THE STUDY ON ADDIS ABABA
FLOOD CONTROL PROJECT

CHAPTER 3

RIVER AND ROAD SURVEY

THE STUDY

ON

ADDIS ABABA FLOOD CONTROL PROJECT

IN

THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

CHAPTER 3 RIVER AND ROAD SURVEY

Contents

List of Tables

List of Figures

3. RIVER AND ROAD SURVEY

3.1 General

In order to carry out the feasibility study for the selected priority projects, river and road surveys were conducted in the period of second work in Ethiopia. The outline of the surveys is described below.

3.2 River and Road Cross-section Survey

3.2.1 Survey Items and Subcontract

The river cross-section and road cross-section surveys were conducted for priority projects consisting of flood control works and urban drainage improvement. The surveys consist of traverse survey, leveling and cross-section survey for river cross-sections, and leveling cross-section survey for road cross-sections.

The survey was conducted in accordance with the subcontract between the Study Team and Aquatec (Ab) Co., Ltd. appointed as the subcontractor. The survey works have been carried out for the period from the beginning of December 1997 to middle of January 1998 (around 1.5-month) under instruction and supervision by the Study Team.

3.2.2 Survey Area and Work Volume

Figures 3.2.1 and 3.2.2 show the objective river stretches for river survey and road survey, respectively.

The main work items and quantities are as follows.

1) For river cross-sections

- Traverse survey : 310 points
  (Total of control points and cross-section posts)
- Leveling : 8.5 km
  (Total length of cross-section routes and connecting routes to existing bench marks or control points)

- Cross-section survey : 160 sections
  (In total with intervals of approx. 20m to 100m)

2) For road cross-sections

- Leveling : 5 km
  (Total length of cross-section routes and connecting routes to existing bench marks or control points)
- Cross-section survey : 50 sections
  (In total with intervals of approx. 100 m)

3.2.3 Reference Bench Marks and Control Points

The verified reference bench marks and control points for the survey work have been established by the Master Plan for this study (1997) and Blue Nile Geodetic Control Project (1957 to 1960), Mapping Project for Urban Planning in Addis Ababa (1972 to 1973).

These reference points to used for the survey work are shown in Table 3.2.1.

3.2.4 New Control Points and Cross-section Posts to be established

The coordinates and elevation of new control points and cross-section posts to be established for the survey work are shown in Table 3.2.2, 3.2.3 and 3.2.4.

3.2.5 Final Products

The results of the survey works are compiled into the followings.

1) River Cross-section Survey

- Location Maps of Surveyed River Cross-sections
- Drawings of River Cross-sections
- Drawings of Longitudinal Profiles of Surveyed Rivers

2) Road Cross-section Survey

- Location Maps of Surveyed Road Cross-sections

- Drawings of Road Cross-sections
- Drawing of Longitudinal Profiles of Surveyed Roads

3) Reports and Survey Data

- Survey Report
- Descriptions of Control Points
- Field Measurement and Computation Sheets

Table 3.2.1 Data List of Reference Control Points and Bench Marks

STATION No.	NORTH (m)	EAST (m)	ELEVATION (m)	REMARKS
382	65296.36	32934.09	2300.099	*
BM 25	---	---	2309.529	
BM 11	—	—	2319.591	
506	66708.16	32765.94	2333.504	*
BM 10	---	---	2323.175	Elevation data before revised : 2319.240m
258	67819.76	31379.23	2351.96	*
BM 09	—	—	2332.164	Elevation data before revised : 2331.828m
259	67573.35	31304.97	2341.898	*
139	68019.17	30378.52	2345.985	*
318'	68305.38	30604.53	2349.463	* Coordinates is the revised data on this study.
320	68305.41	30604.5	2348.031	*
BM 07	—	—	2389.099	Elevation data before revised : 2389.108m
253	69068.66	31236.26	2409.783	*
254	68838.39	31107.21	2407.08	*
No.2	---	—	2440.077	**
535	70501.47	30616.77	2439.258	*
1176	71842.84	30831.73	2506.837	*
1186'	72740.39	30151.74	2554.396	* Coordinates is the revised data on this study.
BM 04	—	—	2507.111	
1214	71055.83	29724.31	2499.016	*
BM 12	---	---	2360.372	

Note: * Data of the Addis Ababa Mapping Project in 1972/73.
** Data of the Blue Nile Geodetic Control Project in 1957/60.

Table 3.2.2 Data List of Control Points (1/2)

STATION No.	NORTH (m)	EAST (m)	ELEVATION (m)	REMARKS
TP 01 (04L)	65545.46	32806.69	2304.961	
TP 02	65637.88	32852.48	2304.889	
TP 03	65969.53	32708.62	2312.928	
TP 04	66108.41	32576.68	2314.659	
TP 05 (12L)	66250.01	32543.48	2314.828	
TP 06	66409.39	32483.21	2316.444	
TP 07	66460.90	32608.47	2315.304	
TP 08	66568.72	32592.02	2316.409	
TP 09	66660.71	32606.66	2317.658	
TP 10 (24R)	66790.39	32628.57	2320.552	
TP 11 (26R)	66857.22	32544.69	2323.280	
TP 12 (28R)	66943.09	32464.69	2321.538	
TP 13	66946.82	32391.05	2326.553	
TP 14	67007.12	32322.59	2322.546	
TP 15 (35R)	67094.12	32240.44	2323.856	
TP 16 (37R)	67150.71	32155.12	2328.613	
TP 17	67203.23	32061.11	2334.297	
TP 18	67280.11	31951.90	2334.578	
TP 19	67263.78	31799.30	2331.662	
TP 20 (46R)	67205.59	31795.62	2327.684	
TP 21 (51L)	67390.25	31704.03	2331.903	
TP 22 (55L)	67518.46	31570.29	2331.518	
TP 23 (58L)	67579.36	31450.85	2332.159	
TP 24	67661.16	31238.21	2335.910	
TP 25 (64L)	67549.28	31167.57	2335.066	
TP 26 (67L)	67453.11	31152.23	2337.757	
TP 27 (69R)	67424.93	31105.10	2337.156	
TP 28	67435.36	30964.01	2339.070	
TP 29	67534.77	30926.88	2339.930	
(TP 30)	—	—	2343.641	Canceled post No.
TP 31	67569.83	30873.76	2341.372	
TP 32	67740.63	30710.01	2342.686	
TP 33	67830.69	30673.89	2341.546	
TP 34 (86L)	67919.38	30584.74	2343.286	
TP 35	68071.18	30544.50	2346.318	
TP 36	68130.37	30493.91	2346.403	
TP 37	68237.10	30464.58	2348.648	
TP 38	68241.73	30375.05	2347.760	
TP 39	68320.66	30327.84	2349.188	
TP 40	68398.94	30517.24	2352.397	
TP 41	68507.38	30491.43	2354.616	
TP 42	68671.47	30571.26	2359.051	
TP 43	68767.75	30632.83	2364.217	
TP 44	68891.46	30683.37	2369.065	
TP 45	68965.63	30697.81	2372.578	
TP 46	69089.73	30682.48	2382.037	
TP 47	69125.38	30746.91	2380.797	
TP 48	69212.63	30832.84	2382.210	
TP 49	69285.01	30796.84	2393.226	
TP 50	69365.07	30893.53	2390.303	

Table 3.2.2 Data List of Control Points (2/2)

STATION No.	NORTH (m)	EAST (m)	ELEVATION (m)	REMARKS
TP 51	69462.97	30729.73	2404.146	
TP 51-1	68883.94	31118.38	2406.457	*
TP 52	69662.32	30719.13	2399.975	
TP 53	69723.70	30633.05	2412.490	
TP 54	69731.34	30619.98	2414.698	
TP 55	69920.92	30682.81	2413.839	
TP 56	69927.26	30567.73	2422.986	
TP 57	70175.18	30675.82	2435.374	
TP 58	70361.95	30501.35	2439.358	
TP 59	70272.85	30685.43	2439.316	
TP 60	71920.98	30763.96	2506.193	
TP 61	71975.55	30689.65	2498.726	
TP 62 (00L)	72114.37	30653.79	2488.979	
TP 63 (O3L)	72263.91	30657.03	2492.918	
TP 64 (05L)	72365.14	30645.00	2504.672	
TP 65 (07R)	72416.28	30555.56	2505.975	
TP 66 (10R)	72559.85	30534.25	2513.151	
TP 67 (14R)	72791.25	30496.84	2524.541	
TP 68	72954.32	30420.60	2536.268	
TP 69	72680.40	30249.39	2551.039	
TP 70	72532.82	30280.11	2539.744	
TP 71	72563.69	30157.20	2540.547	
TP 72	72317.28	30182.17	—	
TP 73	72241.72	30090.37	—	
TP 74	71920.86	29892.99	—	
TP 75	71452.22	29472.15	—	
RBP 1	68046.13	30626.80	2344.520	Bantyiketu Regulating Pond
RBP 2	67807.92	30654.69	2342.028	Bantyiketu Regulating Pond
BM 4	71798.15	29781.74	2507.111	Kostre Regulating Pond
BM 4-1	71677.33	29913.44	2501.356	Kostre Regulating Pond

Note: * Elevation is indirectly measured using the Total-station from existing control point No.253.

