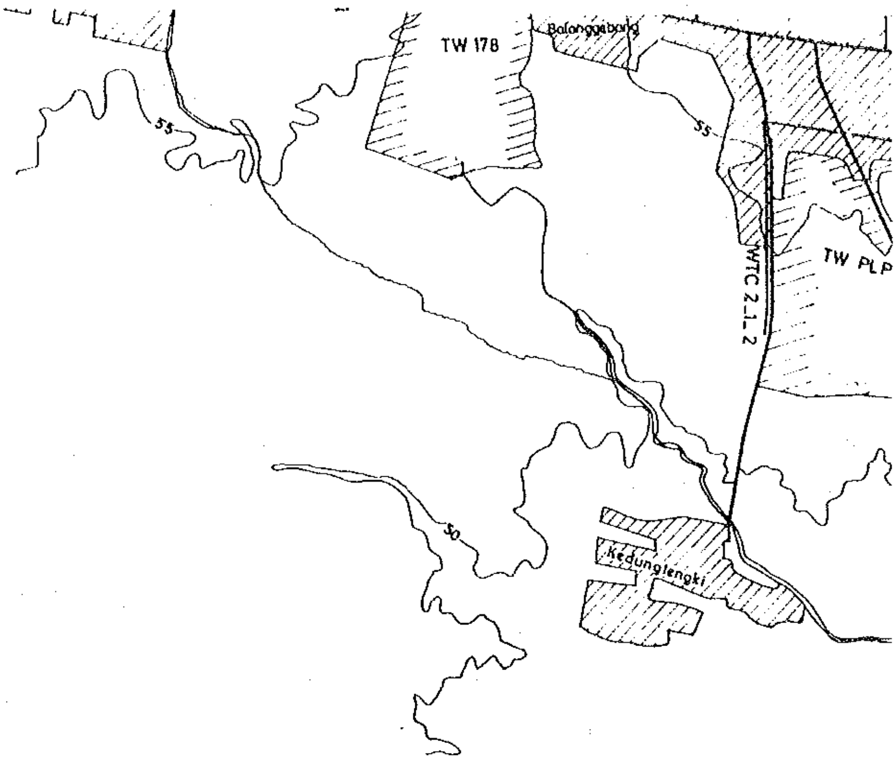


Fig. 7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (6/10)

1	2	3	4	5
6	7	8	9	10

0 200 400 600 800 1000m

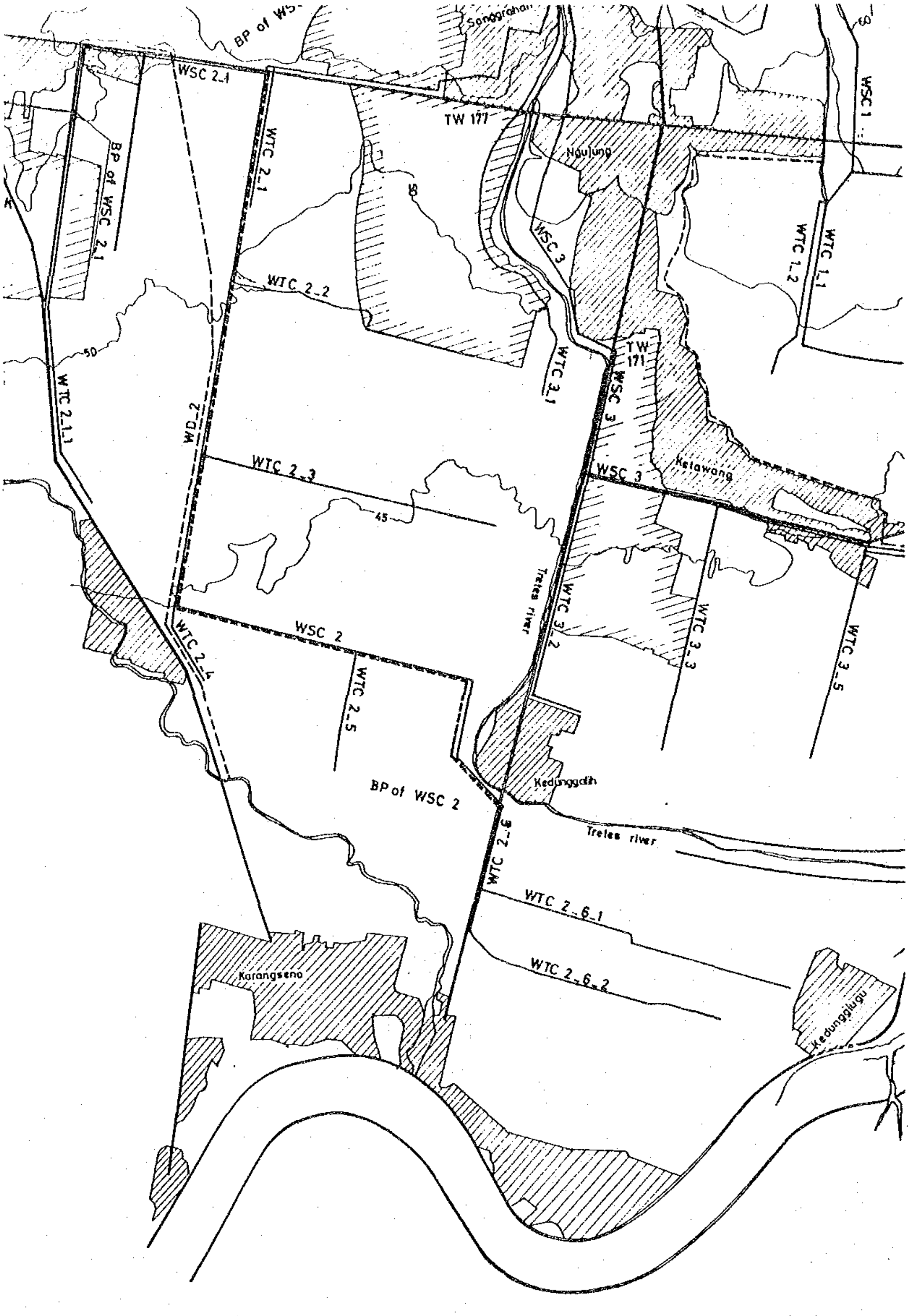


Fig. 7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (7/10)

1	2	3	4	5
6	7	8	9	10

0 200 400 600 800 1000m

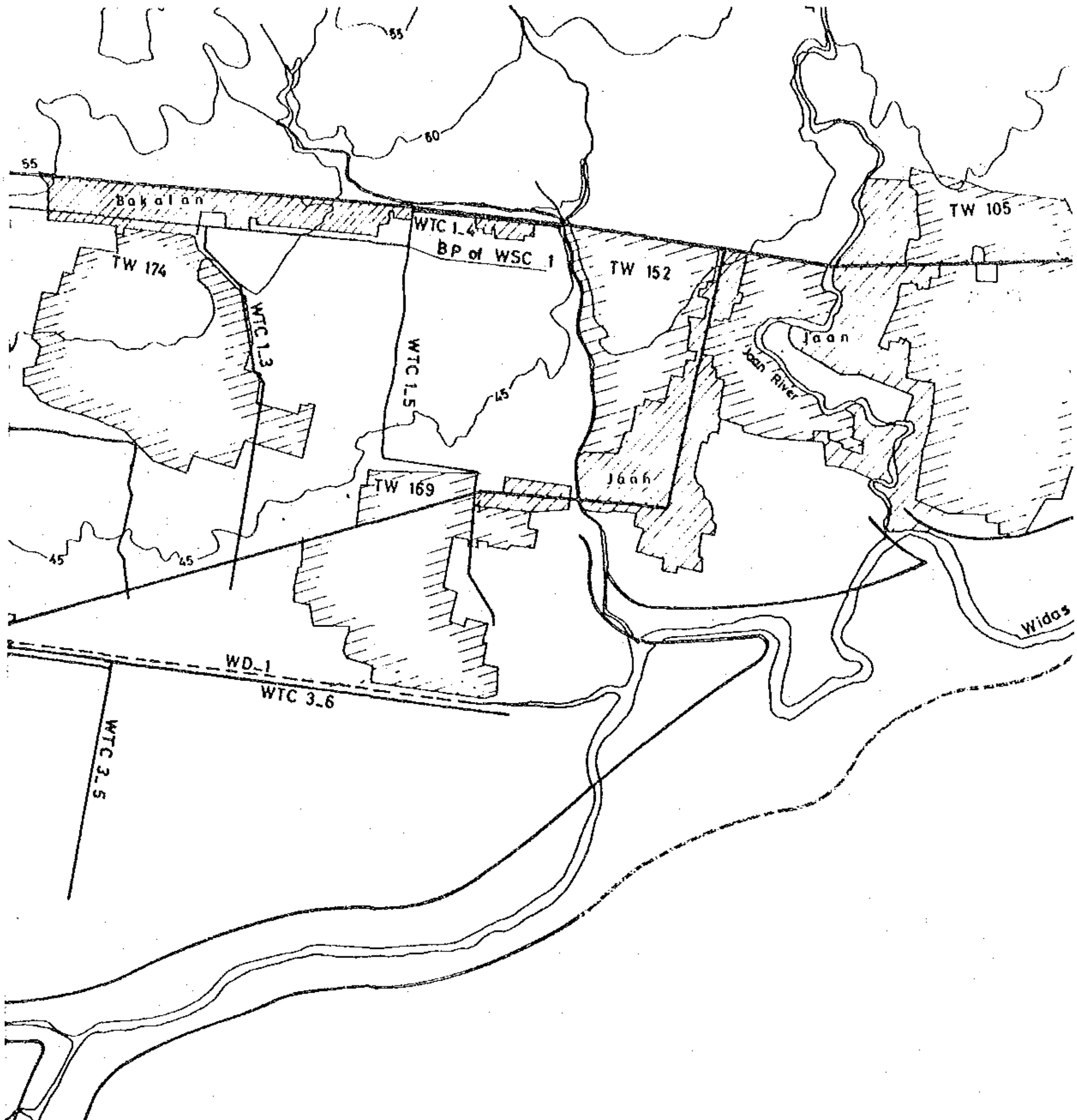
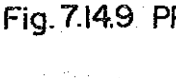
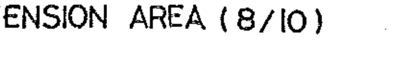


Fig. 7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (8/10)





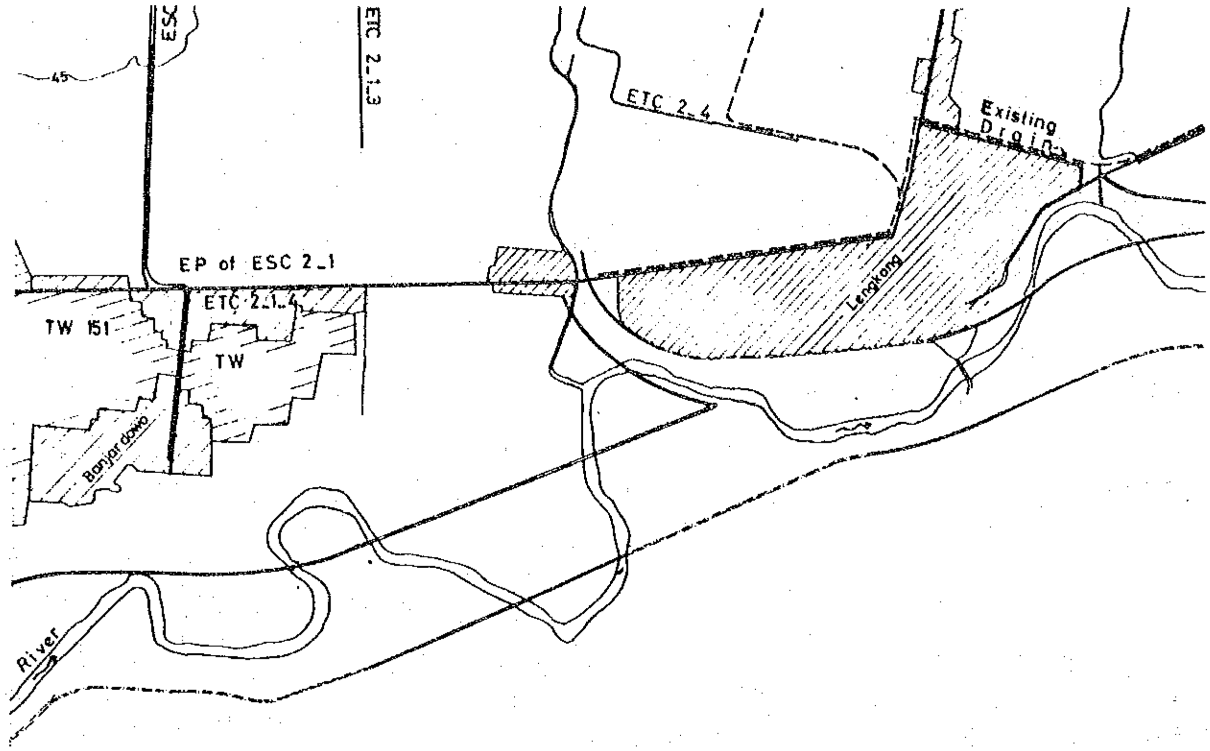
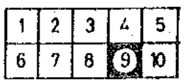
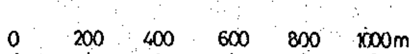


Fig.7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (9/10)





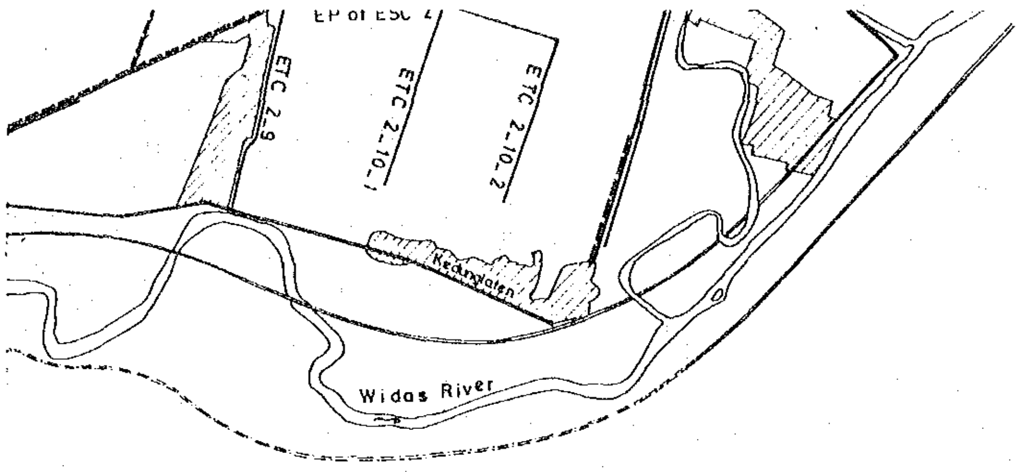
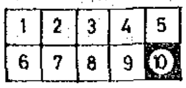
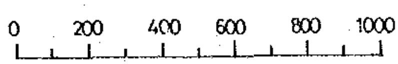


Fig.7.14.9 PROPOSED CANAL LAY OUT ON THE WIDAS EXTENSION AREA (10/10)





