APPENDIX-H

TABLES

Table H.1 EXISTING WATER RIGHTS IN THE BASIN (1/2)

Ser. No.	Reg. No.	Grantee	Water Source	Purpose	Extract Water(m3/s)	Remarks
1	3564	The Procura,the Holy Fathers	Bigwa R.	Dom/Irr	0.00329	
2	338	Karimjee Jivanjee Estate	Brama L./Soga	Dom/Ind	0.00288	Water impounded
3	337	Karimjee Jivanjee Estate	Factory L./Soga	Dom/Ind	0.00360	Water impounded
4	336	Karimjee Jivanjee Estate	Hippo L./Soga	Dom/Ind	0.00086	Water impounded
5	1417	P.S. Ministry of Agriculture	Kihonde R.	Dom/Irr	0.00708	
6	1418	P.S. Ministry of Agriculture	Kikundi R.	Dom/Irr	0.01416	
7	1477	Morogoro Native Auth. Coun.	Kikundi Stream	Dom	0.00005	
8	1494	Mafiga Sisal Estate Ltd.	Kikundi Stream	Dom	0.00058	
9	1489	National Lutheran Council	Kinyanduni R.	Dom	0.00003	
10	3335	Fatehali K. Ramji	Kiroka R.	Dom/Irr	0.00160	
11	964	J.W.T. Holloway	Kivungwi Spr.	Dom/Liv.	whole	
12	242	Karimjee Jivanjee Estate	Lake Soga	Dom/Ind	0.00842	
13	4868	Wilson M.Karuwesa	Lukuyu R.	Dom/Irr/Liv	(0.0123)	Expire Mar.'92
14	3563	The Procura,the Holy Fathers	Mahangazi R.	Dom/Ind	0.00263	
15	138	Tanzania Sisal Corp.	Mbiki R.	Ind.	0.00362	
16	2912	Tanzania Sisal Corp.	Mbiki R.	Ind.	0.00079	Dam
17		Chairman Mlali/Kipera/Melela Vg.	Mgera R.	Dom	0.00700	
18	3301	Morogoro Native Auth. Coun.	Mgera R.	All purpose	0.02832	
19	4602	Taj Mohamed	Mgera R.	Dom/Ind/Liv	0.00788	
20	931	The Procura,the Holy Fathers	Mgeta R.	Dom	0.00016	
21	3333	Edward Seitz	Mgeta R.	Dom/Irr	0.14269	
22	3562	The Procura,the Holy Fathers	Mgeta R.	Dom/Irr	0.00526	Mgeta Total (m3/s)
23	3962	Edward Seitz	Mgeta R.	Dom/Irr	0.14269	0.334
24	1613	Morogoro Native Auth. Coun.	Mgolole R.	Dom	0.00210	
25	4299	E.L.C.T. Arusha	Mgolole R.	Dom	0.00158	
26	4691	Principal Morogoro CNE	Mgolole R.	Dom	0.01911	
27	4701	Regional Dev. Director	Mgolole R.	Fishery	(0.2170)	Expire Apr.'85
28	4828	Bigwa Folk Dev.Colledge	Mgolole R.	Dom/Irr/Liv	0.00500	Mgolole Total (m3/s)
29	4553	Deocese of Morogoro	Mgololo R.	Ind/Liv	0.00132	0.029
30	**4714**	**P.S. Water & Energy**	**Mindu Dam**	**Dom/Ind**	**(0.3009)**	**Expire Dec.'84**
31	1419	P.S. Agriculture	Mlali R.	Dom/Irr	0.00708	
32	2729	Morogoro Dist.Council	Mlali R.	Dom	0.00105	Mlali Total (m3/s)
33	3581	Morogoro Dist.Council	Mlali R.	Irr	0.14160	0.150
34	2028	Mwananchi Sisal Estate Ltd.	Morogoro R.	Dom/Ind	0.00368	
35	**3502**	**Provincial Agric. Officer**	**Morogoro R.**	**Irr**	**0.01421**	
36	**3503**	**Provincial Agric. Officer**	**Morogoro R.**	**Irr**	**0.21309**	
37	3527	Distr.Eng., EAR&H	Morogoro R.	Dom/Railway	0.00474	Morogoro Total (m3/s)
38	3545	Provincial Eng. P.W.D.	Morogoro R.	Dom	0.05262	0.288
39	1024	Ruvu Valley Sugar Co.,Ltd.	Msumbiji R.	Dom/Liv/Irr	0.29028	
40	3298	Morogoro Native Auth. Coun.	Mzinga R.	Dom	0.00284	
41	3299	Morogoro Native Auth. Coun.	Mzinga R.	Dom/Irr	0.01421	
42	2850	Chief of Defenceforces(TPDF Mainga)	Mzinga stream	Dom/Ind	0.01368	Mzinga Total (m3/s)
43	3623	Morogoro Native Auth. Coun.	Mzinga/Mindu R.	Dom/Irr	0.02841	0.059
44	3302	Morogoro Native Auth. Coun.	Ngadangi R.	Dom/Irr	0.00284	

Table H.1 EXISTING WATER RIGHTS IN THE BASIN (2/2)

Ser. No.	Reg. No.	Grantee	Water Source	Purpose	Extract Water(m3/s)	Remarks
45	327	Karimjee Jivanjee Estate	Ngerengere R.	Dom/Ind	0.00758	
46	328	Karimjee Jivanjee Estate	Ngerengere R.	Ind	0.57877	to impound
47	498	Commissoner of Prisons	Ngerengere R.	Dom	0.00263	
48	644	Liverpool Uganda Co.,Ltd.	Ngerengere R.	Dom/Ind	0.00053	
49	926	Amatouglu Sisal Estate Ltd.	Ngerengere R.	Dom/Ind	0.00347	
50	982	Kihonda Sisal Estate Ltd.	Ngerengere R.	Dom/Ind	0.00526	
51	1025	George Stylianos	Ngerengere R.	Irr/Liv	0.00047	
52	1486	NACO Ltd.	Ngerengere R.	Dom	0.00053	
53	1487	NACO Ltd.	Ngerengere R.	Dom/Liv	0.00684	
54	1953	Masimba Sisal Estate Ltd.	Ngerengere R.	Dom	0.00526	
55	2293	Tanzania Sisal Cooporation	Ngerengere R.	Ind	0.00526	
56	2999	PS Water Dev. & P(TPDF Ngerengere)	Ngerengere R.	Dom	0.03738	upto Jul.'77
57	3222	Tanzania Sisal Cooporation	Ngerengere R.	Dom/Ind	0.00631	
58	3223	Tanzania Sisal Cooporation	Ngerengere R.	Dom/Ind	0.00758	
59	3236	Asgerali Akberali	Ngerengere R.	Dom/Ind	0.00168	
60	3347	Afentakis Estate Ltd.	Ngerengere R.	Dom/Ind	0.00053	
61	3505	Mafiga Estate Ltd.	Ngerengere R.	Dom/Ind	0.00631	
62	3507	Commissoner of Prisons	Ngerengere R.	Dom/Liv	0.00395	
63	3508	Droungas Sisal Estate Ltd.	Ngerengere R.	Dom/Ind	0.00631	
64	3509	Lukosee Estate Ltd.	Ngerengere R.	Dom/Ind	0.00063	
65	3512	Fazal Kassani Mills Ltd.	Ngerengere R.	Dom/Ind	0.00379	
66	3512	Kizuka Sisal Estate Ltd.	Ngerengere R.	Dom/Ind	0.00631	
67	3513	Commissoner of Prisons	Ngerengere R.	Dom/Ind/Liv	0.00342	
68	3536	Tungi Ltd.	Ngerengere R.	Dom/Ind	0.00991	
69	3546	Distr.Eng., EAR&H	Ngerengere R.	Dom/Ind	0.00210	
70	3550	Fazal Kassani Mills Ltd.	Ngerengere R.	Dom/Irr	0.03552	Ngere. Total (m3/s)
71	4007	Tanzania Pipelines Ltd.	Ngerengere R.	Dom/Ind	0.00053	0.764
72	4426	Tanzania Leather Ass. Indust.	Ngerengere R.	Dom/Ind	0.00525	
73	4585	Chief of Defenceforce	Ngerengere R.	Dom/Ind	(1.2000)	expire Dec.'?????
74	4609	Tanzania Leather Ass. Indust.	Ngerengere R.	Ind	0.00525	provisional
75	4709	Principal ID M. Mzumbe	Ngerengere R.	Dom/Ind	0.00423	
76	4859	A.N.C. Mazibabu	Ngerengere R.	Irr	(0.0167)	Expire Mar.'92
77	4883	Register SUA	Ngerengere R.	Irr	0.00007	differred Dec.'92
78	3297	Morogoro Native Auth. Coun.	Nyambuywa R.	Dom/Irr	0.01421	
79	172	H.Kumbruch	Pangani Dam	Dom/Ind	0.00852	Water impounded
80	4851	Charles A.Mrema	Pangwa Spr.	Dom	0.00002	under process
81	3237	Tanzania Sisal Cooporation	Pangwe Spr.	Dom	0.00090	
82	3300	Morogoro Native Auth. Coun.	Parambili Dam	Dom/Ind	0.52616	to impound
83	195	Ruvu Sisal Estate Ltd.	Ruvu R.	Dom/Ind	0.00532	
84	196	Ruvu Sisal Estate Ltd.	Ruvu R.	Dom/Ind	0.00477	
85	609	Chhtlar Shivramvyas & VKB	Ruvu R.	Dom/Irr	0.00326	
86	**797**	**DG.NUWA (Upper)**	**Ruvu R.**	**Dom/Ind**	**3.15694**	**Dar es Salaam W/S**
87	798	Chow Hsien	Ruvu R.	Dom/Irr	0.00326	
88	966	JWT Holloway	Ruvu R.	Dom/Liv/Irr/Ind	0.17100	
89	1012	H.Kumbruch	Ruvu R.	Irr	0.11328	
90	1023	Ruvu Valley Sugar Co.,Ltd.	Ruvu R.	Dom/Irr/Ind	0.43188	
91	1036	Director National Service	Ruvu R.	Irr	0.84960	provisional
92	1653	Native authority	Ruvu R.	Dom	0.00005	
93	1721	NACO Ltd.	Ruvu R.	Dom/Liv.	0.00063	
94	1895	General Manager EAR&H	Ruvu R.	Ind	0.00105	
95	**2427**	**DG.NUWA (Lower)**	**Ruvu R.**	**Dom/Ind**	**1.05231**	**Dar es Salaam W/S**
96	2441	General Manager EAR&H	Ruvu R.	Dom/Ind	0.00526	
97	2877	Bagamoyo Dist. Council	Ruvu R.	Dom/Liv.	0.00368	
98	2897	Director Production Kilimo	Ruvu R.	Irr	0.01841	
99	2900	Director Production Kilimo	Ruvu R.	Dom/Liv.	0.00342	
100	4433	Tanzania Zambia R/way Auht.	Ruvu R.	Dom/Ind	0.00272	
101	4449	DDD. Bagamoyo	Ruvu R.	Irr	0.08496	
102	4700	DR Sugarcane breeding Sta. Kibaha	Ruvu R.	Dom/Irr/Ind	0.05675	Ruvu Total (m3/s)
103	4805	United Farming Co.,Ltd.	Ruvu R.	Dom/Irr	0.89422	6.863
104	3571	The Procura,the Holy Fathers	Spr.near Mgeta R.	Dom/Irr	0.00142	
105	225	Karimjee Jivanjee Estate	Swamp A/Soga	Dom/Ind	0.00086	Water impounded
106	339	Karimjee Jivanjee Estate	Swamp B/Soga	Dom/Ind	0.00086	Water impounded
107	340	Karimjee Jivanjee Estate	Tanganyika L./Sog	Dom/Ind	0.00144	Water impounded
108	341	Karimjee Jivanjee Estate	Tanganyika L./Sog	Dom/Ind	0.00144	Water impounded
109		The Procura,the Holy Fathers	Tangeni R.	Dom/Irr	0.00053	
110	3331	Principal ID M. Mzumbe	Tangeni R.	Dom	0.00921	Tangeni Total (m3/s)
111	4570	The Procura,the Holy Fathers	Tangeni R.	Dom/Irr	0.00011	0.010
112	3528	Morogoro Town Council	Trib. Kiarakala R.	Irr	0.00005	
113	3338	Tom Henshaw	un-named stream	Dom/Irr	0.00011	transf.from No.955
114	3549	Mica Mining Ltd.	Vikwere Stream	Dom	0.00003	
115	4855	G.Sambetakis	Well near N/R.	Dom/Irr	0.00005	
					9.39545	296,294,777

Table H.2 SUMMARY OF WATER EXTRACTION FROM RIVERS

Source of Water	No. of Water Rights	Abstruction Amount (m3/s)
Ruvu River(direct)	21	6.863
Ngerengere River	34	0.764
Mgeta River	6	0.334
Other Tributaries	41	0.879
Small Ponds	9	0.555
Spring	3	0.001
Well/boreholes	1	0.001
Total	115	9.397

Table H.3 SUMMARY OF WATER USES

Purpose	No. of Water Rights	Abstruction Amount (m3/s)	Weight (%)
Domestic(main)	25	5.035	53.6
NUWA Upper Ruvu		1.052	11.2
NUWA Lower Ruvu		3.157	33.6
Mindu Dam(Morogoro)		0.301	3.2
Others		0.525	5.6
Irrigation	43	3.167	33.7
Mlali Irrigation Project		0.142	1.5
Bagamoyo Irrigation Dev.Project		0.085	0.9
Sugarcane Breeding Station		0.568	6.0
United Farming Co.,Ltd.		0.894	9.5
Prov. Agricultural Office		0.213	2.3
Others		1.265	13.5
Industry	6	0.596	6.3
Others	41	0.598	6.4
Total	115	9.396	100.0

Table H.4 LOW WATER CHANNEL FLOW CAPACITY IN THE LOWER RUVU FLOOD PLAIN

Section No.	Chainage (km)	Lowest River Bed EL(m)	High Water Channel Bank EL(m)	Mean EL(m)	Water Level in meter 100m3/s EL(m)	150m3/s EL(m)	200m3/s EL(m)	250m3/s EL(m)	300m3/s EL(m)	Flow Capacity (m3/s)
0	0.00	-3.70	3.00	3.00	2.30	2.30	2.30	2.30	2.30	
1	15.20	-7.70	1.90	1.75	2.33	2.38	2.43	2.51	2.59	>100 m3/s
2	23.80	-2.59	1.48	2.60	2.42	2.55	2.71	2.88	3.05	>100 m3/s
2C	26.30	-2.85	1.70	2.50	2.47	2.65	2.86	3.07	3.28	>100 m3/s
3	31.90	-4.32	3.30	3.54	2.66	2.98	3.32	3.65	3.97	200 m3/s
4	42.50	-0.83	6.67	7.21	4.40	5.10	5.67	6.15	6.68	300 m3/s
5	51.20	2.16	9.50	8.04	7.00	7.80	8.42	8.94	9.38	
6	61.70	4.82	12.70	11.40	9.83	10.62	11.26	11.82	12.31	
7	70.30	9.41	15.41	13.90	12.54	13.26	13.87	14.42	14.91	
7A	79.70	10.51	17.02	16.44	14.96	15.61	16.19	16.70	17.16	300 m3/s
8	80.60	11.14	17.84	16.90	15.11	15.77	16.35	16.86	17.32	
9	94.20	16.31	21.00	19.80	19.56	20.39	21.07	21.54	21.92	200 m3/s
10	107.10	20.52	25.30	23.60	23.67	24.38	25.01	25.48	25.87	250 m3/s
10A	113.20	22.04	27.22	25.50	25.30	26.04	26.68	27.23	27.72	250 m3/s
11	115.60	22.27	27.80	26.00	25.86	26.62	27.26	27.81	28.30	250 m3/s
12	126.30	26.12	31.38	29.60	29.07	29.82	30.46	31.01	31.47	300 m3/s
13	134.70	28.49	32.51	32.70	31.59	32.27	32.82	33.30	33.74	200 m3/s
14	142.80	31.47	36.36	35.40	34.20	34.79	35.25	35.64	36.00	
15	151.80	34.47	39.80	39.20	36.90	37.44	37.91	38.32	38.69	
16	156.30	35.90	39.90	41.15	38.24	38.82	39.30	39.74	40.12	300 m3/s

Table H.5 FLOOD PLAIN OF LOWER RUVU

Section No.	Chainage (km)	Lowest River Bed EL. (m)	High Water Channel Bank EL. (m)	Mean EL. (m)	Natural Bank Left EL. (m)	Right EL. (m)	Natural Plain Width(m)
0	0.00	-3.70	3.00	3.00	3.00	3.00	
1	15.20	-7.70	1.90	1.75	14.86	11.34	4,754
2	23.80	-2.59	1.48	2.60	11.89	14.36	5,389
2A	24.10	-1.81	1.50	2.50	12.87	16.79	5,714
2B(Road/Ferry)	25.50	-4.90	2.50	4.60	17.44	16.84	4,500
2C	26.30	-2.85	1.70	2.50	12.38	16.43	5,530
3	31.90	-4.32	3.30	3.54	13.44	27.69	3,437
NUWALR D/S	39.48	0.53	6.94	6.00	14.00	20.00	
NUWALR Weir	39.50	3.27	6.94	6.00	14.00	20.00	
NUWALR U/S	39.51	0.53	6.94	6.00	14.00	20.00	
4	42.50	-0.83	6.67	7.21	15.23	19.87	4,120
5	51.20	2.16	9.50	8.04	14.57	32.61	3,850
6	61.70	4.82	12.70	11.40	19.28	30.61	3,990
7	70.30	9.41	15.41	13.90	17.29	21.67	3,750
7A	79.70	10.51	16.90	16.44	23.80	23.81	2,100
7B(Bridge)	79.72	10.65	19.68	19.68	25.80	26.30	1,900
GS1H8	79.97	10.74	17.40	18.30	27.93	24.01	2,200
8	80.60	11.14	17.85	16.90	27.93	24.01	2,200
9	94.20	16.31	21.00	19.80	25.67	38.60	3,000
10	107.10	20.52	25.30	23.60	30.56	28.47	3,380
10A	113.20	22.04	27.10	25.50	30.00	28.55	2,700
10B(R/Wbridge)	113.30	20.38	27.05	28.47	33.91	32.33	3,350
10C	113.35	20.23	27.15	25.20	30.80	32.37	3,500
11	115.60	22.27	27.80	26.00	31.72	38.20	3,900
12	126.30	26.12	31.38	29.60	37.60	34.20	3,850
13	134.70	28.49	33.80	32.70	45.75	36.66	2,800
14	142.80	31.47	36.75	35.40	49.27	42.60	2,575
15	151.80	34.47	39.80	39.20	49.70	44.81	1,600
16	156.30	35.90	40.30	41.15	49.64	54.59	1,700

Table H.6 TIDE LEVEL OBSERVATION AT MBEGANI (1/3)

Hr :Min	April 20	April 21	April ● 22	April 23	April 24	April 25	April 26	April 27	April ○ 28	April 29	April 30	May 1
1 :00		2.22	1.84	1.98 *	1.24	1.08	0.80	0.91	1.14	1.70	2.35	3.13
2 :00			2.62	2.57 #	2.01	1.52	1.25	1.67 *	1.40	1.44	2.16	3.04
3 :00		3.67	3.75 #	3.15	2.65	2.60	1.95	1.97	1.90	1.39	1.54	2.92
4 :00		3.74	3.80 #	3.58	3.35	3.35	2.97	2.62	2.30	1.68	1.48	2.45
5 :00		3.48	3.75	3.90	3.74	3.64	3.28	3.35 #	2.52	2.08	1.62	2.12
6 :00		3.01	3.33	3.63	4.32	3.75	3.62	3.59	2.82	2.31	1.90	1.98
7 :00		2.32	2.61	2.98	3.28	3.40	3.62	3.44	3.21	2.69	2.12	1.78
8 :00		1.62	1.79 *	2.22	2.62	3.00	3.21	3.26	3.40	2.98	2.57 *	2.41
9 :00		0.98	1.18	1.58	1.84	2.21	2.66	2.80 #	3.05	3.06	3.00	2.87
10 :00		0.79	0.75	0.90	1.16	1.50	1.98	2.35	2.70	2.85 *#	2.58	3.02
11 :00	1.70 *	1.05	0.75 *	0.66	0.76	0.94	1.39	1.65 #	2.25	2.60 *	2.46	3.13
12 :00	2.07 *	1.61	1.25	1.00	0.68 #	0.94 *	1.01	1.33	1.88	2.30	2.21	3.19
13 :00	2.72	2.39	2.04	1.67	1.36	1.10	1.03	1.04	1.55	1.96	2.25 #	3.01
14 :00	3.50	3.20	2.85	2.49	2.05	2.08 *	1.48	1.03	1.40	1.79	2.12 #	2.81
15 :00	3.97	3.89	3.65	3.39 #	2.95	2.88 #	2.15	1.08	1.55	1.60	2.02 #	2.54
16 :00	4.03	4.19	4.20	4.04	3.78	3.40	2.91	2.38	1.92	1.80	1.72 #	2.09
17 :00	3.71	3.98	4.25	4.27	4.19	4.00	3.57	2.99	2.50	2.25	1.42 #	1.72
18 :00	3.16	3.44 #	3.79	4.16	4.24	4.30	3.98	3.54	3.00	2.45	1.42	1.57
19 :00	2.43	2.71	3.10	3.58	3.86	3.98	4.04	3.78	3.40	2.78	1.51	1.70
20 :00	1.58	1.86	2.30	2.75	3.18	3.49	3.69	3.83	3.60	3.21	1.74	1.90
21 :00	1.02	0.98	1.43	1.98	2.32	2.72	3.22	3.40	3.50	3.30	1.93	2.18
22 :00	0.81	0.75	0.75	1.07	1.48	1.88	2.47	2.85	3.17	3.25	2.24	2.62
23 :00	1.04	1.03	0.56	0.82	0.80	1.15	1.86	2.15	2.73	3.04	2.59 #	3.09
24 :00	1.01	1.29	1.30	0.86	0.80	0.75	1.07	1.45	2.18	2.70	2.93	3.33

Note : * reading delay within 30 minutes

\# data modified by the Study Team

Table H.6 TIDE LEVEL OBSERVATION AT MBEGANI (2/3)

Hr :Min	May 2	May 3	May 4	May 5	May ○ 6	May 7	May 8	May 9	May 10	May 11	May 12	May ○ 13
1 :00	3.74 #	3.54	3.20	2.65	2.11	2.00 *	1.45	0.54	1.43	0.88	1.22	1.75
2 :00	3.69 #	3.71	3.64	3.40	3.41	2.35	2.02	1.35	1.95	1.08	1.20	1.45
3 :00	3.00	3.45	3.50	3.73 *#	3.96 #	3.29	2.59	1.96	2.41	1.50	1.45	1.61
4 :00	2.74	3.20	2.93	3.80	4.52	3.90	3.64 #	2.95	2.71	2.00	1.75	1.94
5 :00	2.12	1.93	2.30	3.38	3.71	4.00	4.21	3.73	3.14	2.58	2.35	2.04
6 :00	1.25	1.50	2.07	2.74	3.15	3.60	3.80	3.82	3.55	3.05	2.60	2.26
7 :00	1.23	1.05	1.15	1.78	2.36	2.87	3.29	3.56	3.50	3.10	3.01	2.62
8 :00	1.46	1.00	0.85	1.01	1.55	2.06	2.56	3.29	3.30	3.30	3.17	2.84
9 :00	1.80	1.34	0.82	0.63	0.70	1.20	1.78	2.46	2.78	3.00	3.10	3.02
10 :00	2.28	1.78	1.15	0.76	0.40	0.55	0.99	1.56	2.10	2.58	2.85	2.93
11 :00	2.83	2.38	1.89	1.30	0.80	0.46	0.52	1.07	1.35	2.03	2.43	2.82
12 :00	3.30	3.16	2.85	1.96	1.40	0.92	0.58	0.65	0.97	1.50	2.01	2.52
13 :00	3.56	3.75	3.40	2.90	2.25	1.72	1.20	0.95	0.92	1.15	1.60	2.14
14 :00	3.41	3.93	4.10	3.87	3.50	2.60	1.98	1.30	1.36	1.25	1.45	1.90
15 :00	3.10	3.75	4.30	4.45	4.17	3.57	2.91	2.45	1.90	1.62	1.55	1.75
16 :00	2.64	3.31	4.05	4.45	4.65	4.36	3.79	3.51	2.55	2.15	1.86	1.81
17 :00	2.09	2.65	3.25	3.97	4.55	4.57	4.38	4.09 #	3.44	2.67	2.27	2.03
18 :00	1.57	1.94	2.50	3.31	3.65	4.35	4.47	4.63	3.85	3.23	2.70	2.27
19 :00	1.52	1.52	1.80	2.37	2.98	3.45	4.27	4.14 #	4.29	3.56	3.15	2.67
20 :00	1.52	1.38	1.00	1.36	1.89	2.63	3.01	2.85	3.67	3.65	3.30	2.92
21 :00	1.56	1.20	0.88	0.67	0.90	1.65	2.40	2.45 #	3.19	3.34	3.35	3.10
22 :00	1.97	1.65	0.98	0.61	0.30	0.67	1.93	2.04	2.67	3.00	3.09	3.15
23 :00	2.55	2.10	1.70	0.81	0.50	0.42	1.70	1.30	1.60	2.60	2.72	2.82
24 :00	3.40	2.73	2.01	1.29	1.88	0.71	1.00	0.99	1.31	1.85	2.02	2.41

Note : * reading delay within 30 minutes

\# data modified by the Study Team

Table H.6 TIDE LEVEL OBSERVATION AT MBEGANI (3/3)

Hr :Min	May 14	May 15	May 16	May 17	May 18	May 19	May 20
1 :00	2.03	2.74	2.87	3.11	3.00	3.30	2.48
2 :00	1.84	2.38	2.79	3.06	3.25	3.81	3.15
3 :00	1.69	2.04	2.43	2.90	3.20	3.57	3.56
4 :00	1.42	1.92	2.18	2.62	2.60	3.20	3.50
5 :00	1.72	1.75	1.82	2.11	2.10	2.85	3.07
6 :00	1.91	1.76	1.71	1.74	1.93	2.34	2.65
7 :00	2.16	1.81	1.65	1.46	1.54	1.72	1.90
8 :00	2.51	2.09	1.79	1.49	1.35	1.23	1.41
9 :00	2.80	2.41	2.07	1.70	1.37	1.18	1.01
10 :00	2.99	2.77	2.49	2.15	1.71	1.40	1.30
11 :00	2.98	2.95	2.86	2.55	2.25	2.00 *	1.50
12 :00	2.89	3.01	3.15	3.00	2.84	2.42	2.03
13 :00	2.64	3.05	3.33	3.40	3.38	3.14	2.81
14 :00	2.34	2.83	3.20	3.52 *	3.53 *#	3.75	3.56
15 :00	2.06	2.55	2.97	3.30 *	3.70	3.95	4.06
16 :00	1.85	2.14	2.57	2.90	3.52	3.85	4.10
17 :00	1.86	1.89	2.15	2.40	2.96	3.30	
18 :00	2.01	1.85	1.83	2.03	2.24	2.70	
19 :00	2.18	1.88	1.65	1.40	1.74	2.05	
20 :00	2.42	1.99	1.65	1.30	1.30	1.23	
21 :00	2.68	2.23	1.84	1.55	1.21	1.00	
22 :00	2.92	2.62	2.20	2.00	1.38	0.91	
23 :00	2.98	2.91	2.55	2.40 *	1.81	1.40	
24 :00	2.89	2.95	2.82	2.70	2.45	2.20 *	

Note : * reading delay within 30 minutes

data modified by the Study Team

Table H.7 RESULTS OF FLOOD ROUTINE ANALYSIS

Section No.	Chainage (km)	Lowest River Bed EL(m)	High Water Channel Bank EL(m)	High Water Channel Mean EL(m)	Water Level in m 635m3/s EL(m)	820m3/s EL(m)	1005m3/s EL(m)	1255m3/s EL(m)	1460m3/s EL(m)
0	0.00	-3.70	3.00	3.00	2.30	2.30	2.30	2.30	2.30
1	15.20	-7.70	1.90	1.75	2.77	2.97	3.15	3.38	3.55
2	23.80	-2.59	1.48	2.60	3.12	3.34	3.54	3.78	3.96
Ferry	25.50	-4.90			3.22	3.49	3.64	3.88	4.06
	25.51	-4.90			3.31	3.61	3.84	4.32	4.74
2C	26.30	-2.85	1.70	2.50	3.35	3.64	3.88	4.35	4.76
3	31.90	-4.32	3.30	3.54	3.97	4.25	4.48	4.82	5.13
4	42.50	-0.83	6.67	7.21	6.57	6.79	6.96	7.14	7.27
5	51.20	2.16	9.50	8.04	8.80	9.01	9.18	9.39	9.54
6	61.70	4.82	12.70	11.40	12.02	12.21	12.38	12.58	12.72
7	70.30	9.41	15.41	13.90	14.50	14.66	14.80	14.99	15.12
Bridge	79.72	10.65			17.58	17.78	17.94	18.14	18.29
	79.73	10.65			18.50	19.35	19.61	19.77	19.99
8	80.60	11.14	17.84	16.90	18.54	19.37	19.63	19.80	20.01
9	94.20	16.31	21.00	19.80	21.13	21.39	21.63	21.89	22.10
10	107.10	20.52	25.30	23.60	24.85	25.02	25.18	25.38	25.53
10A	113.20	22.04	27.22	25.50	26.49	26.68	26.84	27.03	27.17
R/W	113.30	20.38			27.25	27.25	27.25	27.25	27.25
	113.31	20.38			27.36	27.73	28.10	28.20	28.31
11	115.60	22.27	27.80	26.00	27.48	27.84	28.19	28.31	28.43
12	126.30	26.12	31.38	29.60	30.33	30.49	30.64	30.80	30.93
13	134.70	28.49	32.51	32.70	33.13	33.31	33.45	33.65	33.79
14	142.80	31.47	36.36	35.40	36.00	36.23	36.41	36.62	36.78
16	156.30	35.90	39.90	41.15	41.71	41.94	42.13	42.37	42.54

Table H.8 SUMMARY OF FLOOD CONTROL WORKS FOR IRRIGATION PROJECTS

No.	Name of Scheme	Construction of Flood Dike: Length of Dike (km)	Excavation & Stripping (m3)	Embankment (m3)	Slope Protection Sodding (m2)	Construction of Drainage Outlet (Sluices): No. of Sluices	Concrete (*1) (m3)	Flap Gates (*2)	Slide Gates (*2)
1	Bagamoyo	13.5	90,000	250,000	140,000	8	1,000	16	16
2	Low Lift Pump	11.5	71,000	173,000	73,000	2	250	4	4
3	Makurunge	3.5	23,000	61,000	25,000	1	130	2	2
4	Ruvu National Youth	6.0	20,000	68,000	36,000	2	250	2	2
5	Kidunda	28.5	120,000	333,000	140,000	15	1,250	20	20
6	Mgeta	48.0	310,000	845,000	36,000	10	1,250	20	20

Note (*1) reinforced concrete with strength of 210 kgf/cm2, and reinforcement bar and forms per concrete 1 m3 are assumed at 100 kg and 3.5 m2, respectively.