Table 3.2.3 Data List of Cross Section Posts (1/6)

CODE	POST NO.	NORTH (m)	EAST (m)	ELEVATION (m)	REMARKS
KEB	00L	65241.65	32948.05	2298.931	
	00R	65240.26	32915.98	2299.275	
	01L	65327.88	32917.89	2300.818	
	01R	65336.39	32872.88	2301.131	
	02L	65397.32	32913.1	2301.204	
	02R	65380.77	32870.77	2302.962	
	03L	65496.22	32842.76	2303.06	
	03R	65447.66	32810	2302.893	
	04L (TP1)	65545.46	32806.69	2304.961	
	04R	65565.65	32767.17	2305.382	
	05L	65658.24	32874.24	2303.597	
	05R	65645.2	32850.88	2304.755	
	06L	65787.69	32805.63	2305.228	
	06R	65766.6	32779.54	2307.183	
BAN	07L	65865.53	32733.95	2306.645	
	07R (BM25)	65841.14	32733.17	2309.529	
	08L	65917.16	32675.77	2308.833	
	08R	65889.38	32638.98	2309.614	
	09L	66005.54	32595.66	2309.828	
	09R	65995.56	32573.57	2309.963	
	09-1L	66076.41	32552.83	2310.9	
	09-1R	66064.87	32530.97	2311.066	
	10L	66283.34	32688.68	2313.861	
	10R	66062.53	32483.24	2316.77	
	11L	66166.72	32562	2313.947	
	11R	66175.58	32457.04	2316.422	
	12L (TP5)	66250.01	32543.48	2314.828	
	12R	66268.89	32479.5	2315.823	
	13L	66280.96	32566.09	2314.13	
	13R	66302.64	32554.49	2313.77	
	14L	66369.5	32528.17	2314.492	
	14R	66363.71	32500.48	2315.58	
	15L	66410.3	32613.02	2315.722	
	15R	66419.88	32602.1	2315.782	
	16L	66521.92	32649.78	2316.873	
	16R	66506.23	32638.86	2316.58	
	17L	66537.84	32622.13	2316.893	
	17R	66546.35	32609.14	2317.217	
	18L	66586.71	32645.26	2317.156	
	18R	66589.8	32626.67	2316.914	
	19L	66615.05	32649.2	2317.498	
	19R	66623.3	32619.16	2317.154	
	20L	66642.91	32653.9	2317.754	
	20R	66659.56	32628.88	2317.563	
	21L	66659.87	32673.91	2318.044	
	21R	66691.64	32644.99	2317.379	
	22L	66719.26	32714.59	2318.637	
	22R	66718.11	32678.57	2317.623	
	23L	66775.28	32675.28	2318.801	

Table 3.2.3 Data List of Cross Section Posts (2/6)

	23R	66757.65	32662.74	2320.003	
	24L	66807.6	32642.38	2319.253	
	24R (TP10)	66790.39	32628.57	2320.552	
	25L	66852.26	32620.55	2322.336	
	25R	66828.52	32578.79	2321.48	
BAN	26L	66887.51	32552.09	2319.84	
	26R (TP11)	66857.22	32544.69	2323.28	
	27L	66899.77	32517.88	2320.696	
	27R	66876.58	32502.26	2323.398	
	28L	66967.86	32490.1	2322.074	
	28R (TP12)	66943.09	32464.69	2321.538	
	29L	66988.36	32439.5	2321.065	
	29R	66957.47	32442.91	2321.605	
	30L	66981.21	32404.9	2321.954	
	30R (BM10)	66955.39	32396.84	2323.175	
	31L	67000.09	32374.3	2322.33	
	31R	66981.51	32352.01	2321.765	
	32L	67029.89	32343.41	2323.504	
	32R	67015.9	32327.22	2322.44	
	33L	67068.03	32317.33	2322.779	
	33R	67043.97	32296.45	2322.774	
	34L	67092.43	32275.66	2323.9	*
	34R	67073.81	32264.9	2323.301	
	35L	67104.91	32248.23	2324.444	
	35R (TP15)	67094.12	32240.44	2323.856	
	36L	67148.89	32209.36	2324.221	
	36R	67112.73	32199.27	2325.334	
	37L	67172.9	32174.31	2325.889	
	37R (TP16)	67150.71	32155.12	2328.613	
	38L	67202.88	32087.72	2330.162	
	38R	67140.22	32139.08	2328.337	
	39L	67200.75	32078.59	2326.917	
	39R	67151.95	32089.55	2327.606	
	40L	67188.4	32048.17	2325.658	
	40R	67162.56	32047.44	2325.26	
	41L	67177.4	32000.92	2325.581	
	41R	67161.57	32002.92	2325.009	
	42L	67178.33	31964.67	2328.925	
	42R	67152.11	31971.16	2327.284	
	43L	67178.09	31933.2	2327.045	
	43R	67154.09	31917.86	2325.497	
	44L	67192.76	31889.99	2327.364	
	44R	67177.42	31882.3	2327.394	
	45L	67207.02	31850.29	2327.282	
	45R	67178.51	31844.94	2327.198	
	46L	67225.53	31800.56	2327.343	
	46R (TP20)	67205.59	31795.62	2328.734	
	47L	67239.3	31778.13	2327.058	
	47R	67208.93	31749.64	2328.057	
	48L	67268.74	31754.35	2331.941	
	48R	67273.75	31707.66	2332.273	

Table 3.2.3 Data List of Cross Section Posts (3/6)

	49L	67293.14	31759.99	2331.91	
	49R	67304.44	31707.57	2332.592	
	50L	67355.18	31736.52	2332.407	
	50R	67323.37	31716.41	2328.833	
	51L (TP21)	67390.25	31704.03	2331.903	
	51R	67363.56	31666.51	2328.227	
BAN	52L	67428.42	31668.08	2331.155	
	52R	67414.29	31648.24	2328.640	
	53L	67463.61	31632.84	2331.899	
	53R	67443.93	31615.89	2329.092	
	54L	67491.73	31599.62	2331.456	
	54R	67457.96	31584.64	2330.986	
	55L (TP22)	67518.46	31570.29	2331.518	
	55R	67498.82	31553.96	2330.118	
	56L	67542.96	31528.69	2332.262	
	56R	67520.92	31514.92	2330.621	
	57L	67563.41	31491.39	2332.607	
	57R	67543.31	31481.01	2331.517	
	58L (TP23)	67579.36	31450.85	2332.159	
	58R	67557.39	31445.90	2331.526	
	59L	67579.06	31400.49	2332.868	
	59R	67555.99	31397.79	2332.669	
	60L	67582.37	31345.58	2334.415	
	60R	67556.19	31336.96	2339.434	
	61L	67646.19	31295.74	2341.921	
	61R	67561.69	31285.25	2341.564	
	62L	67617.22	31252.67	2334.020	
	62R	67587.43	31261.90	2334.666	
	63L	67583.06	31188.72	2334.915	
	63R	67571.39	31218.41	2334.449	
	64L (TP25)	67549.28	31167.57	2335.066	
	64R	67543.76	31213.66	2334.518	
	65L	67508.68	31169.58	2335.179	
	65R	67514.54	31205.38	2335.104	
	66L	67476.16	31170.67	2335.531	
	66R	67474.00	31201.34	2337.879	
	67L (TP26)	67453.11	31152.23	2337.757	
	67R	67434.75	31181.20	2337.312	
	68L	67449.96	31137.32	2337.805	
	68R	67427.46	31141.93	2337.627	
	69L	67452.01	31104.91	2339.940	
	69R (TP27)	67424.93	31105.10	2337.156	
	70L	67454.97	31072.14	2340.704	
	70R	67426.50	31068.44	2338.719	
	71L	67454.34	31031.85	2339.206	
	71R	67429.25	31032.16	2339.157	
	72L	67450.36	30987.16	2339.345	
	72R	67432.06	30985.11	2338.850	
	73L	67464.55	30964.97	2339.104	
	73R	67450.34	30949.23	2339.044	**
	74L	67496.32	30934.94	2339.356	

Table 3.2.3 Data List of Cross Section Posts (4/6)

	74R	67482.83	30919.31	2339.389	
	75L	67532.33	30915.81	2340.422	
	75R	67517.95	30896.16	2340.432	
	76L	67569.60	30886.64	2341.419	
	76R	67555.92	30871.67	2341.251	
	77L	67629.70	30881.35	2340.883	
	(77R)	—	—	—	***
BAN	78L	67667.97	30814.17	2340.761	
	78R	67644.96	30791.17	2340.803	
	79L	67690.27	30788.17	2340.912	
	79R	67673.32	30769.62	2340.663	
	80L	67721.25	30751.22	2341.252	
	80R	67705.47	30736.55	2341.097	
	81L	67749.77	30719.12	2342.324	
	81R	67736.48	30703.04	2342.266	
	82L	67781.97	30683.50	2342.623	
	82R	67769.66	30674.56	2341.214	
	83L	67811.95	30648.12	2342.155	
	83R	67801.88	30638.71	2341.778	
	84L	67841.18	30623.37	2342.617	
	84R	67832.23	30619.32	2339.546	
	85L	67884.07	30598.08	2342.643	
	85R	67878.48	30581.67	2340.872	
	86L (TP34)	67919.38	30584.74	2343.286	
	86R	67914.27	30568.17	2341.593	
	87L	67969.41	30572.19	2344.541	
	87R	67957.29	30556.10	2342.823	
	89L	68038.13	30512.63	2346.741	
	89R	68035.14	30474.09	2346.745	
	90L	68068.20	30490.63	2347.135	
	90R	68062.50	30435.99	2346.675	
KEC	91L	68076.65	30490.02	2345.571	
	91R	68079.66	30473.72	2343.575	
	92L	68152.33	30487.13	2346.604	
	92R	68147.43	30468.93	2346.397	
	92-1L	68215.56	30466.86	2348.466	
	92-1R	68205.22	30434.49	2348.393	
	93L	68246.39	30440.08	2348.191	
	93R	68226.86	30408.69	2348.373	
	94L	68337.67	30388.21	2347.984	
	94R	68347.23	30367.81	2349.260	
	95L	68436.76	30463.10	2352.728	
	95R	68454.42	30439.07	2352.312	
	96L	68485.60	30511.66	2353.707	
	96R	68498.72	30509.37	2354.624	
	97L	68595.66	30571.03	2355.643	
	97R	68608.69	30546.51	2357.420	
	98L	68622.19	30676.01	2360.663	
	98R	68629.75	30648.31	2360.074	
	99L	68706.65	30737.29	2363.887	