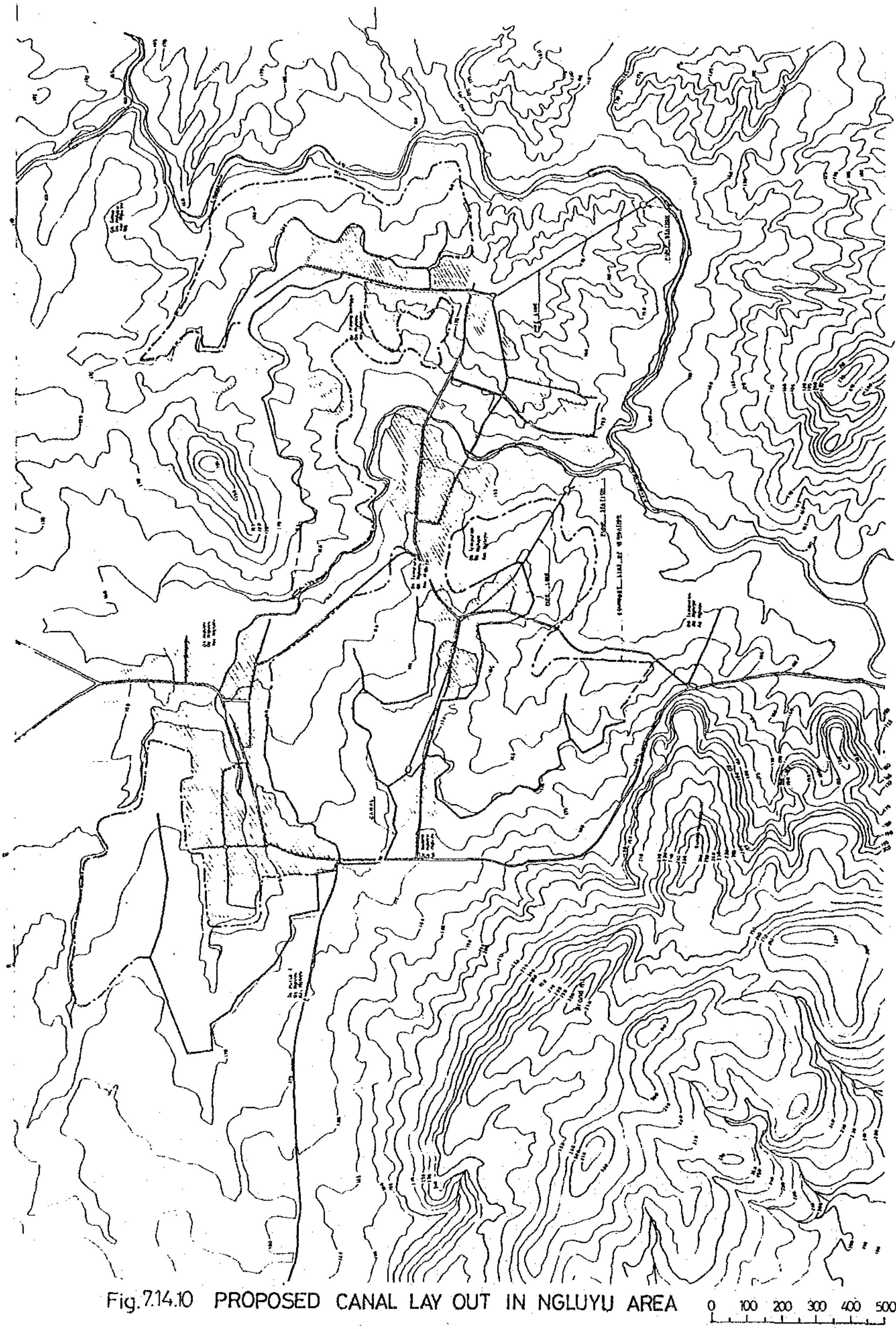


Fig. 7.14.10 PROPOSED CANAL LAY OUT IN NGLUYU AREA 0 100 200 300 400 500m

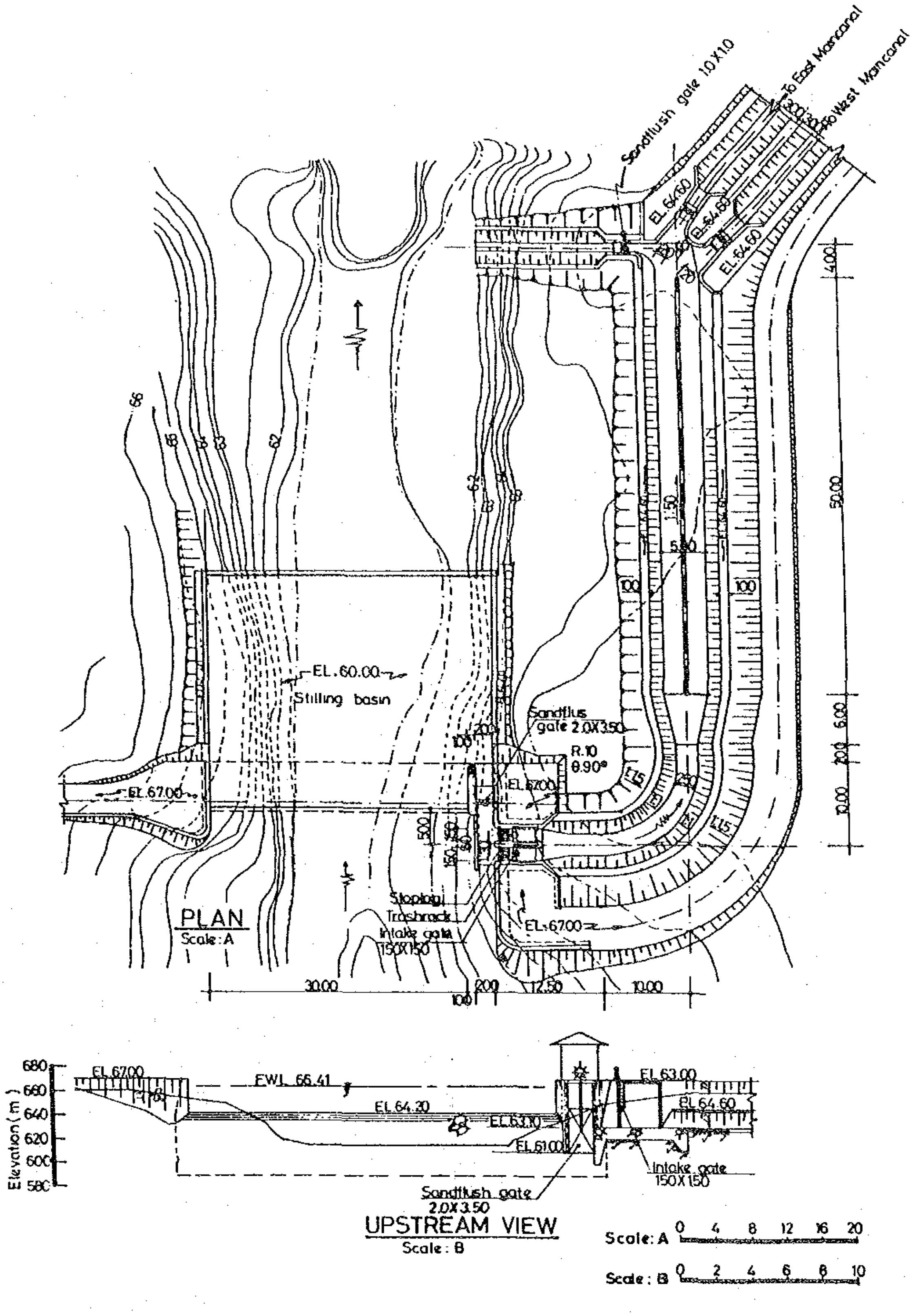


Fig.7.14.11. BANGLE HEADWORK. (1/3)

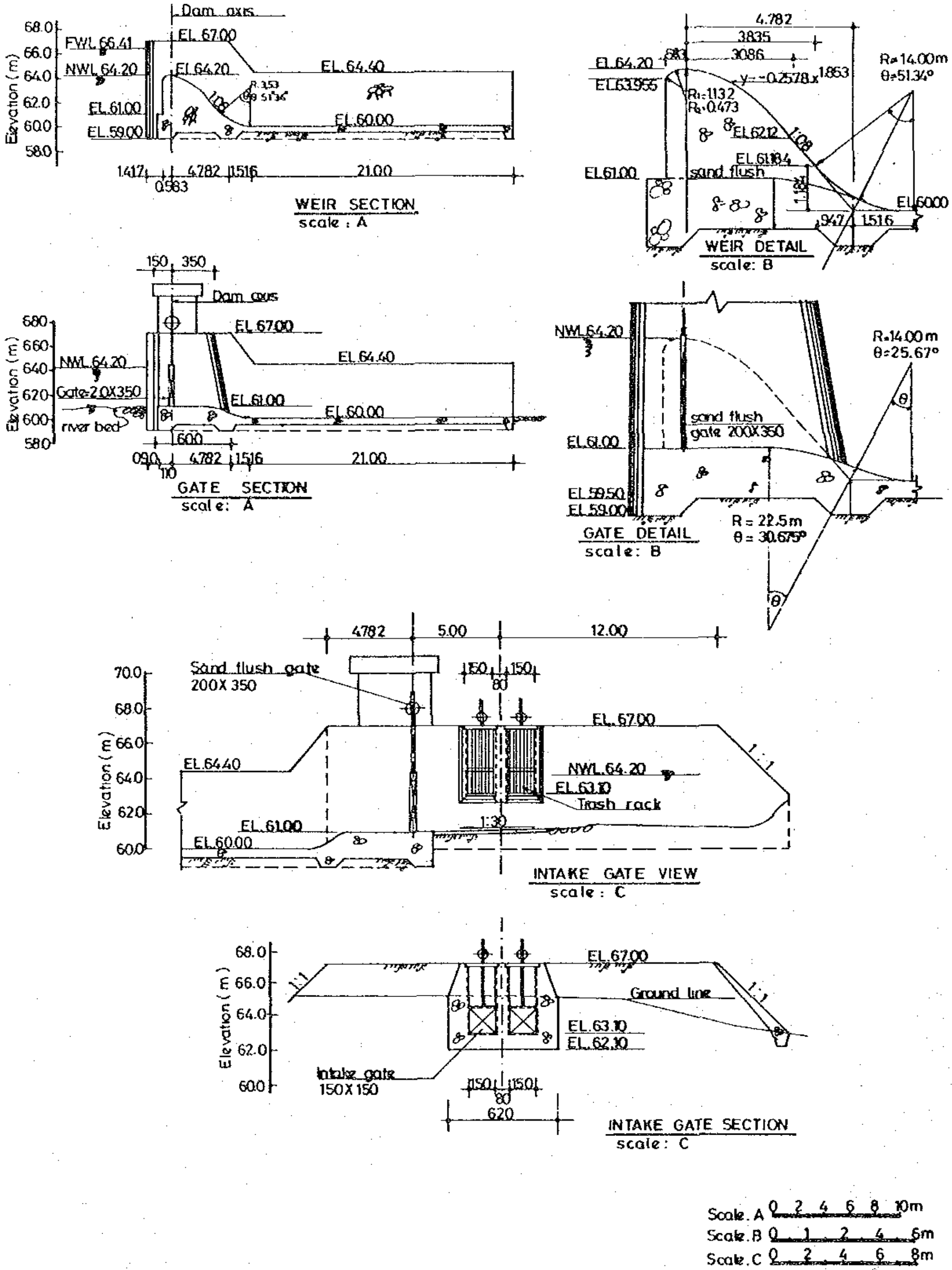
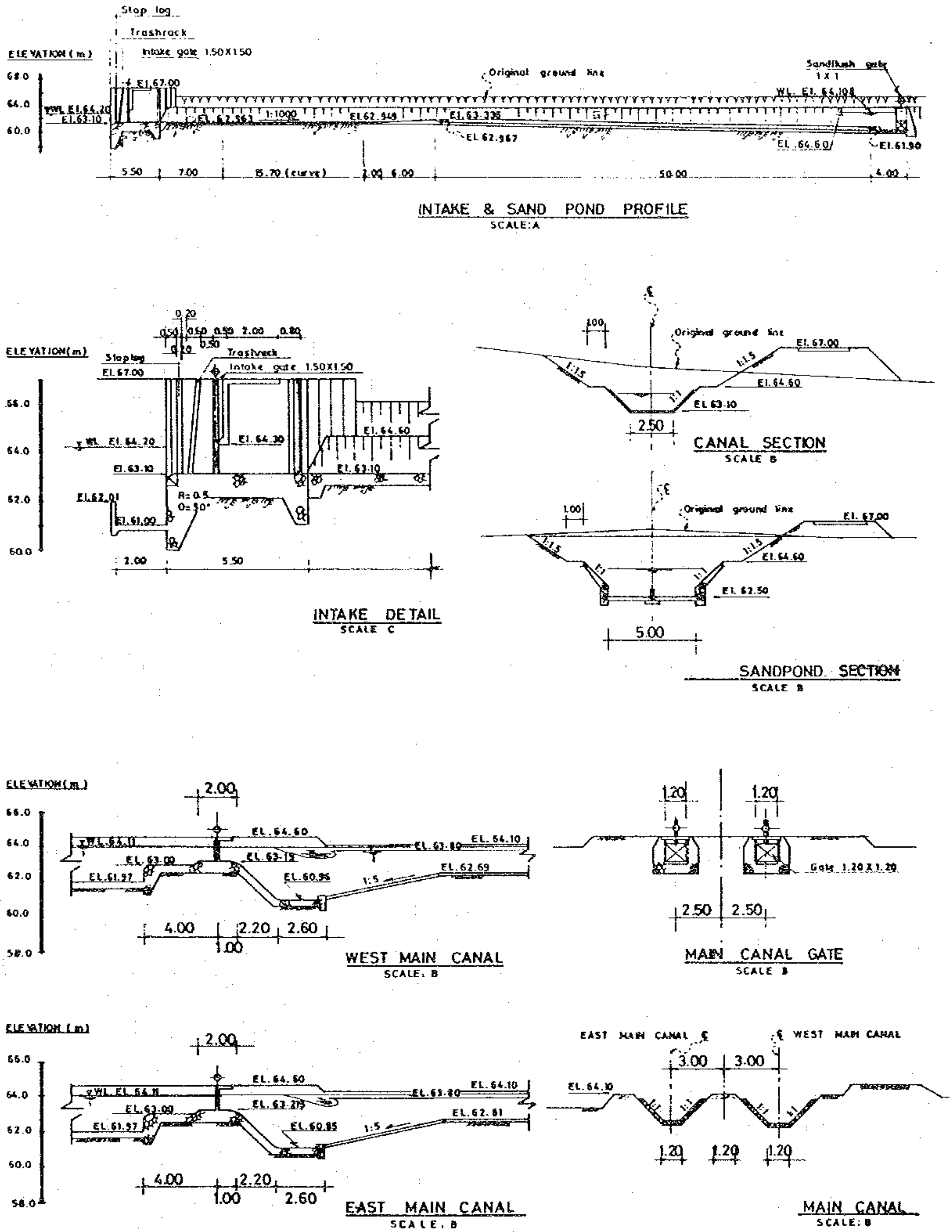


Fig.7.14.11 BANGLE HEADWORK (2/3)



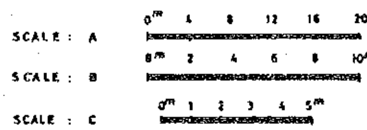
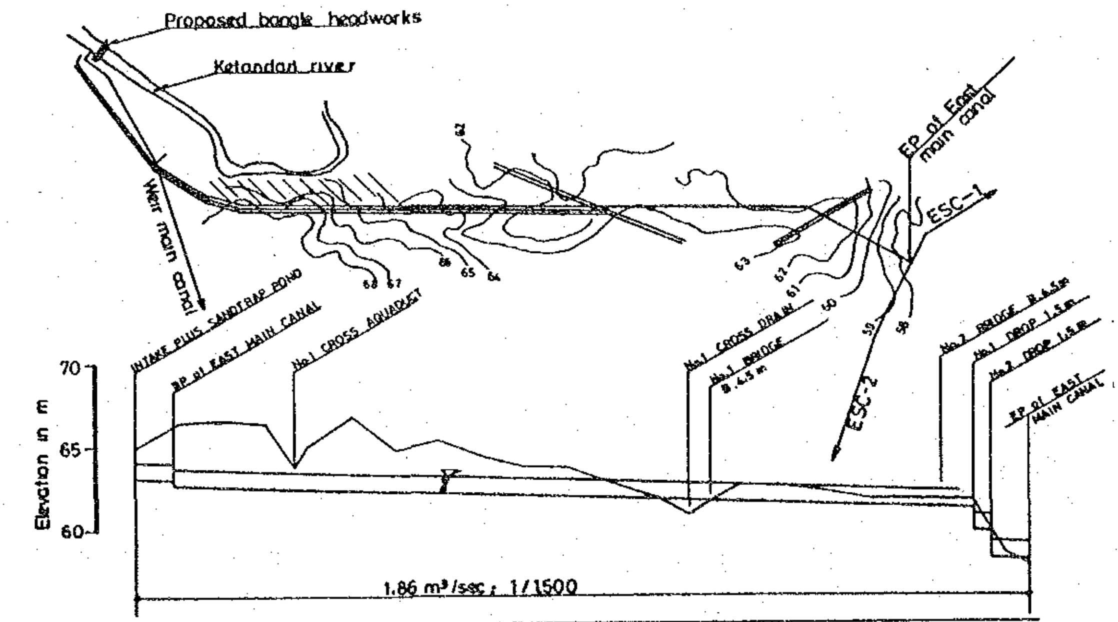


Fig.7.14.11 BANGLE HEADWORK (3/3)