(*2) 1,500 x 1,500 mm

Table H.9 BREAKDOWN OF CONSTRUCTION COST FOR FLOOD CONTROL WORK FOR BAGAMOYO IRRIGATION PROJECT (DEVELOPMENT SCENARIO-1)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (US$) Unit Price	Local Currency (US$) Amount	Total (US$) Unit Price	Total (US$) Amount
I	Direct Construction Cost								
1.	Preparatory Works (General)	L.S.			243,000		115,000		358,000
2.	Flood Dike								
	2.1 Excavation	m3	90,000	2.20	198,000	1.30	117,000	3.50	315,000
	2.2 Embankment	m3	250,000	5.00	1,250,000	2.90	725,000	7.90	1,975,000
	2.3 Slope protection	m2	140,000	0.00	0	0.50	70,000	0.50	70,000
	2.4 Others(5 %)	L.S.	0		72,400		45,600		118,000
	(Subtotal-2)				1,520,400		957,600		2,478,000
3.	Drainage Outlet								
	3.1 Concrete	m3	1,000	85.40	85,400	43.10	43,100	128.50	128,500
	3.2 Flap gate	no	16	22860.00	365,760	4030.00	64,480	26,890.00	430,240
	3.3 Slide gate	no	16	25970.00	415,520	4580.00	73,280	30,550.00	488,800
	3.4 Others(5 %)	L.S.			43,334		9,043		52,377
	(Subtotal-3)				910,014		189,903		1,099,917
	Total of Direct Construction Cost (I)				2,673,414		1,262,503		3,935,917
II	Land Aquisition and Compensation	L.S.			0		0		0
III	Administration Expenses	L.S.			0		39,000		39,000
IV	Engineering Services (Detailed design and supervision)	L.S.			335,000		59,000		394,000
	Total(I to IV)				3,008,414		1,360,503		4,368,917
V	Physical Contengency (15%)	L.S.			451,000		204,000		655,000
	Grand Total				3,459,414		1,564,503		5,023,917

Table H.10 BREAKDOWN OF CONSTRUCTION COST FOR FLOOD CONTROL WORK FOR LOW LIFT PUMP IRRIGATION PROJECT (DEVELOPMENT SCENARIO-1)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (US$) Unit Price	Local Currency (US$) Amount	Total (US$) Unit Price	Total (US$) Amount
I	Direct Construction Cost								
1.	Preparatory Works (General)	L.S.			130,000		71,000		201,000
2.	Flood Dike								
	2.1 Excavation	m3	71,000	2.20	156,200	1.30	92,300	3.50	248,500
	2.2 Embankment	m3	173,000	5.00	865,000	2.90	501,700	7.90	1,366,700
	2.3 Slope protection	m2	73,000	0.00	0	0.50	36,500	0.50	36,500
	2.4 Others(5 %)	L.S.			51,060		31,525		82,585
	(Subtotal-2)				1,072,260		662,025		1,734,285
3.	Drainage Outlet								
	3.1 Concrete	m3	250	85.40	21,350	43.10	10,775	128.50	32,125
	3.2 Flap gate	no	4	22860.00	91,440	4030.00	16,120	26,890.00	107,560
	3.3 Slide gate	no	4	25970.00	103,880	4580.00	18,320	30,550.00	122,200
	3.4 Others(5 %)	L.S.			10,834		2,261		13,094
	(Subtotal-3)				227,504		47,476		274,979
	Total of Direct Construction Cost (I)				1,429,764		780,501		2,210,264
II	Land Aquisition and Compensation	L.S.			0		0		0
III	Administration Expenses	L.S.			0		22,000		22,000
IV	Engineering Services (Detailed design and supervision)	L.S.			188,000		33,000		221,000
	Total(I to IV)				1,617,764		835,501		2,453,264
V	Physical Contengency (15%)	L.S.			243,000		125,000		368,000
	Grand Total				1,860,764		960,501		2,821,264

Table H.11 BREAKDOWN OF CONSTRUCTION COST FOR FLOOD CONTROL WORK FOR MAKURUNGE IRRIGATION PROJECT (DEVELOPMENT SCENARIO-1)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (US$) Unit Price	Local Currency (US$) Amount	Total (US$) Unit Price	Total (US$) Amount
I	Direct Construction Cost								
1.	Preparatory Works (General)	L.S.			49,000		25,000		74,000
2.	Flood Dike								
	2.1 Excavation	m3	23,000	2.20	50,600	1.30	29,900	3.50	80,500
	2.2 Embankment	m3	61,000	5.00	305,000	2.90	176,900	7.90	481,900
	2.3 Slope protection	m2	25,000	0.00	0	0.50	12,500	0.50	12,500
	2.4 Others(5 %)	L.S.			17,780		10,965		28,745
	(Subtotal-2)				373,380		230,265		603,645
3.	Drainage outlet								
	3.1 Concrete	m3	130	85.40	11,102	43.10	5,603	128.50	16,705
	3.2 Flap gate	no	2	22860.00	45,720	4030.00	8,060	26,890.00	53,780
	3.3 Slide gate	no	2	25970.00	51,940	4580.00	9,160	30,550.00	61,100
	3.4 Others(5 %)	L.S.			5,438		1,141		6,579
	(Subtotal-3)				114,200		23,964		138,164
	Total of Direct Construction Cost (I)				536,580		279,229		815,809
II	Land Aquisition and Compensation	L.S.			0		0		0
III	Administration Expenses	L.S.			0		8,000		8,000
IV	Engineering Services (Detailed design and supervision)	L.S.			69,000		12,000		81,000
	Total(I to IV)				605,580		299,229		904,809
V	Physical Contengency (15%)	L.S.			91,000		45,000		136,000
	Grand Total				696,580		344,229		1,040,809

Table H.12 BREAKDOWN OF CONSTRUCTION COST FOR FLOOD CONTROL WORK FOR RUVU NATIONAL YOUTH IRRIGATION PROJECT (DEVELOPMENT SCENARIO-1)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (US$) Unit Price	Local Currency (US$) Amount	Total (US$) Unit Price	Total (US$) Amount
I	Direct Construction Cost								
1.	Preparatory Works (General)	L.S.			53,000		28,000		81,000
2.	Flood Dike								
	2.1 Excavation	m3	20,000	2.20	44,000	1.30	26,000	3.50	70,000
	2.2 Embankment	m3	68,000	5.00	340,000	2.90	197,200	7.90	537,200
	2.3 Slope protection	m2	36,000	0.00	0	0.50	18,000	0.50	18,000
	2.4 Others(5 %)	L.S.			19,200		12,060		31,260
	(Subtotal-2)				403,200		253,260		656,460
3.	Drainage Outlet								
	3.1 Concrete	m3	250	85.40	21,350	43.10	10,775	128.50	32,125
	3.2 Flap gate	no	2	22860.00	45,720	4030.00	8,060	26,890.00	53,780
	3.3 Slide gate	no	2	25970.00	51,940	4580.00	9,160	30,550.00	61,100
	3.4 Others(5 %)	L.S.			5,951		1,400		7,350
	(Subtotal-3)				124,961		29,395		154,355
	Total of Direct Construction Cost (I)				581,161		310,655		891,815
II	Land Aquisition and Compensation	L.S.			0		0		0
III	Administration Expenses	L.S.			0		9,000		9,000
IV	Engineering Services (Detailed design and supervision)	L.S.			76,000		13,000		89,000
	Total(I to IV)				657,161		332,655		989,815
V	Physical Contengency (15%)	L.S.			99,000		50,000		149,000
	Grand Total				756,161		382,655		1,138,815

Table H.13 BREAKDOWN OF CONSTRUCTION COST FOR FLOOD CONTROL WORK FOR KIDUNDA IRRIGATION PROJECT (DEVELOPMENT SCENARIO-1)

Item No.	Work	Unit	Quantity	Foreign Currency (US$) Unit Price	Foreign Currency (US$) Amount	Local Currency (US$) Unit Price	Local Currency (US$) Amount	Total (US$) Unit Price	Total (US$) Amount
I	Direct Construction Cost								
1.	Preparatory Works (General)	L.S.			316,000		149,000		465,000
2.	Flood Dike								
	2.1 Excavation	m3	120,000	2.20	264,000	1.30	156,000	3.50	420,000
	2.2 Embankment	m3	333,000	5.00	1,665,000	2.90	965,700	7.90	2,630,700
	2.3 Slope protection	m2	140,000	0.00	0	0.50	70,000	0.50	70,000
	2.4 Others(5 %)	L.S.			96,450		59,585		156,035
	(Subtotal-2)				2,025,450		1,251,285		3,276,735
3.	Drainage Outlet								
	3.1 Concrete	m3	1,250	85.40	106,750	43.10	53,875	128.50	160,625
	3.2 Flap gate	no	20	22860.00	457,200	4030.00	80,600	26,890.00	537,800
	3.3 Slide gate	no	20	25970.00	519,400	4580.00	91,600	30,550.00	611,000
	3.4 Others(5 %)	L.S.			54,168		11,304		65,471
	(Subtotal-3)				1,137,518		237,379		1,374,896
	Total of Direct Construction Cost (I)				3,478,968		1,637,664		5,116,631
II	Land Aquisition and Compensation	L.S.			0		0		0
III	Administration Expenses	L.S.			0		51,000		51,000
IV	Engineering Services (Detailed design and supervision)	L.S.			435,000		77,000		512,000
	Total(I to IV)				3,913,968		1,765,664		5,679,631
V	Physical Contengency (15%)	L.S.			587,000		265,000		852,000
	Grand Total				4,500,968		2,030,664		6,531,631

Table H.14 ANNUAL DISBURSEMENT SCHEDULE FOR CONSTRUCTION COST OF FLOOD CONTROL WORK

i) Annual disbursement schedule - Bagamoyo irrigation scheme

(Unit : 1,000 US$)

Year	Foreign currency	Local currency	Total
4th	385	68	453
5th	1,558	453	2,011
6th	1,983	577	2,560
Total	3,926	1,098	5,024

ii) Annual disbursement schedule - Low Lift Pump P/S irrigation scheme

(Unit : 1,000 US$)

Year	Foreign currency	Local currency	Total
7th	41	7	48
8th	376	112	488
9th	0	0	0
10th	0	0	0
11th	0	0	0
12th	175	30	205
13th	515	153	668
14th	515	153	668
15th	574	171	745
Total	2,196	626	2,822

iii) Annual disbursement schedule - Makurunge Irrigation scheme

(Unit : 1,000 US$)

Year	Foreign currency	Local currency	Total
20th	80	15	95
21st	732	214	946
Total	812	229	1,041

iv) Annual disbursement schedule - Ruvu National Youth irrigation scheme

(Unit : 1,000 US$)

Year	Foreign currency	Local currency	Total
20th	87	16	103
21st	795	241	1,036
Total	882	257	1,139

v) Annual disbursement schedule - Kidunda irrigation scheme

(Unit : 1,000 US$)

Year	Foreign currency	Local currency	Total
6th	180	32	212
7th	1,662	476	2,138
8th	0	0	0
9th	160	29	189
10th	1,478	425	1,903
11th	0	0	0
12th	0	0	0
13th	160	28	188
14th	1,478	424	1,902
Total	5,118	1,414	6,532

APPENDIX-H

FIGURES

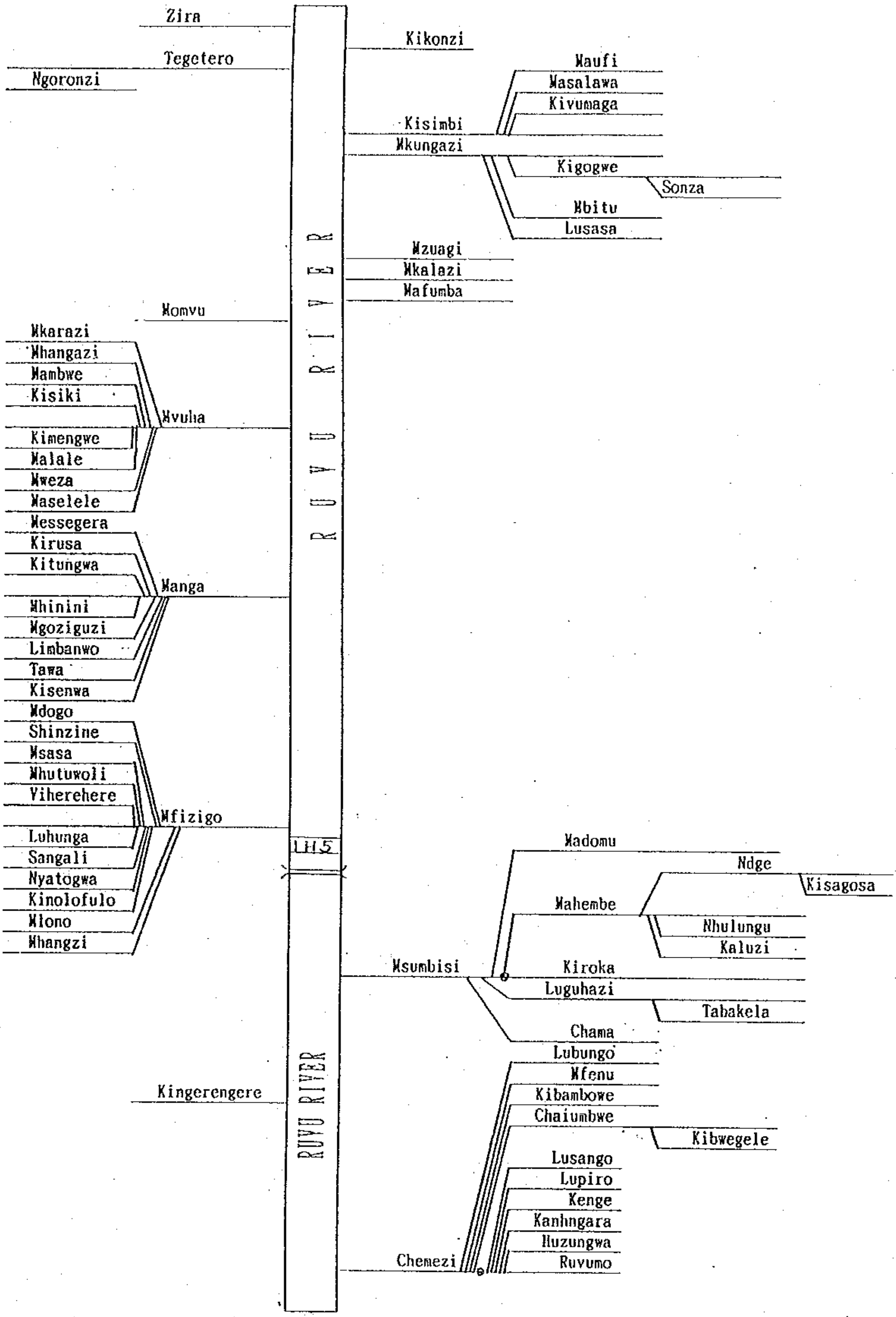

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Fig. H.1 RUVU RIVER DRAINAGE SYSTEM (1/5)

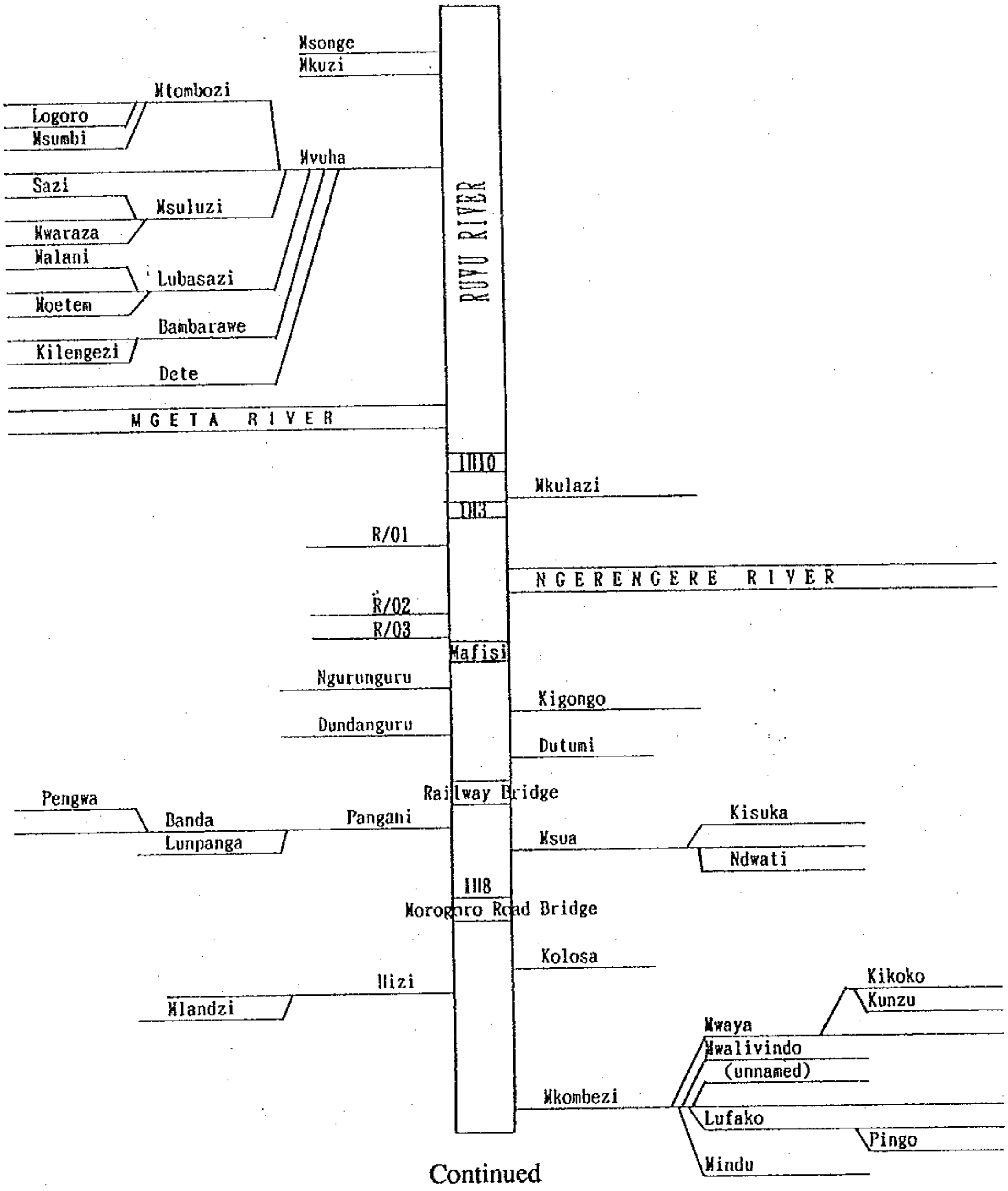


Fig. H.1 RUVU RIVER DRAINAGE SYSTEM (2/5)

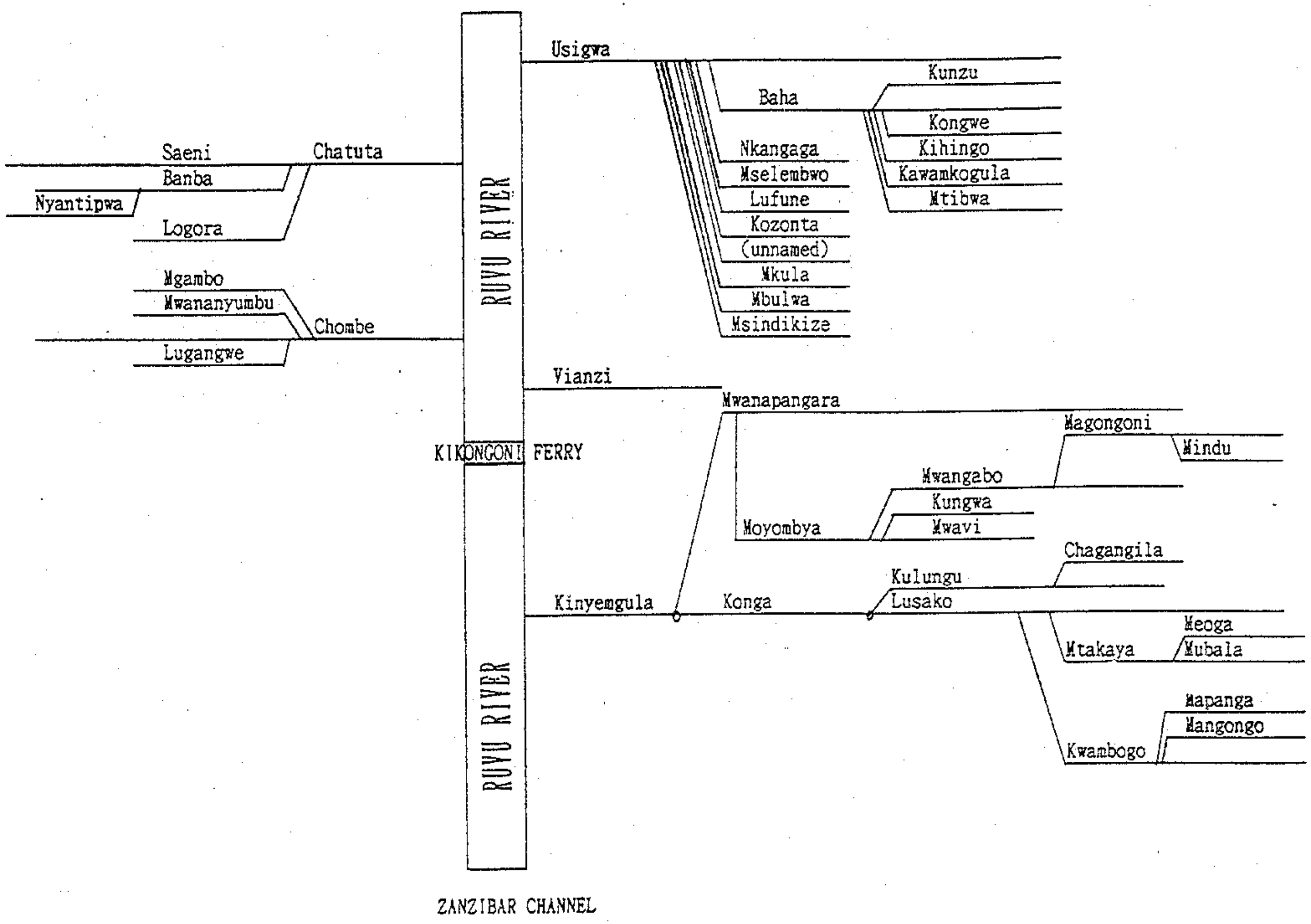


Fig. H.1 RUVU RIVER DRAINAGE SYSTEM (3/5)

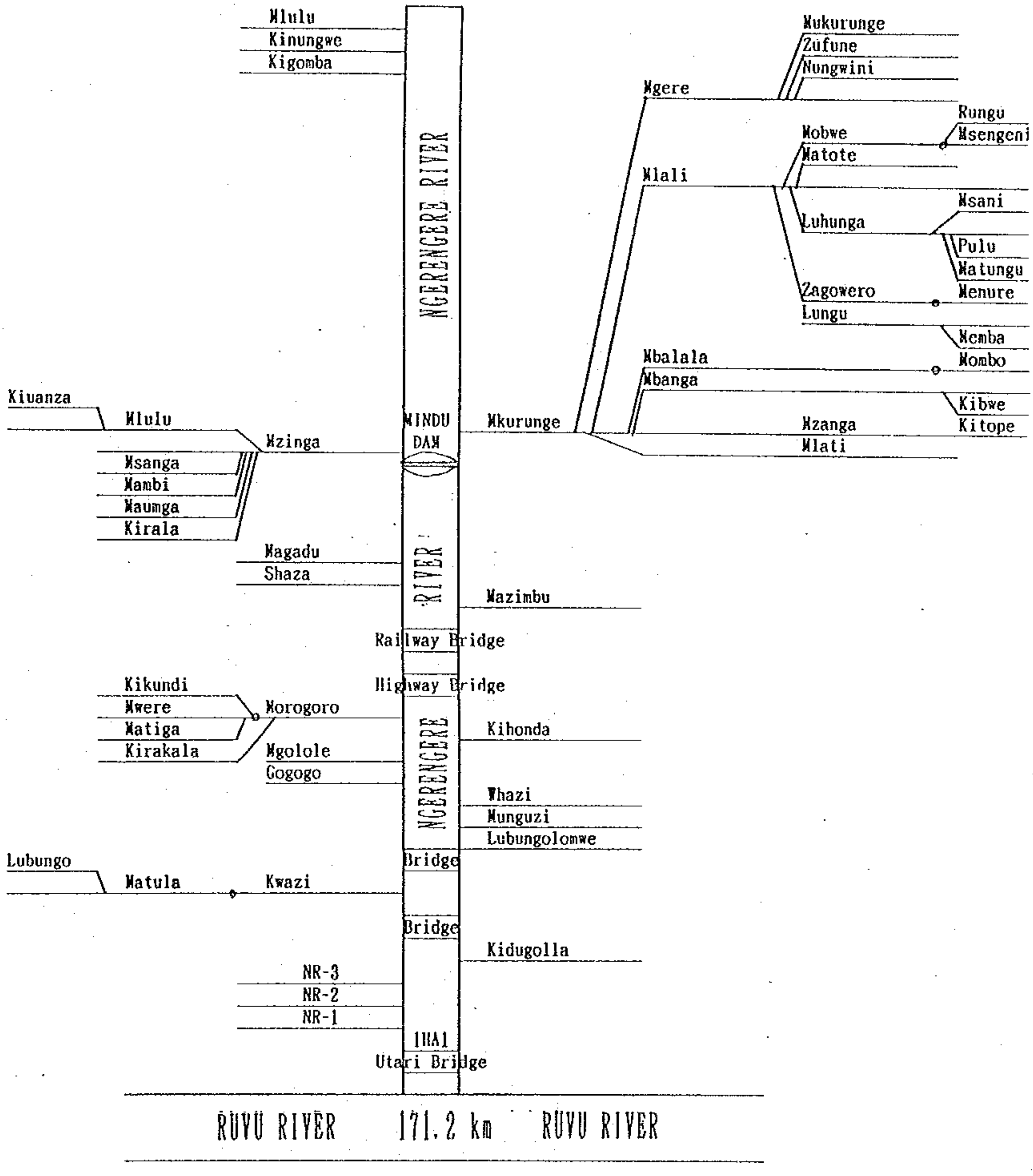


Fig. H.1 RUVU RIVER DRAINAGE SYSTEM (4/5)