Table 3.2.3 Data List of Cross Section Posts (5/6)

	99R	68722.36	30712.79	2363.809	
	100L	68821.56	30736.14	2367.835	
	100R	68837.43	30731.42	2367.106	
	101L	68958.00	30809.14	2372.118	
	101R	68972.58	30794.30	2372.081	
	102L	69077.65	30866.08	2381.512	
	102R	69090.35	30842.98	2381.440	
	103L	69151.35	30890.22	2378.179	
	103R	69160.84	30864.29	2378.646	
KEC	104L	69312.12	30856.93	2388.666	
	104R (BM7)	69310.06	30838.66	2389.085	
	105L	69397.54	30823.87	2384.556	
	105R	69387.68	30810.92	2384.874	
	106L	69427.91	30759.91	2385.073	
	106R	69444.68	30722.20	2405.198	
	107L	69526.04	30826.01	2391.447	
	107R	69557.56	30790.80	2393.226	
	108L	69636.14	30829.78	2395.681	
	108R	69622.03	30805.81	2392.666	
	109L	69718.27	30777.18	2399.863	
	109R	69689.42	30749.38	2395.923	
	110L	69794.75	30733.55	2403.747	
	110R	69812.92	30680.65	2404.240	
	111L	69861.57	30677.56	2406.504	
	111R	69832.12	30675.57	2402.370	
	112L	69914.77	30650.70	2408.308	
	112R	69907.98	30606.05	2412.833	
	113L	69989.89	30619.56	2412.660	
	113R	70017.43	30592.26	2413.655	
KECW	00L (TP62)	72114.37	30653.79	2488.979	
	00R	72148.04	30644.41	2487.967	
	01L	72177.51	30681.41	2488.304	
	01R	72175.20	30647.40	2487.494	
	02L	72236.27	30666.30	2488.425	
	02R	72217.50	30627.09	2488.431	
	03L (TP63)	72263.91	30657.03	2492.918	
	03R	72261.62	30616.25	2496.715	
	04L	72336.29	30655.55	2499.838	
	04R	72310.00	30613.01	2499.424	
	05L (TP64)	72365.14	30645.00	2504.672	
	05R	72351.66	30601.12	2501.158	
	06L	72394.61	30622.30	2502.200	
	06R	72383.36	30594.79	2499.334	
	07L	72437.12	30602.91	2504.862	
	07R (TP65)	72416.28	30555.56	2505.975	
	08L-1	72508.88	30594.73	2507.964	
	08L-2	72516.92	30655.28	2514.273	
	08R	72500.34	30530.57	2513.767	
	09L	72535.76	30627.20	2513.209	
	09R	72533.48	30522.20	2516.115	

Table 3.2.3 Data List of Cross Section Posts (6/6)

	10L	72623.39	30604.24	2513.331	
	10R (TP66)	72559.85	30534.25	2513.151	
	11L	72631.11	30564.49	2511.667	
	11R	72642.39	30485.23	2515.511	
	12L	72685.39	30555.14	2509.253	
	12R	72683.35	30496.19	2518.608	
	13L	72756.81	30557.37	2516.215	
	13R	72764.66	30497.85	2521.967	
	14L	72828.83	30533.86	2518.580	
	14R (TP67)	72791.25	30496.84	2524.541	
KECW	15L	72846.09	30532.62	2522.630	
	15R	72829.23	30459.44	2527.090	
	16L	72882.61	30501.55	2526.532	
	16R	72882.61	30450.68	2526.272	
	17L	72971.27	30474.83	2529.982	
	17R	72952.47	30430.85	2534.237	
	18L	73028.06	30436.71	2531.991	
	18R	72992.37	30411.44	2534.820	
	19L	73122.91	30424.09	2535.942	
	19R	73102.36	30387.07	2537.695	
	20L	73180.03	30400.74	2537.457	
	20R	73124.41	30354.94	2540.776	
KECR	01L	71820.74	29799.18	2507.450	
	01R	71800.28	29782.15	2507.048	
	02L	71772.31	29780.49	2503.614	
	02R	71777.64	29765.52	2507.117	
	03L	71754.94	29817.98	2503.571	
	03R	71738.21	29803.85	2501.378	
	04L	71691.23	29824.98	2502.340	
	04R	71714.45	29785.93	2500.623	
	05L	71688.67	29809.91	2500.263	
	05R	71668.08	29810.07	2499.436	

Note: * Elevation is indirectry measured using Total Station.
** Elevation is measured using Total-Station from Post 73L.
*** Because the area is under construction, this post is not established.

Table 3.2.4 Data List of Road Cross Section Posts

POST NO.	ELEVATION (m)	REMARKS	POST NO.	ELEVATION (m)	REMARKS
A 01	2341.765		D 01	2341.825	
A 02	2341.564		D 02	2341.956	
A 03	2338.792		D 03	2343.496	
A 04	2340.273		D 04	2346.270	
A 05	2339.159				
A 06	2338.201		E 01	2349.133	
A 07	2337.293		E 02	2346.752	
A 08	2337.944		E 03	2346.229	
A 09	2338.531		E 04	2346.368	
A 10	2339.036		E 05	2346.395	
A 11	2339.405		E 06	2345.447	
A 12	2339.604		E 07	2343.525	
A 13	2340.792		E 08	2343.267	
A 14	2343.550		E 09	2344.196	
A 15	2349.073				
A 16	2349.267		F 01	2348.239	
			F 02	2348.470	
B 01 & B 01-1	2339.619		F 03	2349.027	
B 02 & B 02-1	2340.244				
B 03	2340.304		G 01 (BM 12)	2360.372	*
B 03-1 & B 04	2341.063				
B 05	2342.524				
B 06	2343.854				
B 07	2345.286				
B 08	2348.627				
B 09	2351.185				
C 01	2351.230				
C 02	2349.133				
C 03	2347.791				
C 04	2346.265				
C 05	2348.992				

Note : This post (G 01) is the same point with BM 12.