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

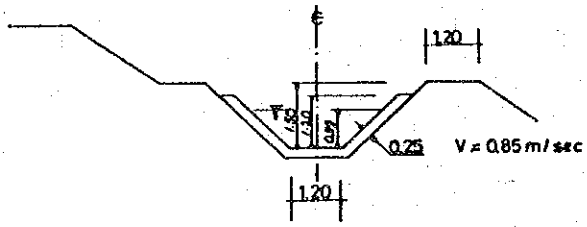


Fig. 7.14.12 PLAN AND PROFILE OF EAST MAIN CANAL

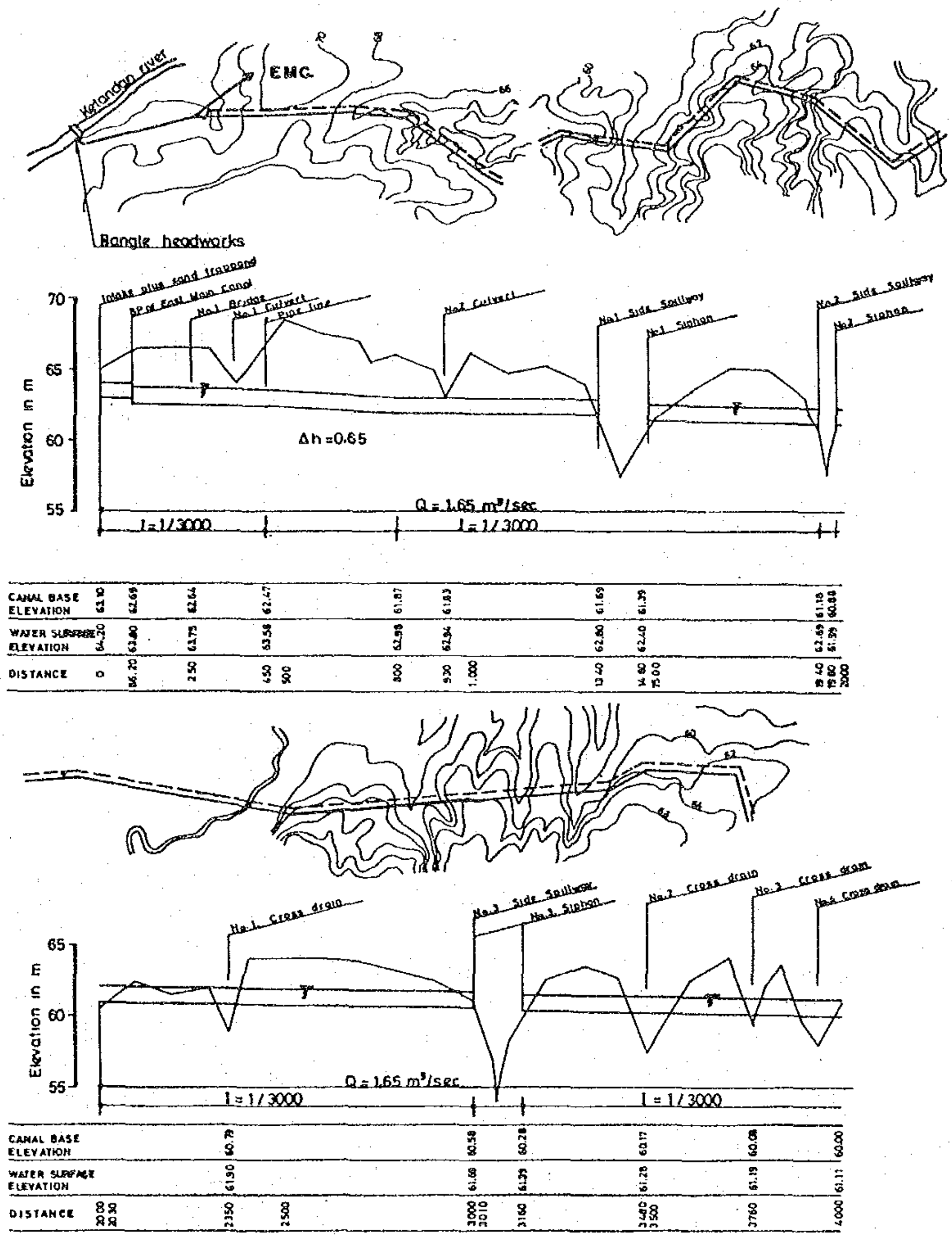


Fig. 7.14.13 **PLAN AND PROFILE OF WEST MAIN CANAL (1/2)**

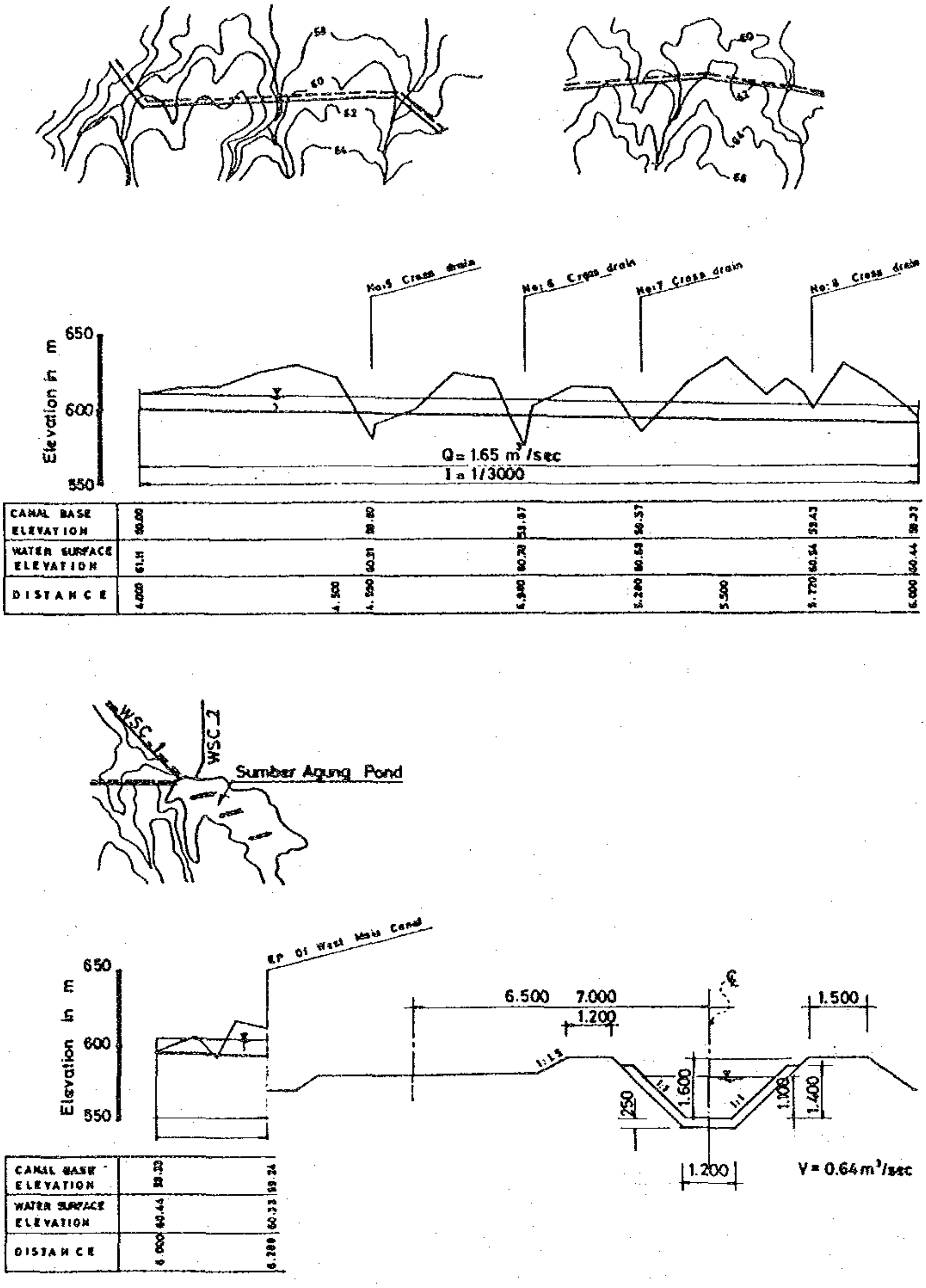
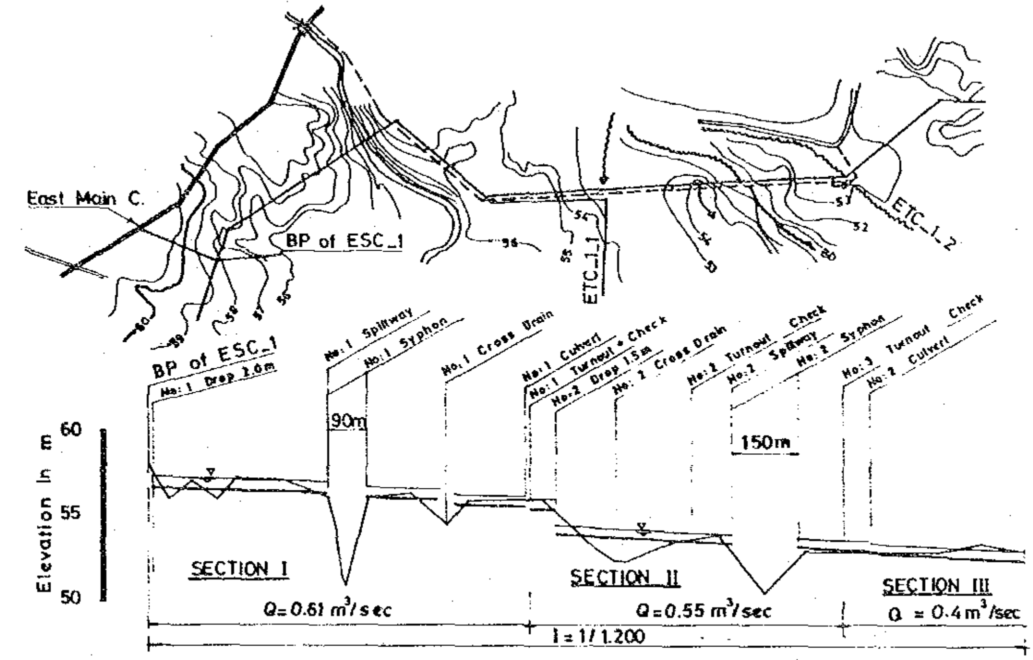
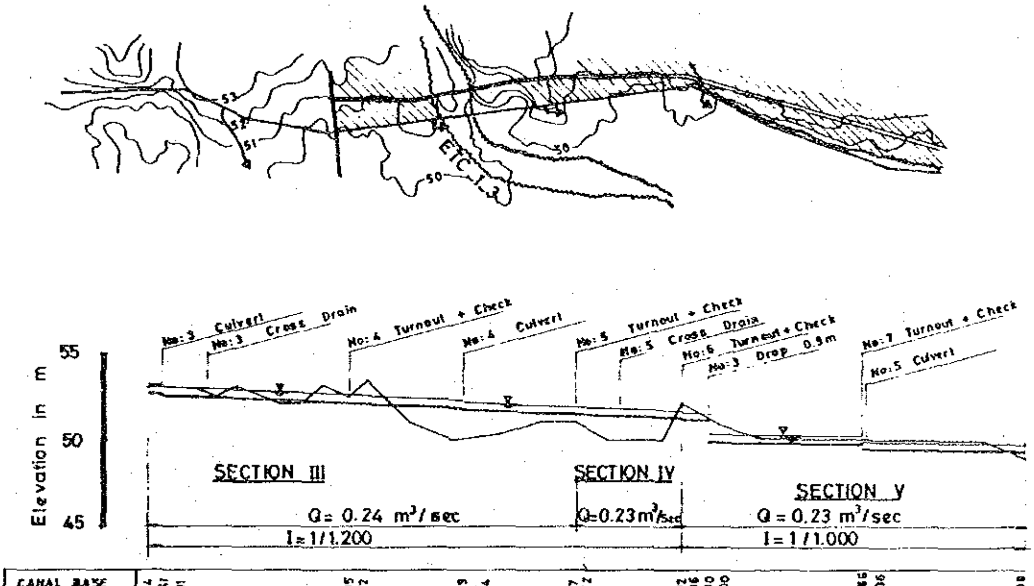


Fig. 7.14.13 PLAN AND PROFILE OF WEST MAIN CANAL (2/2)

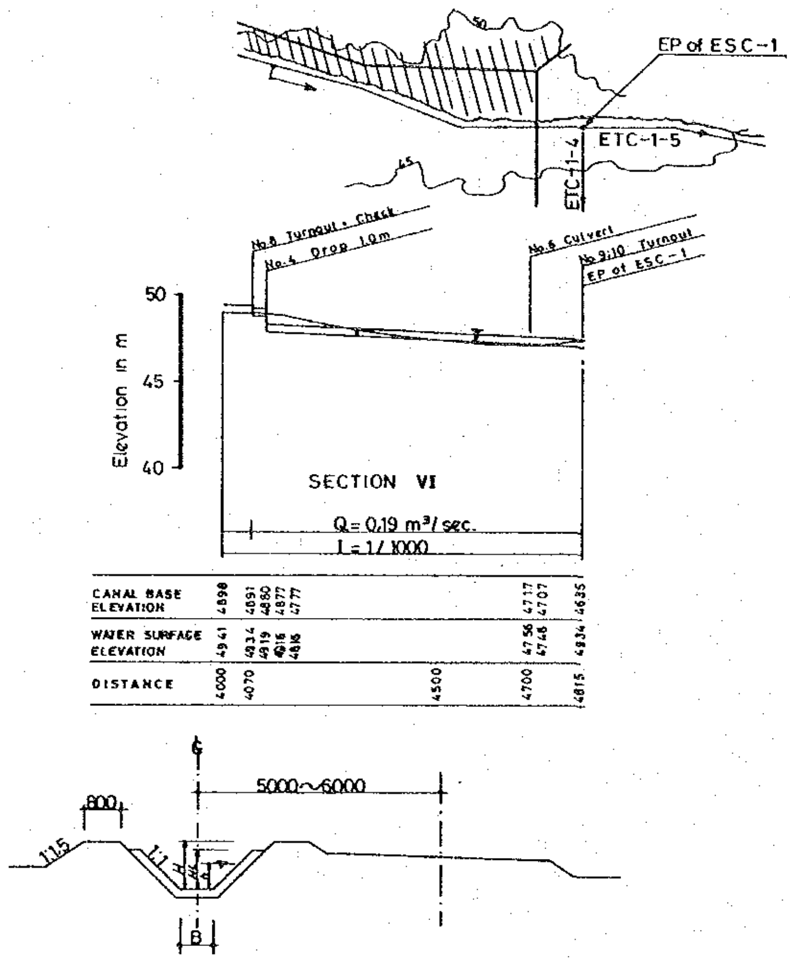


CANAL BASE ELEVATION	56.66 / 56.56	56.32	56.02	55.49 / 55.74	55.44 / 55.29	55.26	53.76	53.50 / 53.45	53.38	53.00	52.87 / 52.80 / 52.84	52.74	51.44
WATER SURFACE ELEVATION	59.27 / 57.37	50.93	56.63	56.50 / 56.35	56.05 / 55.90	55.25	54.35	54.09 / 54.04	53.97	53.87	53.46 / 53.41 / 53.86	53.26	52.96
DISTANCE	0.00	410	500	680 / 700	860	930	1,000	1,240	1,330	1,500	1,580	1,640	2,000



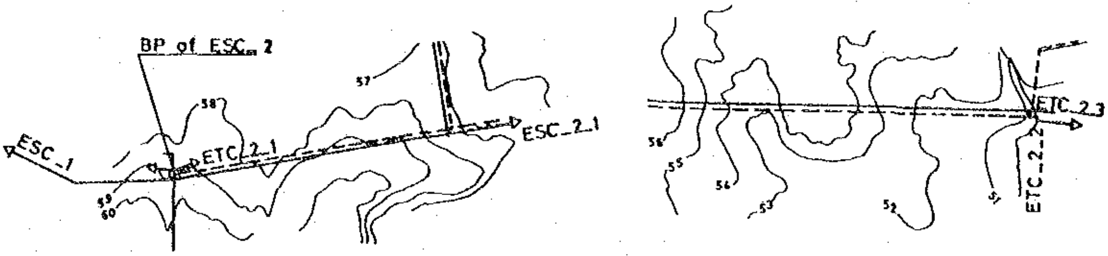
CANAL BASE ELEVATION	51.44 / 52.47 / 52.31	51.95 / 51.72	51.49 / 51.34	51.17 / 51.22	51.02 / 50.96 / 50.90 / 50.00		49.66 / 49.36	49.38
WATER SURFACE ELEVATION	52.96 / 52.93 / 52.63	52.47 / 52.22	52.01 / 51.91	51.69 / 51.64	51.44 / 51.39 / 51.33 / 50.43		50.09 / 49.79	49.41
DISTANCE	2,000 / 2,030	2,460 / 2,500	2,720	2,975 / 3,000	3,220	3,500	3,620	4,000

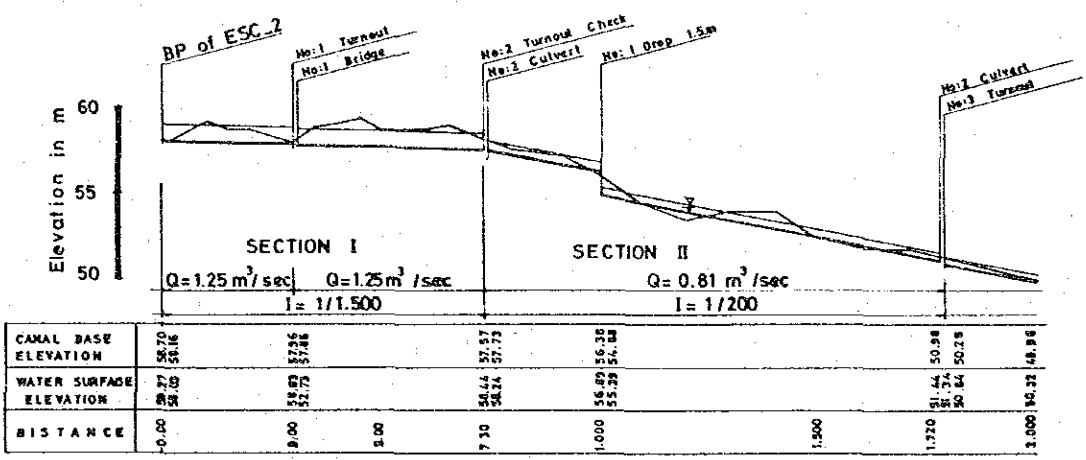
Fig:7.14.14 PLAN AND PROFILE OF ESC - 1. (1/2)

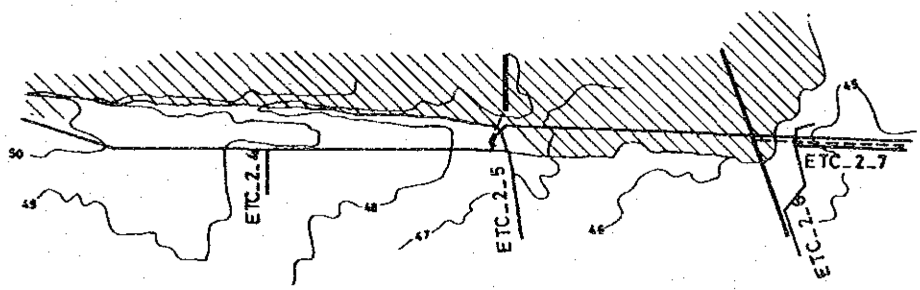


Section	V (m/sec)	h (m)	H (m)	HL (m)	B (m)	BB (m)
I	0.70	0.61	1.10	0.80	0.80	1.00
II	0.69	0.59	1.00	0.80	0.80	0.80
III	0.65	0.52	0.90	0.70	0.80	0.80
IV	0.55	0.42	0.80	0.60	0.60	0.60
V	0.59	0.43	0.80	0.60	0.50	0.60
VI	0.57	0.39	0.80	0.60	0.50	0.60

Fig.7.14.14 PLAN AND PROFILE OF ESC-1 (2/2)