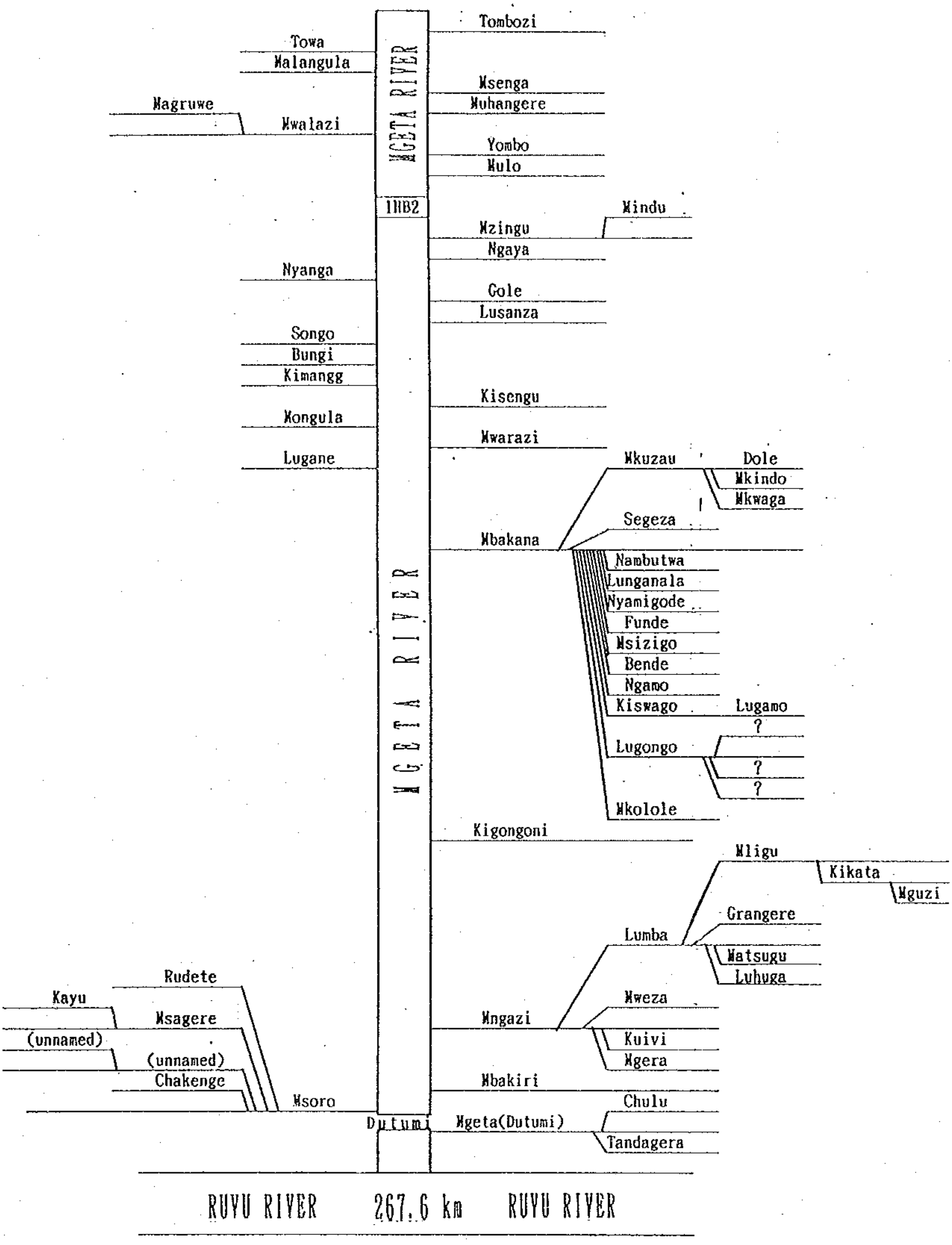


Fig. H.1 RUVU RIVER DRAINAGE SYSTEM (5/5)

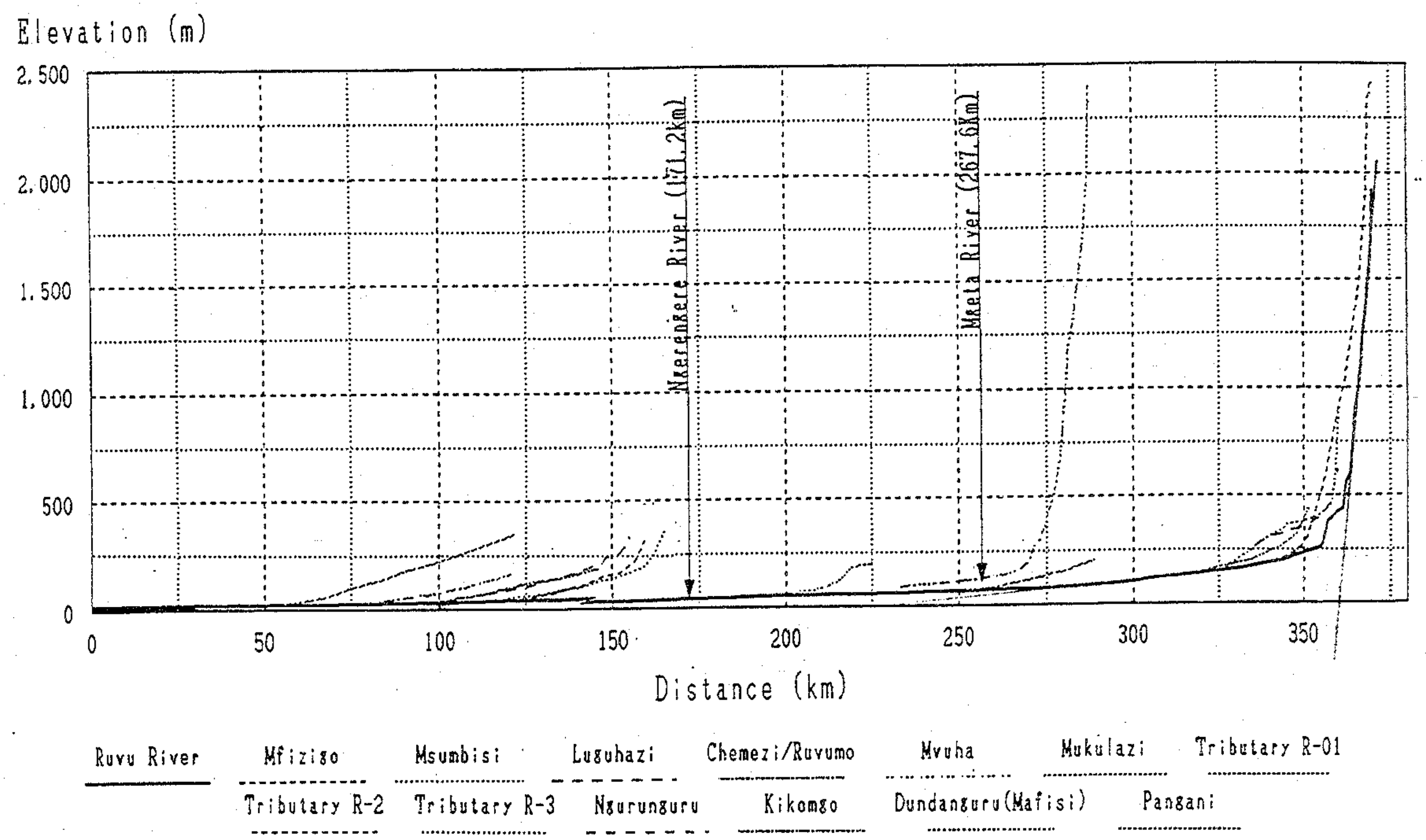


Fig. H.2 LONGITUDINAL PROFILES OF MAJOR RIVERS (1/3)

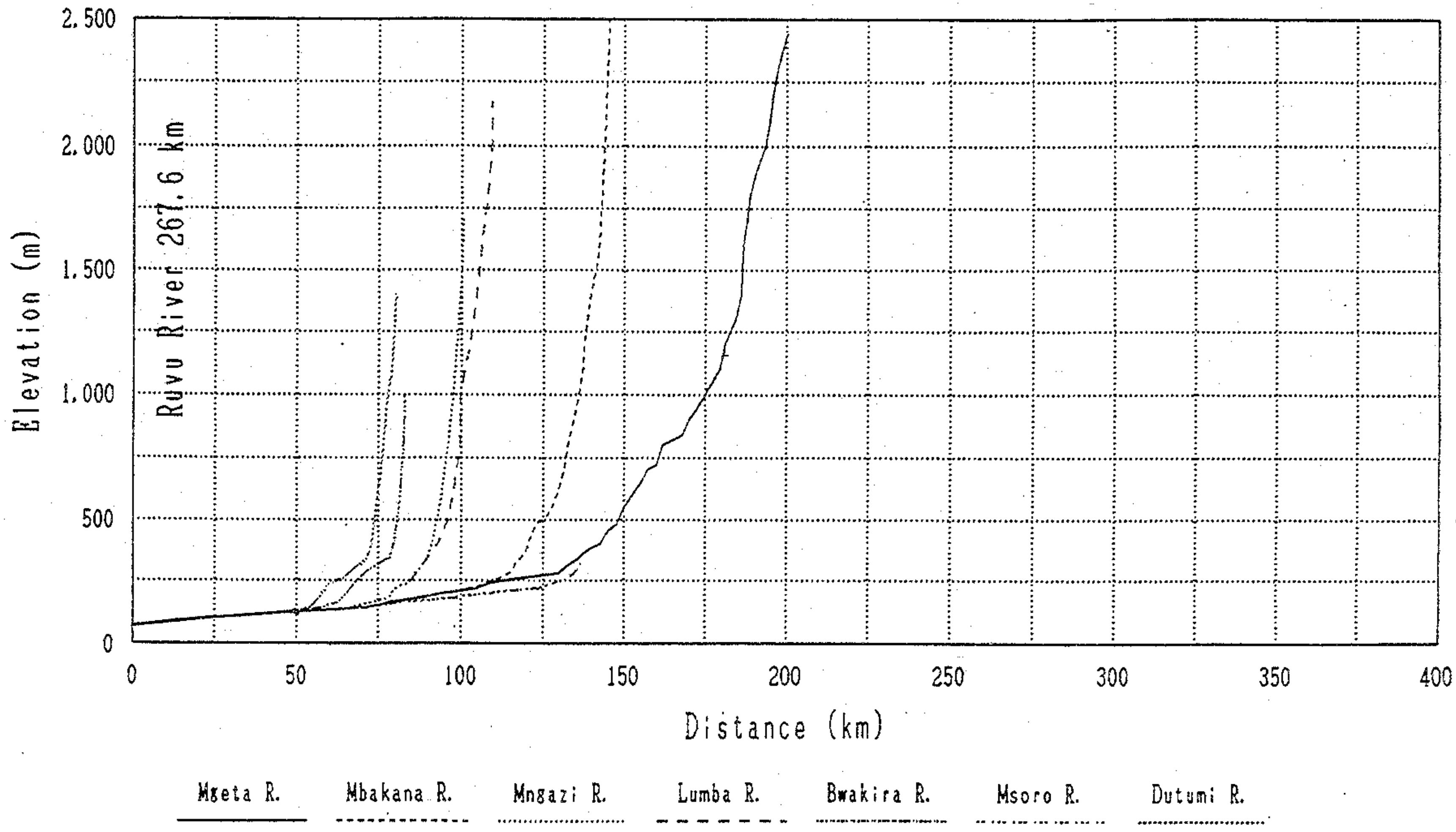


Fig. H.2 LONGITUDINAL PROFILES OF MAJOR RIVERS (2/3)

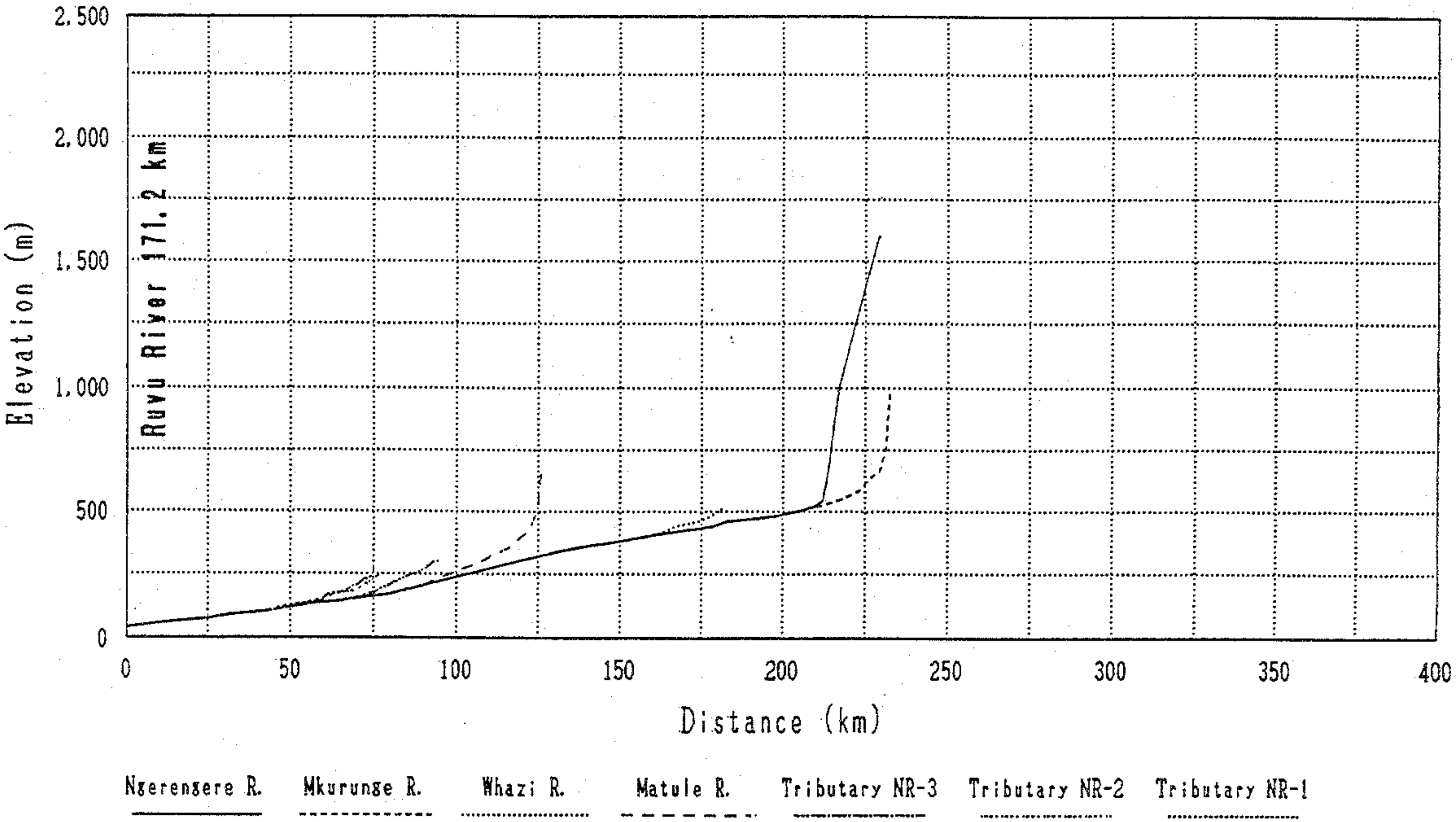


Fig. H.2 LONGITUDINAL PROFILES OF MAJOR RIVERS (3/3)

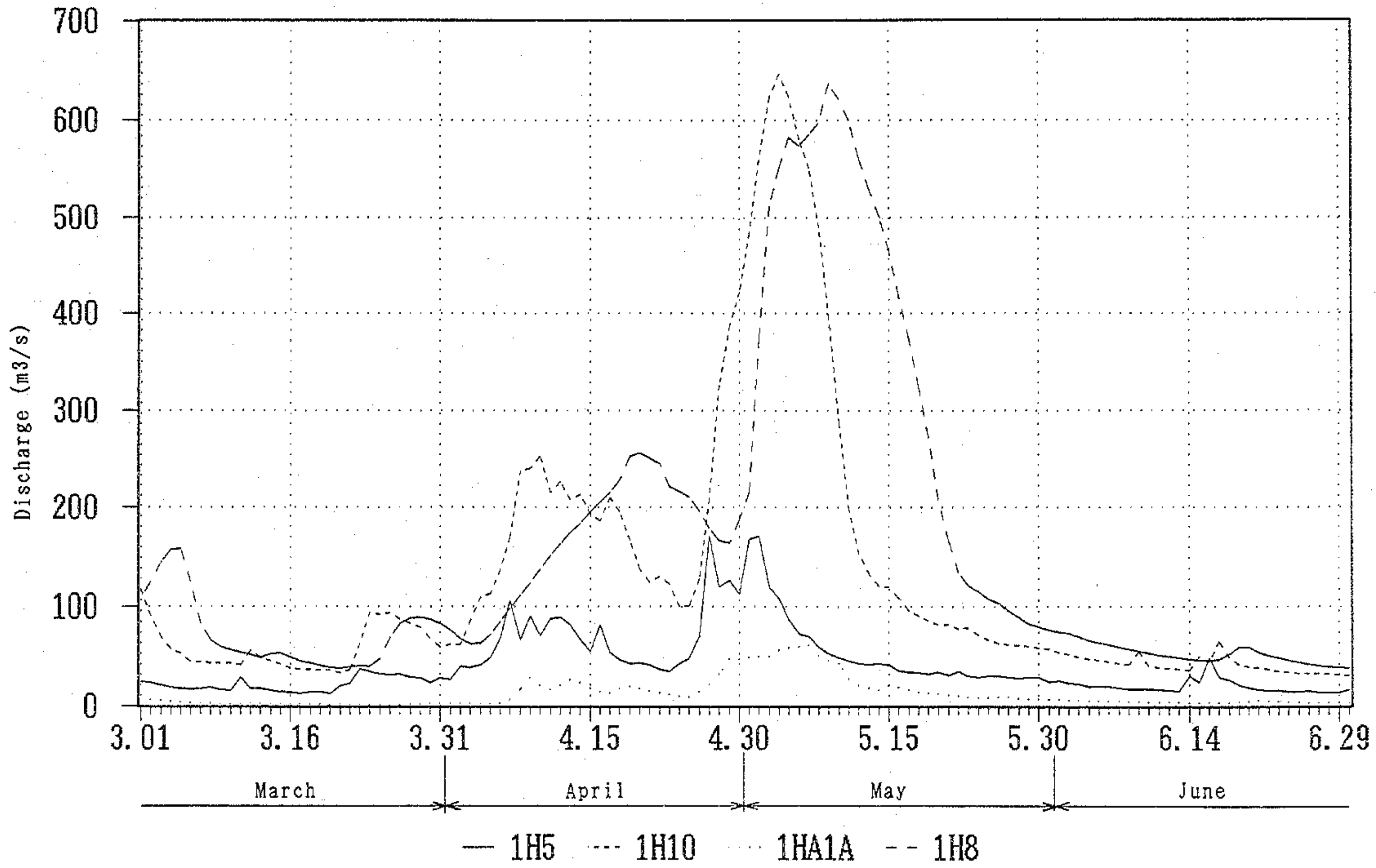


Fig. H.3 HYDROGRAPH OF FLOOD IN APRIL/MAY 1973

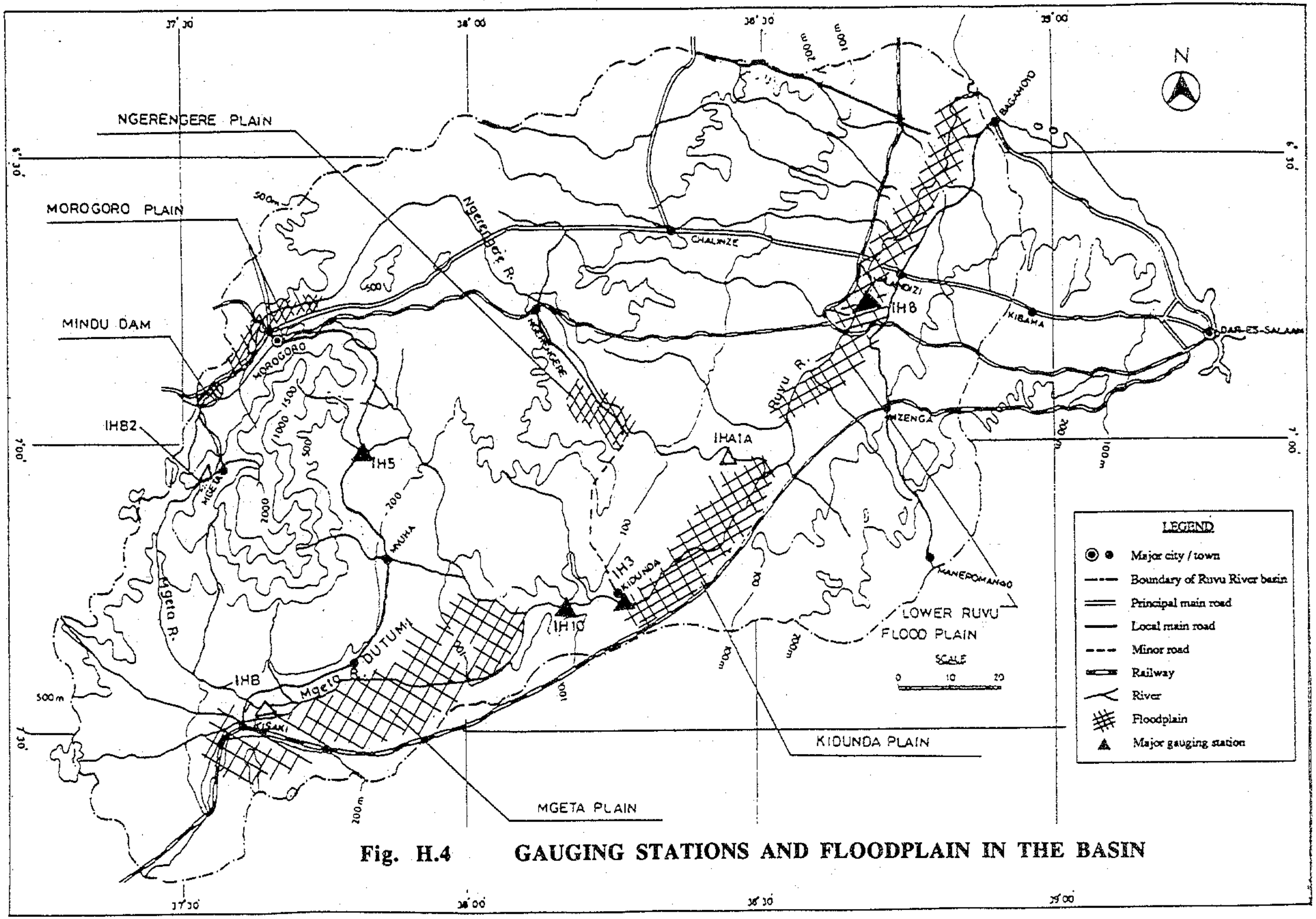


Fig. H.4 GAUGING STATIONS AND FLOODPLAIN IN THE BASIN

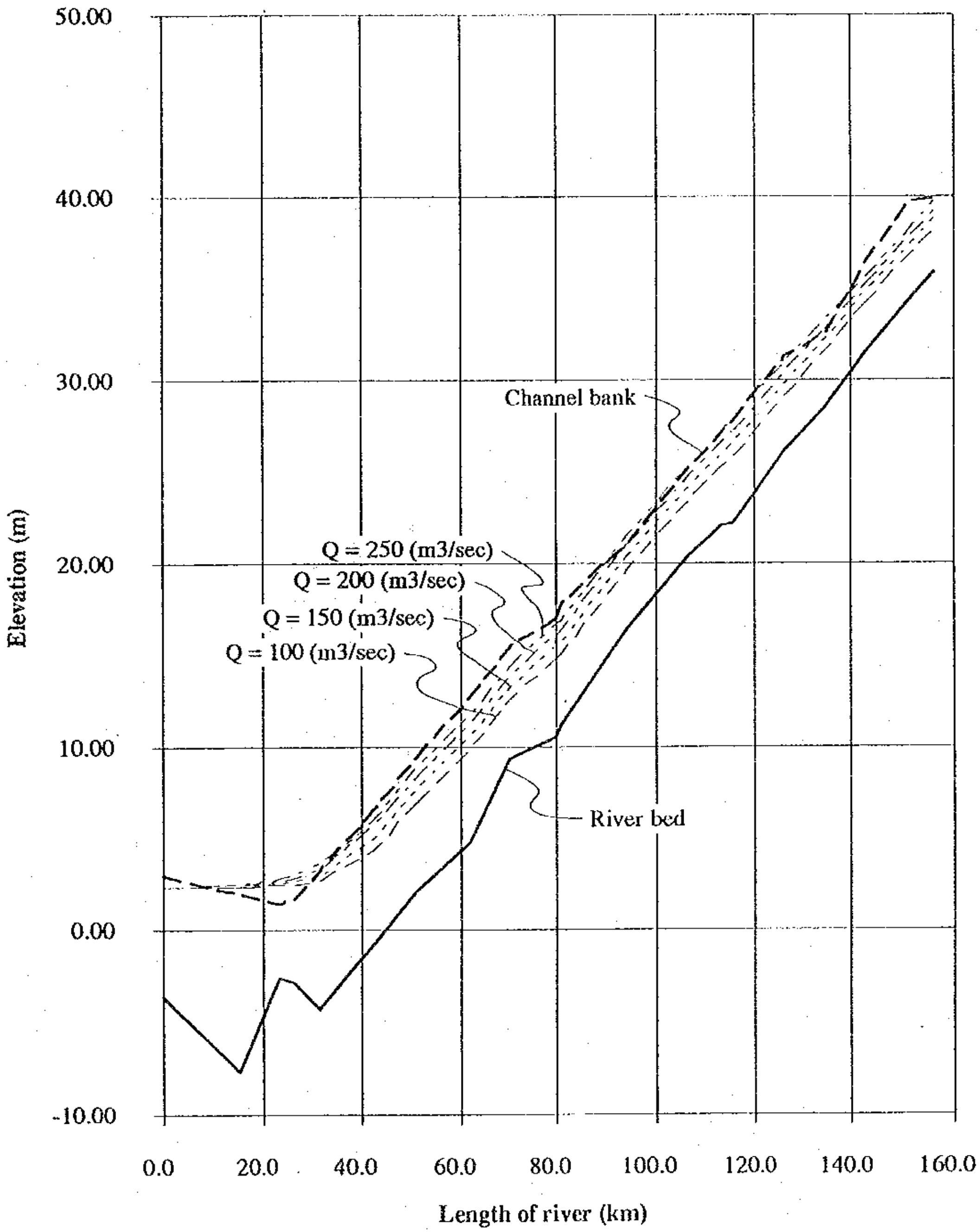


Fig. H.5 LOW WATER CHANNEL FLOW CAPACITY IN THE LOWER RUVU FLOOD PLAIN

No.	Bank	Name of Village	Award
1	R	Nunge Salt Works (near rivermouth)	Kigongoni
2	R	Daraja la Kofia Bridge (Kikongoni Ferry)	Kigongoni
3	R	Daraja la Kofia Bridge (ferry-Bagamoyo)	Kigongoni
4	R	Irrigation Development Project (JICA)	Kigongoni
5	R	Kigongoni Ferry Terminal	Kigongoni
6	R	Kigongoni Prison (downstream resourvoir)	Kigongoni
7	R	Matimbwa (near village, upland)	
8	R	Matimbwa (near Ruvu)	
9	R	NUWA Lower Ruvu Intake	Migude
10	R	Kongo Village(near Ruvu)	Migude
11	R	Chasimba Ruvu swamp	Fulwe
12	L	Mbwawa(cross No.5/6)	Kikongoro
13	L	Mbwawa (cross No.6/5)	Kitemvu
14	R	Kwaraza (near 1h8)	Kitera
15	R	NUWA Upper Intakes	Mlandizi
16	L	Kwaraza Agricultural Secondary school	
17	R	Ruvu Factory (Ruvu Estate)	
18	R	Ruvu Railway Bridge	
19	R	Mafisi (cross No.15)	
20	R	Mafisi (cross No.16)	
21	R	Mafisi (old Morogoro road)	
22	L	Mikadini Salt Works	
23	L	Makurunge D-1	
24	L	Makurunge D-2	
25	L	Makurunge (between cross No.2 & 3)	
26	L	Kitonga/Msumbiji (cross No.6)	
27	L	Kiwaraza (cross No.8-2: Morogoro Road)	
28	L	NAFCO RUVU RICE CPMPANY	
29	L	Kitaroni R/W Station	
30	L	Utari Bridge	
31	R	Mvuha	