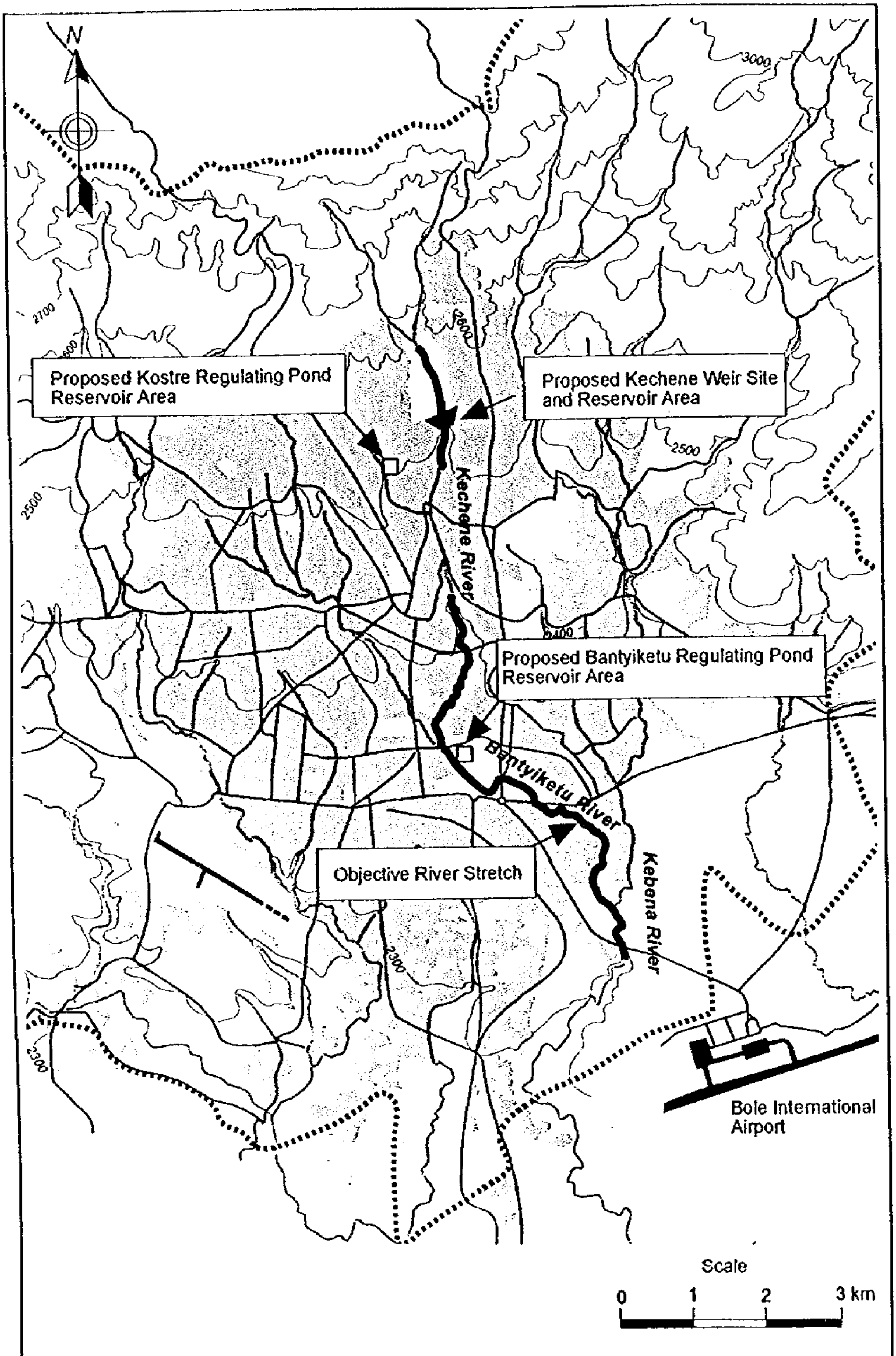


Figure 3.2.1 Survey Area - River Cross Section Survey

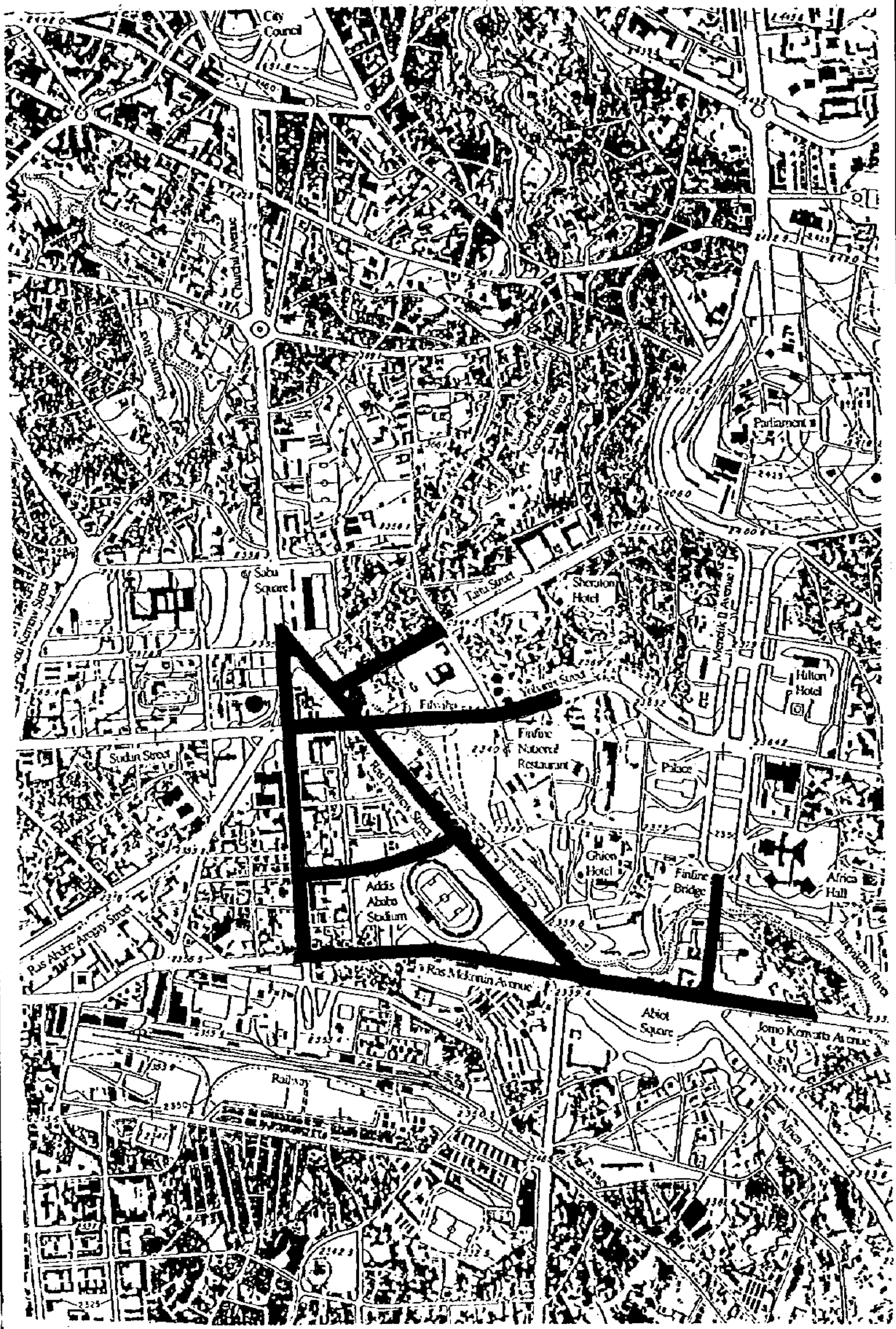


Figure 3.2.2 Survey Area - Road Cross Section Survey

THE STUDY ON ADDIS ABABA
FLOOD CONTROL PROJECT

CHAPTER 4

FLOOD CONTROL PLAN

THE STUDY

ON

ADDIS ABABA FLOOD CONTROL PROJECT

IN

THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

CHAPTER 4 FLOOD CONTROL PLAN

Contents

List of Tables

List of Figures

4. FLOOD CONTROL PLAN

4.1 General

The following are components for the flood control works of the selected priority projects for the feasibility study.

1) Structural Measures

Bantyiketu river

- River channel improvement (widening of river bank, bank protection, construction of floodwall, repair of intake gate), and
- Construction of the Bantyiketu regulating pond.

Kechene river

- Construction of the Kostre regulating pond in the Kostre river, and
- Construction of the Kechene weir in the upper Kechene.

2) Non-Structural Measures

- Authorization of river zone and 2) regulation of illegal activities in the viewpoint of rivers management, and
- Flood warning system, 4) flood fighting system and 5) social education in the viewpoint of flood risk management.

Planning on the above components and the proposed flood control plan of the priority projects are explained in the following.

4.2 Basic Conditions and Methodology

4.2.1 Basic Conditions

(1) Objective Rivers and Stretches

Objective rivers of the priority projects are basically the Bantyiketu and the upper Kechene. Respective parts of the lower Kebena and the lower Kechene rivers are incorporated in the planning from the viewpoint of transitions to the Bantyiketu.

Accordingly, the following are objective rivers and stretches to be considered in the planning, as shown in Figure 4.2.1.

- Lower Kebena river: just upstream of the Bole road bridge
- Bantyiketu river: the confluence with the Kebena river - Filwiha bridge
- Lower Kechene river: just upstream of 2nd bridge
- Upper Kechene including Kostre river: respective proposed sites of weir and pond

(2) Design Discharge Distribution

Design discharges of the priority projects have been estimated in the Phase1 study with 30-year probable flood for the Bantyiketu (and Kebena rivers,) and 20-year probable flood for Kechene river. Figure 4.2.2 shows the design discharges distribution of the flood control works in the priority projects.

(3) Treatment of Urgent Works in the Lower Kechene River

AFCPO has an urgent plan to construct floodwall on both the river banks between the 1st bridge and the 2nd bridge, and repair of broken abutment of the 2nd bridge in the lower Kechene river. The construction works have been scheduled to carry out by contracting system in 1998. The total length of floodwall amounts to 300 m on the left and 340 m on the right, respectively, as explained in chapter 2.

These works are therefore excluded from the components of the priority projects.

4.2.2 Methodology

(1) Topographic Maps and Channel Cross Sections of Rivers to be Used

1) Topographic Maps

Topographic maps of a scale of 1/2,000 with one-meter interval contour developed by Ethiopian Mapping Authority (EMA) in 1995 are available to the planning. The maps were produced for the Addis Ababa Water Supply Project, Stage III A, using air photographs taken in the period from1993 to 1994.

2) Channel Cross Sections

Cross sections of river channel surveyed are used. The selected contractor surveyed river channel cross sections under the supervision of the Study Team.

(2) Design Criteria of Flood Control Works

1) River Channel Improvement

The existing river is partly channeled so as to convey the design flood safely by means of widening of the existing river channel, construction of earth dike and floodwall, protection of bank slopes, and reconstruction or modification of the related structures. The following are major design criteria to be applied.

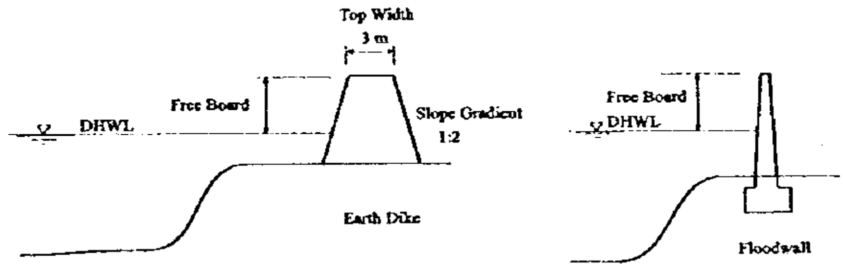
a) Design high water level of the channel is set at an average river bank elevations from the viewpoint of smooth storm water drainage from riparian areas.

b) Longitudinal channel profiles are prepared based on the survey results of the river cross sections.

c) Required flow area for the design discharge is estimated by Manning formula. Single section or composite section is employed depending on site conditions.

d) The following are freeboards above the design high water level for floodwall and dike, and dimensions of dike.