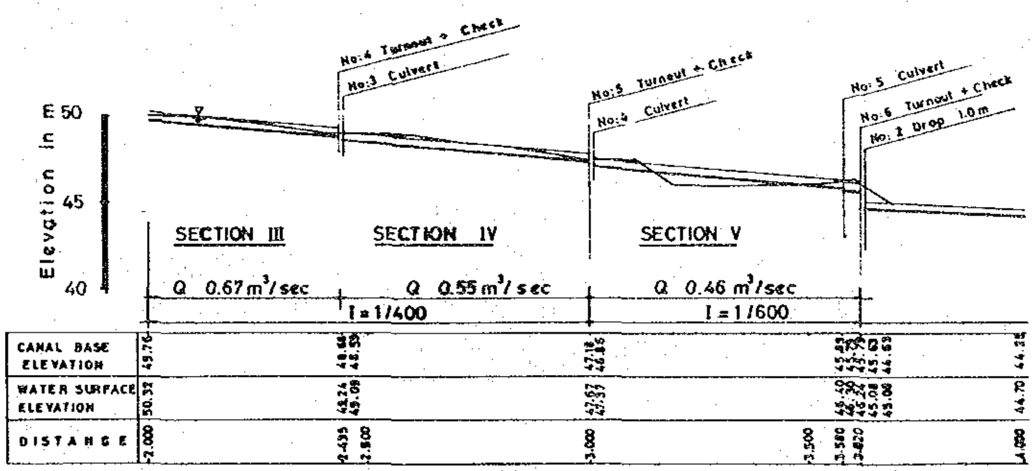
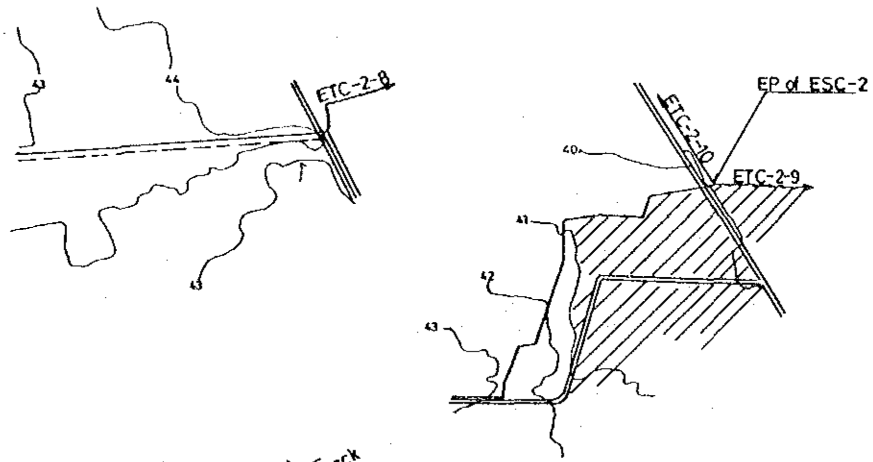
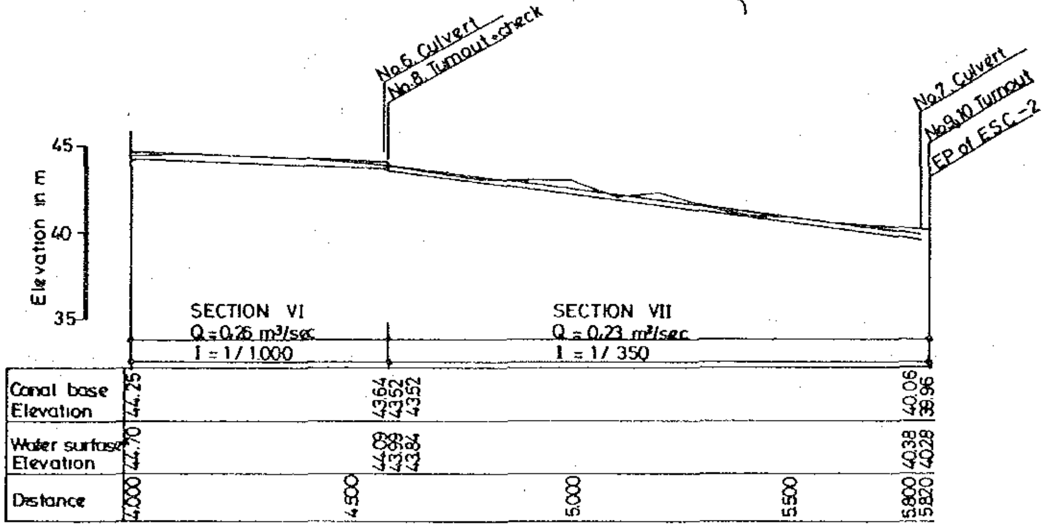


Fig. 7.14.15 PLAN AND PROFILE OF ESC _ 2 (1/2)





SECTION	V m/sec	h m	H m	HL m	B m	BB m
I	0.77	0.87	1.40	1.10	1.00	1.20
II	1.49	0.51	1.00	0.70	0.60	0.80
III	1.10	0.56	1.00	0.80	0.60	0.80
IV	1.04	0.49	0.90	0.70	0.60	0.80
V	0.86	0.51	0.90	0.70	0.60	0.80
VI	0.61	0.45	0.80	0.60	0.50	0.60
VII	0.87	0.32	0.70	0.50	0.50	0.60

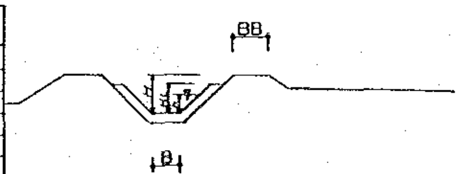
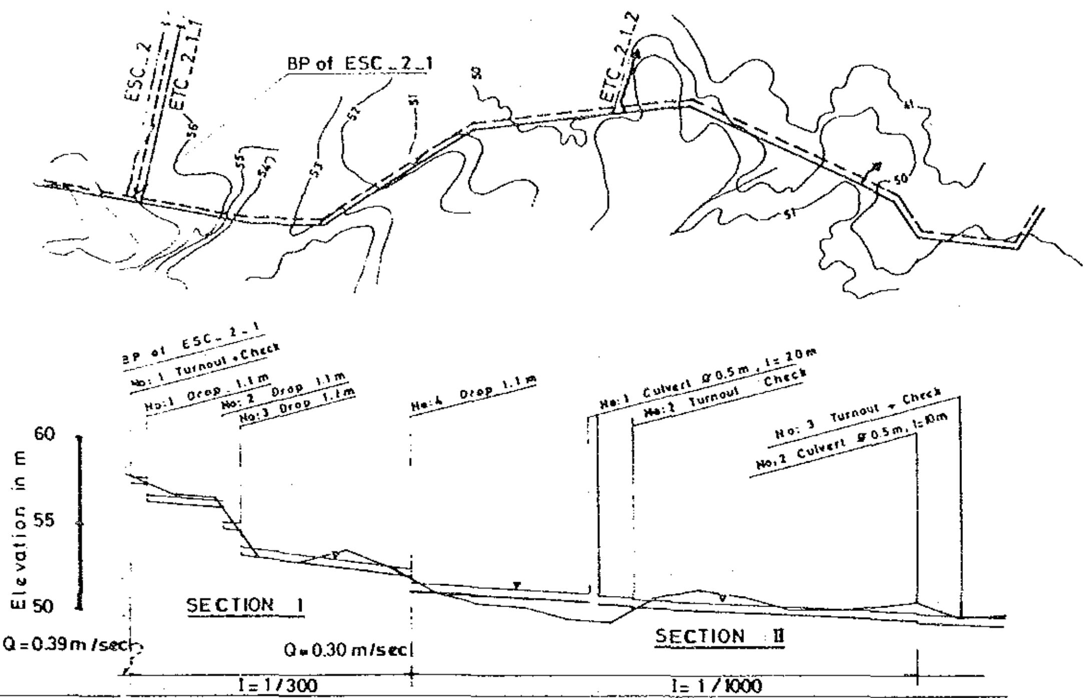
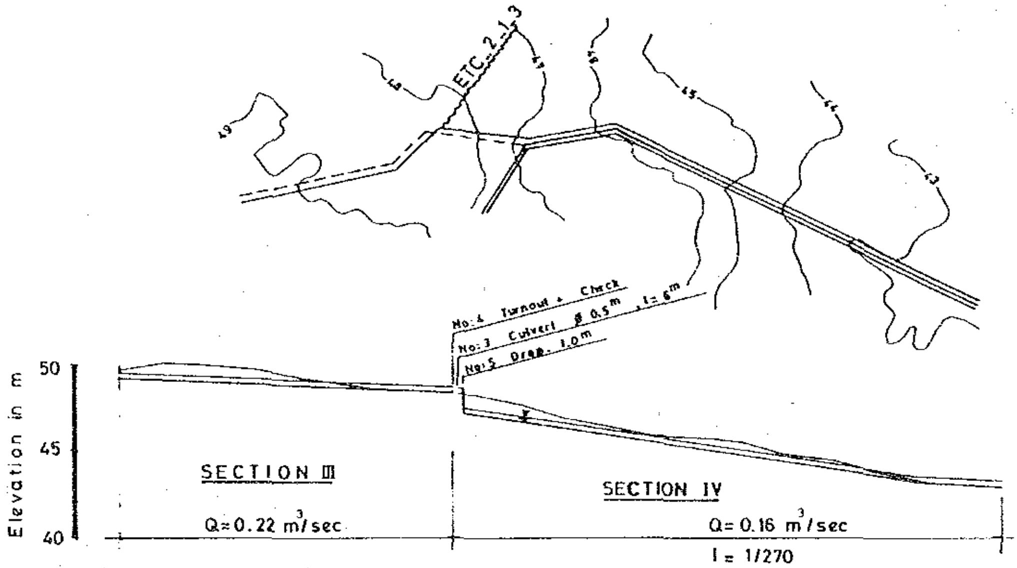


Fig: 7.14.15 PLAN AND PROFILE OF ESC _2 (2/2)

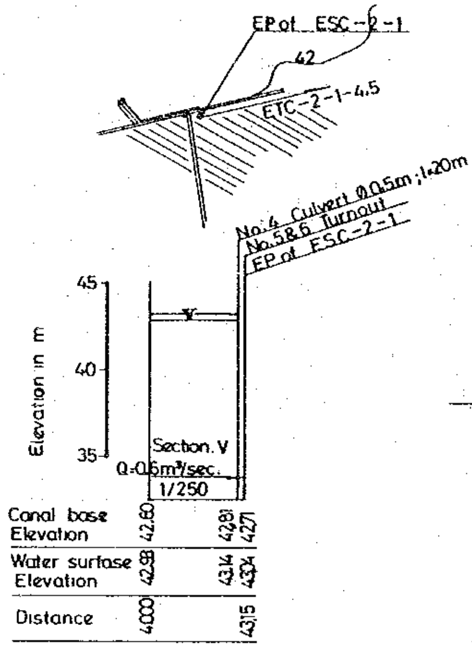


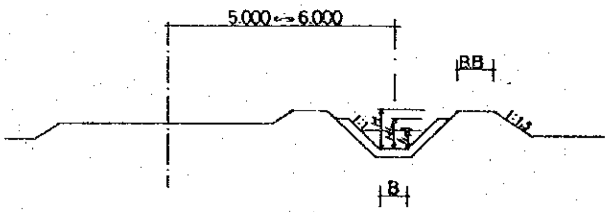
CANAL BASE ELEVATION	[illegible]	55.34 / 54.54 / 54.41 / 53.31		52.02 / 50.82		50.42 / 50.22	50.12 / 50.05		49.40 / 49.34 / 49.14 / 49.04 / 48.94
WATER SURFASE ELEVATION	[illegible]	56.00 / 54.90 / 54.77 / 53.67		52.38 / 51.20		50.84 / 50.68	50.58 / 50.51		49.86 / 49.76 / 49.86 / 49.46 / 49.36
DISTANCE	0.000 / 50	220 / 260	500	650	1.000	1.050	1.150	1.500	1.800 / 1.900 / 2.000



CANAL BASE ELEVATION	48.94		48.29 / 48.30 / 47.30			43.41	42.60
WATER SURFASE ELEVATION	48.38		48.71 / 48.56 / 47.56			43.67	42.93
DISTANCE	2.000	2.500	2.750	3.000	3.500	3.800	4.000

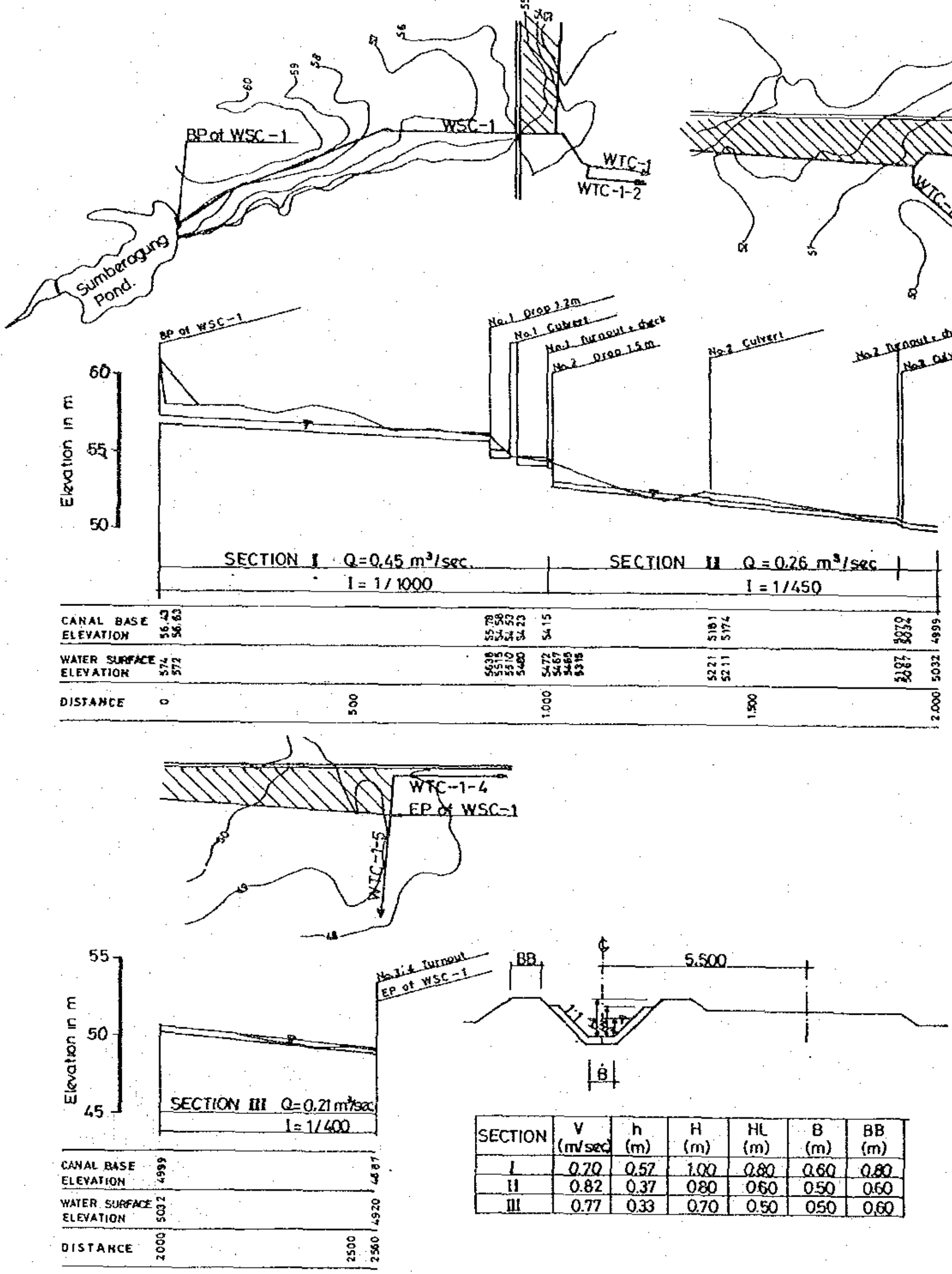
Fig: 7.14.16 . PLAN AND FROFILE OF ESC_2_1 (1/2)





SECTION	V (m/sec)	h (m)	H (m)	HL (m)	B (m)	BB (m)
I	0.99	0.36	0.80	0.60	0.50	0.60
II	0.63	0.46	0.90	0.70	0.60	0.80
III	0.58	0.42	0.80	0.60	0.50	0.60
IV	0.88	0.26	0.70	0.50	0.50	0.60
V	0.60	0.33	0.70	0.50	0.50	0.60

Fig: 7.14.16 PLAN AND PROFILE OF ESC - 2 - 1 (2/2)



SECTION	V (m/sec)	h (m)	H (m)	HL (m)	B (m)	BB (m)
I	0.70	0.57	1.00	0.80	0.60	0.80
II	0.82	0.37	0.80	0.60	0.50	0.60
III	0.77	0.33	0.70	0.50	0.50	0.60

Fig. 7.14.17 PLAN AND PROFILE OF WSC - I.