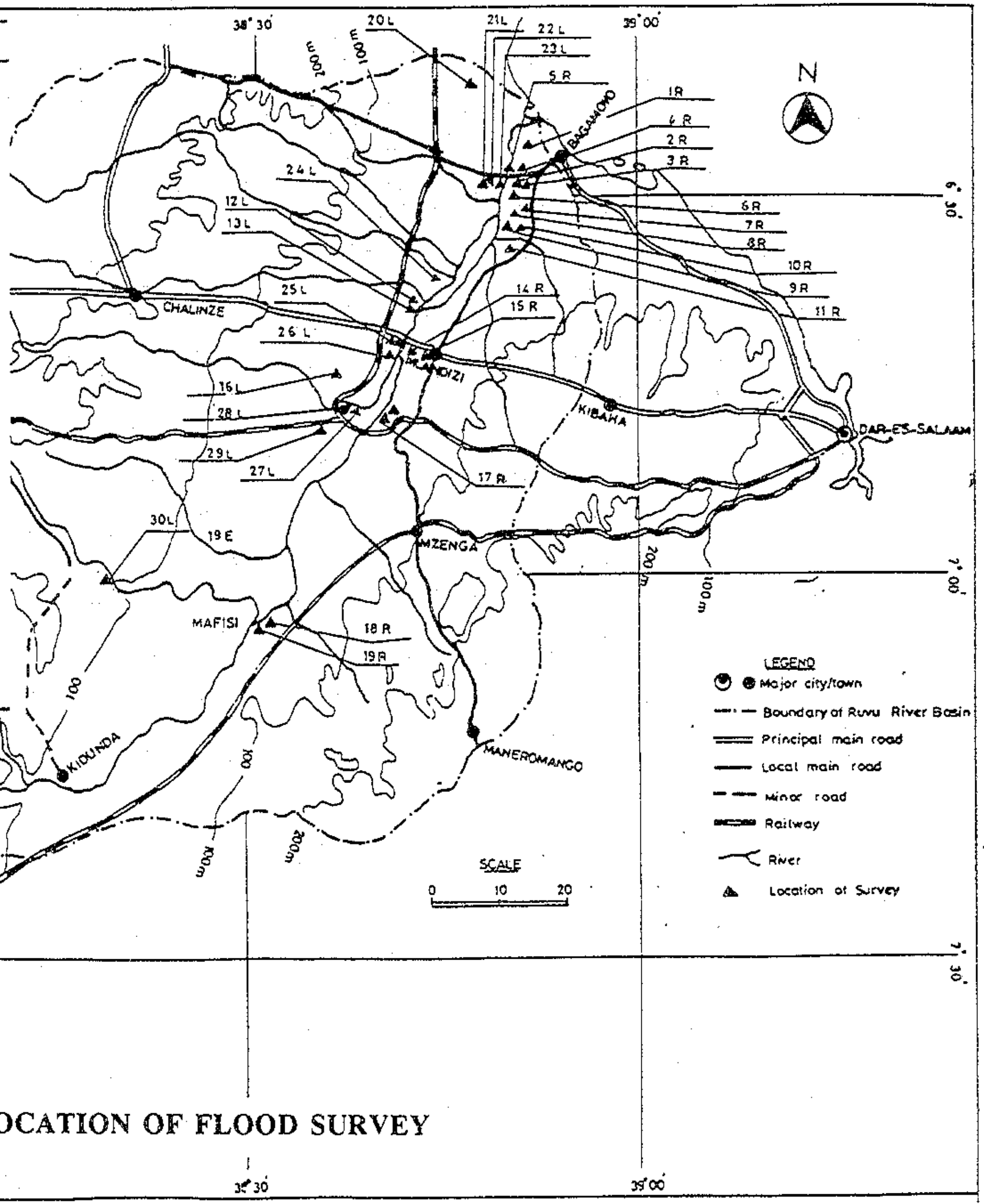


Fig. H.6 LOCATION OF FLOOD SURVEY

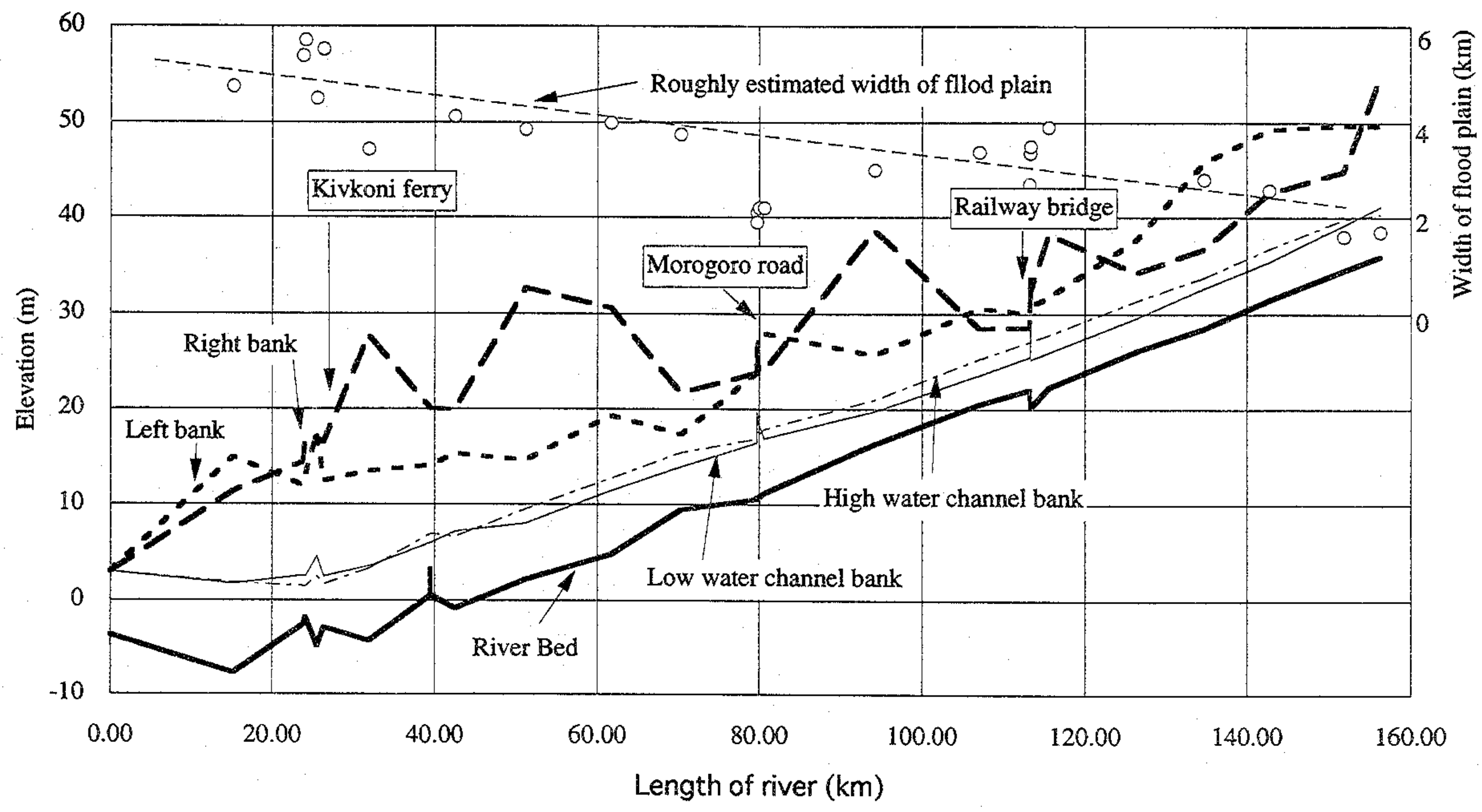


Fig. H.7 FLOOD PLAIN CHARACTERISTICS OF LOWER RUVU

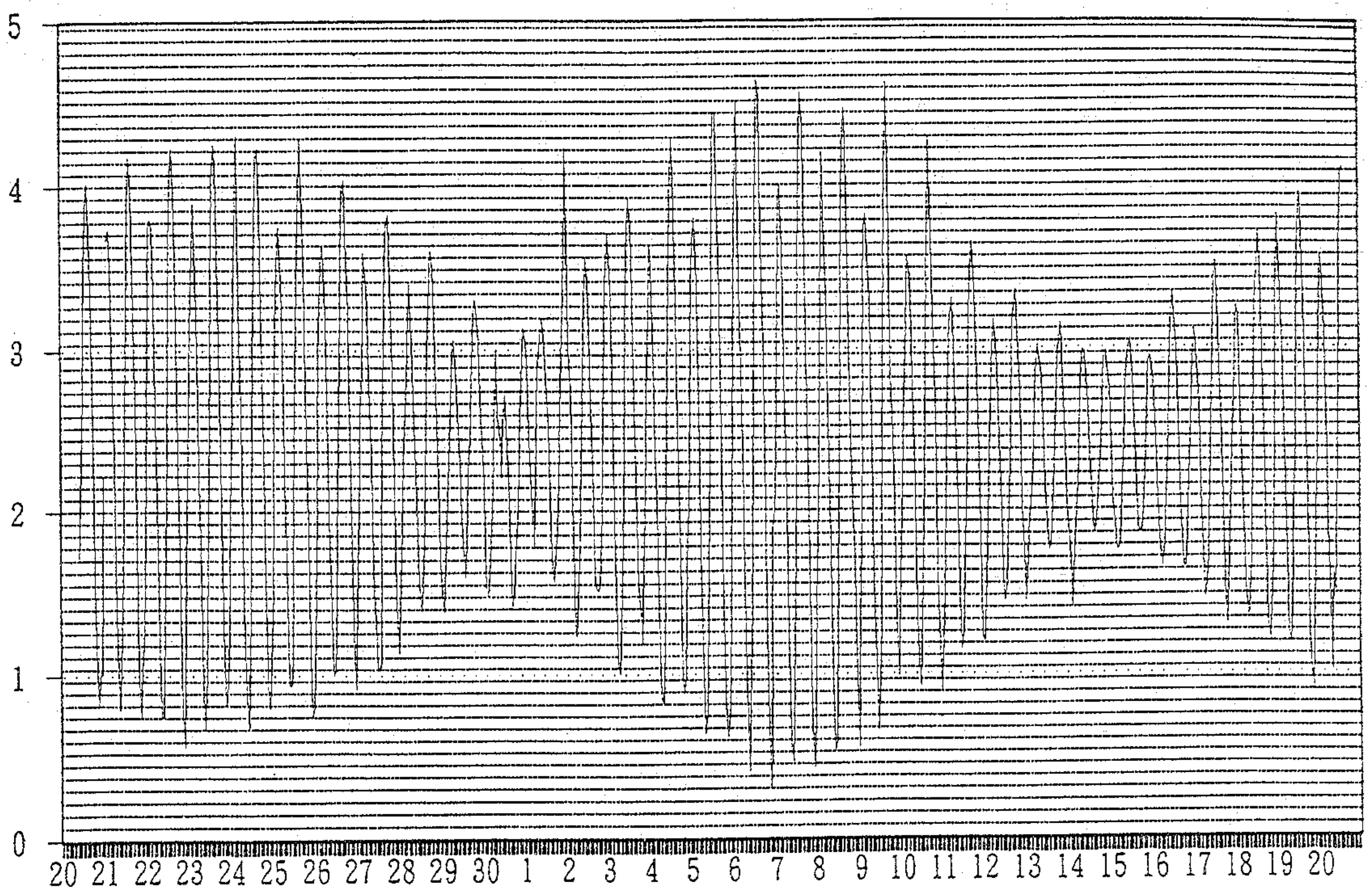


Fig. H.8 TIDE OBSERVATION AT MBEGANI

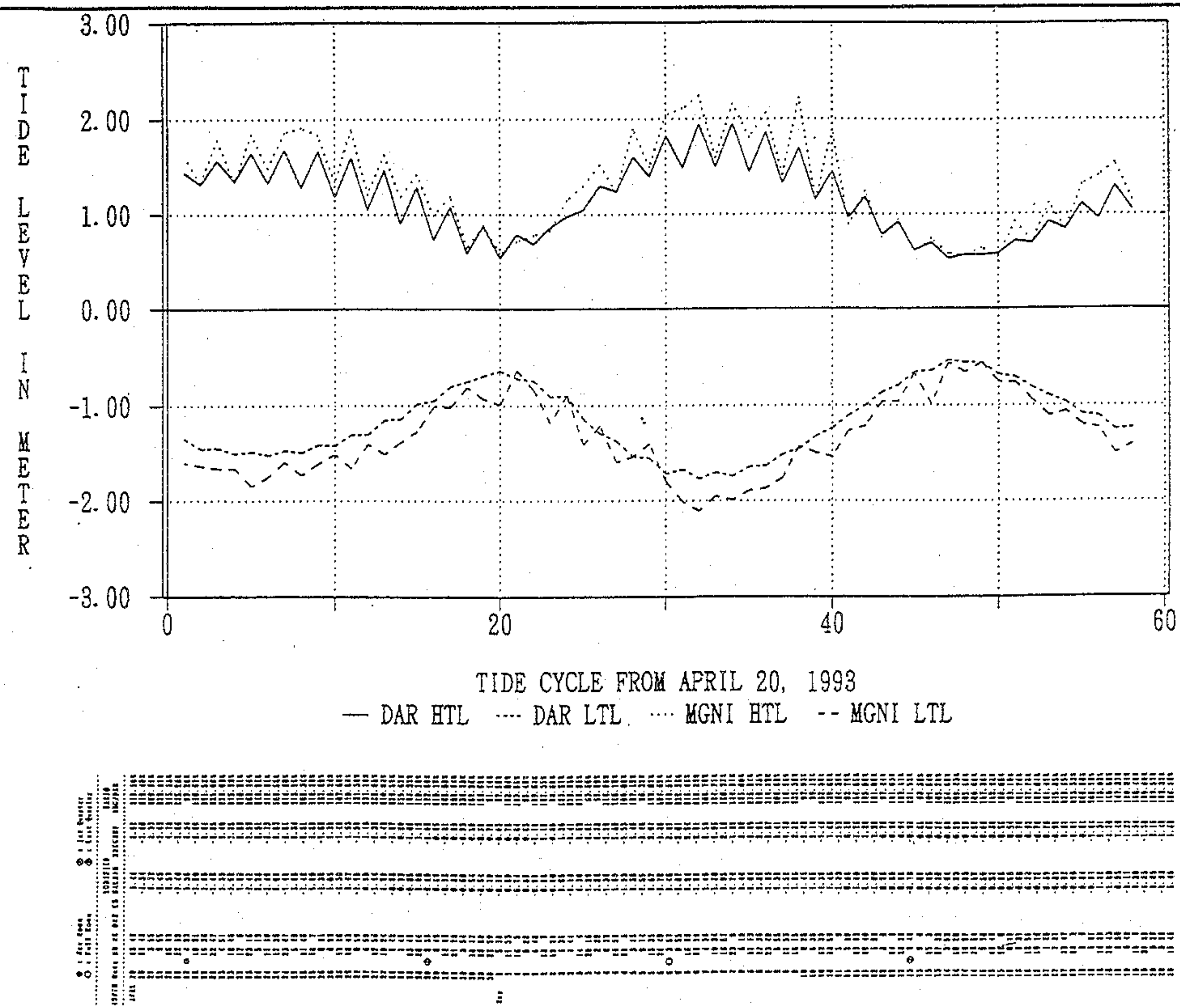


Fig. H.9 TIDE LEVEL 1993 AT DAR ES SALAAM AND MBEGANI

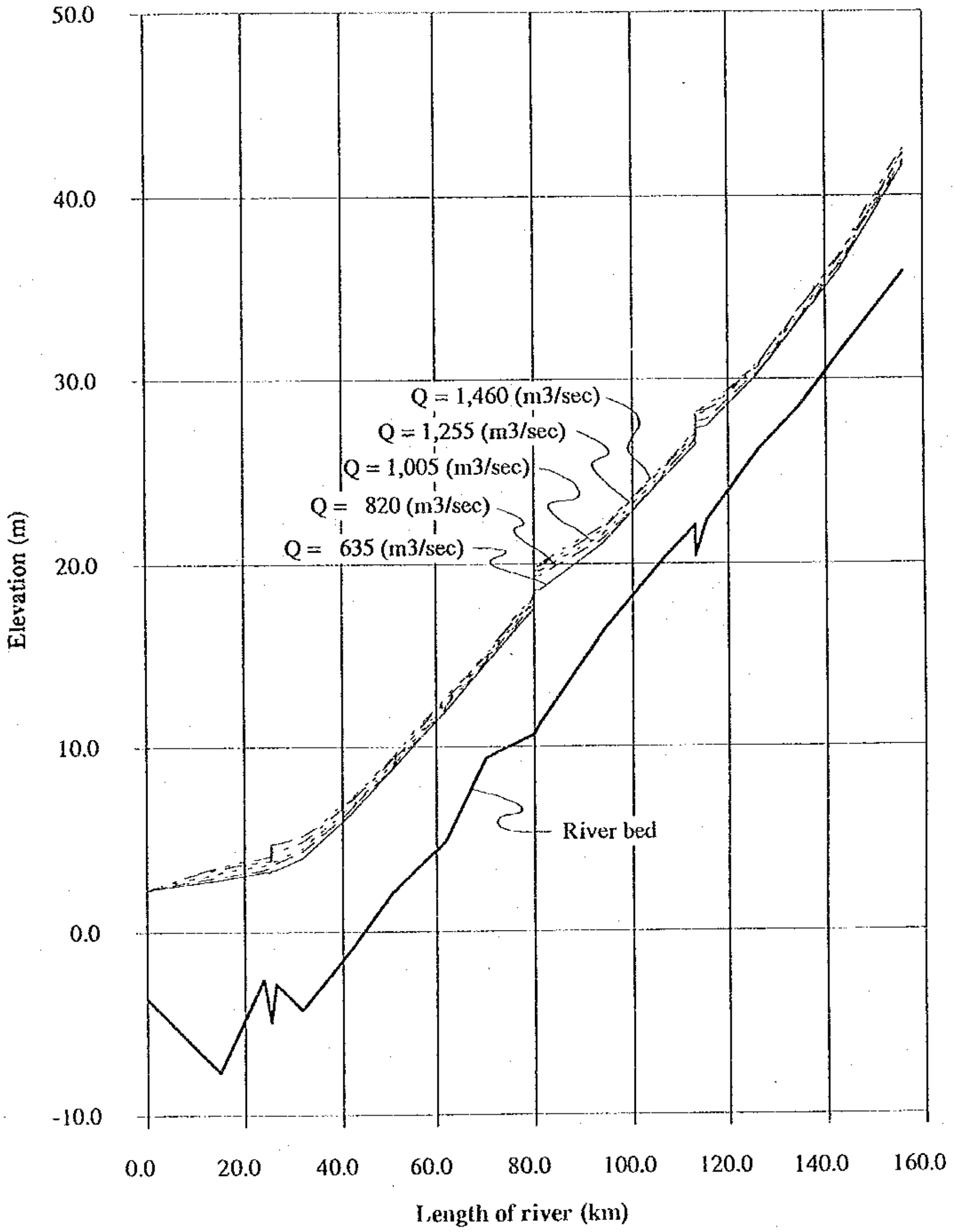
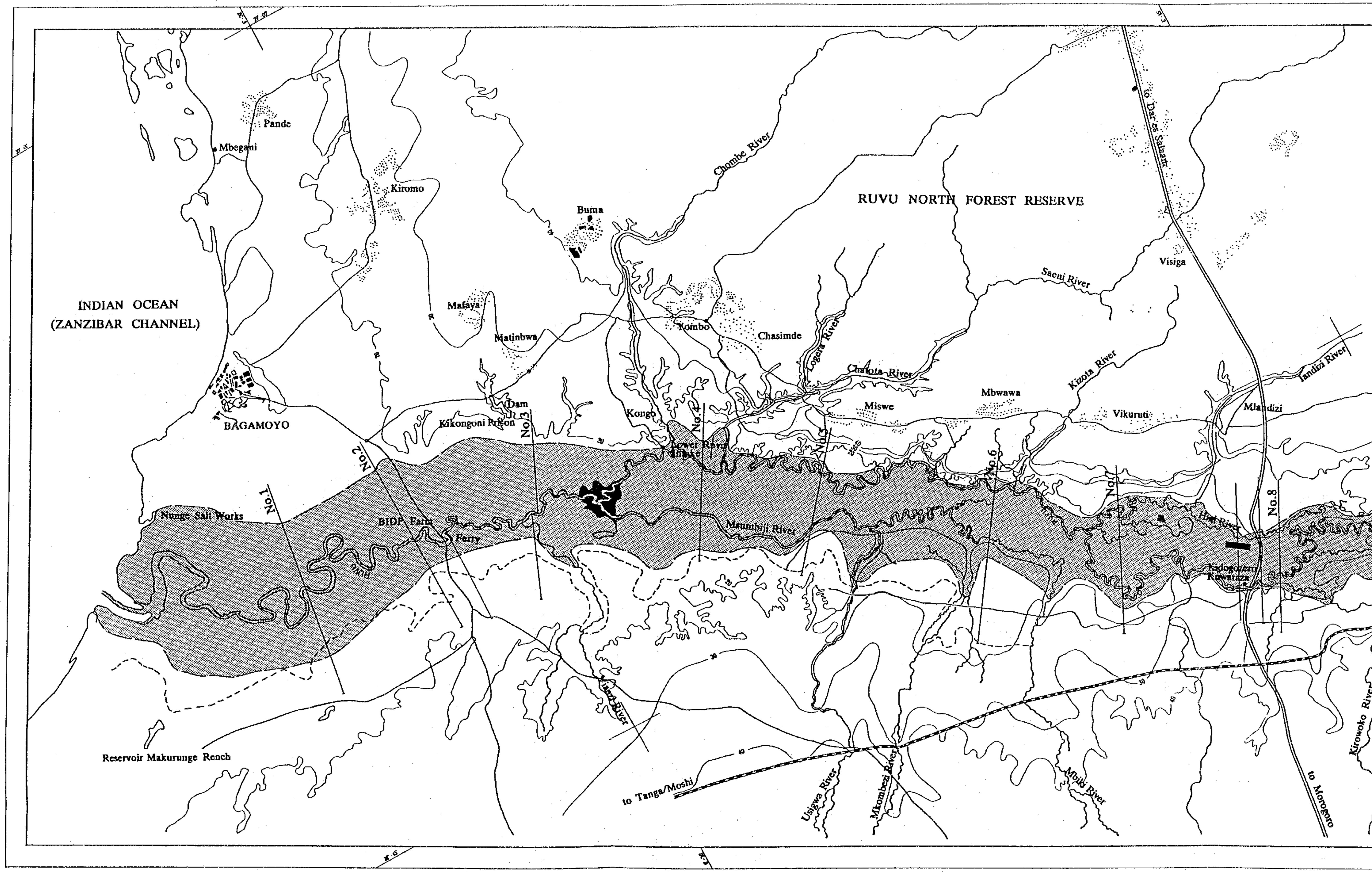


Fig. H.10 FLOOD WATER LEVEL AT LOWER RUVU


INDIAN OCEAN
(ZANZIBAR CHANNEL)
Pande
Mbegani
Kiromo
Buma
Mafaya
Matinbwa
BAGAMOYO
Dam
Kikongoni Prison
Chombe River
RUVU NORTH FOREST RESERVE
to Dar es Salaam
Visiga
Saeni River
Chasimde
Logera River
Chalota River
Kizota River
Iandizi River
Mbwawa
Miswe
Vikuruti
Mlandizi
Kongo
Lower Ruvu Intake
No.1
No.2
No.3
No.4
No.5
No.6
No.7
No.8
Nunge Salt Works
BIDP Farm
Ferry
Ruvu
Msumbiji River
Kwaraza
Reservoir Makurunge Rench
to Tanga/Moshi
Usigwa River
Mkombezi River
Mbiki River
Kirowoko River
to Morogoro

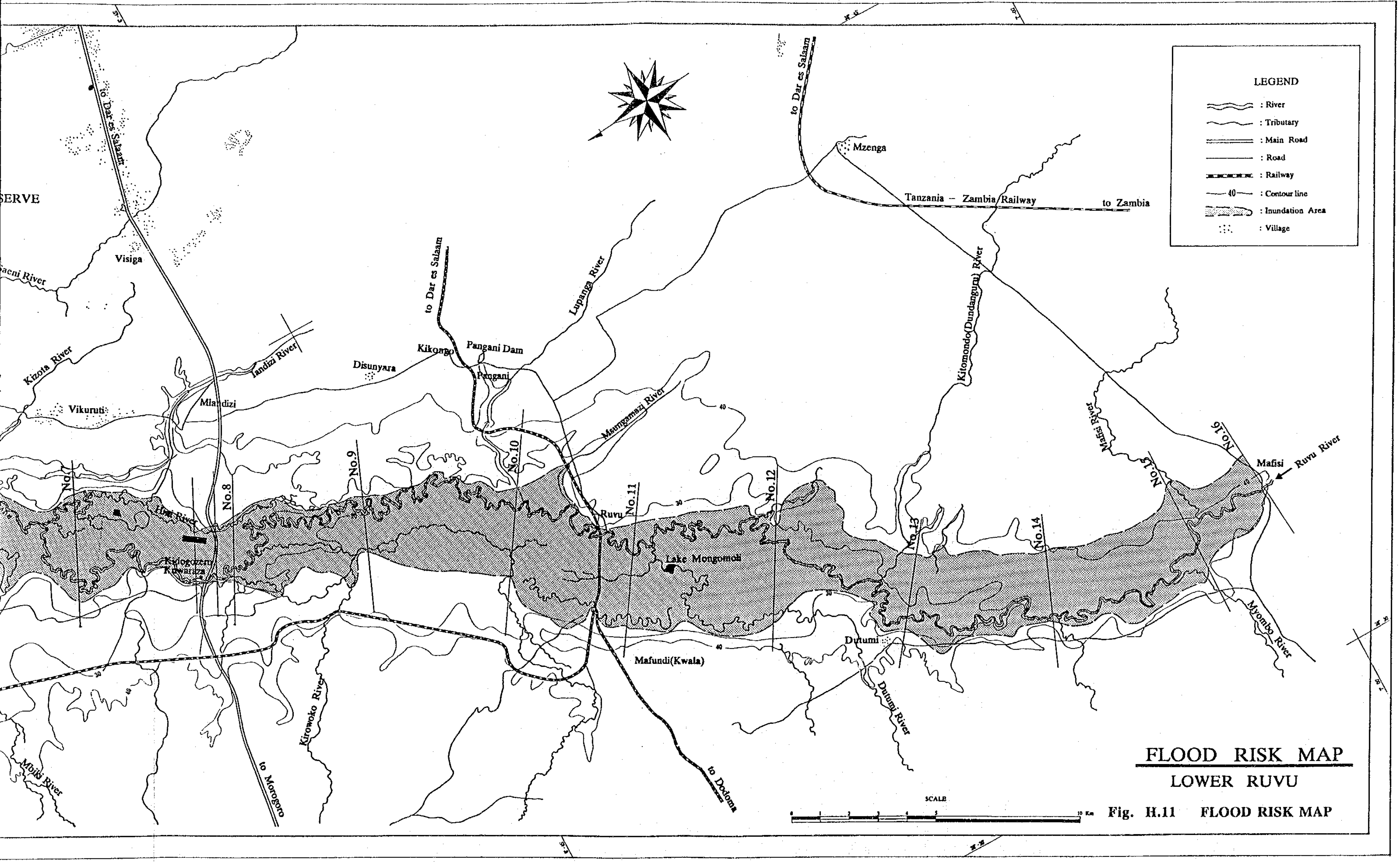
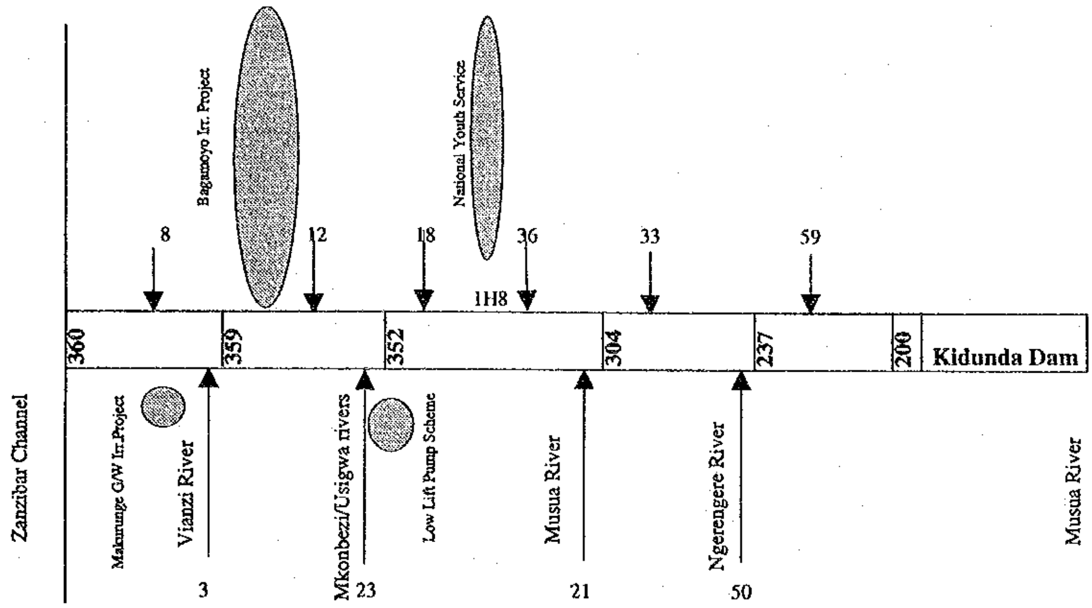


Fig. H.11 FLOOD RISK MAP

(RETURN PERIOD 1/5)



(RETURN PERIOD 1/100)