- Earth dike: 0.6 m for discharges less than 200 m^3/sec
  0.8 m for discharges equal to 200 and less than 500 m^3/sec
- Floodwall: 0.6 m for discharges less than 200 m^3/sec



c) Water supply pipes and sewerage pipes are running along the river courses. In widening the existing channel, replacement of these pipes is considered to avoid as much as possible and to minimize.

2) Regulating Pond

In order to reduce flood peaks to the downstream reaches, a regulating pond is taken in the flood control plan. The pond consists of side overflow dike, reservoir and drainage pipe with flap gate. An image of the pond and the formula to be applied to hydraulic calculation of side overflow dike are shown in Figure 4.2.3.

An elevation of side overflow dike is set around river water level equivalent to that of a flood discharge which occurs once in a year. The reservoir scale is designed for the volume to be cut in the design discharge hydrograph. After finishing the flood, the stored water in the reservoir is to be drained through a flap gate that no operation is required. The drain time of stored water is around a half-day.

Heavy rain time only occupies the pond with water. Therefore, the pond area can be utilized throughout the year as football ground or other inhabitant's purposes.

As described in section 2.1 of chapter 2, the Bantyiketu regulating pond area is to be prepared by Region 14 Administration for a multi-functioned public park as one of the model parks to be developed in Addis Ababa city.

3) Kechene Weir

A weir with orifice is taken into the flood control plan to decrease a flood peak to the downstream reaches. The site of the weir is proposed at valley area in the upper Kechene river.

The weir consists of weir body with orifice that drains base flow in the channel and reservoir to store the excess flood. No operation of the weir is required. Figure 4.2.4 shows an image of the weir and the formula to be applied for hydraulic calculation of the weir.

4.3 Study on Flood Control Plan

4.3.1 Channel Improvement

(1) Bantyiketu River

1) Longitudinal Profile and Cross-Sections of the Channel

Figure 4.3.1 shows the proposed longitudinal profile of the channel and Figure 4.3.2, the standard cross sections and cross sections at major points of the existing channel, respectively. Table 4.31 presents proposed dimensions of the longitudinal profile.

The river channel of the Bantyiketu is divided into 5 reaches, as shown in Table 4.3.2. Depending on the site conditions of the present river channel, single or composite section is applied

2) Alignment of River Channel

In line with present river courses, river channel alignment is drawn up in Figure 4.3.3.

3) River Structures and Related Structures

The proposed river structures and related structures are as follows.

- Floodwall,
- Slope protection,
- Improvement of intake weir
- Improvement of aqueduct
- Protection of water supply pipes (2 places around 7th bridge)

The details of the proposed structures are explained in chapter 6 and outline of the works is shown in Table 4.3.3.

(2) Lower Kebena and Lower Kechene

1) Lower Kebena River

The bank slopes of the lower Kebena just upstream of Bole bridge are prone to bank erosion. Slope protection works are taken up in the said reach.

Figures 4.3.4 and 4.3.5 show a tentative longitudinal profile and cross sections of the lower Kebena. Tables 4.3.1 and 4.3.4 show dimensions of longitudinal profile and standard cross section in the lower Kebena.

The existing channel has sufficient capacity for a design discharge. Based on this plan, both the present bank slopes are guarded by slope protection works. The alignment and work quantity of the protection works is shown in Figure 4.3.3 and Table 4.3.3, respectively. The details of the protection works are described in chapter 6.

2) Lower Kechene River

Just upstream of 2nd bridge in the lower Kechene river, both the river banks have been eroded and riparian areas are subject to inundation and washing away. Accordingly, this reach is protected by construction of floodwall.

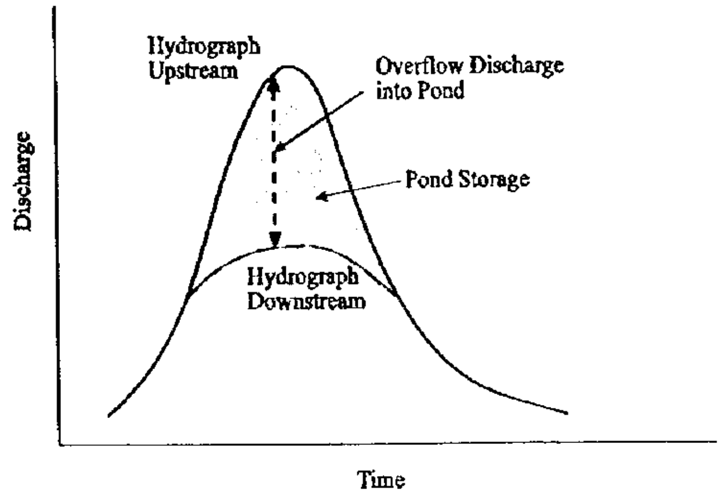
Figures 4.3.6 and 4.3.7 show a tentative longitudinal profile and cross section of the lower Kechene river. Tables 4.3.1 and 4.3.5 show dimensions of longitudinal profile and standard cross section in the lower Kechene.

As seen in the said figure, the existing Kechene river has sufficient flow capacity for a design discharge. Therefore, the existing bank slopes are protected by construction of floodwall. The alignment and work quantity of the floodwall are shown in Figure 4.3.3 and Table 4.3.3, respectively. The details of the floodwall are described in chapter 6.

4.3.2 Bantyikctu and Kostre Regulating Ponds

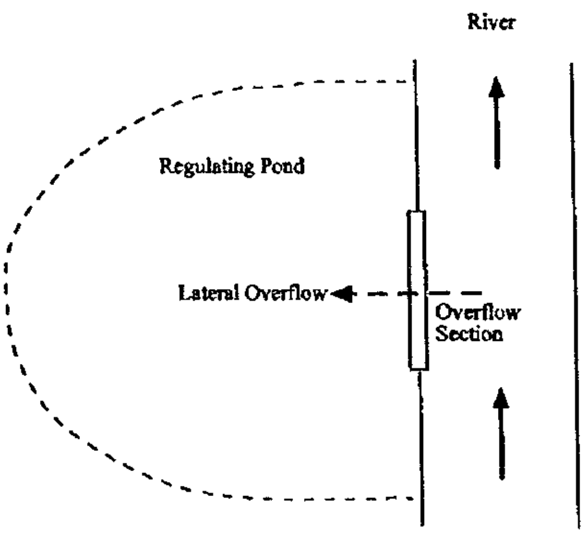
(1) Outline

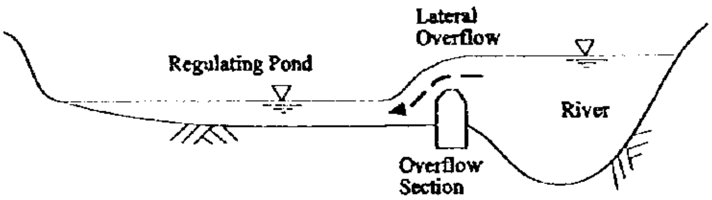
The Bantyiketu regulating pond is proposed near the confluence of the Kechene and the Kurtume rivers on the downstream left bank of the Bantyiketu river where the open area is mostly covered with grassland. The proposed site of the Kostre regulating pond is a soccer field on the left bank of the Kostre river, a tributary joining with the Kechene river at 2 km downstream from the proposed site. Both sites are to be utilized as temporary storage to reduce flood peak discharge in the manner of 'peak cut'. A concept of discharge regulation by pond is illustrated below.



(2) Analysis on Regulating Pond

The analysis is carried out to determine a required storage capacity of pond and dimensions (width and height) of lateral overflow section. Flood discharge is introduced into pond in the manner of lateral overflow as illustrated below.





Along lateral overflow section, water level - discharge (H-Q) relationships of river channel are known from the survey data of river cross sections. Whereas, H-Q relationship of lateral overflow section is obtained on the basis of the following equations.