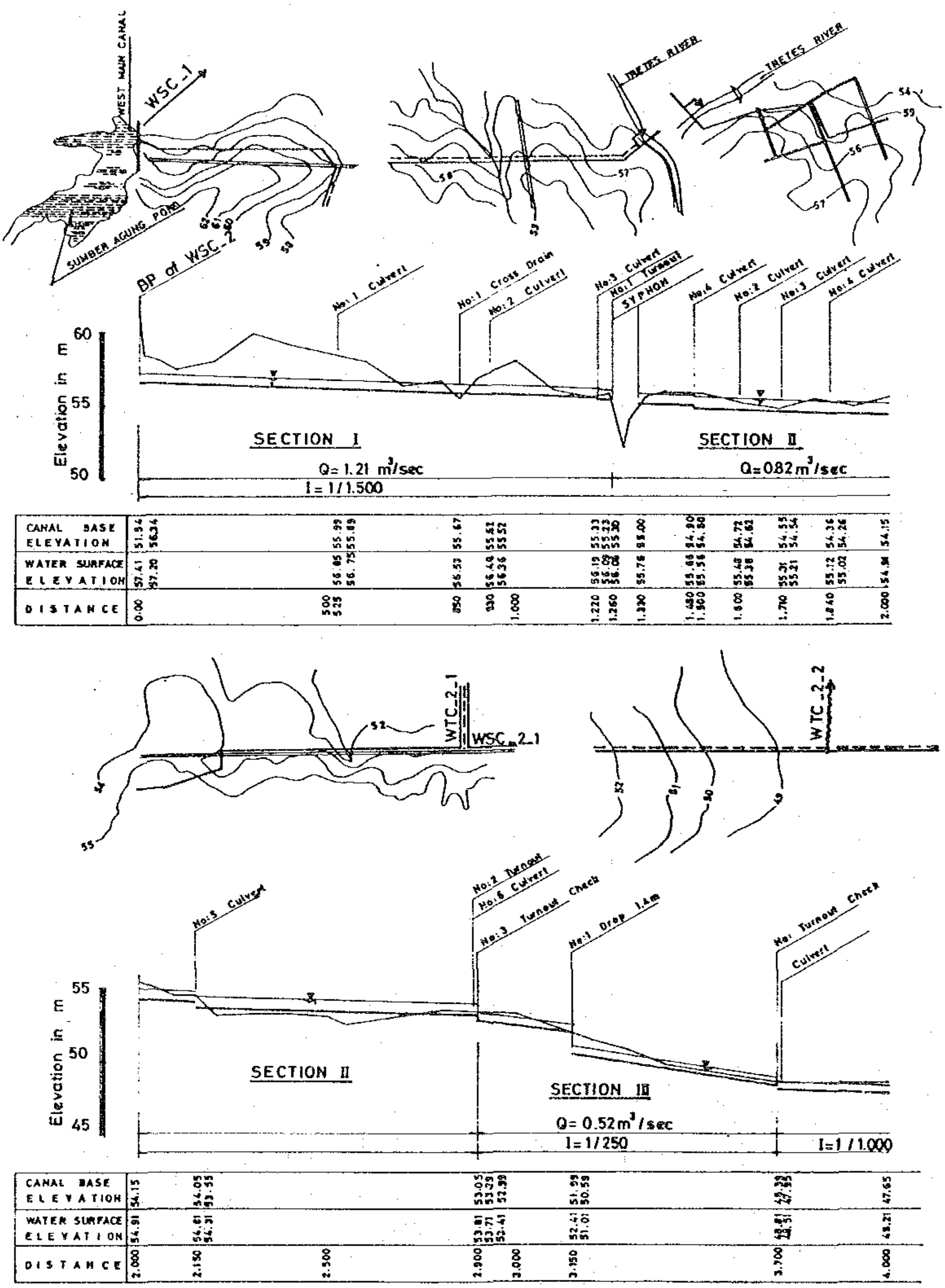
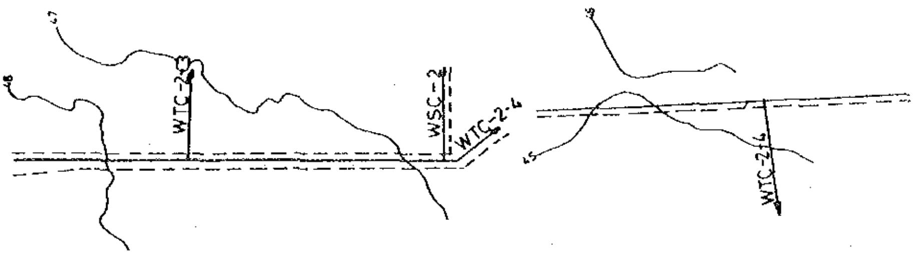
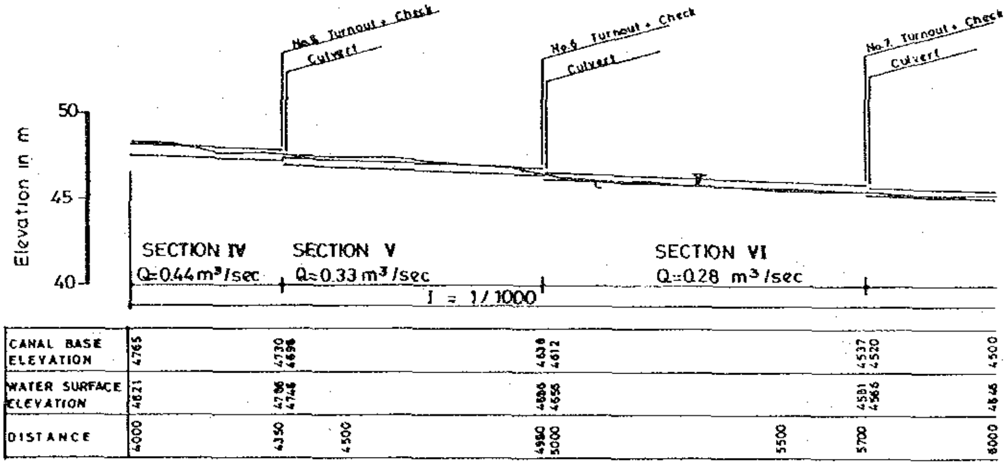
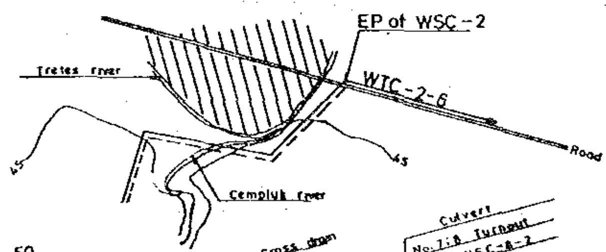
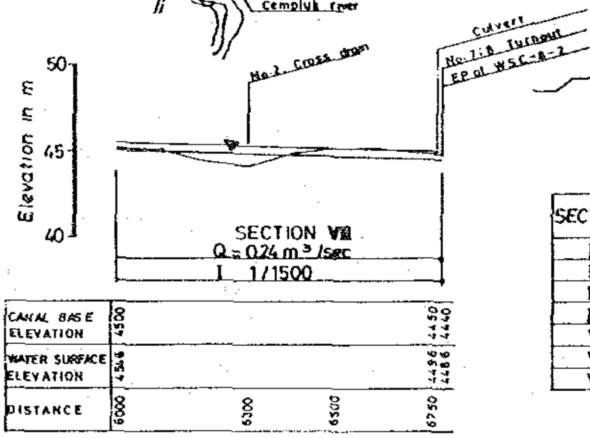


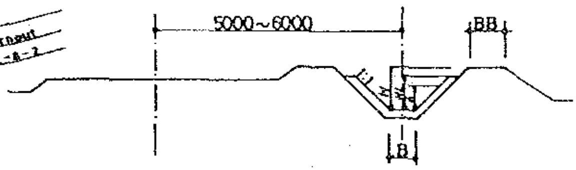
Fig. 7.14.18 PLAN AND PROFILE WSC _ 2 (1/2)





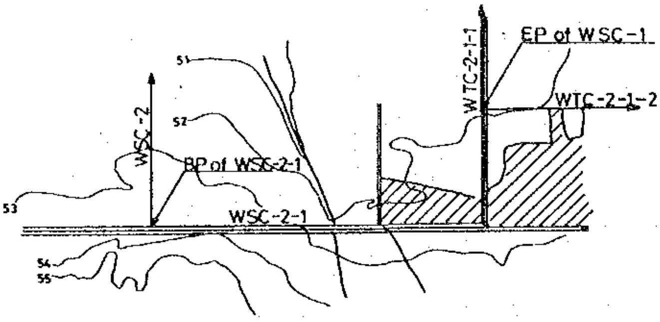


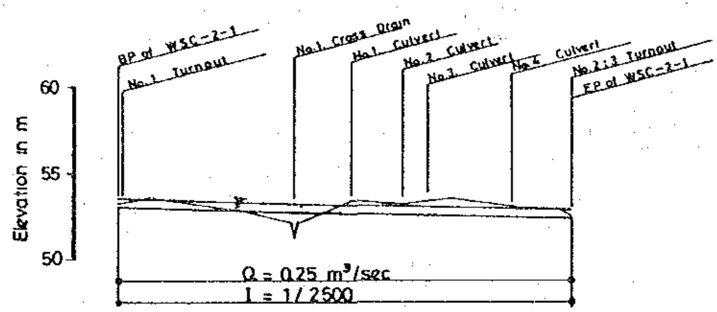




SECTION	V (m/sec)	h (m)	H (m)	HL (m)	B (m)	BB (m)
I	0.77	0.86	1.30	1.10	1.00	1.00
II	0.70	0.76	1.20	1.00	0.80	1.00
III	1.22	0.42	0.80	0.60	0.60	0.60
IV	0.70	0.56	1.00	0.80	0.60	0.80
V	0.65	0.48	0.90	0.70	0.60	0.80
VI	0.62	0.44	0.80	0.60	0.60	0.60
VII	0.51	0.46	0.90	0.70	0.60	0.60

Fig.7.14.18 **PLAN AND PROFILE OF WSC - 2 (2/2)**





CANAL BASE ELEVATION	5319 5314	5298 5288	5283 5270	5268 5258	5256 5246	5238 5228	5223
WATER SURFACE ELEVATION	5371 5366	5350 5340	5375 5325	5320 5310	5308 [illegible]	5290 5280	5275
DISTANCE	0	400	500 530	650	710	900	1000 1035

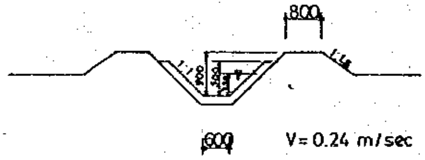
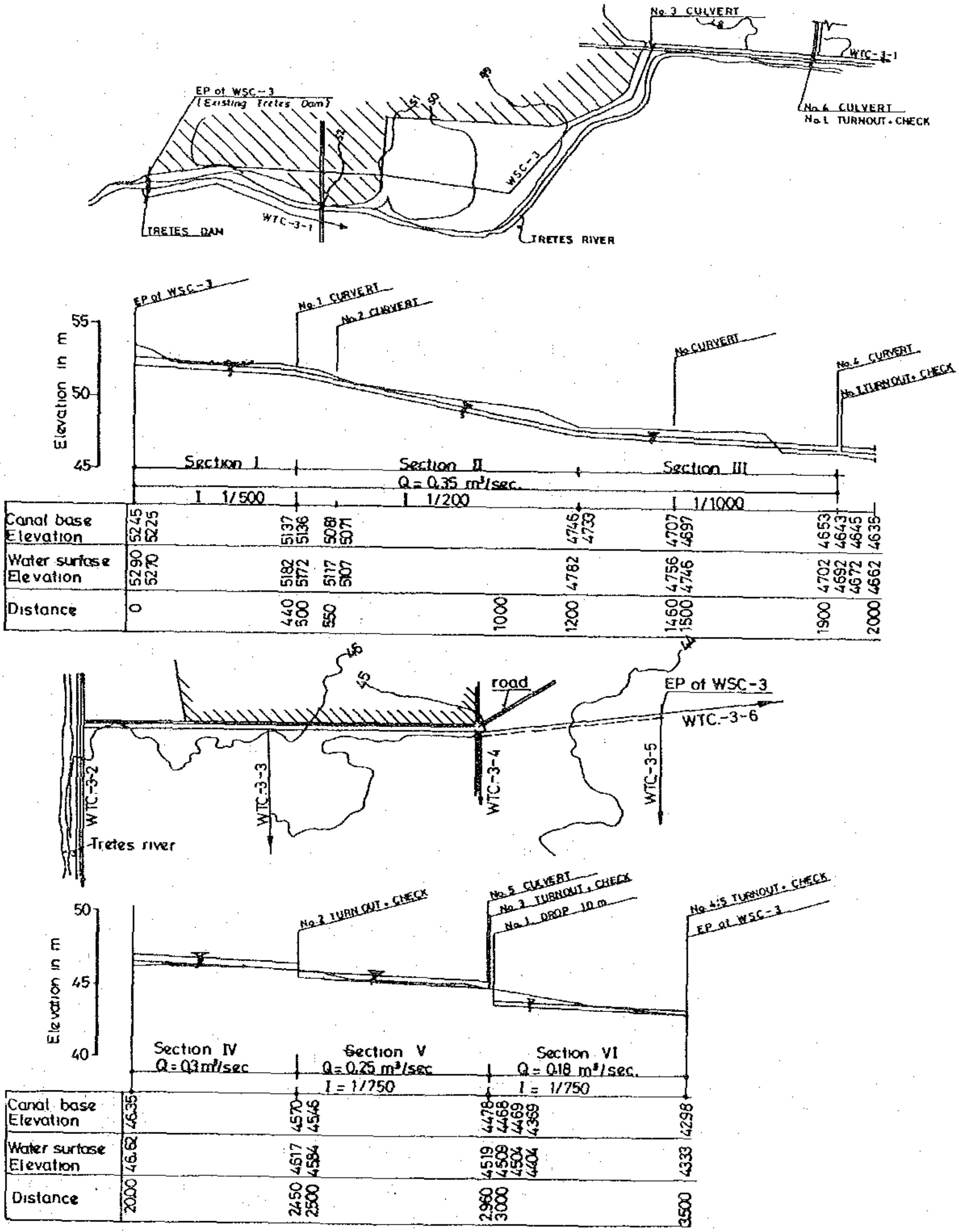


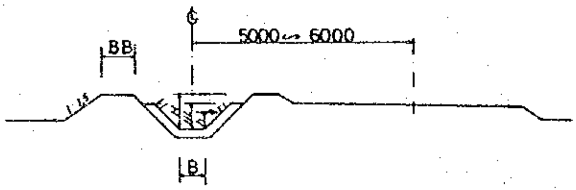
Fig. 7.14.19 PLAN AND PROFILE OF WSC - 2 - I



Canal base Elevation	5245 5225	5137 5136	5081 5071		4746 4733	4707 4697		4653 4643 4645 4635	
Water surfase Elevation	5290 5270	5182 5172	5117 5107		4782	4756 4746		4702 4692 4672 4662	
Distance	0	440 500	550	1000	1200	1460 1500	1900	2000	

Canal base Elevation	46.35	4570 4546	4478 4468 4469 4369	4298
Water surfase Elevation	46.62	4617 4584	4519 4509 4504 4404	4333
Distance	2000	2450 2500	2960 3000	3500

Fig. 7.14.20 PLAN AND FROFILE OF WSC _3 (1/2)



WSC - 3

	SECTION	V (m/sec)	h (m)	H (m	HL (m)	B (m)	BB (m)
35	I	0.86	0.45	0.90	0.60	0.50	0.80
35	II	1.21	0.36	0.80	0.60	0.50	0.60
35	III	0.65	0.49	0.90	0.70	0.60	0.80
31	IV	0.64	0.47	0.90	0.70	0.60	0.80
25	V	0.67	0.41	0.80	0.60	0.50	0.60
18	VI	0.61	0.35	0.70	0.50	0.50	0.60

Fig. 7.14.20 PLAN AND PROFILE OF WSC _3 (2/2)

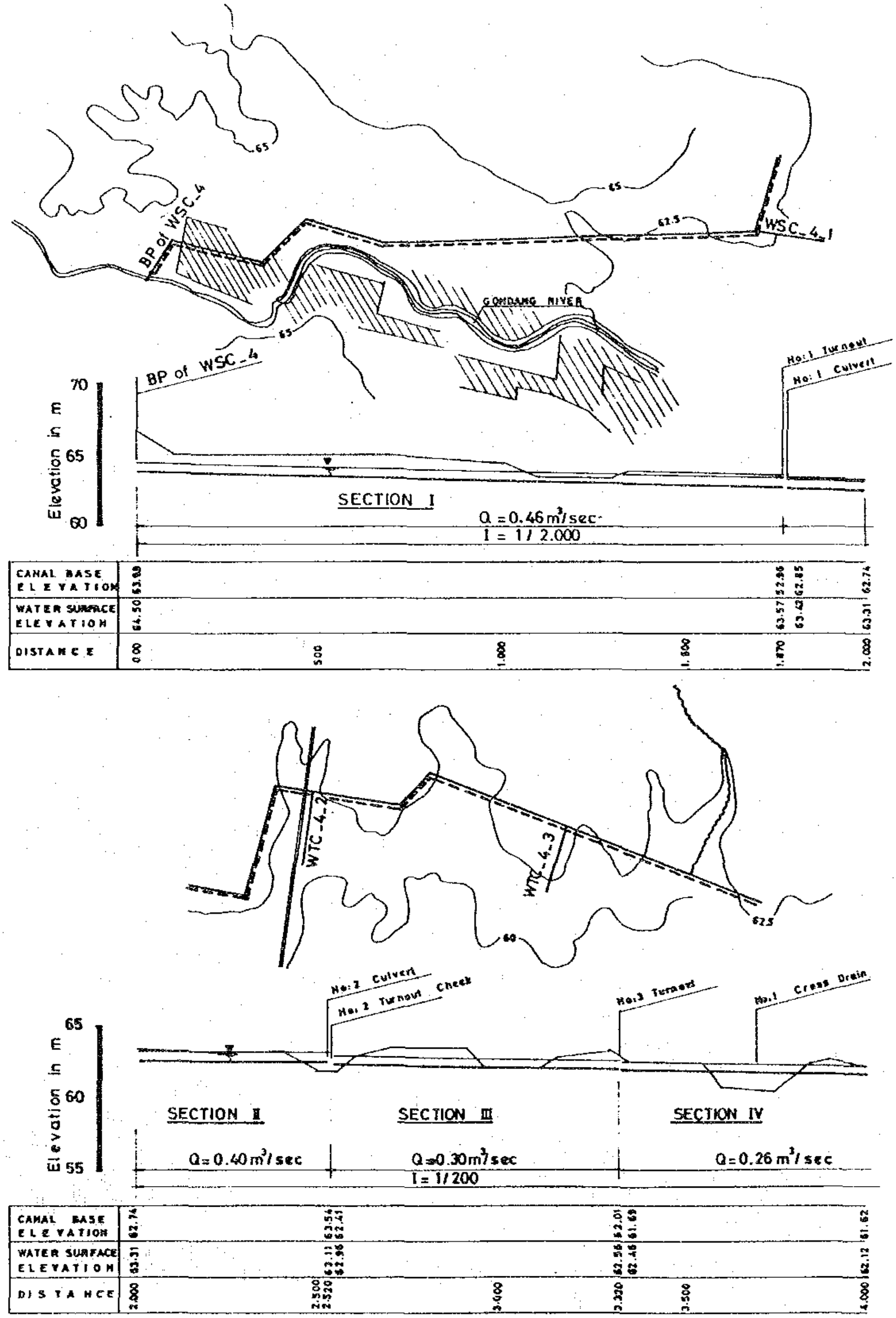
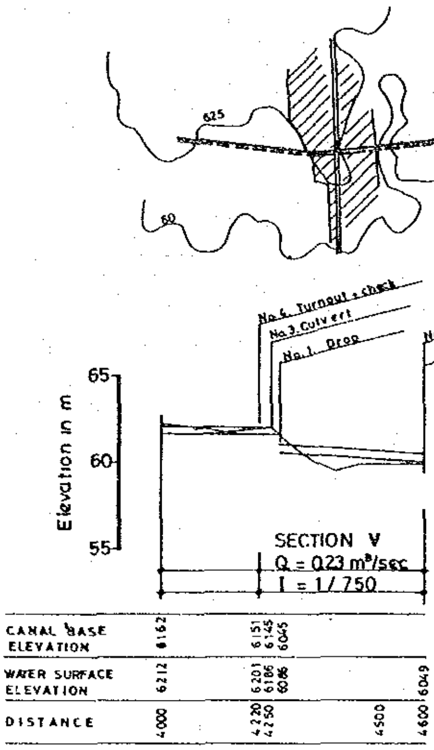
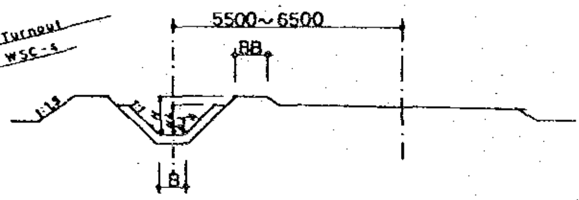