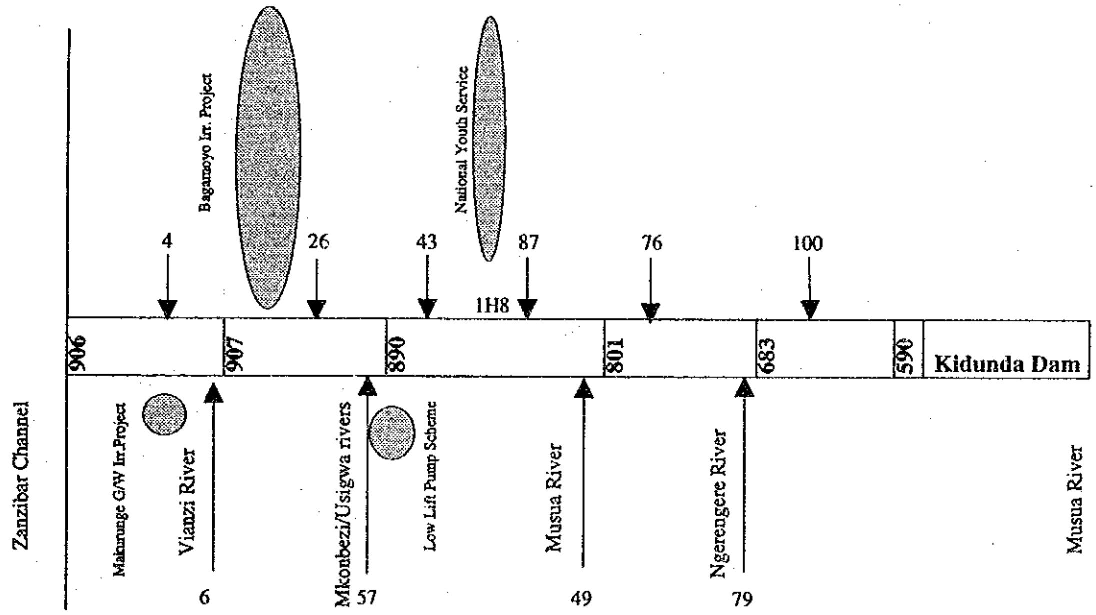


Fig. H.12 FLOOD DISCHARGE ESTIMATED BY STORAGE FUNCTION ANALYSIS AFTER KIDUNDA DAM

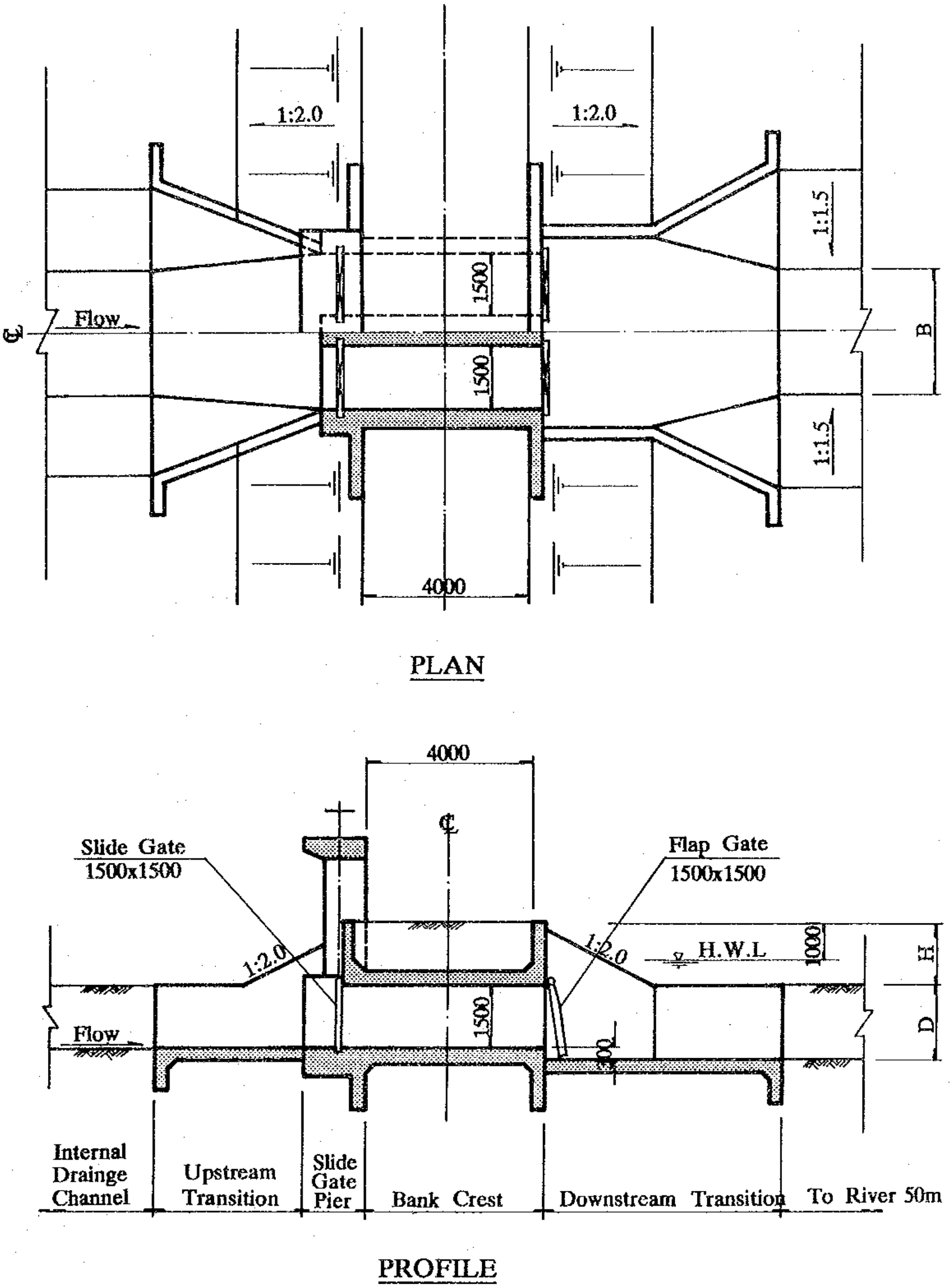
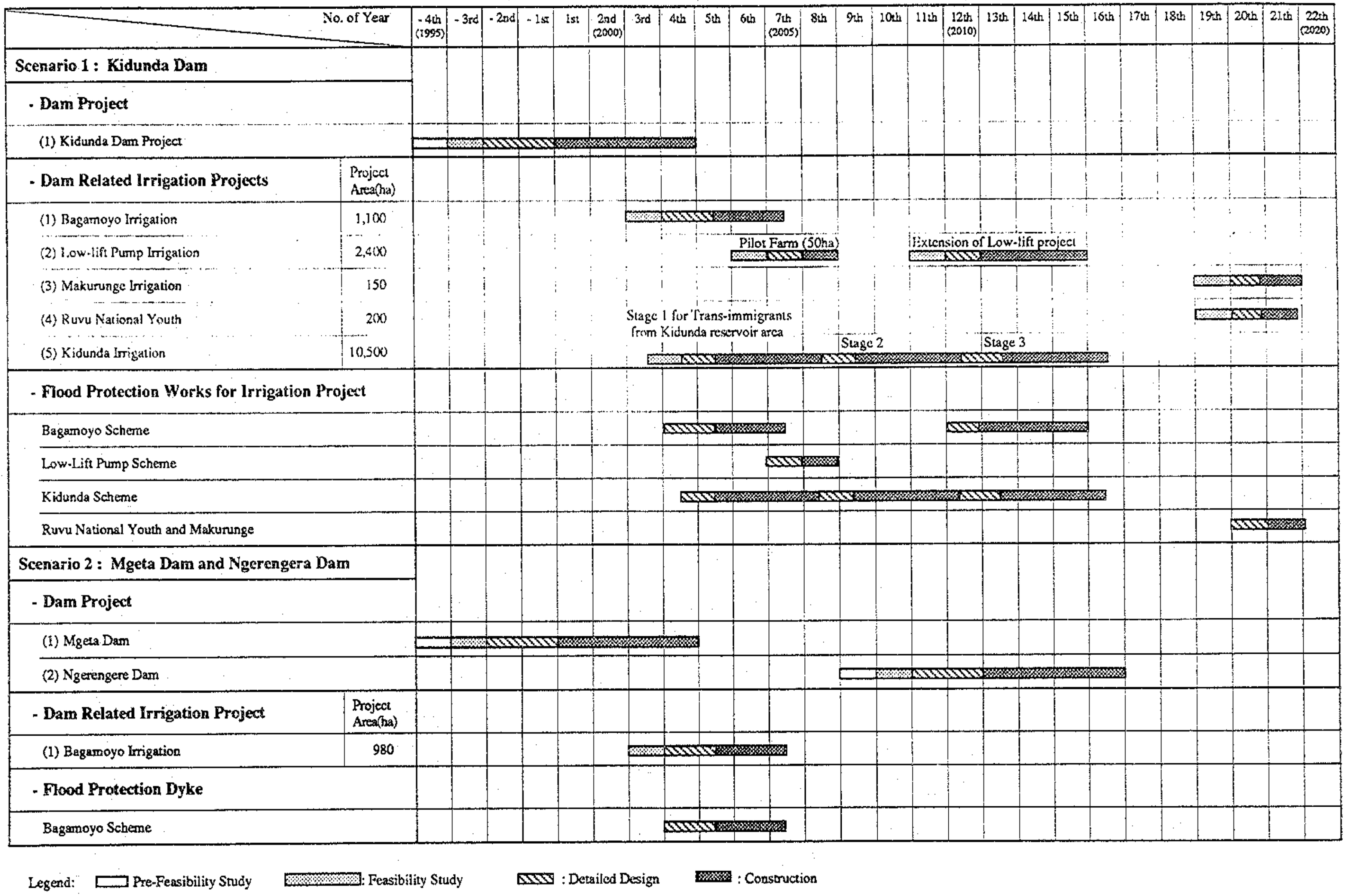


Fig. H.13 TYPICAL DRAINAGE SLUICES

Fig. H.14 IMPLEMENTATION SCHEDULE OF FLOOD CONTROL WORKS FOR IRRIGATION PROJECT BY DEVELOPMENT SCENARIO



APPENDIX-I

WATER RESOURCES DEVELOPMENT PLAN

APPENDIX - I

WATER RESOURCES DEVELOPMENT

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APPENDIX - I

WATER RESOURCES DEVELOPMENT

1. BASIC POLICY

1.1 Principles for Planning Water Resources Development

As stressed in the Inception Report, the primary objective of the Study is to formulate a water resource development plan in the Ruvu River basin to meet the municipal water demand in Dar Es Salaam city by the year 2020. Thus, the municipal water supply to Dar Es Salaam City is given the first priority in establishing the water resources development plan.

Since the streamflow of the Ruvu River varies seasonally throughout the year to a large extent and even year by year, it is necessary to construct a reservoir type dam to augment the dry season flow in order to enable the stable water supply to Dar Es Salaam city over the entire period by means of developing the surface water. Another way to suffice the municipal water demand is exploitation of the ground water resources by combining the surface water development. As explained in Appendix-B of this Supporting Report, however, the ground water resources economically exploitable in the Study Area are considered very less from the hydrogeological condition and quality of ground water. Hence, most of new water resources required to meet the municipal water demand would have to rely on the surface water.

The dependability of design discharge for municipal water supply and return flow from the irrigation area are set at the following figures in order to examine the water balance in the Ruvu River basin in connection with planning of the water resources development;

- Dependability of design discharge for municipal water supply scheme : 95 %
- Rate of return flow for irrigation scheme : 20 %

With regard to other water resources development than the municipal water supply such as irrigation and hydropower development, the development plan is established so that the surplus water in excess of the municipal water demand in Dar Es Salaam city which might be exploitable through provision of the promising reservoir type dams in the basin will be utilized for other development than the municipal water supply as far as possible.

1.2 Necessity of Water Resources Development

At present, most of the municipal water for Dar Es Salaam city is being supplied from the Ruvu River. As the Government's policy, the increasing water demand of the city is planned to be met through water resources development in the Ruvu River basin which comprise provision of reservoir type dams because of its proximity to the city as compared with other surrounding rivers.

The municipal water demand in Dar Es Salaam city is forecast to reach about 11.2 m^3/sec or 969,173 m^3/day in the year 2020 as discussed in Appendix-E of this Supprting Report. While, a 95 % dependable discharge at the NUWA's Upper Ruvu intake site is estimated at 9.1 m^3/sec based on the long-term mean daily runoff data at existing gauging station 1H8, which is situated at the existing Morogoro Road Bridge, about 80 km upstream of the Ruvu River mouth. Thus, it is envisaged that no urgent water resources development plan would need to be implemented to cope with the municipal water demand in Dar Es Salaam, if the entire river flow of the Ruvu River could be utilized for the municipal water supply.

On the other hand, it was confirmed through the field investigation in the Phase 1 Field Work that the water rights along the downstream reach of the NUWA's Upper Ruvu intake site have already been officially registered by existing various kind of farms. A total of the required irrigation water supply for the downstream farms comes to about 1.0 m^3/sec.

In addition to the irrigation water supply, it is essential to discharge down the river maintenance flow to the river mouth from the environmental aspects, in particular in order to safeguard the mangrove trees growing in the lowermost area as well as to avoid occurrence of salinity problems in the downstream farm lands due to intrusion of sea water. The required minimum river maintenance flow is derived to be 4.3 m^3/sec, which is equivalent to the minimum mean monthly discharge at the Upper Ruvu intake site.

As a result, the minimum discharge to be released to the downstream reach of the lower Ruvu intake sites is derived to be 5.1 m^3/sec by summing up the required net irrigation water supply (0.8 m^3/sec) in consideration of the return flow and the river maintenance flow (4.3 m^3/sec). Therefore, the discharge available for the municipal water supply to Dar Es Salaam city comes to about 3.9 m^3/sec with 95 % confidence under the present condition. Thus, the available discharge is by far insufficient for the municipal water demand in Dar Es Salaam in 2020 and it is considered essential to develop the water resources in the Ruvu River basin, if it is possible to exploit the municipal water therein economically.

2. ASSESSMENT OF DAM SITES IDENTIFIED IN THE PREVIOUS STUDY

2.1 Dam Sites Identified by the FAO's Study

In 1961, the previous study carried out under FAO in relation to the water resources development in the Ruvu River basin identified 23 dam sites therein, whose locations are depicted in Fig. I.1.

In succession to the FAO's study, the further study on the identified dam sites was made by the aid of the French Government in 1962 so that 4 dam sites, namely Mkombezi, Mgeta, Ngerengere and Kidunda, were retained as the priority ones among the 23 dam sites identified by FAO. Moreover, the study report states that out of the four dams the Kidunda dam would enable the most efficient storage of the river runoff for the purpose of flood control, municipal and irrigation water supply, hydroelectric power generation. Thereafter, the additional investigation on the Kidunda dam, which includes core drilling at the dam site, was carried out in 1964. The investigation results are summarized in a report titled "Selection of the Kidunda Dam Site, Ministry of Agriculture, Tanzania (1964)".

With regard to the aforesaid 23 dam sites, the preliminary assessment was made to screen out the prospective dam sites from the following aspects applying the project features proposed in the FAO's Report ;

- Geological condition
- Hydrological condition
- Storage efficiency
- Accessibility to the dam site
- Topographic condition

2.2 Geological Condition

On the basis of the site reconnaissance and geologic data collected, the geological assessment was made for each of the 23 dam sites in the Ruvu River basin, identified by the previous studies, as summarized in Table I.1.

In case of the water resources development by means of providing the dam in the Ruvu River basin, it is detected that the following issues on the dam geology might come out;

1) Major fault
2) Seepage through dam foundation and surrounding mountains of reservoir
3) Insufficient bearing capacity of dam foundation

(1) Major fault

The active fault is one that has a possibility to cause movement of ground in near future. Concerning dam constructed on or near the active fault, there is a high possibility that it cause the dam failure when an earthquake takes place. Therefore, the dam needs to be constructed not adjacent to the active fault.

In the Ruvu River basin, there exists the major fault along the Mgeta River, southern section of the Uluguru Mountains according to the geological maps collected during the Phase 1 Field Work. The major fault delineates the Pre-Cambrian rock and Quaternary alluvial deposit. Although the further study is required to clarify the extent of the major fault and geological movement in the next study stage, there is a possibility that the dam sites selected on the Mgeta River and its tributaries are to be affected by the major fault in view of the dam safety. Of the proposed 23 dam sites, the following five (5) ones are located close to the major fault as mentioned in Appendix-B of this Supporting Report;

- Mgeta
- M/LB/R1
- Mngazi
- Bwakila
- Dutumi

(2) Seepage through dam foundation and surrounding mountain of reservoir

In the Jurassic limestone, Calcareous rocks and Cretaceous marl and limestone distributing in the Ruvu River basin, there is a possibility that there exist a lot of holes in those rocks. At these sites, therefore, the reservoir could not store inflow discharge as expected, due to seepage along the foundation rock and surrounding mountain after construction of dam. Moreover, the dam body might result in failure due to piping and uplift in the foundation. Judging from the geologic maps, there is a possibility that the following dam sites are dominated by such geological condition;

- Kidunda
- Mkulazi
- LB/R1
- Mbiki

(3) Insufficient bearing capacity

It is considered that dam founded on alluvial deposits with insufficient bearing capacity would result in failure of dam, provided that the dam is founded on the alluvial layer. Besides, the seepage through the dam foundation is expected to occur so that it may not function properly as expected. On the other hand, it is anticipated that the dam construction cost will increase remarkably, in case the dam is founded on the firm rock overlaid by the alluvial layer. On the basis of the geological data and site reconnaissance, it deems that the following dam sites are covered by the comparatively thick river deposits;

- RB/R2
- Banda
- Mbwawa
- Chomthe

2.3 Hydrological Condition

As mentioned in Appendix-C of this Supporting Report, the high annual rainfall exceeding 2,000 mm takes place in and around the Uluguru Mountains areas located in the western part of the Ruvu River basin, while the relatively low annual rainfalls of less than 1,000 mm are usually recorded in the eastern part thereof. Besides, the low runoff coefficients are obtained through the present hydrological analyses in the tributaries originating on the left bank side of the Ruvu mainstream. Using isohyetal map of annual rainfall which is explained in Appendix-C, the basin average rainfall for those covered by each of the 23 dam sites is estimated as shown in Table I.1.

For each sub-basin of the Ruvu River, the runoff coefficient is derived as explained in Appendix-C. The runoff coefficient in the entire Ruvu River basin is estimated at about 12%. The rather low runoff coefficient of less than 10 % is derived for the Ngerengere basin and the lower Ruvu basin.

The following two (2) factors are applied to represent the hydrological features for each catchment of the 23 dam sites;

Specific runoff depth ("IR" in mm/year/km^2) : $IR = Ra \times f/100$
Annual inflow volume ("IV' in Million m^3) : $IV = A \times Ra \times f/1000$

where, Ra : Annual mean rainfall in the catchment (mm/year)
f : Runoff coefficient (%)
A : Catchment area (km^2)

The factor "IR" shows annual average runoff rate per km^2, while annual mean gross runoff volume from the whole catchment is represented by the factor "IV". The larger values of "IR" and "IV" mean larger inflow volume that exhibits the high attractiveness from the hydrological viewpoint. Those factors for the respective dam sites are tabulated in Table I.1.

2.4 Efficiency of Reservoir

The storage efficiency factor defined below is used to compare with the efficiencies of the respective reservoirs;

Storage efficiency (SE) : $SE = Vr/Ve$

where, Vr : Reservoir storage capacity (Million m^3)
Ve : Embankment volume of main dam (Thousand m^3)

The factor "SE" exhibits a simple storage efficiency. The larger value means more efficient dam scheme. As shown in Table I.1, the Kidunda dam reveals the distinguished high storage efficiency among the 23 dams.

2.5 Accessibility

In implementing the dam scheme, construction of the access road from existing trunk road to the dam site is indispensable. The approximate length of access rood required therefor is measured on existing 1 to 50,000 scaled maps based on the site reconnaissance and with reference to aero photographs. The required access road is divided into two portions, namely the section for which road is required to be newly constructed and that requiring only improvement works for existing road such as widening and/or pavement.

2.6 First Screening of Dam Sites

The above factors for the respective dam sites are summarized in Table I.1. As seen in the Table, the dam sites No.11 to No.22 show rather low runoff depth and inflow volume due to their extremely small runoff coefficients. Presumably, such unattractive hydrological features would be responsible for lesser annual rainfall in the catchment as well as geologic condition of the catchment. These dam schemes are considered to be not attractive from the hydrological viewpoint.

Out of the retained 10 dam schemes, 5 dam sites are located closed to the major fault as aforesaid. In this Study stage, however, the major fault is not necessarily critical issue to disqualify them as the unfavorable dam sites for the water resources development, but as a matter of course these dam sites require detailed geological investigation in the successive prefeasibility or feasibility study stage.

Concerning the Kidunda dam, the geological investigation including core drilling was performed for the downstream locations under the French aid, which covers a catchment area of about 5,760 km^2. Since the runoff at the downstream locations is by far than that at the upstream site identified by the FAO's Study, it is determined that the further examination is to be made for the downstream sites. It deems that the downstream area of the proposed dam site is clearly composed of limestone judging from the geological maps and topographic features of both banks based on existing 1 to 50,000 scaled topographic maps. While, the bore holes drilled at the proposed dam site in the course of the French study encountered the sandstone and shales as well as clayey layer. Although the Kidunda dam requires more detailed geological investigation in the next prefeasibility or feasibility study stage, it is retained as one of the candidate dam sites for the reason of the high reservoir efficiency as well as abundant inflow at the proposed dam site.

The results of the overall assessment on the 23 dam sites are summarized in Table I.2. Although the Msoro dam site is given the highest rank of "A" in the Table, it is judged that the topographic condition at the dam sites could not allow construction of a storage type dam. Hence, the Msoro dam is excluded from the candidate dams. As a result, the following four (4) dam schemes are selected as the candidate dams for the water resource development ;

- Rudete
- Ngerengere
- Kidunda
- Mgeta

As mentioned above, it is essential to clarify the geological condition of the Mgeta and Kidunda dams in the prefeasibility or feasibility study that is expected to be carried out after this Study.

3. PRELIMINARY OPTIMIZATION OF DAM DEVELOPMENT SCALES

3.1 General

Four (4) dam sites have been selected as the candidate dam sites among the 23 ones through the first screening as aforesaid. These four dam sites include three dams out of four (4) ones selected by the French study as the promising ones in the Ruvu River basin. In this Section, the optimization study to determine the most appropriate development scale is made for the five dams which comprise the aforesaid four (4) candidates dams and the Mkombezi dam for reference.

The development scale for each of five (5) dam schemes selected above is optimized through the following procedures;

- Preparation of reservoir storage curve showing a relation among reservoir water level, reservoir area and volume, and river cross section along dam axis
- Selection of alternative development cases with respect to dam height
- Reservoir operation for each case to estimate the available discharge
- Construction cost estimate for each case based on the dam embankment volume and required length of access road
- Determination of the least cost case for each dam scheme

The above procedures are explained in the following Sections;

3.2 Reservoir Operation Study

(1) Reservoir storage curve and river cross section along dam axis

The reservoir storage curve is constructed based on existing 1 to 50,000 scaled topographic maps to be applied to the reservoir operation study for each of the five (5) dams. Besides, the river cross section along the dam axis, which is used to calculate the embankment volume for each dam, is prepared based on the 1 to 50,000 scaled topographic maps and river cross sections obtained through the topographic survey performed in the Phase 1 Field Work.

The reservoir storage curve and river cross section thus derived are shown in Figs. I.2 to I.6 by the dam scheme.

(2) Selection of alternative development cases for each dam scheme

a. Dead storage capacity of the reservoir

In planning the reservoir type development, at first, the dead storage capacity needs to be secured below the low water level (LWL) of the reservoir. As stated in Appendix-C, the sediment transport rate was derived to be about 100 $m^3/km^2/year$ and 400 $m^3/km^2/year$ at the existing stream gauging stations 1H8 and 1H10 respectively based on the limited data of suspended sediment load. On the other hand, in case of the Lower Kihansi Hydrower Project whose construction is going to start soon, the sediment yield at the Lower Kihansi intake dam site with a catchment area of 590 km^2 was estimated at about 70 $m^3/km^2/year$. Broadly speaking, therefore, the denudation rate in the Ruvu River basin seems to range between 1 mm/year and 5 mm/year depending on the regional conditions including vegetation, land slopes, vegetation, land use, etc. Hence, it is recommended to carry out the intensive water sampling for the suspended load analysis at the proposed dam site in the next study stage so as to estimate the sediment transport rate with accuracy. In this Study carried out at a level of master plan study, the dead storage capacity was determined to be the volume yielded at the denudation rate of 5 mm/year for 100 years taking into the slightly safer side design for a life of reservoir. The required dead storage volume was calculated by the following formula;

$$Vd = Er \times Ca \times 0.1$$

Where, Vd : Required dead storage capacity (Million m^3)
Er : Denudation rate of the Ruvu River basin (mm/year)

Ca : Catchment area covered by the proposed dam site (km^2)

b. Selection of alternative development cases

The low water level (LWL) is taken at the reservoir water level which corresponds to the above dead storage capacity. To find out the least-cost case for each dam scheme, six alternative cases are selected by varying the full supply level which is set above the dead minimum operation level for every case. Those alternative cases are shown in Tables I.3 to I.7 by the dam scheme.

(3) Reservoir operation study

Concerning each alternative case, the reservoir operation study is carried out to estimate the dependable discharge to be increased after regulating the natural inflow through the planned reservoir storage volume. The reservoir operation study is made applying the reservoir storage curve, long-term mean monthly discharges at the proposed dam site, obtained through the hydrological analysis, and monthly evaporation observed in the Ruvu River basin. The general equation for the reservoir operation is expressed as follows;

$$V_{n+1} = V_n - (A_n + A_{n+1}) \times Ev \times Nd \times 0.001 + (Qi - Qd) \times Nd \times 0.0864$$

Where,

V_{n+1} : Effective storage volume at the end of the month (Million m^3)
V_n : - do - at the end of the previous month (Million m^3)
A_{n+1} : Reservoir area at the end of the month (km^2)
A_n : - do - at the end of the previous month (km^2)
Ev : Average evaporation from the reservoir surface for the month (mm/day)
Nd : Number of days of the month
Qi : Mean monthly inflow into the reservoir (m^3/sec)
Qd : Dependable outflow from the reservoir

The inflow data for forty (40) years are worked out for the reservoir operation study through the hydrological analysis. The evaporation rate from the reservoir surface is adopted to be 70 % of the Pan-A evaporation records at Kibaha. The dependable discharge in each alternative case is estimated to enable a definite outflow throughout the available period of inflow data of 40 years.

The results of the reservoir operation study are summarized in Tables I.3 to I.7. It is verified through the reservoir operation study that the dependable discharge doesn't increase in proportion to the effective storage volume when the full supply level rises, since rate of loss of water stored in the reservoir becomes larger according to enlargement of the reservoir area. Especially, this phenomenon is seen in case of the Kidunda dam. Thus, it is not necessarily economical to construct high dam taking into account the evaporation loss from the reservoir surface.

3.3 Preliminary Construction Cost Estimate

In the optimizations study, the construction cost for each alternative development case is estimated simply based on the dam embankment volume as well as that for access road to the dam site. Concerning the dam type, the fill type dam is selected for every dam site in consideration of the geological conditions. The dam embankment volumes are estimated applying the following criteria based on the river cross section at each dam site;

- Dam crest level is set at 5 m above the Full Supply Level (FSL), adopting a free board of 5 m.
- Upstream and downstream slopes of dam body are 1 : 2.50 and 1: 1.95, respectively.
- Depth of excavation for placing foundation of impervious core zone of embankment is assumed at 5 m below original ground surface except for the Kidunda dam whose geological profile is made available through the previous French study.

According to the Study on the National Water Master Plan in Kenya, the relation between the embankment volume and the dam construction cost is derived to be represented by exponential curve shown in Fig. I.7. This formula is tentatively applied to estimate the dam construction cost. Besides, the construction cost of the access road is estimated using unit rate of US$ 400,000/km and US$ 55,000/km for new construction of access road and improvement of existing road, respectively, with reference to the unit rates prevailing in Tanzania. Thus, the direct construction cost is estimated by summing up these costs.

The total construction cost is then estimated adding the engineering service/administration cost and physical contingency cost, which are assumed to be equivalent to 12.5 % and 15 % of the direct cost, respectively. The estimated total construction cost for each alternative case is depicted in Figs. I.8 to I.12.

3.4 Optimum Development Scale of Dam

The alternative cases for each dam scheme are compared with one another in terms of the construction cost per dependable discharge, which is derived dividing the total construction cost by the dependable discharge. The values are depicted in Figs. I.8 to I.12. As a result, the optimum case for each dam scheme is determined by means of the least-cost criteria as shown below;

Name of Dam	Catchment Area (km2)	Mean Inflow (m3/sec)	Dam Height (m)	Effective storage Volume (Mill. m3)	Dependable discharge (m3/sec)	Construct. Cost per Dep. Disch. (Mill. US$/m3/sec)
Rudete	247	3.03	35.0	15.9	1.40	31.6
Ngerengere	2,809	4.32	31.0	143.9	1.81	56.9
Mkombezi	603	1.13	25.0	40.2	0.36	173.1
Mgeta	939	12.63	40.0	63.4	5.82	13.7
Kidunda	5,761	48.97	26.0	456.4	28.16	1.6

As shown in above table, the Kidunda dam exhibits the considerably low construction cost per dependable discharge for the sake of the distinguished reservoir storage efficiency, while the Mkombezi dam requires very high construction cost as compared with that of the Kidunda to develop the same quantity of water for the municipal water supply.

3.5 Features of Selected Dam Schemes

From the above preliminary examination, the following results are derived for each dam scheme;

a. Kidunda dam

The Kidunda dam shows the lowest rate in terms of construction cost per dependable discharge exploitable, if there exists no fatal geologic problems in relation to the existence of limestone at the dam foundation and in the reservoir area. As stated in Appendix-B, it is recommended that two alternative sites, the "Lower Downstream site" and "Intermediate site", are investigated in detail in the next study stage with respect to their geological conditions. As a result of the field reconnaissance conducted in the Phase 1 Field Work, it is found that there exist sandy limestone layers at the "Lower Downstream Site". On the other hand, the "Intermediate Site" consists of the carbonate and mudstone, which is differentiated from the "Lower Downstream Site" by fault running between these two alternative dam sites. Of these two alternative dam sites, the upper site may be hardly affected by the limestone. In view of the existence of the limestone at the "Lower Downstream Site", it is considered that the "Intermediate site" is more favorable, although there is a possibility that the clayey layer exist in the mudstone at the "Intermediate Site". Furthermore, the Kidunda dam would be able to yield abundant water which exceeds the municipal water demand in Dar Es Salaam city in the year 2020. Accordingly, in case it is verified through geological investigation in the successive prefeasibility or feasibility study that the dam site and reservoir area are technically sound for construction of around 21 m high fill type dam above the river bed, the Kidunda dam will be ranked as the most attractive one from the economical aspect. In addition, the surplus water which exceeds the water demand in Dar Es Salaam City in 2020 enables to develop new irrigation areas spreading in the downstream areas of the dam site.

b. Mgeta dam

The Mgeta River is also blessed with abundant river flow which is sourced mainly from the high rainfall in the Uluguru Mountains area. The Mgeta dam is located very far from the NUWA's Upper Ruvu intake site, about 300 km downstream therefrom. While, a wide area of potential irrigation areas spread downstream thereof. Therefore, it is anticipated that water to be yielded by the Mgeta dam is to be utilized for the irrigation development. On the other hand, the Mgeta dam is located comparatively close to the major fault running in the downstream floodplain of the Mgeta River. Accordingly, the geological issue will have to be resolved in the next feasibility or feasibility study stage before implementing the Mgeta dam scheme.