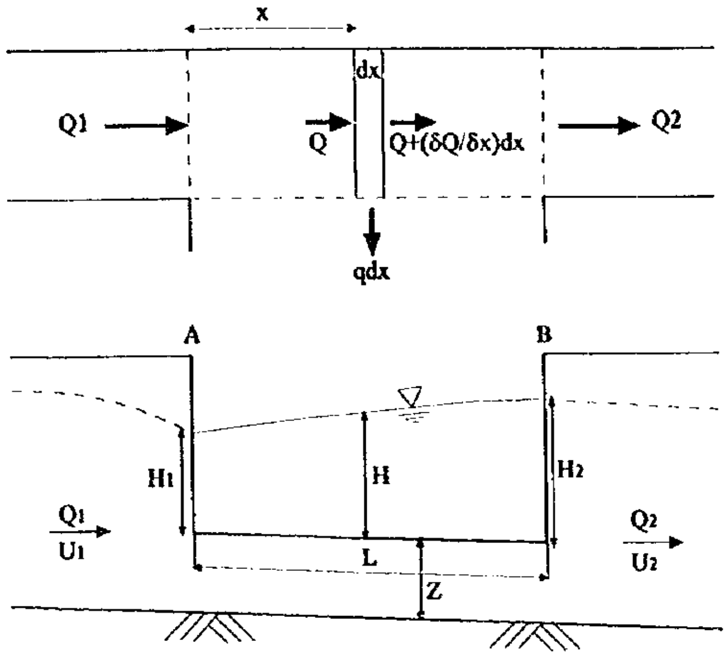
$$q = K \times H^{3/2}$$

$$\delta Q / \delta x = -q$$

$$Q_2 = Q_1 - \int_0^L q dx$$

where,

q	: lateral overflow for unit width (m^2/sec)
K	: discharge coefficient of lateral overflow
H	: water depth from crest of lateral overflow section (m)
Q_1	: river discharge at upstream end of lateral overflow section (m^3/sec)
Q_2	: river discharge at downstream end of lateral overflow section (m^3/sec)
x	: distance from upstream end of lateral overflow section (m)
Q	: river discharge at distance 'x' (m^3/sec)
L	: width of lateral overflow section (m)



When channel water depth at each end of lateral overflow section is given as 'H_1+Z' at upstream end (Section-A) and 'H_2+Z' at downstream end (Section-B), overflow water depth at distance 'x' can be obtained assuming that overflow water depth in between is known by linear interpolation.

$$H = H_1 + (H_2 - H_1) / L \times x$$

$$Q_2 = Q_1 - \int_0^L K \times \{ H_1 + (H_2 - H_1) / L \times x \}^{3/2} dx$$
$$= Q_1 - 2/5 \times L \times (H_2^{5/2} - H_1^{5/2}) / (H_2 - H_1)$$

Providing that Bernoulli Theorem (energy conservation law) is applicable between Section A and B, the following equation can be obtained.

$$H_1 + U_1^2/2g = H_2 + U_2^2/2g$$
$$H_1 = H_2 - (U_1^2 - U_2^2)/2g$$

where,

U_1 : flow velocity at upstream end (m/sec)
U_2 : flow velocity at downstream end (m/sec)
g : acceleration of gravity (=9.8 m/sec^2)

When Q_1 and Q_2 are given, length of lateral overflow section 'L' is calculated by means of trial and error for U_1 and H_1 solving the equations above simultaneously.

Applying the above-mentioned method, hydraulic calculation is carried out. Design discharge for each regulating pond is given below.

Regulating Pond	Return Period	Peak Discharge in River Channel (m^3/sec)		Lateral Overflow (m^3/sec)
		Upstream (Q_1)	Downstream (Q_2)	($Q_1 - Q_2$)
Bantyiketu	30-Year	175	145	30
Kostre	20-Year	28	14	14

Discharge hydrographs for the respective regulating ponds are shown in Figure 4.3.8. As the results of the hydraulic analysis described above, the basic design features of regulating pond are obtained as follows.

Bantyiketu Regulating Pond

1) Design Discharge (Peak Discharge)	Probable 30-Year Flood - Upstream River Channel : 175 m^3/sec - Downstream River Channel : 145 m^3/sec - Lateral Overflow : 30 m^3/sec
2) Lateral Overflow Section	Length : 50 m Height : 3.3 m
3) Required Storage	73,000 m^3

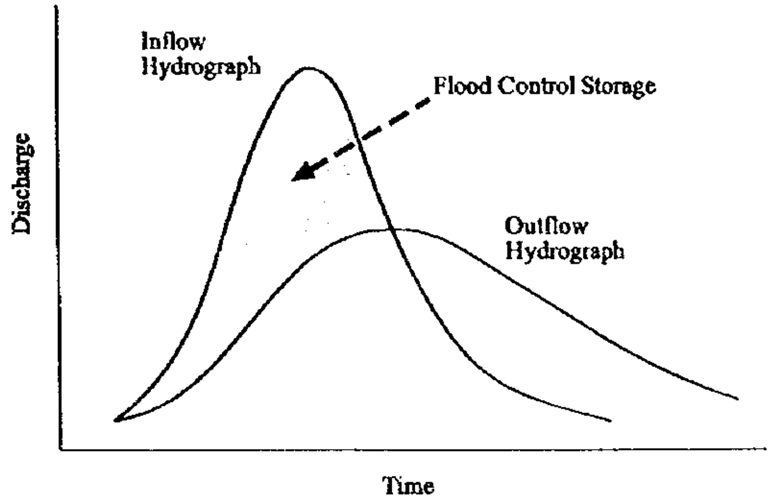
Kostre Regulating Pond

1) Design Discharge (Peak Discharge)	Probable 20-Year Flood - Upstream River Channel : 28 m^3/sec - Downstream River Channel : 14 m^3/sec - Lateral Overflow : 14 m^3/sec
2) Lateral Overflow Section	Length : 30 m Height : 4.5 m
3) Required Storage	26,000 m^3

4.3.3 Kechene Weir

(1) Outline

The Kechene Weir is proposed in the upper basin of the Kechene river at 5 km upstream from the confluence of the Bantyiketu river. It consists of weir and orifice type outlets to reduce flood peak discharge by means of a reservoir in the upstream of weir. A concept of discharge regulation by reservoir is illustrated below.



(2) **Reservoir Water Level, Surface Area and Storage**

A relationship between reservoir water level and storage is obtained from the topographic maps with a scale of 1/2,000 as shown in Figure 4.3.8 and summarized below. The lowest riverbed elevation is EL. 2,494 m. The highest reservoir water level should be less than EL. 2,512 m in order to minimize resettlement of houses covered by reservoir surface area.

Water Level (EL. m)	2,495	2,500	2,505	2510	2,515
Surface Area (m^2)	115	4,096	9,331	17,013	31,127
Storage (m^3)	60	10,600	44,200	110,100	230,500

(3) **Analysis on Flood Control Storage**

The analysis is carried out to determine a flood control storage by weir in compliance with inflow – outflow calculation. The basic equation for this analysis is given below.

$\Delta Si = Ii - Oi$

where,

ΔSi : difference of reservoir storage within time step (i)

Ii : reservoir inflow within time step (i)

Oi : reservoir outflow within time step (i)

In the equation above, reservoir inflow is known as the flood hydrograph of the Kechene river at the proposed weir site. Reservoir outflow is calculated by the following equations used for orifice flow.

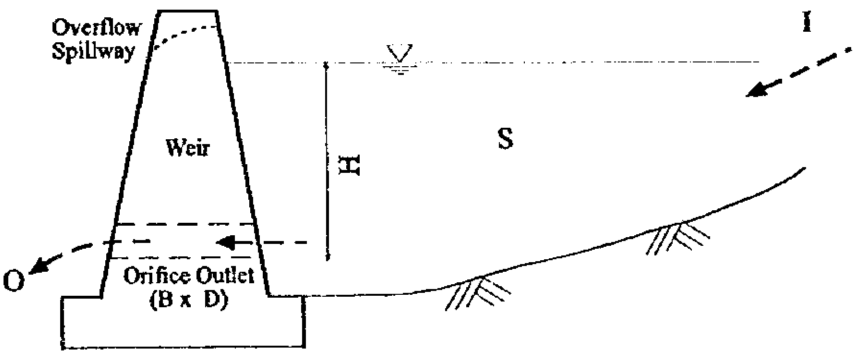
$$O = 1.8 \times B \times H^{3/2} \qquad (H < 1.2D)$$

$$O = C \times B \times D \times \{ 2 \times g \times (H - D/2) \}^{1/2} \qquad (H > 1.8D)$$

$$O = O_{H=1.2D} \sim O_{H=1.8D} \text{ (interpolation)} \qquad (1.2D < H < 1.8D)$$

where,

O	: outflow (m^3/sec)
B	: width of orifice outlet (m)
D	: height of orifice outlet (m)
H	: water depth (m)
C	: discharge coefficient (=0.85)
g	: acceleration of gravity (=9.8 m/sec^2)



Reservoir storage at each time step is calculated by the equations above and reservoir water level is obtained from reservoir storage on the basis of the relationship between water level and storage.

Elevation of invert level of orifice outlet is set at EL. 2,500 m in consideration of topographic feature of riverbed.

The flood control storage of reservoir is examined by inflow – outflow calculation. The design flood hydrographs of probable 20-year and 30-year flood are applied as reservoir inflow. The results of calculation are illustrated in Figure 4.3.9 and summarized below.

Low Water Level of Reservoir : EL. 2,499 m

Orifice Outlet : 1.2 m×1.2 m, Invert Level EL. 2,499 m

Design Flood	Peak Discharge Inflow (m^3/sec)	Peak Discharge Outflow (m^3/sec)	Design Flood Water Level (EL. m)	Reservoir Storage (m^3)
Probable 20-year Flood	85	49	2,508.3	83,000
Probable 30-year Flood	91	50	2,509.0	96,000

(4) Discharge Capacity of Spillway

For construction of weir, it is necessary to provide an overflow spillway discharging excessive flood from reservoir. Discharge capacity of overflow spillway was therefore examined using the following equation.

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

where,

Q : overflow discharge (m^3/sec)

B : width of overflow spillway (m)

H : water depth from crest of overflow spillway (m)

C : discharge coefficient (=1.8)

The probable 200-year flood was applied as design capacity of overflow spillway. The results of calculation are summarized below.

Crest of Overflow Spillway : EL. 2,509.5 m

Width of Overflow Spillway : 20 m

Design Flood	Peak Discharge (m^3/sec)	Water Depth of Overflow Discharge	Highest Water Level (EL. m)
Probable 200-year Flood	120	2.5	2,511.5

4.4 Proposed Flood Control Plan of the Priority Projects

The proposed flood control plan of the priority projects consists of both the measures of the structural and non-structural. The proposed plan is summarized below.