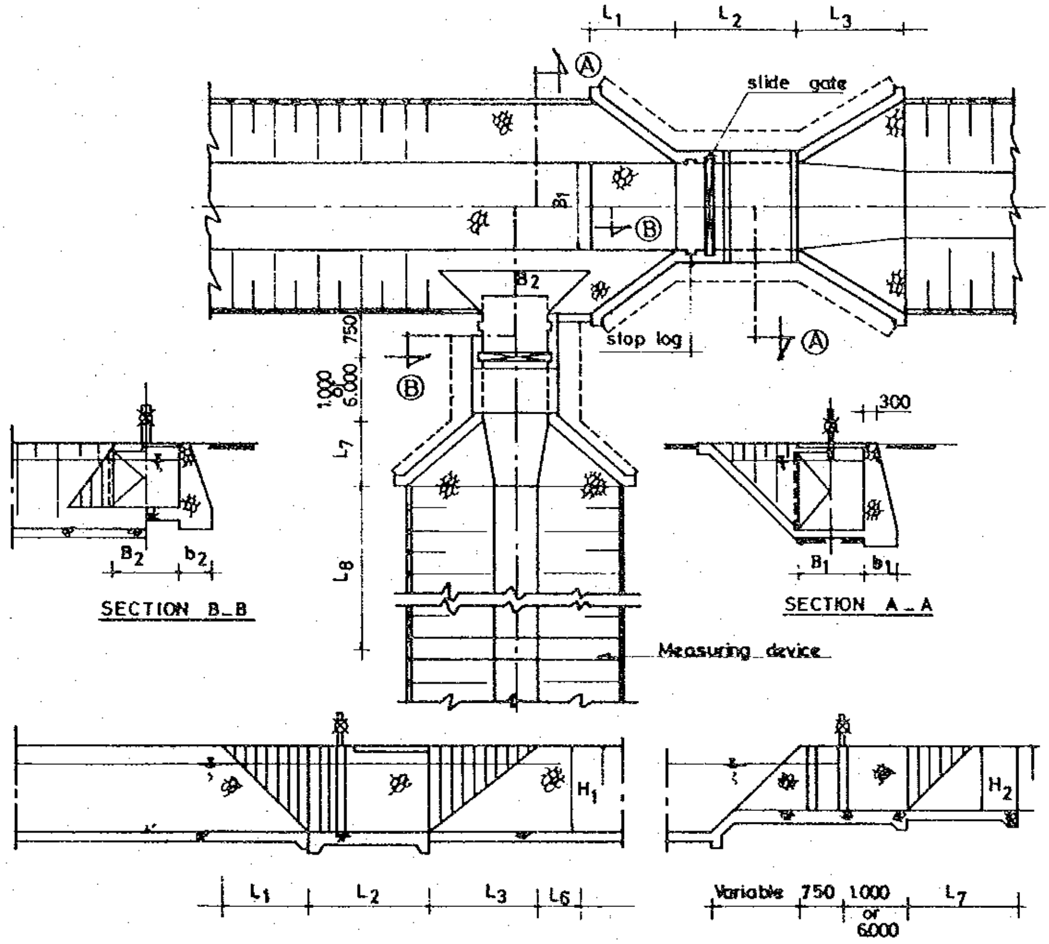
Fig. 7.14.21 PLAN AND PROFILE OF WSC _4 (1/2)





SECTION	V (m/sec)	h (m)	H (m)	HL (m)	B (m)	B B (m)
I	0.54	0.61	1.00	0.80	0.80	0.80
II	0.52	0.57	1.00	0.80	0.80	0.80
III	0.49	0.55	0.90	0.70	0.60	0.60
IV	0.47	0.50	0.70	0.70	0.60	0.60
V	0.67	0.41	0.80	0.60	0.50	0.60

Fig. 7.14.21 PLAN AND PROFILE OF WSC _ 4 (2/2)



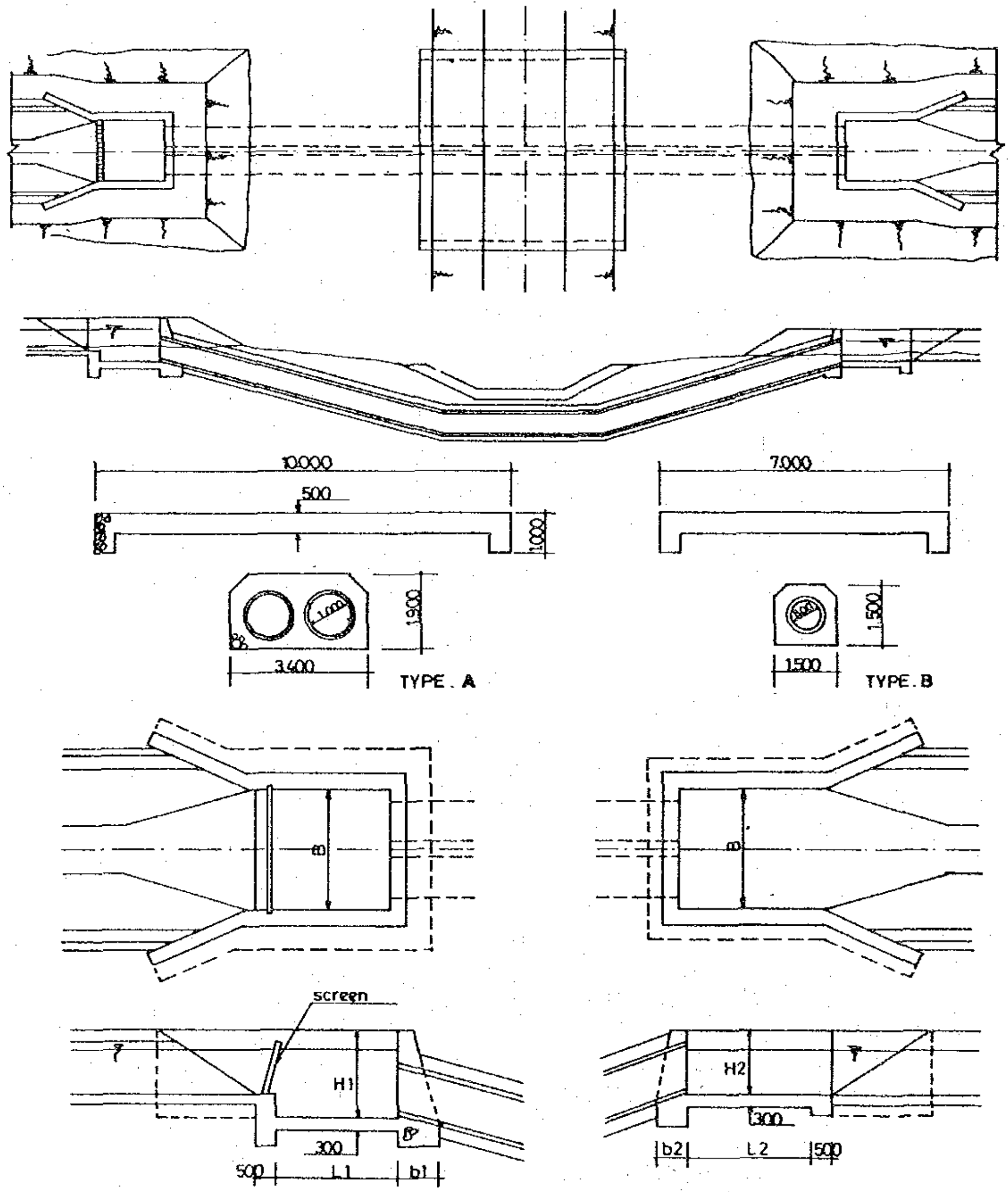
DIMENSIONS OF CHECKS

Type	DISCHARGE (m^3/sec)	L_1	L_2	L_3	B_1	b_1	H_1
A	1.0∽0.6	1.200	2.500	1.300	1.000	650	1.200
B	0.6∽0.4	1.100	2.500	1.100	800	650	1.100
C	0.4∽0.2	1.000	2.000	1.000	600	600	1.000
D	0.2∽	800	2.000	800	500	600	800

DIMENSIONS OF TURNOUTS

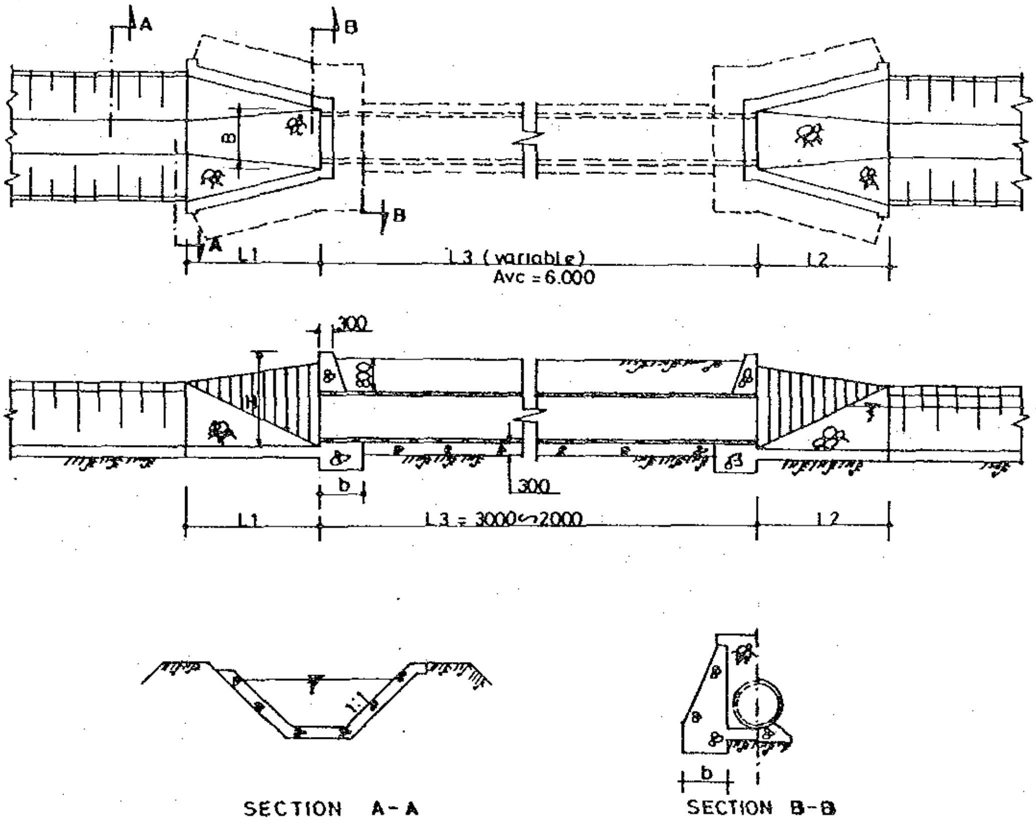
Type	DISCHARGE (m^3/sec)	L_7	B_2	b_2	L_8	H_2
A	1.5∽1.0	1.500	1.200	750	8.000	1.500
B	1.0∽0.6	1.200	1.000	650	7.000	1.200
C	0.6∽0.4	1.100	800	650	7.000	1.100
D	0.4∽0.2	900	600	600	6.000	900
E	0.2∽	900	500	600	5.000	800

Fig. 7.14.22 CHECK AND TURNOUT TYPE



Canal name	No.	Type	B	H1	L1	b1	H2	L2	b2
WMC	1	A	3.000	2.200	3.000	1.000	1.600	3.000	750
	2								
	3								
ES C-1	1	B	1.200	1.900	1.900	800	1.300	1.900	700

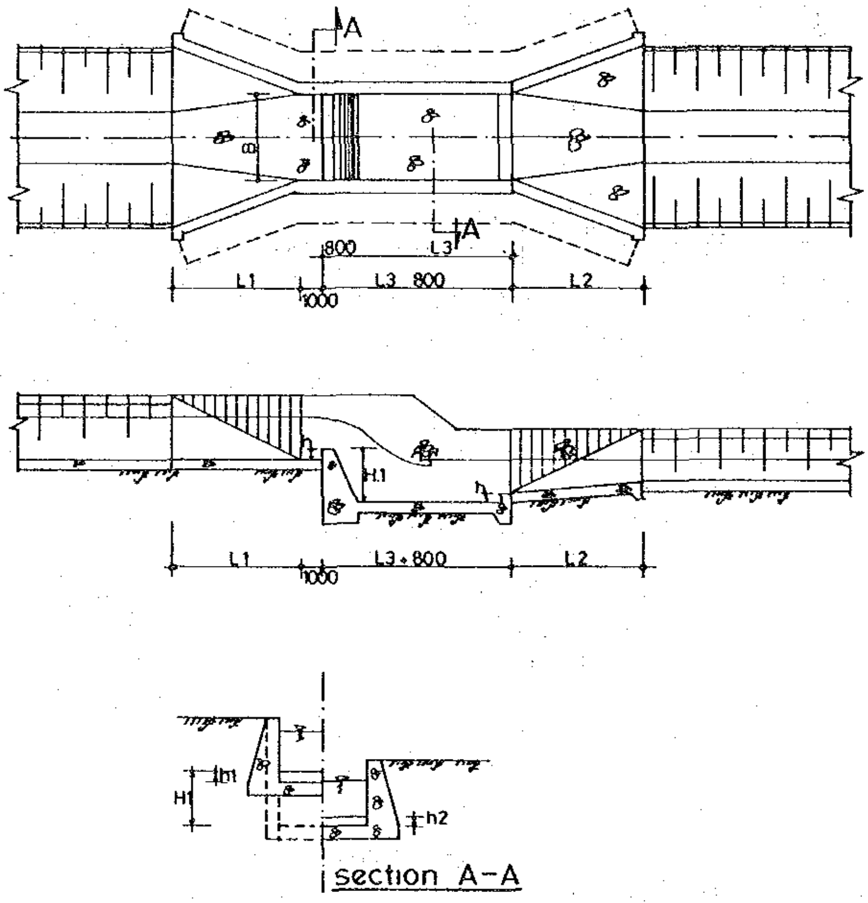
Fig. 7.14.23 SYPHON STRUCTURE



DIMENSIONS OF CULVERTS

Type	Discharge(m³/sec)	L1	L2	B	H	Ø	b
A	1.25～0.6	1.200	1.200	1.200	1.800	1.000	850
B	0.6 ～0.4	1.100	1.100	1.000	1.500	800	750
C	0.4 ～0.1	900	900	700	1.200	500	650
D	1.0 ～	800	800	500	1.000	300	600

Fig.7.14.24 CULVERT TYPE



DIMENSIONS OF DROPS.