The Mgeta reservoir can discharge downstream a comparatively large quantity of regulated flow throughout the whole period. In planning the Mgeta dam for the purpose of water supply to Dar Es Salaam, however, it is considered necessary to clarify the loss of water discharged from the reservoir, which may take place in the downstream floodplains due to evaporation before arriving at the intake sites.

c. Ngerengere dam

The Ngerengere dam is located about 175 km downstream of existing Mindu dam on the Ngerengere River. Although the construction cost of the Ngerengere dam estimated in this stage is higher than those of the Kidunda and Mgeta dams, the water to be regulated by the

Ngerengere dam would contribute to municipal water supply to Dar Es Salaam city. Besides, it is possible to utilize water to be exploited through provision of the Ngerengere dam for irrigation development in the downstream areas of the planned dam site.

d. Rudete dam

The Rudete River is a tributary of the Msoro River, draining the most western part of the Ruvu catchment. The Rudete dam site is located about 15 km upstream of the confluence of the Rudete and Msoro Rivers or about 310 km upstream of the NUWA's Upper Ruvu intake site. Thus, the Rudete dam site is very distant from the NUWA's Upper/Lower Ruvu intake sites as well as the case in the Mgeta dam so that there is a possibility that a larage part of water released from the Rudete reservoir is loosed until it arrives at the downstream intake sites taking into consideration the smaller regulated flow, even though the dam scheme is planned to be developed for the purpose of municipal water supply to Dar Es Salaam. Therefore, it is foreseen that water regulated by the Rudete reservoir is to be utilized to irrigate the downstream areas of the dam site if there exists the promising potential irrigation areas therein.

e. Mkombezi dam

The Mkombezi dam is assessed to be unattractive in terms of the considerable high rate of construction cost per dependable discharge exploitable. Therefore, the Mkombezi dam is excluded from the candidate dam sites as verified through the first screening.

The general plans of above four (4) dams are shown in Fig. I.13 to I.16. As a result of the above examination, three (3) dams of the Kidunda, Ngerengere and Mgeta are selected as the candidate dam schemes for coping with the municipal water demand in Dar Es Salaam by to the year 2020.

4. WATER BALANCE FOR WATER SUPPLY TO MOROGORO MUNICIPALITY

4.1 Existing Morogoro Water Supply Plan

The municipal water for Morogoro, the second largest town in the Study Area, is being supplied from existing Mindu dam. In this Section, the water balance of water demand in Morogoro and water supply capacity of the Mindu dam is examined based on the dam heightening plan and water demand up to the year 2020.

The Mindu dam is situated on the Ngerengere River, about 7 km southwest of the Morogoro municipality. It was constructed for the purpose of the municipal water supply to Morogoro municipality.

In 1972, the Ministry of Water Development and Power carried out a feasibility study on Morogoro town water supply covering a period up to the year 1995. The study examined various alternative sources of water to meet the future water requirement therein. The alternative modes of water supply were as follows:

- Construction of Mindu dam

- Extension of the existing water supply system using the Morogoro River water
- Development of tributaries of the Ngerengere River
- Draw-off from the Ngerengere River (at Konga)
- Supply from Mlali River
- Ground water supply

As a result of the study, construction of the Mindu dam was selected as the best alternative. The project has inherent problems but it had advantages and was more substantial alternative than the other modes. The Mindu dam was completed in 1985. Main features of the dam are shown in Table I.8.

Also the project considered the second stage construction, which includes heightening the dam by 2.5 m to get additional storage reservoir capacity to meet the future water demand and cope with siltation in the reservoir.

4.2 Balance of Water Demand and Water Supply for Morogoro Municipality

As explained in the foregoing Appendix-E, the municipal water demand in Morogoro in the year 2020 is forecast at 0.95 m^3/sec or 82,373 m^3/day. The balance of water demand and water supply for the Morogoro municipality is shown in Fig. I.17. As seen in the Figure, the water deficit is forecast to take place in the year 2017, even though the water supply capacity of the Mindu dam is augmented through heightening of existing dam as originally planned.

5. WATER BALANCE FOR WATER SUPPLY TO DAR ES SALAAM

5.1 General

Apart from the irrigation development in the Ruvu River basin, as discussed in the forgoing Section 10.3, the Kidunda, Mgeta and Ngerengere dams are expected to be prospective water resources for coping with the municipal water demand in Dar Es Salaam. In principle, the water resources development plan is established to meet the municipal water demand in Dar Es Salaam in the year 2020 by means of provision of those dams, in case the natural flow of the Ruvu is not able to meet the increasing water demand in Dar Es Salaam.

Judging from the topographic condition along the Ruvu River, there exist the suitable intake sites only in the downstream reach of the Kidunda dam site, which include existing Upper and Lower Ruvu intake sites. Therefore, the water balance is examined at the existing stream gauging station 1H8, the Morogoro Road Bridge site.

5.2 River Maintenance Flow

In making the balance of water demand and supply, the river maintenance flow constitutes key component of water demand. The maintenance flow of a river needs to be determined taking into account various aspects such as navigation, fishing, picturesque scenery, salt water intrusion, clogging of river mouth, riparian structures, ground water table, flora and fauna, river water quality. In case of the Ruvu River, it is the most important to secure a river flow required to conserve mangrove trees growing in the lowermost reach. Besides, there exist various farms in the downstream reach of the Upper Ruvu intake site, which register the water rights with respect to use of the river water. Therefore, the dams planned in the upstream reach have to be operated to release a discharge which is equivalent to a sum of the river maintenance flow and water requirement for existing farms.

To determine the river maintenance flow, the minimum monthly discharges observed and simulated at existing stream gauging station 1H8 are compared with the probable minimum mean daily discharges thereat.

The lowest mean monthly discharge at the stream gauging station is derived to be 4.3 m^3/sec in November 1959 among the mean monthly runoff data for 31 years from 1959 to 1989 according to the simulation results. On the other hand, the water requirement in the downstream reach totals about 1.0 m^3/sec. Consequently, the minimum flow to be secured in the downstream reach is derived to be 5.1 m^3/sec taking account the return flow from the downstream farms. While, the probable 10-year and 20-year minimum mean daily discharges at the gauging station 1H8 are calculated at 5.4 and 4.6 m^3/sec, respectively, based on the observed annual minimum data. Thus, the river maintenance flow of 5.1 m^3/sec is considered to be in an appropriate range as the minimum requirement.

5.3 Scenario of Water Resources Development to Meet Water Demand in Dar Es Salaam

The 95 % dependable mean daily discharge at the Upper Ruvu intake site is derived to be about 9.1 m^3/sec based on the long-term mean daily discharges observed at existing stream gauging station 1H8 which covers a catchment area of 15,180 km^2. By deducting the aforesaid minimum flow of 5.12 m^3/sec in the downstream reach from the 95 % dependable discharge, the maximum water which can be supplied from the Ruvu River to Dar Es Salaam under the present condition comes to about 3.9 m^3/sec. In case no upstream dams are developed, that is, under the present condition, the natural flow of the Ruvu would meet the municipal water in Dar Es Salaam up to the year 1994. Therefore, the natural flow in the dry season is required to be regulated by the upstream dams in order to cope with the water demand in Dar Es Salaam by the year 2020, which is forecast to be about 11.2 m^3/sec.

Thus, it is essential to provide the reservoir type dam(s) in the upstream reaches of the Ruvu River. The water balance is made concerning the discharges at the Upper Ruvu intake site at the existing Morogoro Road Bridge. The surplus water available for irrigation is calculated by the following equation neglecting evaporation loss of the released outflow;

$$QI = \Sigma QDi + QR_{95\%} - Qm - Q_{2020}$$

Where,

QI	:	Discharge available for new irrigation development (m^3/sec)
ΣQDi	:	Regulated outflow from upstream dam(s) (m^3/sec)
$QR_{95\%}$	:	95 % dependable discharge for area not covered by the upstream dam(s) (m^3/sec)
Qm	:	Sum of river maintenance flow and irrigation water requirement in the downstream reach (m^3/sec)
Q_{2020}	:	Water demand in Dar Es Salaam City in the year 2020 (m^3/sec)

To make the above value of "QI" positive, the following three (3) scenarios are tentatively conceived in terms of the reservoir type development;

Development Scenario -1 : Kidunda dam only
Development Scenario -2 : Mgeta dam and Ngerengere dam

The water balance in each of the Development Scenarios-1 and -2 is shown in Table I.9. The development plans of the those dam projects in the Development Scenarios-1 and -2 are depicted in Figs. I.18 and I.19 respectively taking into consideration the future municipal water demand in Dar Es Salaam and time required for construction of those dam projects.

6. POTENTIALS OF HYDROPOWER

6.1 General

Following provision of the reservoir type dams, the regulated water will be able to be utilized for development of new irrigation area as well as hydropower generation. The former is planned to use the surplus water that exceeds the municipal water demand in Dar Es Salaam in the year 2020 out of water to be exploited through provision of the upstream dams. In case of the latter, electricity will be generated by harnessing a head created through provision of dam as well as regulated outflow, which is released downstream to be utilized for the municipal water supply to Dar Es Salaam.

6.2 Hydropower Development

The Ruvu River basin is located relatively close to Dar Es salaam, the largest electricity-consuming area in Tanzania, as compared with other river basins with the hydropower potentials around the city. In the Ruvu River basin, on the other hand, the large head to generate hydropower is exploitable only in the Uluguru Mountain area located in the western part of the Ruvu River basin, but the available discharge at these locations are less because of small catchments. Thus, it is envisaged that the large scale of hydropower potential sites are considered very less in the Ruvu River basin.

The installed capacity and annual energy output of the hydropower plant are determined by the following equation for each of the dam schemes which are examined in the aforesaid second screening;

$$P = Cf \times 9.8 \times He \times Qd \times Fc$$
$$E = P \times 24 \times 365/10^3$$

Where,
- P : Installed capacity (kw)
- Cf : Combined efficiency of generator and turbine (=0.85)
- He : Effective head (m)
- Qd : Dependable discharge released from reservoir (m^3/sec)
- Fc : Plant factor
- E : Average annual energy output (MWh/year)

The daily power output of hydropower plant to be installed at each dam site will be controlled by discharge released from the reservoir for the water supply to Dar Es Salaam. On the other hand, discharge to be released from the reservoir varies in accordance with the water demand in Dar Es Salaam during 24 hours. According to the water demand forecast for Dar Es Salaam which is stated in the foregoing Appendix-E, a ratio of maximum daily water demand to mean daily one in the year 2020 is predicted to be about 1.25. Therefore, 1.25 is adopted as the plant factor.

The rated water level of the reservoir is set at an elevation of Normal High Water Level (NHWL) minus one-third of a difference between NHWL and Low Water Level (LWL). The effective head is then estimated by deducting the tail water level and head loss from the rated water level.

The installed capacity and annual average energy output for each dam scheme which are worked out through the aforesaid procedures are summarized below;

Name of Dam Scheme	Installed Capacity (KW)	Annual Energy Output (MWh/year)
Rudete	500	4,380
Ngerengere	400	3,504
Mgeta	2,300	20,148
Kidunda	3,900	34,164

As shown in above table, the installed capacities for the Rudete and Ngerengere schemes are as small as to 400 kw to 500 kw. Therefore, it is recommended that electricity generated by these hydropower plants are utilized for use in the rural area and/or station use, even though the dam scheme will involve installation of hydropower plant.

The main features of hydropower plants for each dam scheme are described in Appendix-J of this Supporting Report.

7. WATER RESOURCES DEVELOPMENT PLAN IN THE RUVU RIVER BASIN

As discussed in the foregoing Section 5.3, two development scenarios of the water resources development in the Ruvu River basin were set up for the purpose of coping with the municipal water demand in Dar Es Salaam by the year 2020. In association with the construction of dam projects involved in the development scenario, it is prospected that the irrigation and hydropower development, and flood control in case of the development scenario-1 (Kidunda dam project) will be able to be realized. Those water resources development are summarized below;

(1) Dam Project(s)

Development Scenario-1	Development Scenario-2
(1) Kidunda dam project	(1) Mgeta dam project
	(2) Ngerengere dam project

(2) Hydropower development

Scenario -1		Scenario -2	
Name of Dam Project	Installed Capacity (kw)	Name of Dam Project	Installed Capacity (kw)
- Kidunda	3,900	- Megta	2,300
		- Ngerengere	400
Total	3,900	Total	2,700

(3) Irrigation Development

Name of Irrigation Project	Irrigated Area under the Development Scenario (ha)	
	Scenario -1	Scenario -2
i) Kidunda Irrigation	10,500	-
ii) Bagamoyo Irrigation	1,100	980
iii) Low-lift pump irrigation	2,400	-
iv) Ruvu National Youth	200	-
v) Makurunge Irrigation	150	-
Total	14,350	980

Note: The above irrigation projects are explained in detail in Appendix-G of this Supporting Report.

(4) Flood Control Plan in the Kidunda Dam Project (Scenario-1)

The flooding damage in the Ruvu River basin is insignificant as a result of the field survey conducted in the course of the Study as discussed in Appendix-H of this Supporting Report. On the other hand, the aforesaid new irrigation areas which mostly lie close to the floodplains along the river require the flood control works in order to ensure the stable agricultural production at a certain level.

The 5-year probable flood is adopted as the design flood for the flood control. As seen in the deteriorated dikes in the lower reaches, it appears that it is rather difficult to obtain the earth embankment materials with good quality in the flood prone areas. Therefore, it is preferred from the technical viewpoint that a height of the dike should be limited to less than 2 m above the original ground surface. Taking into consideration such a situation in the planned irrigation areas, it was proposed that in case of the Development Scenario-1 the surcharge water level (SWL) of the Kidunda reservoir was set up to retain the outflow from the reservoir at a constant discharge of 200 m3/sec at the time of occurrence of the 5-year probable flood in the basin.

In case of the Development Scenario-1, thus, the flood control plan for the new irrigation projects consists of the one combined by the proposed flood control works and the flood control by the Kidunda reservoir.

8. PRELIMINARY DESIGN OF SELECTED DAM PROJECT

With regard to each of the three (3) dam projects involved in the two Development Scenarios, namely the Kidunda, Mgeta and Ngerengere dam projects, the dam and its appurtenant structures are preliminarily designed in accordance with the following criteria and principles;

8.1 Dam

The dam is designed to be of a rockfill type dam utilizing abundant rock materials exploitable in the neighborhood of the proposed dam site concerning every dam project. The upstream and downstream slopes are taken at 1:2.55 and 1:1.95, respectively, for every dam as shown in Figs. I.20 to I.22. The embankment volumes are calculated based on the available topographic and geologic data and information as follows;

(Unit : thousand m3)

No.	Embankment Zone	Name of Dam Project		
		Kidunda	Mgeta	Ngerengere
1.	Core	240	420	510
2.	Filter	100	180	220
3.	Rockfill	420	1,500	1,500
	Total	760	2,100	2,230

8.2 Spillway

The gated type spillway is selected in consideration of the rather moderate rise of the reservoir water level during the rainy season. The flood equivalent to 1.2 times of a 200-year probable flood at the proposed dam site is adopted as the design flood for spillway in accordance with the design standard in Japan, while the spillway is designed to pass the 10,000-year flood with a freeboard of 1m below the dam crest. The design flood as well as dimensions of the spillway gate for each of the dam projects are as follows;

No.	Description	Name of Dam Project		
		Kidunda	Mgeta	Ngerengere
1.	Design flood : 1.2 times of 200-year probable flood (m^3/sec)	1,530	580	100
2.	Dimensions of gate leaf (height x width)	6.0 x 13.0	6.0 x 10.0	6.0 x 5.0
3.	Nos. of spillway gates (nos.)	4	2	1

8.3 Diversion Facilities

The diversion facilities during construction of main dam are designed for a 20-year probable flood at the proposed dam site. To use the diversion facilities as the outlet facility to release the water to downstream reach after completion of construction, the diversion tunnel is adopted for the purpose of diverting flood during construction of the main dam. The design flood as well as dimensions of the diversion tunnel are as follows;

No.	Description	Name of Dam Project		
		Kidunda	Mgeta	Ngerengere
1.	Design flood : 20-year probable flood (m^3/sec)	740	260	63
2.	Diameter of diversion tunnel (m)	5.0	3.9	2.0
3.	Nos. of diversion tunnel (lanes)	2	1	1

The intake structure for the outlet facility is aligned to be connected with the diversion tunnel and it is to be utilized as the permanent structure.

8.4 Power Facility

The power house and generating equipment are designed for the following installed capacity and other main features presented in Appendix-J of this Supporting Report;

No.	Description	Name of Dam Project		
		Kidunda	Mgeta	Ngerengere
1.	Installed capacity (kW)	3,900	2,300	400

The penstock line is laid out to connect the power house and diversion tunnel as shown in Figs. I.20 to I.22.

9. PRELIMINARY INSTALLATION PLAN OF NEW WATER CONVEYANCE AND PURIFICATION FACILITY FOR MUNICIPAL WATER SUPPLY TO DAR ES SALAAM

The water conveyance project comprises mainly the intake structure on the downstream reach of the Ruvu River, treatment facilities for raw water, pumping facilities, transmission pipe main and reservoir to store water distributed to each consumer in the city.

There are two existing schemes on the Ruvu River, which are supplying the municipal water to Dar Es Salaam city and its surrounding area, namely the Lower and Upper Ruvu schemes. The design capacity of the treatment facilities for the existing three (3) water supply schemes totals about 3.16 m3/sec as referred to in Appendix-E of this Supporting Report.

Of the three schemes, the Lower Ruvu scheme is originally planned to allow the capacity to be expanded to 3.16 m^3/sec according to the Operation Manual for the scheme and the NUWA has a plan to extend the scheme although it has not been announced officially yet. On the assumption that rehabilitation of existing water supply schemes as well as expansion of the Lower Ruvu scheme are realized under the related projects, the total capacity of water conveyance for Dar Es Salaam comes to about 4.2 m3/sec. While, the gross water demand in the Dar Es Salaam water supply system is predicted to reach about 11.2 m^3/sec in average daily demand and 14.0 m^3/sec in the maximum daily demand in the year 2020.

Since the water conveyance facilities are required to be designed for the maximum daily demand, those facilities for conveying treated water of about 9.8 m^3/sec need to be newly constructed even in case the capacity of the Lower Ruvu scheme is expanded as aforesaid before implementation of the Kidunda dam.

Herein assumed is that the three (3) water conveyance projects, each with a conveyance capacity of a
bout 3.3 m^3/sec, will be newly installed in accordance with the increase of the water demand. To cope with the municipal water demand in Dar Es Salaam, the following three (3) new water conveyance projects will have to be implemented ;

No.	Name of New Water Conveyance Project	Water Conveyance Capacity (m^3/sec)
1.	New Lower Ruvu Scheme-1	3.27
2.	New Lower Ruvu Scheme-2	3.27
3.	New Upper Ruvu Scheme	3.28
	Total	9.82

The installation plan of these three water supply facilities is shown in Fig. I.23.

The preliminary design of water conveyance and purificaation facilities involved in the above 3 new water conveyance projects are discussed in Attachment to this Appendix-I.

APPENDIX-I

TABLES

Table I.1 MAIN FEATURES OF 23 DAM SITES IDENTIFIED BY THE PREVIOUS STUDY

No.	Name of Dam Site	Catchment Area	Dam Height	Hydrological Feature			Storage Efficiency of Reservoir				Requirement of New Access road		
				Annual rainfall	Runoff Coefficient	Inflow Rate	Annual Inflow Volume	Reservoir Storage Capacity	Dam Embank. Volume	Storage Efficiency	Improve. of Existing road	New road Construct.	Total
		(km2)	(m)	(mm)	(%)	(mm/year/km2)	(Mill. m3/year)	(Mill. m3)	(Thous. m3)		(km)	(km)	
		(1)		(2)	(3)	(2)x(3)/100	(4)x(1)/1000	(6)	(7)	(6)/(7)	(9)	(10)	(9)+(10)
1	Mgeta	914	21	1,220	35	427	390	57	405	0.14	121	10	131
2	Rudete	249	20	1,150	33	383	95	13	421	0.03	121	12	133
3	Msoro	899	5	1,080	19	205	184	13	230	0.06	125	8	133
4	M/LB/R1	54	20	1,110	55	611	33	5	380	0.01	116	6	122
5	Mngazi	223	20	1,110	50	555	124	13	278	0.04	110	4	114
6	Bwakira	75	20	1,110	55	611	46	9	278	0.03	102	2	104
7	Dutumi	114	20	1,110	45	500	57	4	464	0.01	95	3	98
8	Ngerengere	2,701	17	970	5	49	131	84	340	0.25	59	3	62
9	Ruvu-Mgeta	3,672	21	1,340	20	268	984	1,665	1,542	1.08	85	4	89
10	Mkulazi	352	16	1,050	10	105	37	62	221	0.28	85	17	102
11	LB/R1	47	9	940	6	56	3	6	192	0.03	40	2	42
12	Msus	526	15	930	6	56	29	37	439	0.08	0	12	12
13	Mbiki (Major)	492	15	940	6	56	28	26	508	0.05	6	1	7
14	Mbiki (Minor)	91	14	940	6	56	5	11	351	0.03	13	1	14
15	Mkombezi	588	18	1,030	6	62	36	47	257	0.18	26	3	29
16	Msigwe	205	17	1,020	6	61	13	39	802	0.05	31	0	31
17	RB/R1	210	14	890	5	45	9	19	141	0.14	54	18	72
18	RB/R2	129	10	890	5	45	6	7	256	0.03	43	9	52
19	RB/R3	67	8	890	5	45	3	6	112	0.05	54	5	59
20	Banda	311	12	920	5	46	14	13	134	0.09	25	3	28
21	Mlandisi	78	17	950	5	48	4	9	229	0.04	7	1	8
22	Mbwawa	184	27	1,090	5	55	10	46	496	0.09	11	4	15
23	Chombe	189	15	1,090	5	55	10	12	164	0.07	30	2	32

Note
4 dam sites, the Mgeta (No.1), Negerengere (No.8), Ruvu-Mgeta (NO.9) and Mkombezi (No.15) are selected by the French study as the promising dam sites in the Ruvu river basin.

Table I.2 RESULTS OF OVERALL ASSESSMENT OF 23 DAM SITES IDENTIFIED BY THE PREVIOUS STUDY

No.	Items of Rating					Overall Rating
	(1) Name of Dam Site	(2) Geologinal Condition	(3) Hydrological Condition	(4) Storage Efficiency	(5) Accessib-ility	
1	Mgeta	B	B	C	C	B
2	Rudete	A	D	D	C	B
3	Msoro	A	C	D	C	A
4	M/LB/R1	B	E	D	C	C
5	Mngagi	B	C	D	B	C
6	Bwakira	B	E	D	B	D
7	Dutumi	B	D	D	B	E
8	Ngerengere	A	C	C	A	A
9	Kidunda	C	A	A	B	B
10	Mkulazi	C	E	C	D	E
11	LB/R1	B	E	D	A	D
12	Msus	C	E	D	C	E
13	Mbiki (Major)	C	E	D	A	E
14	Mbiki (Minor)	A	E	D	A	D
15	Mkombezi	A	E	C	A	D
16	Msigwe	A	E	D	A	D
17	RB/R1	A	E	C	D	D
18	RB/R2	B	E	D	C	E
19	RB/R3	A	E	D	A	D
20	Banda	B	E	D	A	E
21	Malandisi	A	E	D	A	D
22	Mbwawa	B	E	D	A	E
23	Chmbe	B	E	D	A	E

Note

Rating standard applied

(1). Gelogical condition
- A : No geological problem identified
- B : Posiiblity of existence of major fault at dam site or thick alluvial deposit at dam site
- C : Possibility of existence of limestone at dam and reservoir area

(2) Hydrological Condition
- A : $IR>200$ and $IV>450$
- B : $IR<200$ and $IV>450$
- C : $100<IV<450$
- D : $50<IV<100$
- E : $IV<50$

where,
- IR : Inflow rate
- IV : Annual Inflow volume

(3) Stoarge efficiency
- A : $SE>1.0$
- B : $0.5<SE<1.0$
- C : $0.1<SE<0.5$
- D : $SE<0.1$

Where,
- SE : Storage efficiency

(4) Accessibility
- A : $Ln<5.5$ and $Li<60$
- B : $Ln<5.5$ and $Li>60$
- C : $5.5<Ln<15$
- D : $Ln>15$

where,
- Ln : Length of new access road required (km)
- Li : Length of existing access road improved (km)

Table I.3 COMPARISON OF DAM DEVELOPMENT SCALES FOR RUDETE DAM

Case No.	Nomal High Water Level (El.m)	Effective Storage Volume (Mill. m3)	Dependable Discharge (m3/sec)	Dam Crest Level (El.m)	Embankmet Volume (Mill. m3)	Construction Cost (Million US$)	Construction Cost per dependable discharge (Million US$/cms)
1	230.0	0.89	0.61	235.0	0.287	30.8	50.6
2	235.0	7.26	0.98	240.0	0.428	36.8	37.6
3	240.0	15.93	1.40	245.0	0.604	44.1	31.6
4	245.0	29.10	1.61	250.0	0.826	53.0	32.9
5	250.0	43.50	1.78	255.0	1.097	63.7	35.8
6	255.0	61.32	1.99	260.0	1.411	75.8	38.1

Table I.4 COMPARISON OF DAM DEVELOPMENT SCALES FOR NGERENGERE DAM

Case No.	Nomal High Water Level (El.m)	Effective Storage Volume (Mill. m3)	Dependable Discharge (m3/sec)	Dam Crest Level (El.m)	Embankmet Volume (Mill. m3)	Construction Cost (Million US$)	Construction Cost per dependable discharge (Million US$/cms)
1	120.0	19.49	0.13	125.0	1.410	74.4	586.0
2	122.5	72.69	1.15	127.5	1.774	88.1	76.9
3	125.0	143.94	1.81	130.0	2.183	103.2	56.9
4	127.5	229.32	2.00	132.5	2.666	120.8	60.4
5	130.0	318.79	2.20	135.0	3.245	141.6	64.2
6	132.0	404.82	2.40	137.0	3.785	160.7	66.9

Table I.5 COMPARISON OF DAM DEVELOPMENT SCALES FOR MKOMBEZI DAM

Case No.	Nomal High Water Level (El.m)	Effective Storage Volume (Mill. m3)	Dependable Discharge (m3/sec)	Dam Crest Level (El.m)	Embankmet Volume (Mill. m3)	Construction Cost (Million US$)	Construction Cost per dependable discharge (Million US$/cms)
1	130.0	13.37	0.18	135.0	0.750	42.8	238.9
2	135.0	40.22	0.36	140.0	1.262	62.6	173.1
3	140.0	82.60	0.43	145.0	1.962	89.0	205.0
4	145.0	163.17	0.59	150.0	2.892	122.9	208.3
5	147.5	205.76	0.65	152.5	3.462	143.3	222.2
6	148.0	214.28	0.65	153.0	3.583	147.6	227.1

Table I.6 COMPARISON OF DAM DEVELOPMENT SCALES FOR MGETA DAM

Case No.	Nomal High Water Level (El.m)	Effective Storage Volume (Mill. m3)	Dependable Discharge (m3/sec)	Dam Crest Level (El.m)	Embankmet Volume (Mill. m3)	Construction Cost (Million US$)	Construction Cost per dependable discharge (Million US$/cms)
1	205.0	4.00	2.64	210.0	0.717	48.7	18.5
2	210.0	29.01	4.07	215.0	1.076	62.9	15.4
3	215.0	63.39	5.82	220.0	1.512	79.6	13.7
4	220.0	110.11	7.11	225.0	2.035	99.3	14.0
5	225.0	172.25	8.04	230.0	2.655	122.0	15.2
6	230.0	240.54	8.82	235.0	3.376	148.0	16.8

Table I.7 COMPARISON OF DAM DEVELOPMENT SCALES FOR KIDUNDA DAM

Case No.	Nomal High Water Level (El.m)	Effective Storage Volume (Mill. m3)	Dependable Discharge (m3/sec)	Dam Crest Level (El.m)	Embankmet Volume (Mill. m3)	Construction Cost (Million US$)	Construction Cost per dependable discharge (Million US$/cms)
1	87.0	186.89	17.24	93.0	0.489	36.1	2.1
2	88.0	321.64	23.67	94.0	0.605	40.8	1.7
3	89.0	456.40	28.16	95.0	0.739	46.2	1.6
4	90.0	591.15	29.53	96.0	0.889	52.1	1.8
5	91.0	690.16	30.66	97.0	1.061	58.9	1.9
6	92.0	931.16	32.29	98.0	1.256	66.4	2.1

Table I.8 MAIN FEATURES OF EXISTING MINDU DAM

Catchment Area	303	km^2
Reservoir Area	3.8	km^2
Reservoir Storage (total)	13.0	Mill m^3
Reservoir Storage (effective)	11.3	Mill m^3
High Water Level	507.0	El.m
Low Water Level	501.5	El.m
Design Flood Discharge	710.0	m^3/s
Normal Discharge (initial)	57,500	m^3/day
Normal Discharge (after 20 years)	43,000	m^3/day *
Type of Dam	Earth fill with a concrete spillway	
Crest Level of Dam	501.1	El.m
Crest Length of Dam	1,600	m
Crest Width of Dam	8.0	m
Slopes of Dam (down stream)	1:2.25	
Slopes of Dam (up stream)	1:2.50	
Type of Spillway	Overflow	
Crest Level of Spillway	507.0	m
Length of Spillway Weir	100.0	m