4.4.1 Structural Measures

The following are major components of the flood control works of the priority projects. Locations of the proposed works are shown in Figure 4.4.1. The detail dimensions of major facilities are described in chapter 6.

1) River Channel Improvement

- Bantyiketu river channel improvement
  Channel excavation: 20,500 m^3
  Embankment: 400 m^3
  Floodwall: 3,010 m^2
  Slope protection: 5,010 m^2
  Repair of intake weir: 1 set
  Improvement of aqueduct: 1 set
  Protection of sewrage pipe: 2 sets
- Bank slope protection in the lower Kebena
  Slope protection: 4,830 m^2
- Construction of floodwall in the lower Kechene
  Floodwall: 540 m^2

2) Bantyiketu Regulating Pond
- Reservoir area: 29,900 m^2
- Reservoir volume: 73,000 m^3
- Lateral overflow dike: 50 m

3) Kostre Regulating Pond
- Reservoir area: 6,500 m^2
- Reservoir volume: 26,000 m^3
- Lateral overflow dike: 30 m

4) Kechene Weir

- Reservoir volume: 88,000 m^3
- Weir (by concrete) height: 16-19.5 m
- Crest length: 120 m

4.4.2 Non-Structural Measures

The non-structural measures proposed in the priority projects are explained below.

They are 1) authorization of river zone and 2) regulation of illegal activities in the viewpoint of river management, and 3) flood warning system, 4) flood fighting system and 5) social education in the viewpoint of flood risk management.

These measures need to be supported by appropriate institutional systems in accordance with the regulations and institutions of Region 14 Administration, and by wide participation of inhabitants in the flood control and prevention activities. Regarding institutional support, an explanation is made in chapter 8.

The details of the proposed non-structural measures are described below.

(1) River Zone

The river zone is established to administrate and manage the rivers and river structures in proper conditions. Objective rivers and stretches for the river zone are proposed below.

1) Objective rivers and stretches

- Bantyiketu river system : from confluence with Kebena river to head water
- Kebena river system : from Aba Samuel lake to head water
- West Akaki river system : from Aba Samuel lake to head water
- Little Akaki river system : from confluence with West Akaki to head water
- Hanku river system : from confluence with Kebena river to head water

2) Cross-sectional boundary of river zone

The following are cross-sectional boundary of the river zone and shown in Figure 4.4.2.

In case without flood protection wall

- 5 m from present or proposed river bank line

In case with flood protection wall

- 5 m from flood protection wall

For the above purpose, an institutional support with bylaw is required for an overall river management system. The concerned law-section in the Region 14 Administration and Addis Ababa River Management Authority (AARMA, as Executing Body of the Project) which are directed by Addis Ababa River Board (AARB), take charge of these institutional matters in accordance with the regulations of Region 14 Administration. The details of AARMA and AARB are explained in Chapter 8. River Management and O/M Division of AARMA is in charge of matter. The following are the required institutional support items:

- Designation of the highest responsible administrator (President) in the river management for rivers and river structures,
- Rivers, river stretches and river widths to be designated,
- Regulation of land use in the riparian areas,
- Permission system for utilization and construction of facilities in the river zone, and
- Regulation of and penalty for illegal activities such as illegal utilization of river zone, and garbage and soil disposals.

The regulation of garbage and soil disposals is principally progressed in combination with improvement of the present garbage collecting system.

The garbage collecting system by Health Bureau of Region 14 Administration needs to improve in stepwise. While campaigns for "Three R Movement" of 1) reducing, 2) reuse and 3) recycle of garbage need to enlighten people in relation with social education that is explained in the following item of (4). To solve garbage issues is, anyhow, to improve the present garbage collecting system and additionally to change of traditional spirits for garbage treatment. A longstanding feud will be required for this issue.

(2) Flood Warning System

In order to mitigate the damage due to flooding as much as possible, a simple flood warning system is setup in AARMA. AARMA takes charge to issue warning under the direction of AARB. The warning system comes into force firstly in the concerned area of the priority projects, as a pilot one. Then, the system is one after another applied to other areas.

Warning is issued based on the rainfall amount observed at the 1 rainfall observatory station to be newly installed in the mountainous area of the Kechene river and information obtained from National Meteorological Services Agency. In addition, 3 staff gauges are installed in the Kechene and Bantyiketu rivers.

AARMA is to issue warning in accordance with the following manner, as shown in Figure 4.4.3.

- Observation of rainfall amount (entrust to local people),
- Transmission of rainfall data by transceiver to AARMA (Chief of Survey and
- Investigation Division),
- Analysis and warning by AARMA (Survey and Investigation Division),
- Transmission of analysis result to AARB,
- Judgement by AARB and warning by siren,

  Warning is to be issued as follows:

  1st warning: in case rainfall amount exceeds 8 mm/10 minutes (occurs 2-3 times per year)
- Issuance of order for flood fighting by AARMA(Manager) to Zone/Wereda,

  Warning is to be issued as follows:

  2nd warning for stand by for flood fighting: in case the accumulated rainfall amount exceeds 20 mm/20 minutes (100 m^3/sec at Filwiha bridge: occurs once in about 2 years)
- Transmission of order by Wereda to leaders of concerned Kebele, and
- Transmission of order by Kebele leader to community leaders.

It should be noted that other 2 rainfall observatory stations in the Kebena and Little Akaki rivers are to be installed in the implementation period of the priority projects. On the other hand, other 7 staff gauges in the Kebena, Little Akaki and Hanku are to be installed in due time of their implementation periods.

To operating this system needs required institutional system in relation with flood fighting system that is to be operated by community organizations.

(3) Flood Fighting System

In order to mitigate the flooding damage during flooding, a flood fighting system is established. The flood fighting system consists of flood prevention works mainly for prevention of the damage due to overtopping by using sandbags and evacuation of the concerned people for emergency case. In the same manner with the flood warning system, the flood fighting system is operated in the concerned areas of the priority projects.

Each community of the Kebeles principally operates the system under the direction of AARB and AARMA (mainly by Survey and Investigation Division), as shown in Figure 4.4.4. For this purpose, existing community organizations (flood fighting teams) are applied to this system. These communities actually operate the fighting system on the sites, in cooperation with other organizations such as NGO and Wereda Disaster Relief Cell. Participation of inhabitants is essential requisites for this system and self-defense by communities is a basic factor of this system.

A communication and information system among AARMA, Zone/Wereda, Kebele and each community is established. The following are the flowchart of communication and information in the system, as shown in Figure 4.4.4.

- Zone/Wereda receives order from AARMA (Manager),
- Transmission of order by Wereda to leader of the concerned Kebele,
- Order by Kebele to leaders of concerned communities,
- Flood fighting by each community (flood fighting team), and
- Evacuation of riverine people to specified area, if needed.

In order to carry out the system effectively, demonstrations (training) of the flood fighting system are annually needed from the viewpoint of not only maintenance and operation of the system but also social education for flooding.

In the riparian areas, 5 storage houses (for priority projects) are installed to keep necessary materials and equipment for activity use. The following are the required materials and equipment to be stored:

- Transceiver,
- Sand bags,
- Handy light
- Shovel,
- Helmet,
- Raincoat, and
- Others required.

It should be noted that 7 houses for other than priority projects are to be installed in due time of respective implementation periods.

From the above, the system and organization need authorization by the regulations and institutions of the Region 14 Administration. Major matters to be authorized are described in chapter 8.

(4) Social Education

At present, many illegal activities have been observed in the river areas. They are garbage and soil disposal to river areas, and illegal (not permitted) utilization of river areas and construction of private facilities. AARMA (River Management and O/M Division) is newly to manage such illegal ones.

From the viewpoint that river area and river structures are the public facilities and they are considerably important ones for daily life of people, therefore, social education is required to enlighten people for river and flooding.

Kebele and each community are principally responsible for the social education that is directed by AARB and AARMA (mainly by Administration Division). The social education is, at all times, programmed applying community organizations of the flood fighting system. The menus are as follows

- Seminar for community leaders,
- Seminar for people in each community,
- Campaign through TV and radio,
- Designation of River Day and annual River Festival (Love River),
- Annual demonstration of flood fighting activity, and
- Commendation system for outstanding community.