Type	Discharge(m^3/sec)	L1	L2	L3	B	H1 (DROP)			h1	h2
						0.8 ∽ 1.2	1.2 ∽ 1.5	1.5 ∽ 2.0		
A	2.0 ∽ 1.2	2.000	2.000	4.000	1.500	2.000	2.500	3.000	400	400
B	1.2 ∽ 0.8	1.500	1.500	4.000	1.200	1.800	2.200	2.800	300	300
C	0.8 ∽ 0.4	1.200	1.200	3.000	1.000	1.500	2.000	2.500	2.00	200
D	0.4 ∽ 0.1	1.000	1.000	3.000	800	1.200	1.800	2.200	100	100

Fig.7.14.25 DROP TYPE

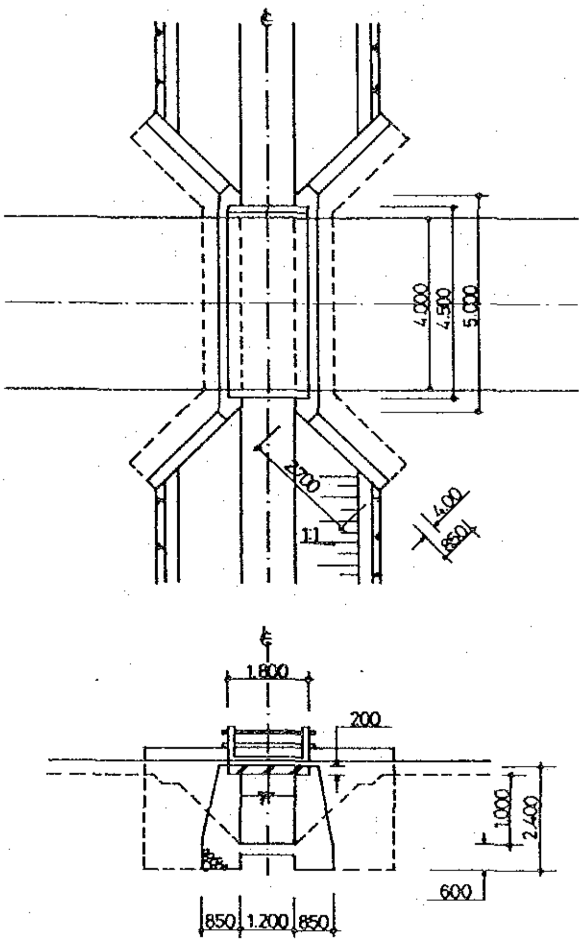
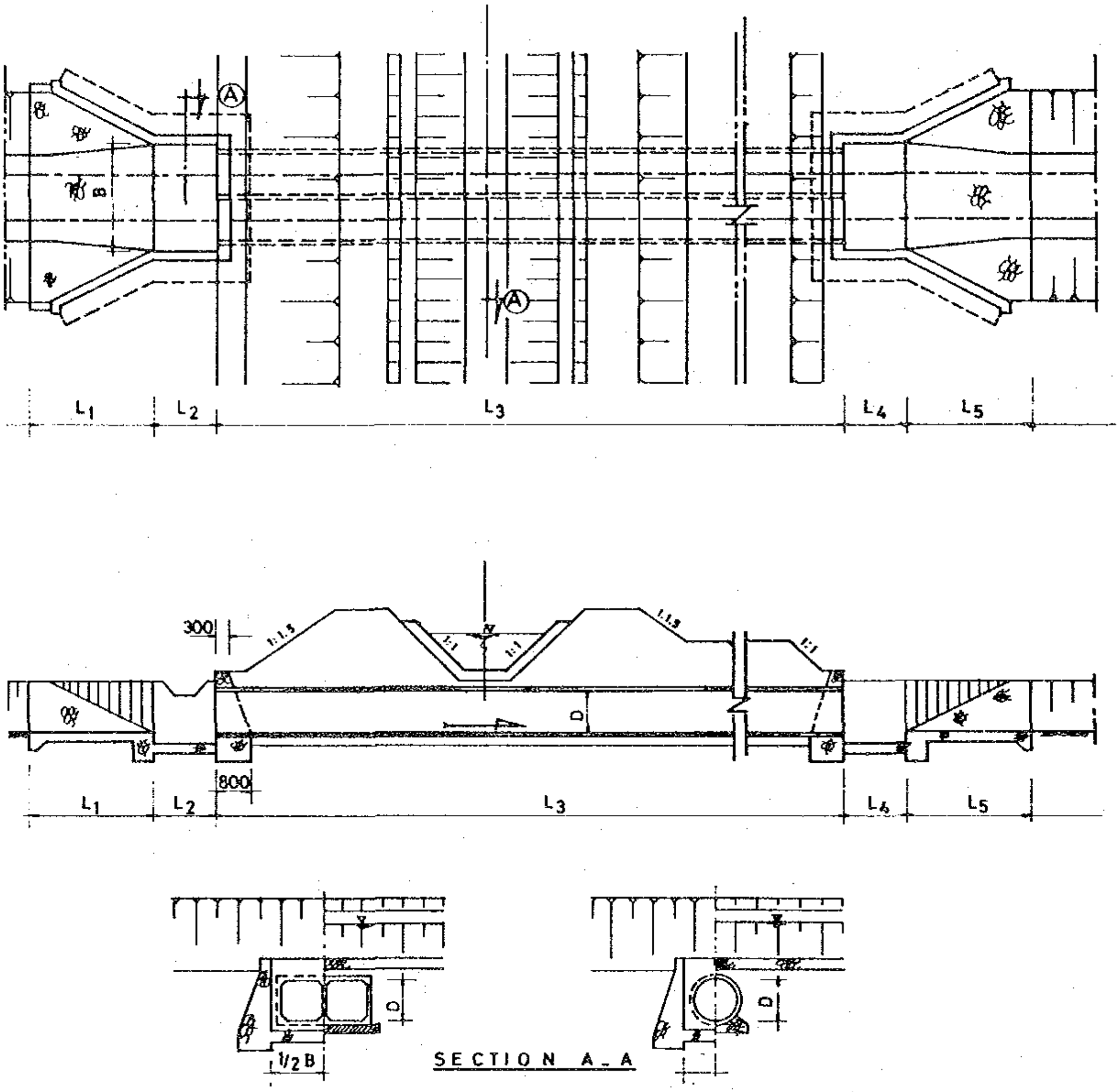


Fig. 7.14.26   BRIDGE



DIMENSION OF CROSS DRAINS

Type	DISCHARGE (m^3/Sec)	L1	L2	L3	L4	L5	B	D	n	Remark
A	9.0 3.0	5.000	2.500	10.000 25.000	2.500	5.000	3.800	1.500	2	□
B	3.0 1.6	4.500	2.000	"	2.000	4.500	2.500	1.000	2	Ø
C	1.6 0.8	3.500	1.500	"	1.500	3.500	1.400	1.000	1	Ø

Fig. 7.14.27 CROSS DRAIN TYPE

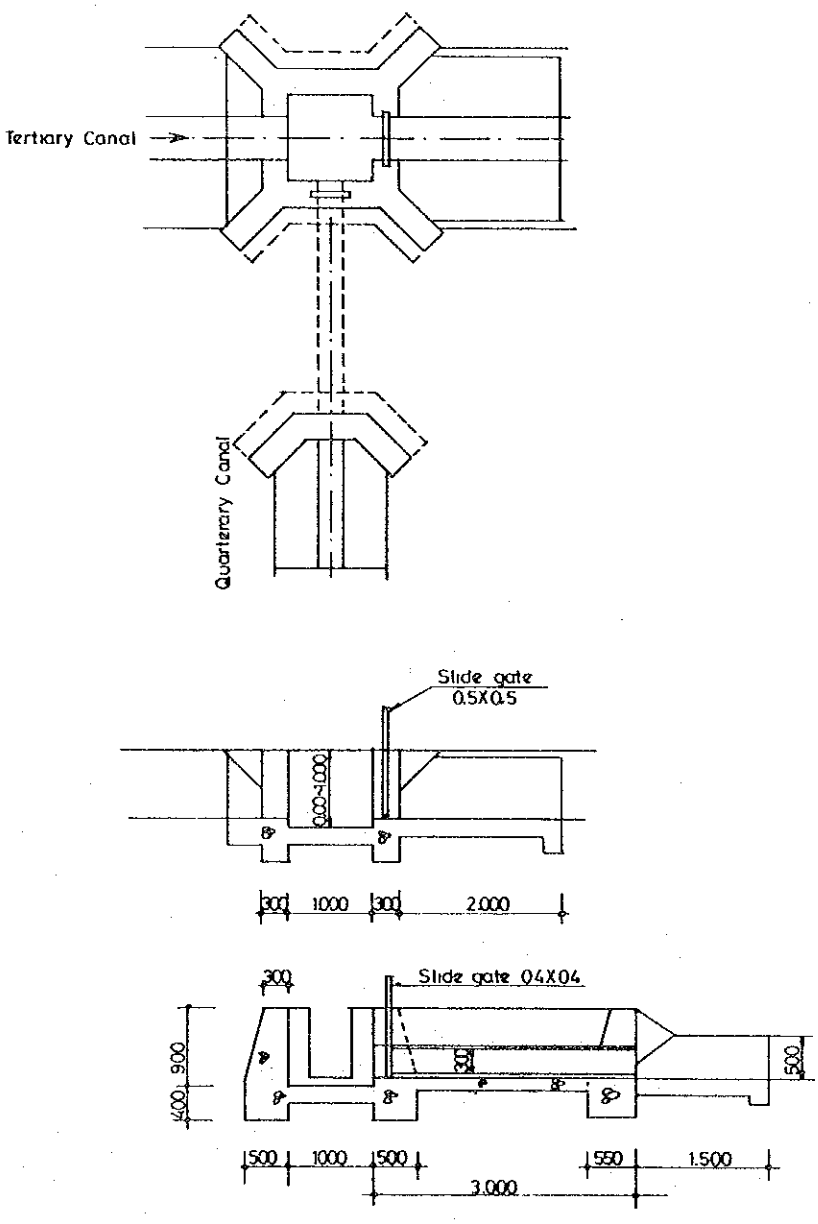


Fig.7.14.28 TERTIARY BOX

ANNEX 8

CONSTRUCTION PLAN AND COST ESTIMATE

ANNEX 8

8. Supporting Tables of Construction Plan and Cost Estimate for Flood Control Scheme

Supporting tables consist of tables for bill of quantities, major construction equipment, labour wages, unit price of material, percentage of foreign and domestic currency components on construction materials and unit costs for major works.

LIST OF TABLES

Table 8.1 CORRELATION COEFFICIENT TABLE

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nop.	Dec.
(1) K.Widas After Ngudikan Water													
Q	(m3/sec)	6.0	6.8	10.3	5.9	2.0	0.0	0.0	0.0	0.0	1.0	1.1	7.4
H	(m)	1.05	1.08	1.28	1.04	0.70	0.0	0.0	0.0	0.0	0.53	0.55	1.13
A	(m2)	9.5	10.0	13.3	9.4	5.0	0.0	0.0	0.0	0.0	2.6	3.0	10.9
V	(m/sec)	0.63	0.68	0.77	0.63	0.40	0.0	0.0	0.0	0.0	0.38	0.37	0.68
(2) K.Widas upstream from confluence with K. Kedungsoko													
Q	(m3/sec)	20.9	22.8	29.6	18.1	8.6	0.2	0.1	0.3	0.7	3.2	4.8	17.1
H	(m)	1.35	1.40	1.53	1.30	1.03	0.15	0.10	0.20	0.50	0.83	0.90	1.26
A	(m2)	25.0	27.0	32.0	23.0	12.0	0.8	0.4	0.9	2.0	6.0	8.0	22.0
V	(m/sec)	0.84	0.84	0.93	0.79	0.72	0.25	0.25	0.33	0.35	0.53	0.60	0.78
(3) K.Widas downstream													
Q	(m3/sec)	41.6	44.9	62.6	38.8	17.3	0.2	0.1	0.3	0.7	6.7	10.0	31.3
H	(m2)	1.65	1.83	1.95	1.62	1.25	0.15	0.10	0.20	0.50	0.98	1.08	1.55
A	(m2)	38.0	40.0	50.0	37.0	21.0	0.8	0.4	0.9	2.0	10.0	14.0	33.0
V	(m3/sec)	1.09	1.12	1.25	1.05	0.82	0.25	0.25	0.33	0.35	0.67	0.71	0.95
(4) K.Kuncir													
Q	(m3/sec)	1.1	1.2	3.3	2.0	1.4	0.0	0.0	0.0	0.0	0.6	0.2	0.7
H	(m)	0.65	0.68	1.00	0.80	0.73	0.0	0.0	0.0	0.0	0.40	0.15	0.55
A	(m2)	2.4	2.6	4.9	3.4	2.9	0.0	0.0	0.0	0.0	1.3	0.5	1.8
V	(m/sec)	0.46	0.46	0.67	0.59	0.48	0.0	0.0	0.0	0.46	0.40	0.40	0.39
(5) K. ULO													
Q	(m3/sec)	7.3	8.0	10.3	6.1	1.5	0.0	0.0	0.0	0.0	0.7	1.6	4.6
H	(m)	1.25	1.35	1.48	1.15	0.63	0.0	0.0	0.0	0.0	0.48	0.65	1.03
A	(m2)	9.8	10.4	12.2	8.9	3.5	0.0	0.0	0.0	0.0	2.1	3.7	7.6
V	(m /sec)	0.75	0.77	0.84	0.69	0.43	0.0	0.0	0.0	0.0	0.33	.43	0.61
(6) K. Kedungsoko upstream from confluence with K. Kuncir													
Q	(m3 / sec)	12.3	12.9	19.4	12.8	5.8	0.0	0.0	0.0	0.0	2.2	3.4	8.9
H	(m)	1.25	1.28	1.55	1.27	0.92	0.0	0.0	0.0	0.0	0.63	0.75	1.10
A	(m2)	15.2	16.0	22.0	16.0	9.2	0.0	0.0	0.0	0.0	4.8	6.4	12.2
V	(m/s)	0.81	0.81	0.88	0.80	0.63	0.0	0.0	0.0	0.0	0.46	0.53	0.73
(7) K. Kedungsoko (K.Kuncir - K. Ulo)													
Q	(m3/sec)	13.4	14.1	22.7	14.8	7.2	0.0	0.0	0.0	0.0	2.8	3.6	9.6
H	(m)	1.30	1.33	1.65	1.35	1.00	0.0	0.0	0.0	0.0	0.68	0.75	1.13
A	(m2)	16.6	17.4	24.2	18.0	10.4	0.0	0.0	0.0	0.0	5.8	6.8	13.0
V	(m/sec)	0.81	0.81	0.94	0.82	0.69	0.0	0.0	0.0	0.0	0.48	0.53	0.74
(8) K. Kedungsoko (K.Ulo - K.Widas)													
Q	(m3/sec)	20.7	22.1	33.0	20.7	8.7	0.0	0.0	0.0	0.0	3.5	5.2	14.2
H	(m)	1.60	1.64	1.98	1.60	1.08	0.0	.0	0.0	0.0	0.80	0.88	1.35
A	(m2)	23.0	24.0	31.4	23.0	12.0	0.0	0.0	.0	0.0	6.8	8.6	17.5
V	(m/sec)	0.90	0.92	1.05	0.90	0.73	0.0	0.0	0.0	0.0	0.51	0.60	0.81

Note: Mean average last 10 years 1975 - 1984.

Table 8.2 COMPREHENSIVE LOWER WIDAS (1/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Dredging in LWC	m^3	1,390,000	1.158	1,609,620	0.164	227,960	746	1,036,940	3,058,278
Excavation in HWC		2,223,000	0.513	1,140,399	0.108	240,084	272	604,656	2,123,187.3
Embank. - Newly		557,000	1.004	559,228	0.5	278,500	786	437,802	1,359,302.8
- Heightening		70,000	0.904	63,280	0.45	31,500	707	49,490	153,748
- Backlevee		89,000	0.904	80,456	0.45	40,050	707	62,923	195,479.6
Disposal - Old Channel		1,176,000	0.798	938,448	0.223	262,248	457	537,432	1,858,197.6
- Reclamation		331,000	0.544	180,064	0.233	77,123	370	122,470	405,375.7
Bank Protection - W.M	m^2	42,700			2.373	101,327	10,083	430,544	542,003.7
- Gabion		42,700			6.988	298,388	16,101	687,513	1,015,739.8
Bridge		.	69,168	69,168	728,062	728,062	1.031556E+09	1,031,556	1,908,509
- Provincial (1)									
- Rural (2)									
- Foot Path (3)									
Culvert - I	Nos	3	3,799	11,397	12,472	37,416	19,683,000	59,049	112,743.3
- II		3	5,807	17,421	30,742	92,226	40,149,000	120,447	241,058.7
D. Sluice in Retarding Basin		1	29,382	29,382	321,380	321,380	297,179,000	297,179	683,017.2
Side Overflow Dike		800	23.7	18,960	397.7	318,160	747,200	597,760	968,592
Collector Drain	m	154,000	1.237	190,498	0.175	26,950	796	122,584	361,776.8
Dike of Al Canal		184,000	0.904	166,336	0.45	82,800	707	130,088	404,137.6
Total				5,074,657		3,164,174		6,328,433	15,391,147.1

Table 8.2 COMPREHENSIVE KEDUNGSOKO (2/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$				Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Dredging in LWC	m^3	813,000	1.237	1,005,681	0.175	142,275	796	647,148	1,909,899.6
Excavation in HWC		376,000	0.513	192,888	0.108	40,608	272	102,272	359,117.6
Embank. - Newly		105,000	1.004	105,420	0.5	52,500	786	82,530	256,242
- Heightening		109,000	0.904	98,536	0.45	49,050	707	77,063	239,407.6
Disposal - Old Channel		130,000	0.798	103,740	0.223	28,990	457	59,410	205,413
- Reclamation		32,000	0.544	17,408	0.233	7,456	370	11,840	39,190.4
Bank Protection - W.M	m^2	6,100			2.373	14,475	10,083	61,506	77,428.5
- Gabion		6,100			6.988	42,627	16,101	98,216	145,105.7
Bridge - National	m	1	43,816	43,816	322,394	322,394	502,309,000	502,309	905,140
- Rural (2)									
- Railway Protection (1)									
Culvert	Nos	3	5,807	17,421	30,742	92,226	40,149,000	120,447	241,058.7
D. Sluice in Retarding Basin	L.S	3	34,852	34,852	263,999	263,999	303,708,000	303,708	632,444.1
Side Overflow Dike	m	720	23.7	17,064	397.7	286,344	747,200	537,984	871,732.8
Irrigation Headwork	Nos	1	18,104	18,104	615,640	615,640	541,212,000	541,212	1,238,330.4
Collector Drain	m	24,000	1.237	29,688	0.175	4,200	796	19,104	56,380.8
Total				1,684,618		1,962,784		3,164,749	7,176,891.2