Note
* : Estimated

Table I.9 WATER BALANCE BY DEVELOPMENT SCENARIO

(Unit : m3/sec)

Component of WaterBalance	Scenario-1		Scenario-2	
	Dam Name	Outflow	Dam Name	Outflow
1 Regulated Outflow from upstream dam(s)	(1)Kidunda	28.16	(1)Ngerenger	1.81
			(2)Mgeta	7.11
	Total-1	28.16	Total-1	8.92
2 95 % Dependable Discharge Yielded in Area not Covered by Upstream Dam(s)	(1)U.R.I.S.	9.06	(1)U.R.I.S.	9.06
	(2)Kidunda	-8.60	(2)Ngerenger	-0.02
			(3)Mgeta	-1.38
	Total-2	0.46	Total-2	7.66
3 River Maintenance Flow for Downstream Reach of U.R.I.S.	(1)River flow*	4.12	(1)River flow	4.12
	(2)Irrigation	1.00	(2)Irrigation	1.00
	Total-3	5.12	Total-3	5.12
4 Water Demand in Year 2020		11.23		11.23
5 Water Balance (Available Discharge for New Irrigation Development)		12.27		0.23

Note

1. U.R.I.S. means existing Upper Ruvu intkae site.
2. The water balance is made on the basis of annual mean discharge data.
3. *; the required minimum river maintenance flow is the minimum mean monthly discharge at the existing gauging station 1H8.
4. Development Scenarios

Scenario-1 : (Kidunda dam)

Scenario-2 : (Mgeta dam) + (Ngerengere dam)

APPENDIX-I

FIGURES

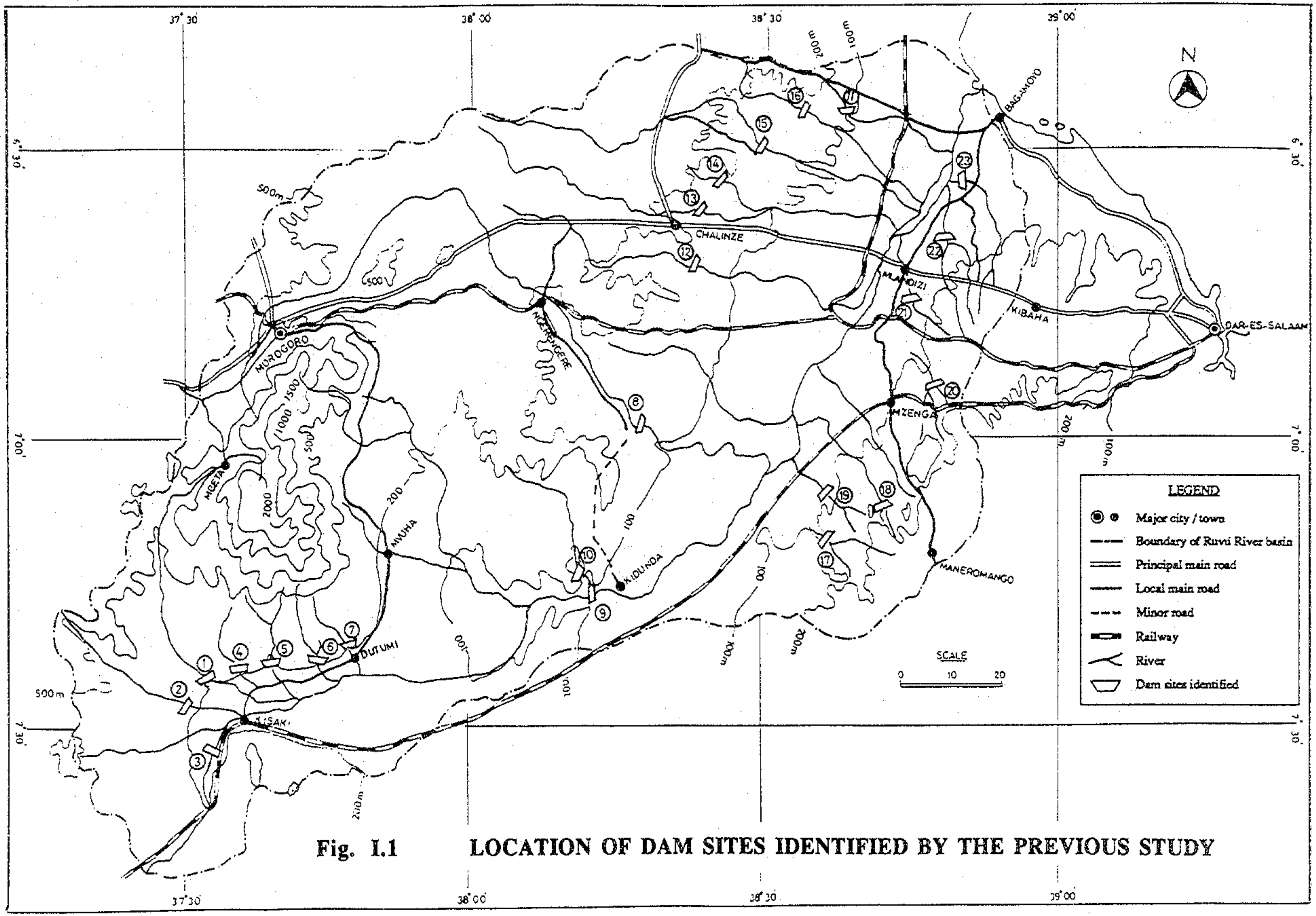
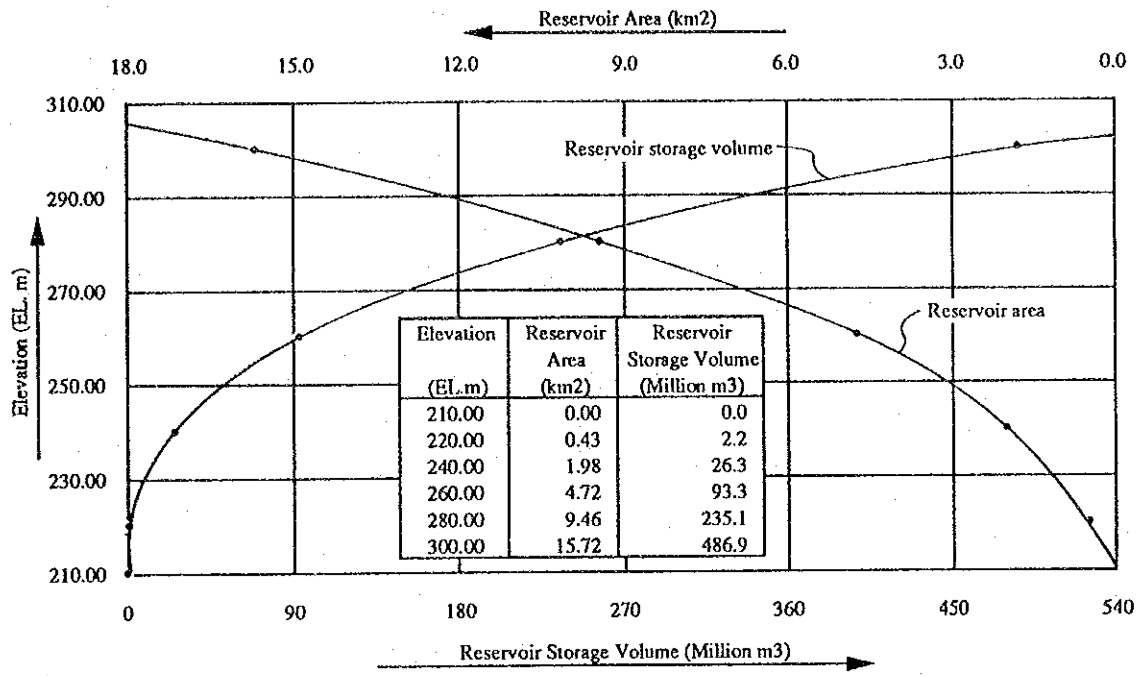
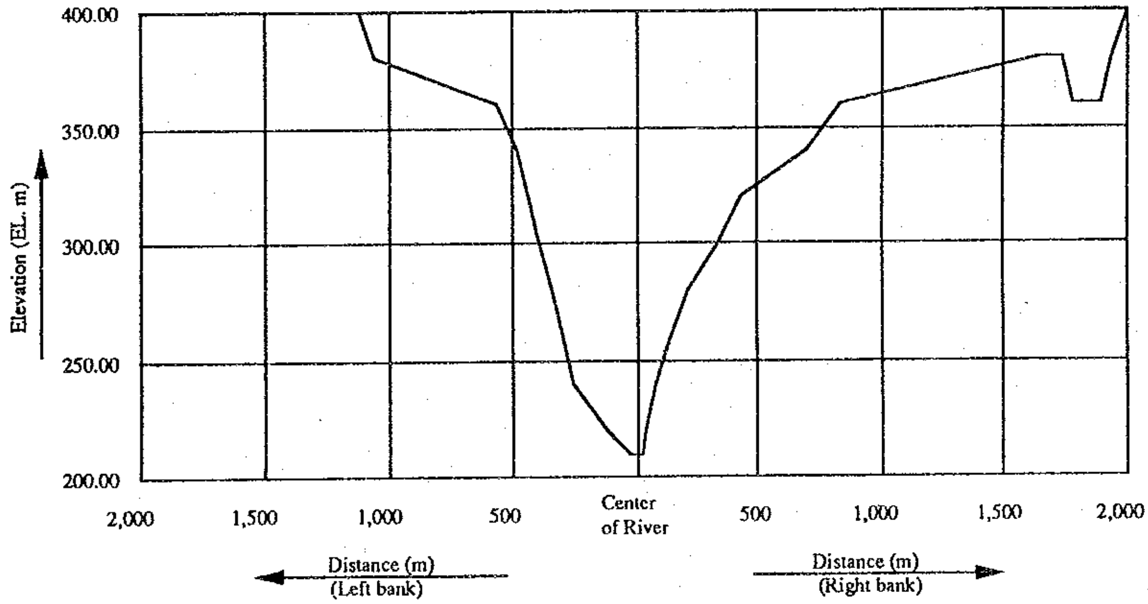


Fig. I.1 LOCATION OF DAM SITES IDENTIFIED BY THE PREVIOUS STUDY



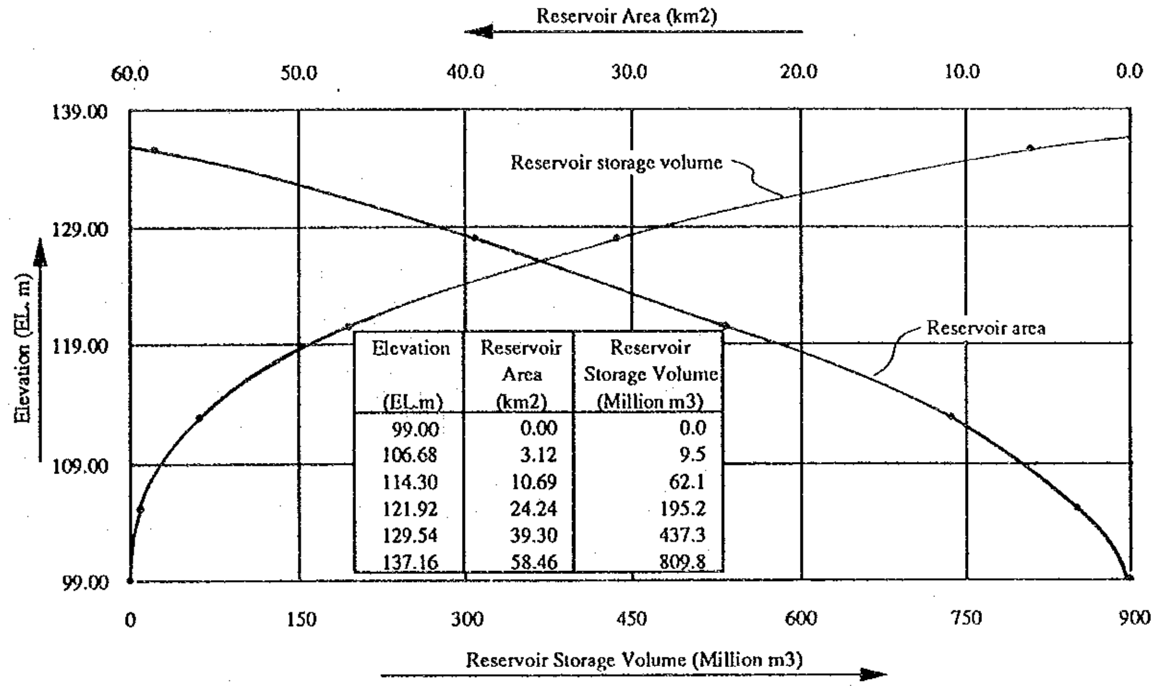
Elevation (EL.m)	Reservoir Area (km2)	Reservoir Storage Volume (Million m3)
210.00	0.00	0.0
220.00	0.43	2.2
240.00	1.98	26.3
260.00	4.72	93.3
280.00	9.46	235.1
300.00	15.72	486.9

RESERVOIR STORAGE CURVE AT RUDETE DAM SITE



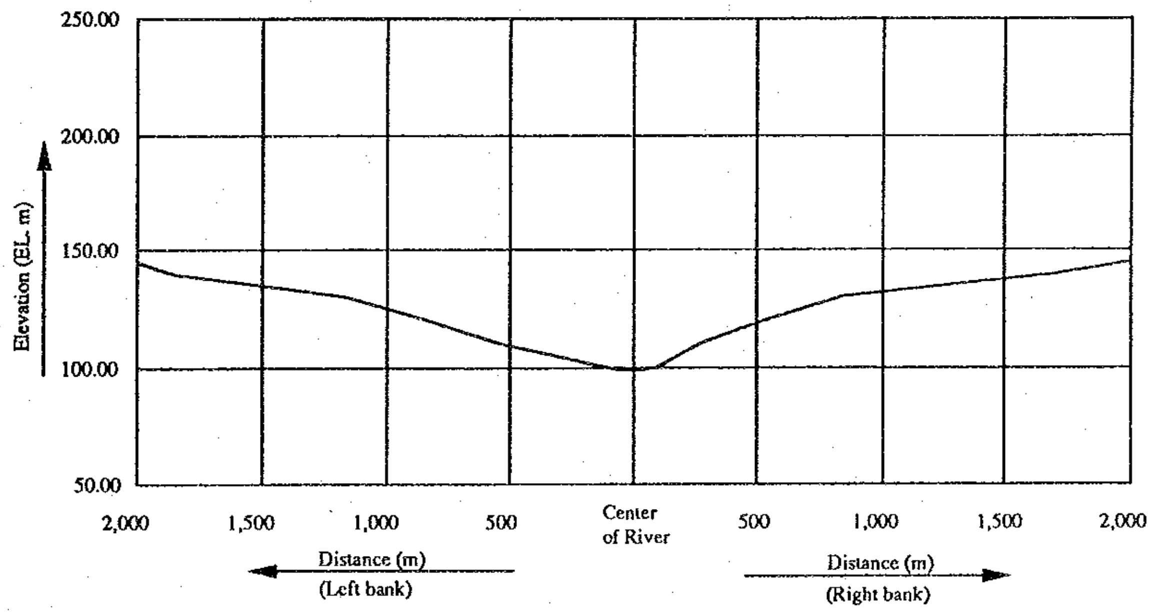
RIVER CROSS SECTION ALONG AXIS OF RUDETE DAM

Fig. I.2 RESERVOIR STORAGE CURVE AND RIVER CROSS SECTION AT THE RUDETE DAM SITE



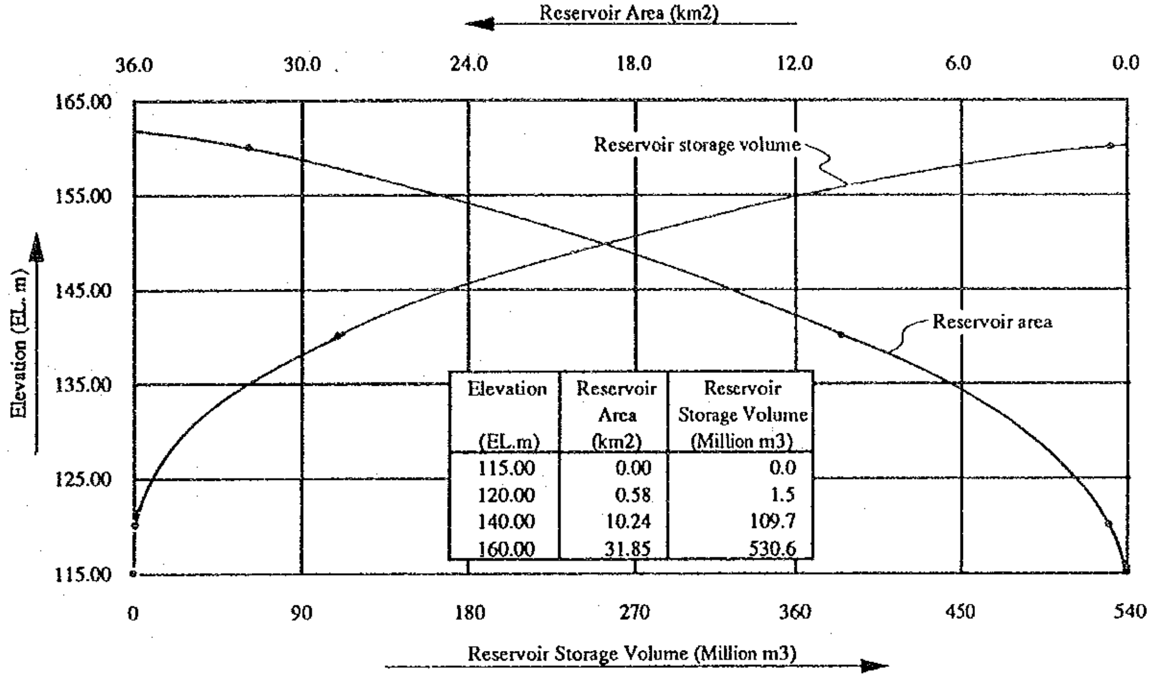
Elevation (EL.m)	Reservoir Area (km2)	Reservoir Storage Volume (Million m3)
99.00	0.00	0.0
106.68	3.12	9.5
114.30	10.69	62.1
121.92	24.24	195.2
129.54	39.30	437.3
137.16	58.46	809.8

RESERVOIR STORAGE CURVE AT NGERENGERE DAM SITE



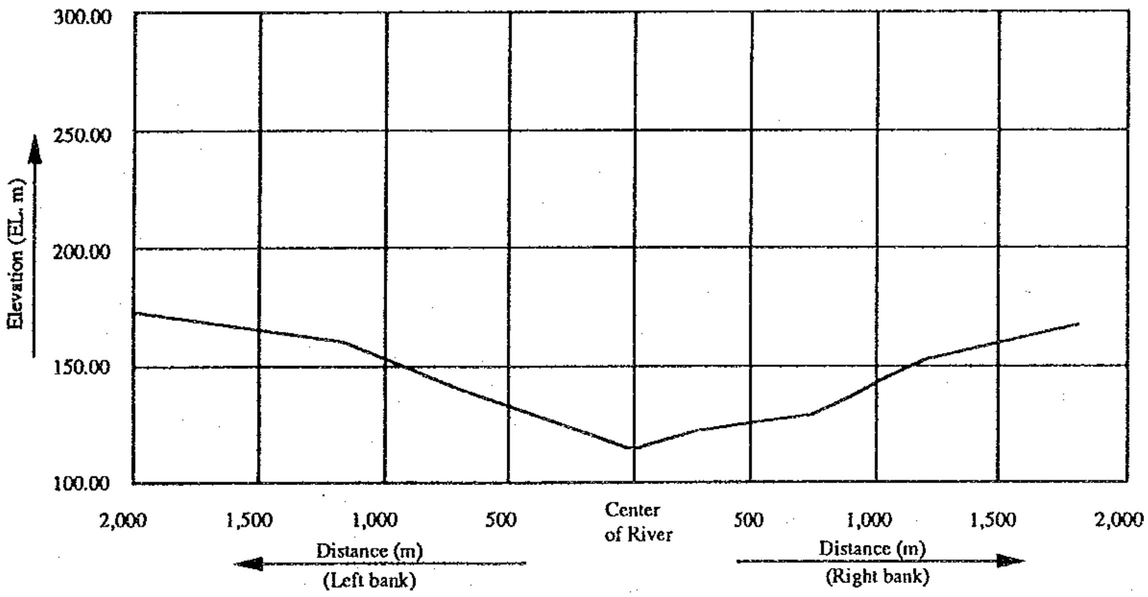
RIVER CROSS SECTION ALONG AXIS OF NGERENGERE DAM

Fig. I.3 RESERVOIR STORAGE CURVE AND RIVER CROSS SECTION AT THE NGERENGERE DAM SITE



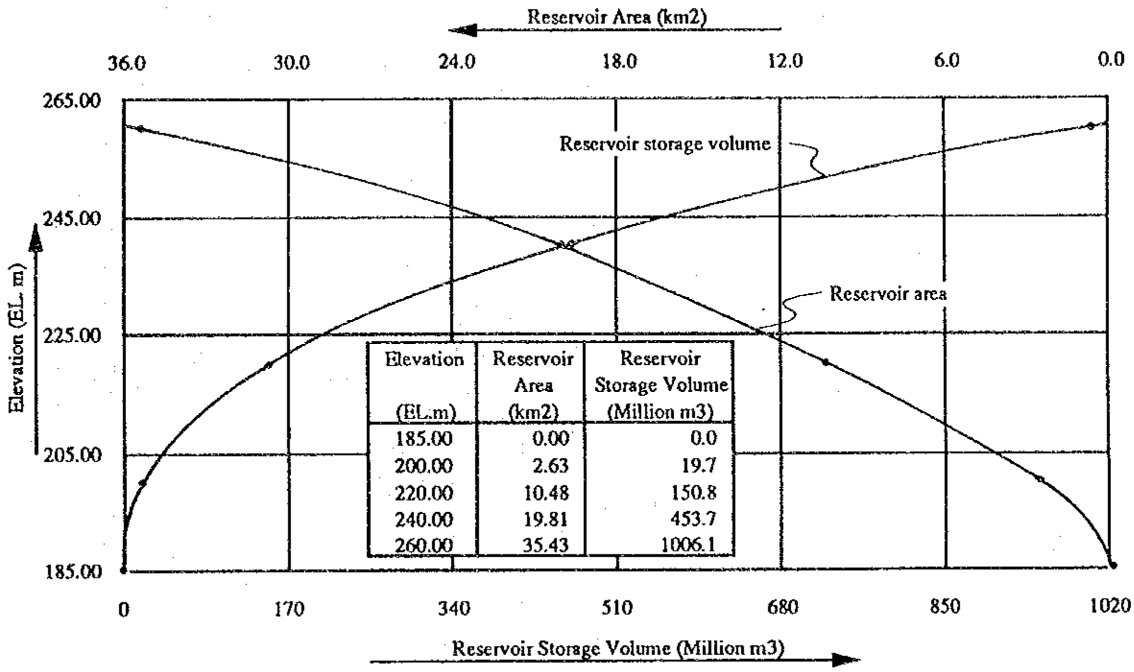
Elevation (EL.m)	Reservoir Area (km2)	Reservoir Storage Volume (Million m3)
115.00	0.00	0.0
120.00	0.58	1.5
140.00	10.24	109.7
160.00	31.85	530.6

RESERVOIR STORAGE CURVE AT MKOMBEZI DAM SITE



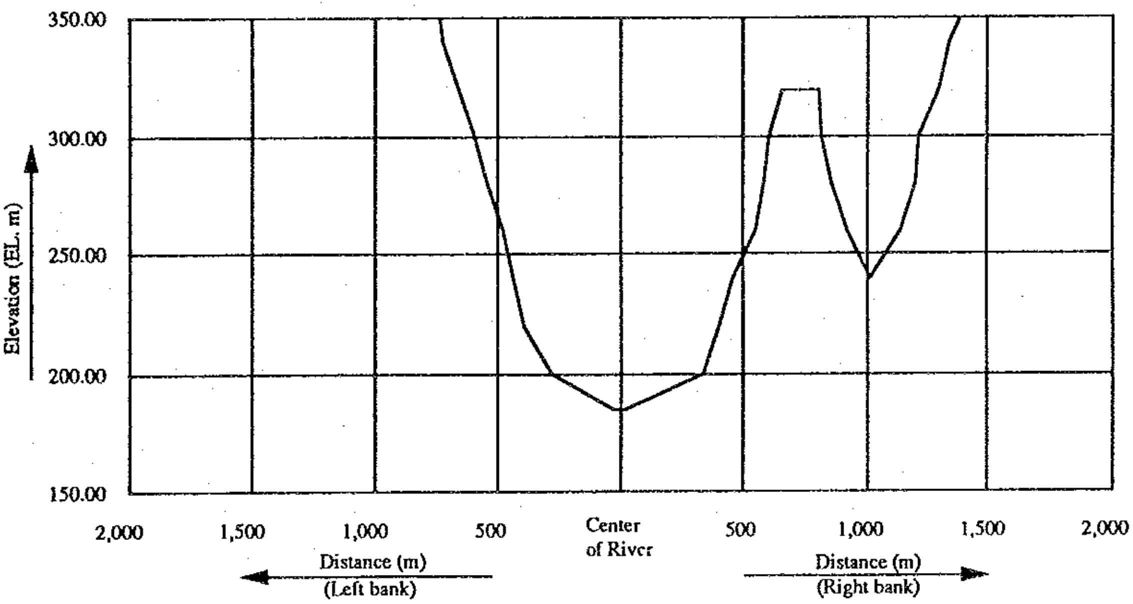
RIVER CROSS SECTION ALONG AXIS OF MKOMBEZI DAM

Fig. I.4 RESERVOIR STORAGE CURVE AND RIVER CROSS SECTION AT THE MKOMBEZI DAM SITE



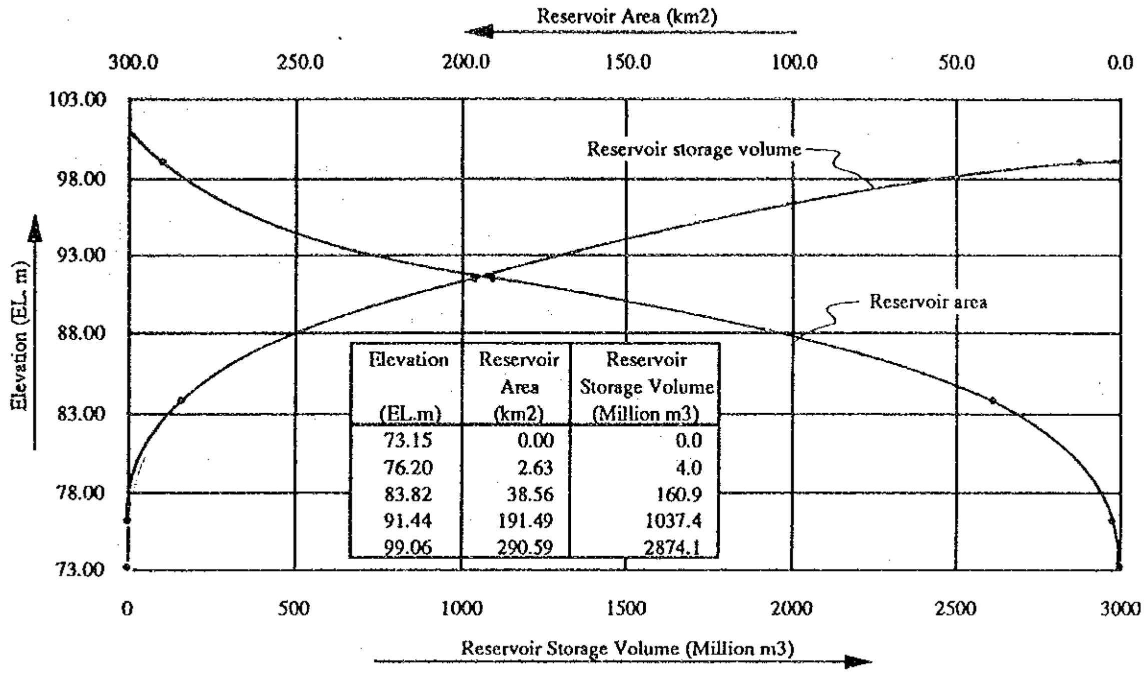
Elevation (EL.m)	Reservoir Area (km2)	Reservoir Storage Volume (Million m3)
185.00	0.00	0.0
200.00	2.63	19.7
220.00	10.48	150.8
240.00	19.81	453.7
260.00	35.43	1006.1