Table 8.2 COMPREHENSIVE KUNCIR (3/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Excavation in HWC	m^3	228,000	0.513	116,964	0.108	24,624	272	62,016	217,762.8
Embank. - Newly		208,000	1.004	208,832	0.5	104,000	786	163,488	507,603.2
- Backlevee		26,000	0.904	23,504	0.45	11,700	707	18,382	57,106.4
Disposal Reclamation		54,000	0.544	29,376	0.233	12,582	370	19,980	66,133.8
Bank Protection - W.M	m^2	7,900			2.373	18,747	10,083	79,656	100,277.7
- Gabion		7,900			6.988	55,205	16,101	127,198	187,923.5
Bridge			60,226	60,226	291,315	291,315	453,849,000	453,849	840,544.1
- Provincial (3)									
- Rural (3)									
- Foot Path (1)									
Culvert - I	Nos	5	3,799	18,995	12,472	62,360	19,683,000	98,415	187,905.5
- II		1	5,807	5,807	30,742	30,742	40,149,000	40,149	80,352.9
- III		1	6,330	6,330	44,841	44,841	57,814,000	57,814	114,102.1
Intake Sluice		1	3,799	3,799	15,685	15,685	20,098,000	20,098	41,530.4
Syphone		1		32,582		62,417		95,791	200,289.9
Irrigation Headwork		2	31,795	31,795	445,499	445,499	461,997,000	461,997	987,020.4
Total				538,210		1,179,717		1,698,833	3,588,552.7

Table 8.2 COMPREHENSIVE UPPER URO RIVER (4/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp)	Amount (Rp. 10^3)	
Excavation in HWC	m^3	300,000	0.513	153,900	0.108	32,400	272	81,600	286,530
Embank. - Newly		112,000	1.004	112,448	0.5	56,000	786	88,032	273,324.8
- Heightening		4,000	0.904	3,616	0.45	1,800	707	2,828	8,785.6
- Backlevee		34,000	0.904	30,736	0.45	15,300	707	24,038	74,677.6
Disposal - Old Channel		51,000	0.798	40,698	0.223	11,373	457	23,307	80,585.1
- Reclamation		99,000	0.544	53,856	0.233	23,067	370	36,630	121,245.3
Bank Protection - W.M	m^2	15,400			2.373	36,544	10,083	155,278	195,476.4
- Gabion		15,400			6.988	107,615	16,101	247,955	366,331.5
Bridge			35,177	35,177	283,894	283,894	428,406,000	428,406	779,384.1
- Provincial (2)									
- Rural (2)									
Inatke Sluice	Nos	1	3,799	3,799	15,685	15,685	20,098,000	20,098	41,530.4
Diversion Weir		1	110,954	110,954	266,723	266,723	393,100	393	415,837.7
Irrigation Headwork		1	35,112	35,112	394,229	394,229	393,919,000	393,919	866,194.1
Total				580,296		1,244,630		1,502,485	3,509,903.6

Table 8.2 COMPREHENSIVE UPPER WIDAS & LOWER ULO (5/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Dredging in LWC	m^3	963,000	1.158	1,115,154	0.164	157,952	746	718,398	2,118,841.6
Excavation in HWC		815,000	0.513	418,095	0.108	88,020	272	221,680	778,406.5
Embank. - Newly		239,000	1.004	239,956	0.5	119,500	786	187,854	583,255.6
- Backlevee		100,000	0.904	90,400	0.45	45,000	707	70,700	219,640
Disposal - Old Channel		370,000	0.798	295,260	0.223	82,510	457	169,090	584,637
- Reclamation		106,000	0.544	57,664	0.233	24,698	370	39,220	129,818.2
Bank Protection - W. M	m^2	9,900			2.373	23,493	10,083	99,822	125,664.3
- Gabion		9,900			6.988	69,181	16,101	159,400	235,499.1
Bridge			73,198	73,198	712,411	712,411		1,361,661	2,225,830.9
- Rural (8)									
Culvert - I	Nos	2	3,799	7,598	12,472	24,944	19,683,000	39,366	75,162.2
- II		2	5,807	11,614	30,742	61,484	40,149,000	80,298	160,705.8
Intake Sluice		1	3,799	3,799	15,685	15,685	20,098,000	20,098	41,530.4
Syphone		1	27,161	27,161	55,969	55,969	80,329,000	80,329	171,772
Drop		1	7,357	7,357	6,636	6,636	18,693,000	18,693	34,085.3
Side Overflow Dike		550	23.7	13,035	397.7	218,735	747,200	410,960	665,907
Collector Drain	m	16,000	1.237	19,792	0.175	2,800	796	12,736	37,587.2
Total				2,380,083		1,708,998		3,690,305	8,188,294.1

Table 8.2 COMPREHENSIVE FLOOD DIVERSION CHANNEL (6/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	Rp. 10^3
Excavation in HWC	m^3	276,000	0.513	141,588	0.108	29,808	272	75,072	263,607.6
Embank. - Newly		19,000	1.004	19,076	0.5	9,500	786	14,934	46,367.6
Disposal - Reclamation		257,000	0.544	139,808	0.233	59,881	370	95,090	314,747.9
Bank Protection - W.M	m^2	26,000			2.373	61,698	10,083	262,158	330,025.8
- Gabion		4,500			6.988	31,446	16,101	72,455	107,045.6
Bridge - National		1	61,781	61,781	702,338	702,338	634,644,000	634,644	1,475,174.9
- Rural		4							
- Railway Newly		1							
Culvert	Nos	4	3,799	15,196	12,472	49,888	19,683,000	78,732	150,324.4
Syphone		2	72,860	72,860	132,736	132,736	211,137	211	226,366.6
Drop		1	7,357	7,357	6,636	6,636	18,693,000	18,693	34,085.3
Total				457,666		1,083,931		1,251,989	2,947,745.7

Table 8.2 1ST STAGE LOWER WIDAS (1/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (RP. 10^3)	
Dredging in LWC	m^3	1,208,000	1.158	1,398,864	0.164	198,112	746	901,168	2,657,841.6
Excavation in HWC		1,932,000	0.513	991,116	0.108	208,656	272	525,504	1,845,253.2
Embank. - Newly		557,000	1.004	559,228	0.5	278,500	786	437,802	1,359,302.8
- Heightening		70,000	0.904	63,280	0.45	31,500	707	49,490	153,748
- Backlevee		89,000	0.904	80,456	0.45	40,050	707	62,923	195,479.6
Disposal - Old Channel		1,176,000	0.798	938,448	0.223	262,248	457	537,432	1,858,197.6
- Reclamation		40,000	0.544	21,760	0.233	9,320	370	14,800	48,988
Bank Protection - W.M	m^2	8,600			2.373	20,408	10,083	86,714	109,162.8
- Gabion		8,600			6.988	60,097	16,101	138,469	204,575.7
Bridge			69,168	69,168	728,062	728,062		1,031,556	1,908,509
- Provincial (1)									
- Rural (2)									
- Foot Path (3)									
Culvert - I	Nos	4	3,799	15,196	12,472	49,888	19,683,000	78,732	150,324.4
- II		3	5,807	17,421	30,742	92,226	40,149,000	120,447	241,058.7
D. Sluice in Retarding Basin		1	29,382	29,382	321,380	321,380	297,179,000	297,179	683,017.2
Side Overflow Dike	m	800	23.7	18,960	397.7	318,160	747,200	597,760	968,592
Collector Drain		154,000	1.237	190,498	0.175	26,950	796	122,584	361,776.8
Dike of Al Canal		184,000	0.904	166,336	0.45	82,800	707	130,088	404,137.6
Total				4,560,113		2,728,357		5,132,647	13,149,964

Table 8.2 1ST STAGE KEDUNGSOKO (2/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Dredging in LWC	m^3	708,000	1.237	875,796	0.175	123,900	796	563,568	1,663,233.6
Excavation in HWC		328,000	0.513	168,264	0.108	35,424	272	89,216	313,272.8
Embank. - Newly		105,000	1.004	105,420	0.5	52,500	786	82,530	256,242
- Heightening		109,000	0.904	98,536	0.45	49,050	707	77,063	239,407.6
Disposal - Old Channel		130,000	0.798	103,740	0.223	28,990	457	59,410	205,413
- Reclamation		16,000	0.544	8,704	0.233	3,728	370	5,920	19,595.2
Bank Protection - W.M	m^2	1,200			2.375	2,848	10,083	12,100	15,232.8
- Gabion		1,200			6.988	8,386	16,101	19,321	28,545.6
Bridge - National		1	43,816	43,816	322,394	322,394	502,309,000	502,309	905,140
- Rual (2)									
Railway Protection (1)									
Culvert	Nos	3	5,807	17,421	30,742	92,226	40,149,000	120,447	241,058.7
D. Sluice in Retarding Basin	L.S.	3	34,852	34,852	263,999	263,999	303,708,000	303,708	632,444.1
Side Overflow Dike	m	720	23.7	17,064	397.7	286,344	747,200	537,984	871,732.8
Irrigation Headwork	Nos	1	18,104	18,104	615,640	615,640	541,212,000	541,212	1,238,330.4
Collector Drain	m	24,000	1.237	29,688	0.175	4,200	796	19,104	56,380.8
Total				1,521,405		1,889,628		2,933,892	6,686,028.3

Table 8.2 1ST STAGE KUNCIR (3/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Excavation in HWC	m^3	164,000	0.513	84,132	0.108	17,712	712	44,608	156,636.4
Embank. - Newly		208,000	1.004	208,832	0.5	104,000	786	163,488	507,603.2
- Backlevee		26,000	0.904	23,504	0.45	11,700	707	18,382	57,106.4
Disposal Reclamation		70,000	0.544	38,080	0.233	16,310	370	25,900	85,729.0
Bank Protection - W.M	m^2	1,600			2.373	3,797	10,083	16,133	20,309.7
- Gabion		1,600			6.988	11,181	16,101	25,762	38,061.1
Bridge			60,226	60,226	291,315	291,315	453,849,000	453,849	840,544.1
- Provincial (3)									
- Rural (3)									
- Foot Path (1)									
Culvert - I	Nos	5	3,799	18,995	12,472	62,360	19,683,000	98,415	187,905.5
- II		1	5,807	5,807	30,742	30,742	40,149,000	40,149	80,352.9
- III		1	6,330	6,330	44,841	44,841	57,814,000	57,814	114,102.1
Intake Sluice		1	3,799	3,799	15,685	15,685	20,098,000	20,098	41,530.4
Syphone		1		32,582		62,417		95,791	200,289.9
Irrigation Headwork		2	31,795	31,795	514,082	445,499	461,997,000	461,997	987,020.4
Total						1,117,559		1,522,386	3,317,191.1

Table 8.2 1ST STAGE UPPER URO RIVER (4/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$				Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Excavation in HWC	m^3	248,000	0.513	127,224	0.108	26,784	272	67,456	236,864.8
Embank. - Newly		112,000	1.004	112,448	0.5	56,000	786	88,032	273,324.8
- Heightening		4,000	0.904	3,616	0.45	1,800	707	2,828	8,785.6
- Backlevee		34,000	0.904	30,736	0.45	15,300	707	24,038	74,677.6
Disposal - Old Channel		51,000	0.798	40,698	0.223	11,373	457	23,307	80,585.1
- Reclamation		47,000	0.544	25,568	0.233	10,951	370	17,390	57,560.9
Bank Protection - W.M	m^2	14,500			2.373	34,409	10,083	146,204	184,053.9
- Gabion		3,600			6.988	25,157	16,101	57,964	85,636.7
Bridge			35,177	35,177	283,894	283,894	428,406,000	428,406	779,384.1
- Provincial (2)									
- Rural (2)									
Intake Sluice	Nos	1	3,799	3,799	15,685	15,685	20,098,000	20,098	41,530.4
Diversion Weir		1	110,954	110,954	266,723	266,723	393,100	393	415,837.7
Irrigation Headwork		1	35,112	35,112	394,229	394,229	393,919,000	393,919	866,194.1
Total				525,332		1,142,304		1,270,034	3,104,433.6

Table 8.2 1ST STAGE UPPER WIDAS & LOWER ULO (5/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$				Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Dredging in LWC	m^3	877,000	1.158	1,015,566	0.164	143,828	746	654,242	1,929,575.4
Excavation in HWC		724,000	0.513	371,412	0.108	78,192	272	196,928	691,492.4
Embank. - Newly		239,000	1.004	239,956	0.5	119,500	786	187,854	583,255.6
- Backlevee		100,000	0.904	90,400	0.45	45,000	707	70,700	219,640
Disposal - Old Channel		370,000	0.798	295,260	0.223	82,510	457	169,090	584,637
- Reclamation		15,000	0.544	8,160	0.233	3,495	370	5,550	18,370.5
Bank Protection - W.M	m^2	2,000			2.373	4,746	10,083	20,166	25,386.6
- Gabion		2,000			6.988	13,976	16,101	32,202	47,575.6
Bridge			73,198	73,198	712,411	712,411		1,361,661	2,225,830.9
- Rural (8)									
Culvert - I	Nos	2	3,799	7,598	12,472	24,944	19,683,000	39,366	75,162.2
- II		2	5,807	11,614	30,742	61,484	40,149,000	80,298	160,705.8
Intake Sluice		1	3,799	3,799	15,685	15,685	20,098,000	20,098	41,530.4
Syphone		1	27,161	27,161	55,969	55,969	80,329,000	80,329	171,772
Drop		1	7,357	7,357	6,636	6,636	18,693,000	18,693	34,085.3
Side Overflow Dike		550	23.7	13,035	397.7	218,735	747,200	410,960	665,907
Collector Drain	m	16,000	1.237	19,792	0.175	2,800	796	12,736	37,587.2
Total				2,184,308		1,589,911		3,360,873	7,512,513.9

Table 8.2 1ST STAGE FLOOD DIVERSION CHANNEL (6/6)

Work Item	Unit	Quantity	Foreign Component US$		Indirect Foreign US$		Domestic		Total Rp. 10^3
			Unit Cost	Amount	Unit Cost	Amount	Unit Cost (Rp.)	Amount (Rp. 10^3)	
Excavation in HWC	m^3	250,000	0.513	128,250	0.108	27,000	272	68,000	238,775
Embank. - Newly		19,000	1.004	19,076	0.5	9,500	786	14,934	46,367.6
Disposal - Reclamation		231,000	0.544	125,664	0.223	53,823	370	85,470	282,905.7
Bank Protection - W.M	m^2	26,000			2.373	61,698	10,083	262,158	330,025.8
- Gabion		1,800			6.988	12,578	16,101	28,982	42,817.8
Bridge - National		1	61,781	61,781	702,338	702,338	634,644,000	634,644	1,475,174.9
- Rural		4							
- Railway Newly		1							
Culvert	Nos	4	3,799	15,196	12,472	49,888	19,683,000	78,732	150,324.4
Syphone		2	72,860	72,860	132,736	132,736	211,137	211	226,366.6
Drop		1	7,357	7,357	6,636	6,636	18,693,000	18,693	34,085.3
Total				430,184		1,056,197		1,191,824	2,826,843.1

Table 8.4 LIST OF MAJOR EQUIPMENT FOR FLOOD CONTROL SCHEME

No.	Description	Capacity	Quantity
1.	Cutter suction dredger	500 PS	2
2.	Amphibious excavator , w/dragline	0.4 m^2	2
3.	Swamp back hoe, long arm	0.4 m^3	5
4.	Bulldozer w/ripper	20 t	4
5.	Bulldozer	11 t	8
6.	Swamp bulldozer	20 t	12
7.	Swamp bulldozer	13 t	10
8.	Swamp bulldozer	7 t	5
9.	Tractor shovel	1.5 m^3	11
10.	Tractor shovel	1.0 m^3	5
11.	Tractor shovel	0.6 m^3	3
12.	Tractor shovel	0.4 m^3	3
13.	Back hoe w/vibro pile driver of 3 sets	0.6 m^3	11
14.	Back hoe, swamp	0.3 m^3	5
15.	Dump truct	8 t	50
16.	Dump truck	6 t	20
17.	Tamping roller	20 t	1
18.	Road roller	8 t	4
19.	Vibration roller	2.5 t	6
20.	Vibro hammer	22 kw	4
21.	Vibro hammer	30 kw	3
22.	Pile hammer w/leader	2.5 t	4
23.	Crawler crane	20 t	4
24.	Crawler crane	27 t	3
25.	Diesel generator	100 kvA	3
26.	Diesel generator	50 kvA	4
27.	Diesel generator	30 kvA	7
28.	Diesel generator	10 kvA	2
29.	Truck crane	20 t	3
30.	Ordinary w/crane	6 t	5
31.	Motor grader	3.1 m	3
32.	Pneumatic breaker	20 kg	15
33.	Port-air compressor	7 m^3/min	3
34.	Port- concrete mixer	0.5 m^3	10
35.	Port concrete mixer	0.3 m^3	15
36.	Water tanker	8 t	5
37.	Fuel tamber	8 t	5
38.	Grease car	8 t	3
39.	Mobile work shop	8 t	3
40.	Welder	270 A	6
41.	Asphalt sprayer	200 l	2
42.	Asphalt finisher	2.4 m	2
43.	Volute pump	4" ø	6
44.	Submersible pump	4" ø	10
45.	Anchor barge	40 PS	2
46.	Tractor & trailer	30 l	1

Table 8.5 LABOUR WAGES

	Item	Unit	Unit Price (Rp) (7 hours per day)
1.	Foreman - A 1/	M/D	6,000
2.	" - B 2/	"	5,000
3.	Skilled labour	"	3,500
4.	Unskilled labour	"	2,500
5.	Operator, skilled	"	4,500
6.	Assistant operator	"	3,500
7.	Driver	"	3,500
8.	Assistant driver	"	2,750
9.	Mechanic, skilled	"	5,000
10.	" , semi-skilled	"	3,500
11.	Electrician	"	4,500
12.	Welder	"	3,500
13.	Mason/Brick Worker	"	3,250
14.	Steel bar worker	"	3,500
15.	Carpenter	"	3,500
16.	Painter	"	3,250
17.	Plasterer	"	3,250
18.	Concrete worker	"	3,250
19.	Crew for dredger	"	4,000
20.	Road const. crew	"	3,250
21.	Surveyor	"	3,500
22.	Watchman	"	2,500
23.	Coordinator	"	4,000
24.	Laboratory Staff	"	4,000
25.	Rigger	"	3,000
26.	Boring/Grout worker	"	3,500
27.	Tunnel worker	"	4,000
28.	Technical guidance 3/	M/D	130 US$

Notes; 1/ : Skilled, 15 years or more experienced
2/ : Semi-skilled, 10 - 15 years experienced
3/ : Skilled, foreigner