RESERVOIR STORAGE CURVE AT MGETA DAM SITE



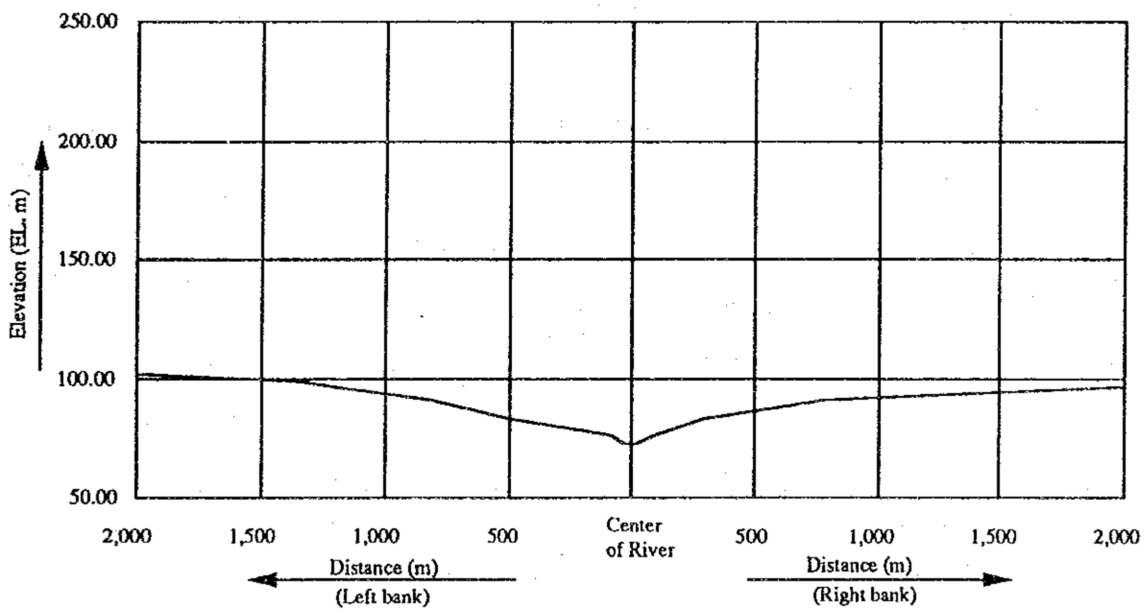
RIVER CROSS SECTION ALONG AXIS OF MGETA DAM

Fig. I.5 RESERVOIR STORAGE CURVE AND RIVER CROSS SECTION AT THE MGETA DAM SITE



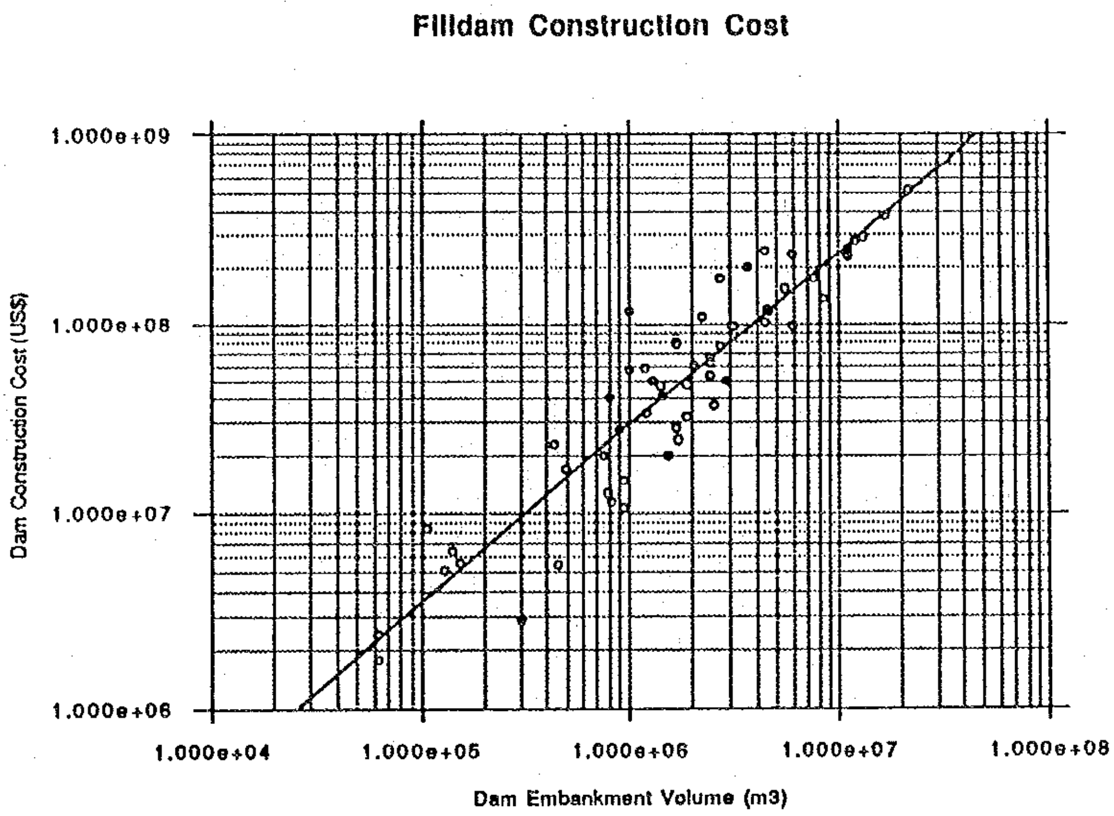
Elevation (EL.m)	Reservoir Area (km2)	Reservoir Storage Volume (Million m3)
73.15	0.00	0.0
76.20	2.63	4.0
83.82	38.56	160.9
91.44	191.49	1037.4
99.06	290.59	2874.1

RESERVOIR STORAGE CURVE AT KIDUNDA DAM SITE



RIVER CROSS SECTION ALONG AXIS OF KIDUNDA DAM

Fig. I.6 RESERVOIR STORAGE CURVE AND RIVER CROSS SECTION AT THE KIDUNDA DAM SITE



Filldam Construction Cost :

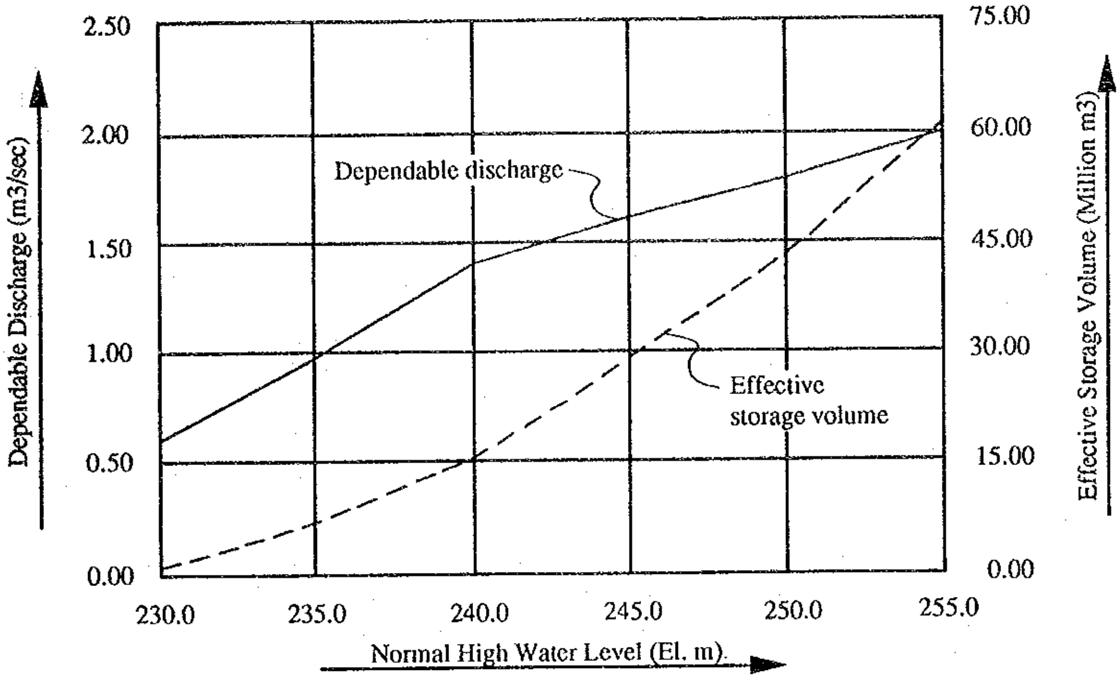
$$C = 100\ V^{0.92}$$

C : Construction Cost (US \$)

V : Embankment Volume (m^3)

Source : The Study on the Water Resources Water Master Plan,Republic Kenya (July 1992)

Fig. I.7 RELATION BETWEEN DAM EMBANKMENT VOLUME AND DAM CONSTRUCTION COST



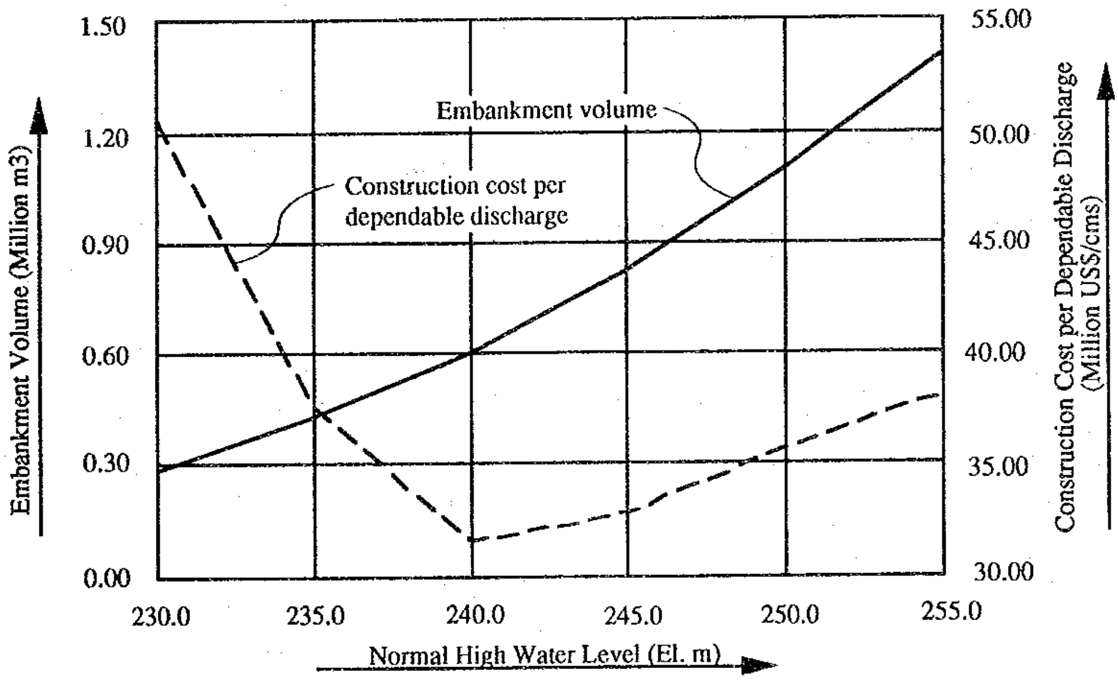
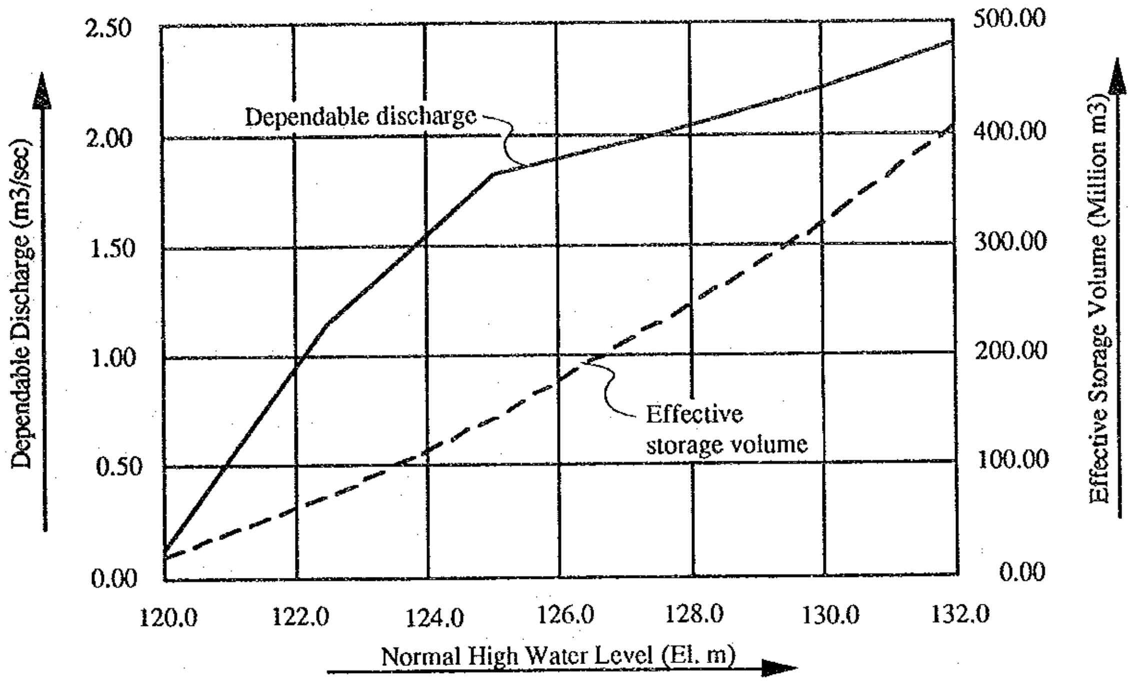


Fig. I.8 COMPARTSON OF DAM DEVELOPMENT SCALE FOR RUDETE DAM



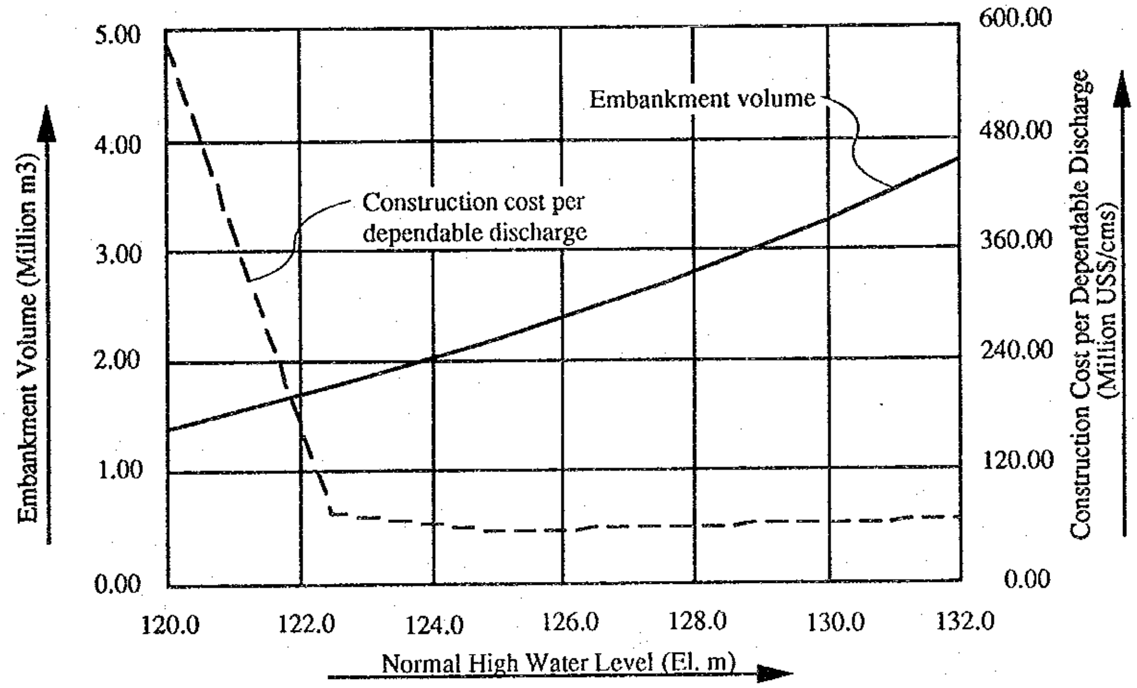
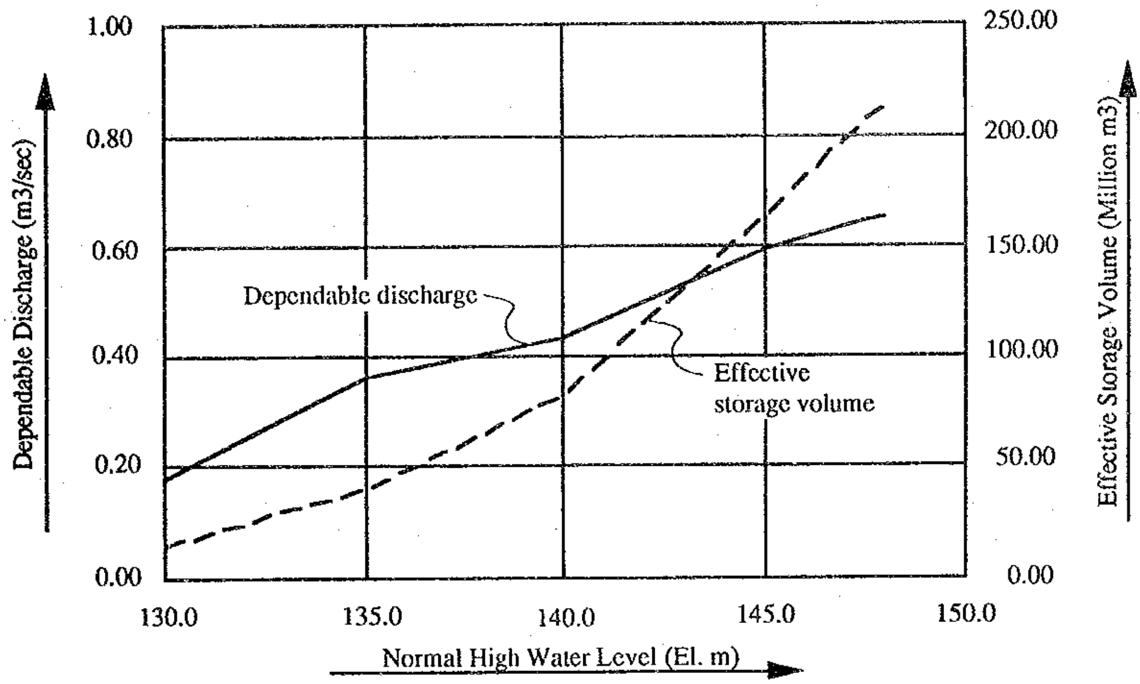


Fig. I.9 COMPARTSON OF DAM DEVELOPMENT SCALE FOR NGERENGERE DAM



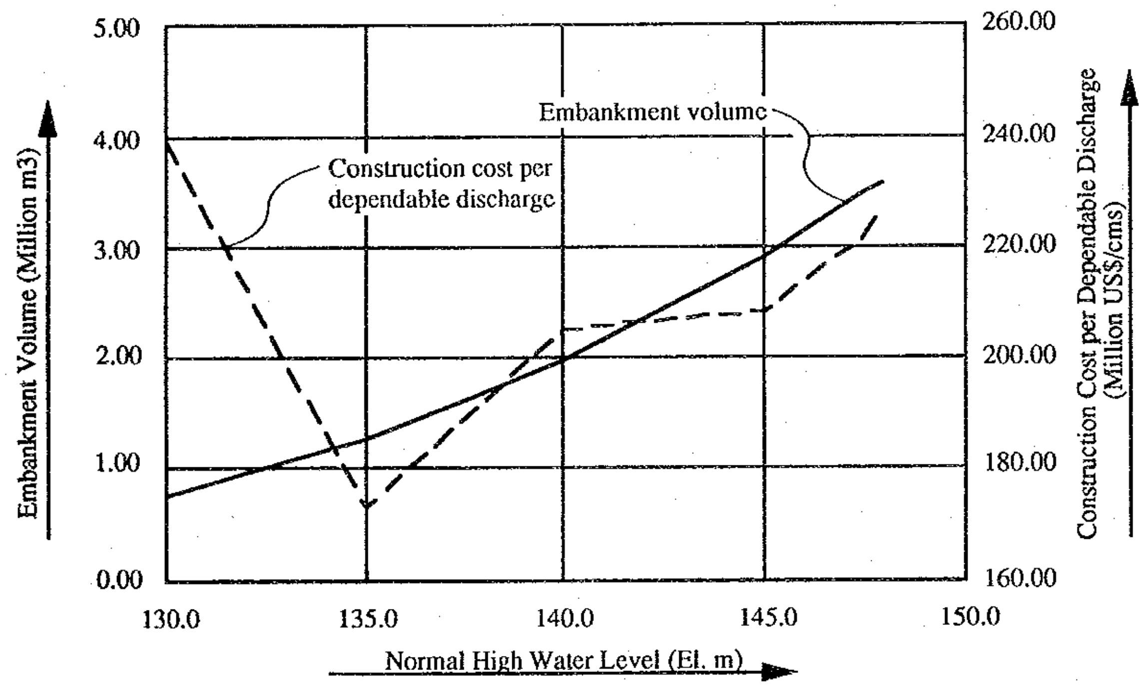


Fig. I.10 COMPARTSON OF DAM DEVELOPMENT SCALE FOR MKOMBEZI DAM

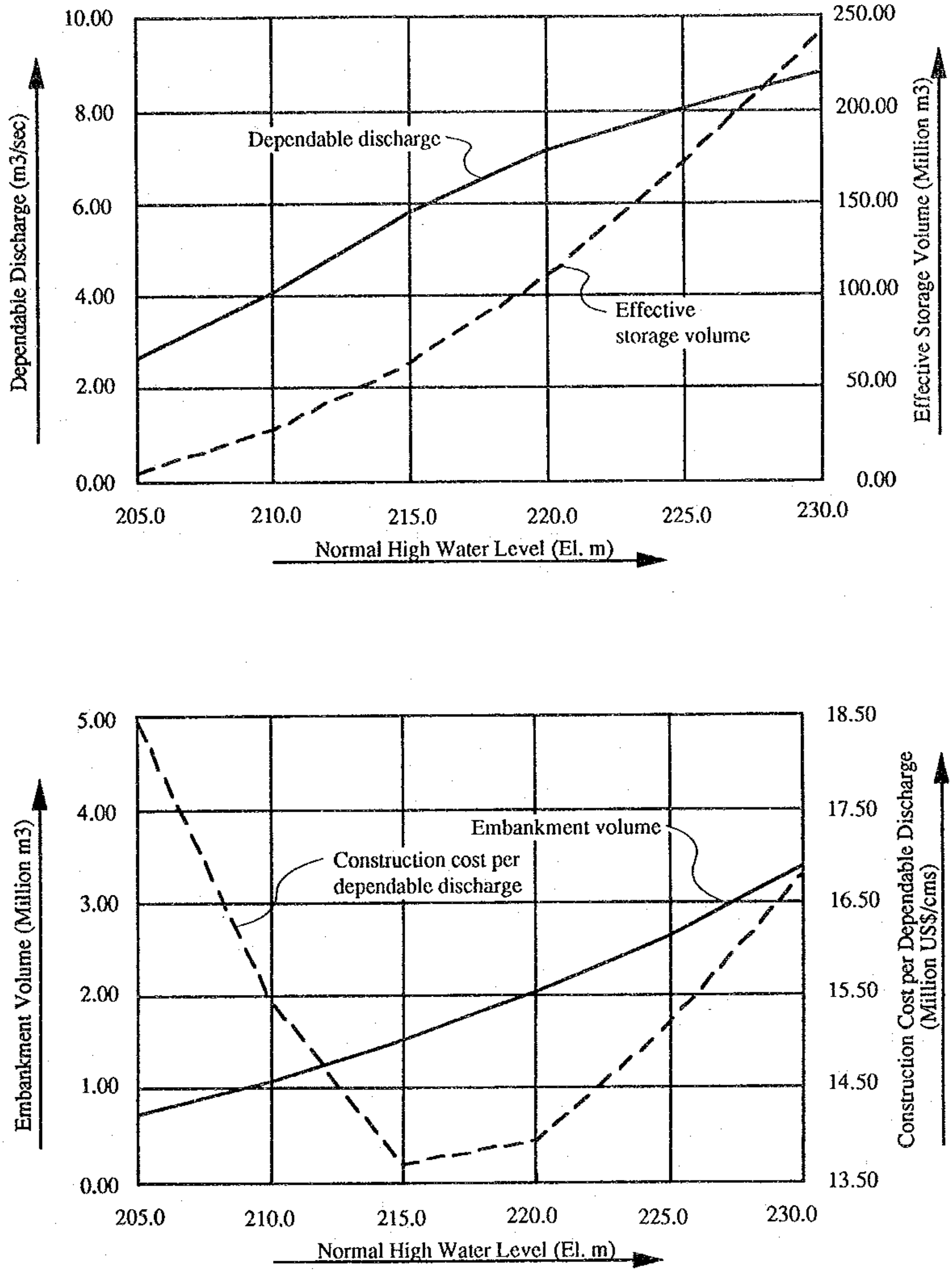
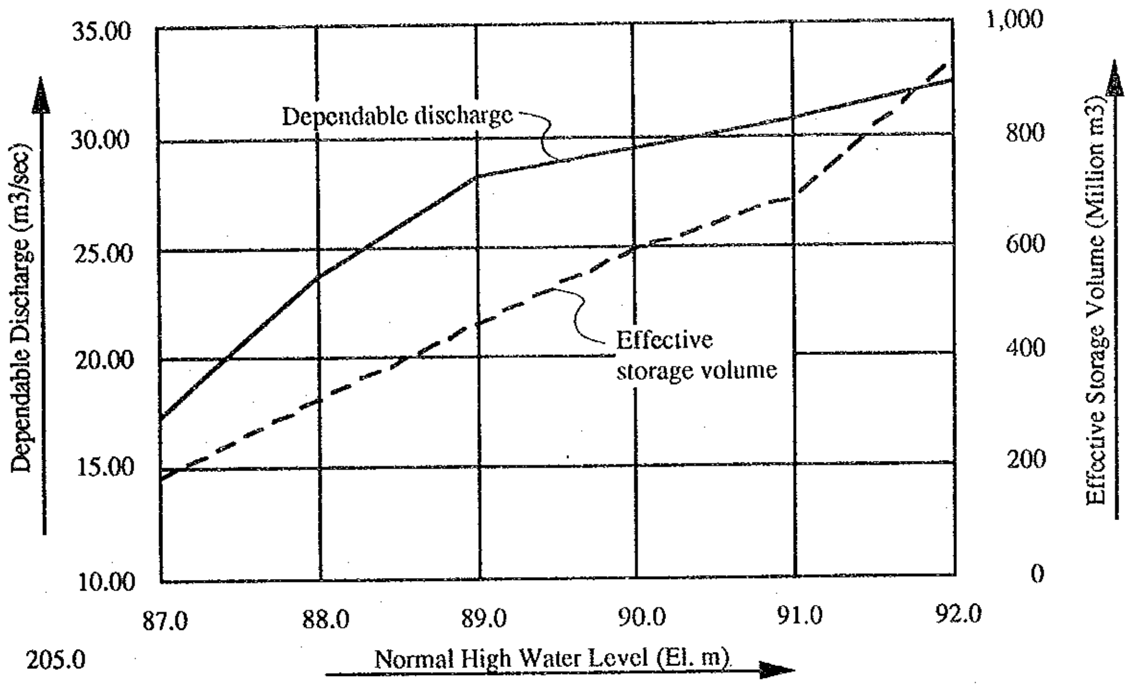


Fig. I.11 COMPARTSON OF DAM DEVELOPMENT SCALE FOR MGETA DAM



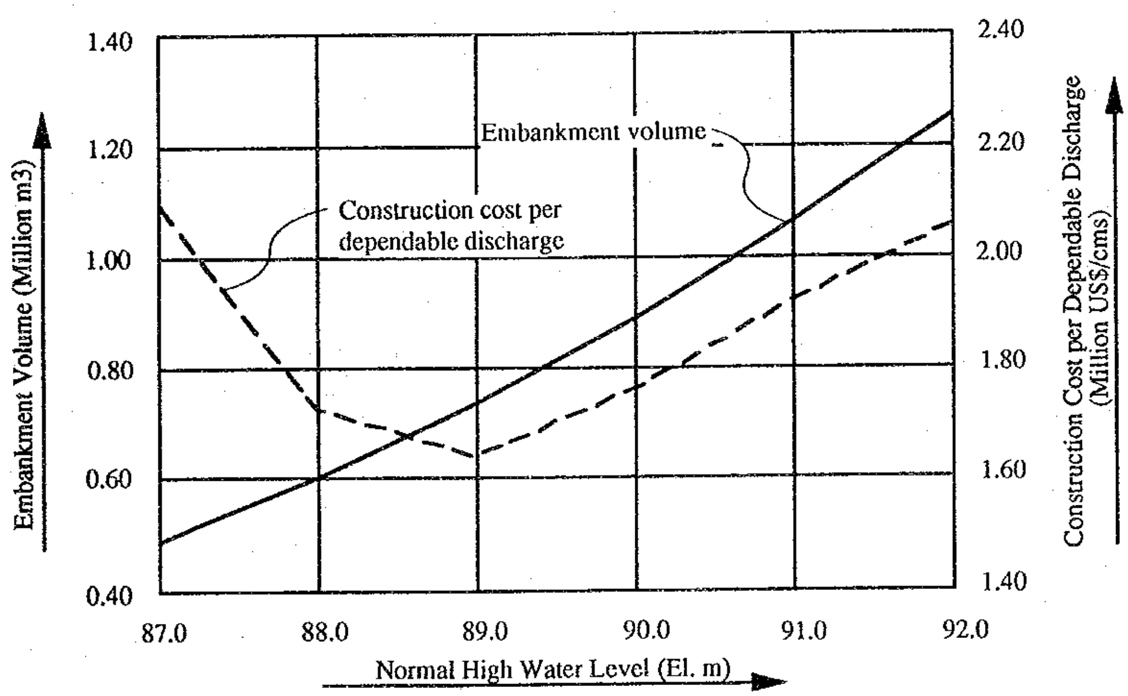


Fig. I.12 COMPARTSON OF DAM DEVELOPMENT SCALE FOR KIDUNDA DAM