Table 4.3.1 Design Values of Longitudinal Profiles of Objective Rivers (1/2)

Bridge	Sect.	Distance	Low riverbed	Ave riverbed	Ave channel depth	Left bank	Right bank	Left flood wall	Right flood wall	Bri. soffit	River width	Total width	D riverbed	DHWL	D dike/wall
(Kabena river) Rail Bri.	0	0.0	2286.8	2287.0	11.0	2298.0	2298.2			2298.2	20.5				
Bole Bri.	1	100.0	2292.2	2293.0	7.6	2300.6	2301.0			2299.4	15.0		2294.20	2299.20	2300.00
	2	176.0	2294.8	2295.0	7.6	2302.6	2303.2				36.0		2295.00	2300.00	2300.80
	3	296.0	2295.0	2296.0	6.6	2303.0	2302.6				30.0	58.0	2296.20	2301.20	2302.00
	4	426.0	2296.8	2297.0	6.0	2305.0	2305.0				26.5	35.0			
	5	578.0	2298.2	2299.0	5.0	2304.0	2304.8				22.0				
	6	696.0	2299.6	2300.0	5.0	2305.4	2305.0				19.0		2300.20	2305.20	2306.00
Conf.	7	812.0	2299.8	2300.0	10.0	2310.0	2310.0				20.0				
(Bantyiketu	8	916.0	2304.1	2305.0	4.0	2309.2	2309.0				14.0	30.0			
river)	9	1056.0	2306.9	2307.5	2.5	2310.0	2310.0				15.0	30.0			
	9.1	1120.0	2307.0	2307.5	4.0	2311.0	2311.0				20.0				
1st.bri	10	1164.0	2307.5	2307.5	6.0	2316.0	2316.0			2314.0	15.0				
	11	1264.0	2308.5	2309.0	3.0	2312.0	2312.0				21.0				
2nd.bri	12	1366.0	2309.0	2309.0	6.0	2314.8	2315.0			2314.2	16.0				
	13	1420.0	2307.5		7.0	2316.8	2314.0						2311.00	2314.00	2314.60
	14	1524.0	2311.6	2313.0	1.6	2314.6	2316.0				18.0	30.0	2311.74	2314.74	
	15	1620.0	2313.1	2313.1	1.9	2315.0	2315.0				15.0		2312.43	2315.43	
	16	1778.0	2313.5	2314.0	1.6	2316.2	2315.6				20.0		2313.56	2316.56	
	17	1832.0	2314.2	2314.5	1.7	2316.6	2316.2				15.0		2313.94	2316.94	
	18	1882.0	2313.4	2314.5	2.5	2317.2	2317.0				15.0		2314.30	2317.30	
	19	1926.0	2314.5	2315.0	2.0	2317.5	2317.0		2318.0		25.0		2314.61	2317.61	
	20	1970.0	2314.7	2315.0	1.2	2317.2	2317.6	2318.0			20.0		2314.93	2317.93	
	21	2016.0	2314.9	2315.5	2.5	2318.0	2318.0				12.0		2315.26	2318.26	
	22	2056.0	2315.3	2316.0	2.0	2318.4	2318.0				20.0		2315.50	2318.50	2319.10
	23	2102.0	2316.6	2317.0	2.0	2319.0	2320.0				21.0		2315.87	2318.87	
	24	2144.0	2315.6	2316.5	2.5	2319.0	2320.6	2323.0			17.0	30.0	2316.17	2319.17	
	25	2186.0	2316.8	2317.0	2.7	2322.0	2319.7	2322.0	2322.0		16.0	38.0	2316.47	2319.47	
	26	2262.0	2317.3	2317.5	2.5	2320.0	2323.2	2321.0			20.0		2317.01	2320.01	
	27	2310.0	2317.0	2318.0	2.6	2320.6	2323.4				21.0		2317.36	2320.36	
	28	2370.0	2317.7	2318.5	2.5	2321.0	2321.2	2322.4	2322.4		30.0		2317.79	2320.79	
	29	2428.0	2318.5	2319.0	3.0	2321.0	2322.0				25.0		2318.20	2321.20	
	30	2488.0	2318.4	2319.0	2.9	2321.9	2323.0				21.0		2318.63	2321.63	
	31	2526.0	2319.0	2319.0	2.6	2322.2	2321.6	2323.4			12.0	28.0	2318.90	2321.90	
	32	2576.0	2319.0	2319.0	3.5	2322.5	2322.5	2323.6			18.0		2319.26	2322.26	
	33	2622.0	2319.4	2320.0	2.6	2322.6	2323.2	2324.4			19.5		2319.59	2322.59	
	34	2680.0	2319.6	2320.0	3.4	2324.0	2323.4	2325.6			18.0		2320.00	2323.00	
	35	2720.0	2320.0	2320.0	4.0	2324.4	2324.0				7.0		2320.29	2323.29	
3rd bri.	36	2760.0											2320.57	2323.57	
	37	2818.0	2320.6	2321.5	4.5	2326.0	2328.5		2328.8		20.0		2320.99	2323.99	
	38	2842.0	2320.6	2321.5				2330.0	2329.0				2321.16	2324.16	
	39	2908.0	2321.8	2322.5	3.1	2327.0	2325.6		2326.8		15.0	30.0	2321.63	2324.63	
	40	2958.0	2321.2	2322.0	4.0	2327.3	2326.0				21.0	30.0	2321.99	2324.99	
	41	2998.0	2322.0	2322.5	2.5	2325.6	2325.0				15.0	30.0	2322.27	2325.27	
	42	3032.0	2322.3	2322.5	4.9	2329.0	2327.4				16.5	27.0	2322.51	2325.51	
	43	3088.0	2322.2	2323.0	2.6	2330.0	2325.6		2326.6		13.0	38.0	2322.91	2325.91	
	44	3150.0	2322.4	2323.0	3.5	2327.4	2326.5		2328.6		17.0		2323.36	2326.36	
	45	3202.0	2323.4	2324.0	3.3	2327.4	2327.3				21.0		2323.73	2326.73	
	46	3242.0	2324.0	2324.0	3.2	2327.2	2327.8				17.0		2324.01	2327.01	
	47	3282.0	2325.0	2326.0	2.0	2327.0	2335.0				26.0		2324.30	2327.30	
Ban.Bri	48	3336.0	2324.8	2325.5	6.5	2332.0	2332.0			2331.0	14.0		2324.70	2327.70	2328.30
	49	3374.0											2326.00	2329.00	2329.60
	50	3398.0	2326.0	2327.0	5.0	2332.5	2332.0				30.0	56.0	2326.19	2329.19	
	51	3448.0	2326.4	2327.0	2.6	2331.9	2329.6				56.0		2326.59	2329.59	
	52	3490.0	2326.8	2327.5	1.8	2331.2	2329.3				26.0		2326.93	2329.93	
	53	3552.0	2326.6	2327.5	2.5	2331.9	2330.0				35.0		2327.42	2330.42	
	54	3614.0	2327.3	2327.5	3.5	2331.5	2331.0				20.0	48.0	2327.92	2330.92	
	55	3676.0	2328.3	2328.5	1.5	2331.8	2330.0				21.0	38.0	2328.35	2331.35	
	56	3730.0	2327.9	2328.5	2.5	2332.1	2331.0				20.0		2328.75	2331.75	
	57	3780.0	2328.5	2329.0	2.6	2333.0	2331.6				16.0		2329.20	2332.20	

Table 4.3.1 Design Values of Longitudinal Profiles of Objective Rivers (2/2)

Bridge	Sect.	Distance	Low riverbed	Ave.riverbed	Ave.channel depth	Left bank	Right bank	Left flood wall	Right flood wall	Br. soffit	River width	Total width	D.riverbed	DHWL	D.dike/wall					
	58	3830.0	2328.1	2329.0	2.5	2332.0	2331.5				20.0		2329.60	2332.60						
	59	3886.0	2329.5	2330.0	3.0	2333.0	2335.0				20.0		2330.10	2333.10						
	60	3936.0	2329.5	2330.0	1.5	2334.5	2339.4				20.0		2330.50	2333.50		DHWL	D.dike/wall			
Fin.Br	61	3994.0	2330.5	2331.0	11.0	2342.0	2342.0			2339.8	45.0		2331.00	2334.00	2334.60	2334.50	2335.10			
	62	4050.0	2331.9	2332.0	3.0	2335.0	2336.4				22.0		2331.40			2334.90				
	63	4100.0	2332.1	2332.5	3.5	2336.0	2336.0				20.0		2331.76			2335.26				
6th bri.	64	4130.0	2331.8	2332.5	3.5	2336.0	2335.0			2337.0	15.5		2331.97			2335.47				
	65	4170.0	2333.0	2333.0	3.0	2336.0	2336.0		2337.5		15.0	28.0	2332.26			2335.76				
	66	4202.0	2334.6	2334.0	2.0	2336.0	2337.0		2339.0		20.0		2332.49			2335.99				
	67	4248.0	2332.6	2333.0	4.0	2337.5	2337.0		2338.0		25.0		2332.81			2336.31				
7th bri.	68	4274.0	2332.6	2333.0	4.0	2337.6	2337.0	2338.0	2338.0	2336.5	15.0		2333.00			2336.50				
	69	4316.0	2333.3	2333.5	3.5	2341.0	2337.0				20.0		2333.30			2336.80				
	70	4348.0	2333.3	2333.5	3.1	2340.5	2336.6		2338.8		25.0		2333.53			2337.03				
	71	4400.0	2334.1	2334.5	2.7	2339.1	2337.2		2339.3		25.0		2333.90			2337.40				
	72	4438.0	2333.6	2334.0	5.0	2339.3	2339.0		2340.0		14.0		2334.17			2337.67				
	73	4478.0	2334.7	2335.0	4.0	2339.0	2339.0	2340.0	2340.0		15.0		2334.46			2337.96				
8th bri.	74	4524.0	2334.8	2335.0	3.2	2339.3	2339.4			2338.6	11.0		2334.79			2338.29				
	75	4576.0	2335.4	2336.0	3.2	2340.4	2339.2		2339.8		15.0		2335.16			2338.66				
9th bri.	76	4616.0	2336.0	2336.0	5.2	2341.4	2341.2			2340.6	12.0		2335.44			2338.94				
	77	4680.0											2335.90			2339.40				
	78	4740.0	2337.1	2337.1	2.9	2340.0	2341.0	2342.8	2342.6		18.5		2336.33			2339.83				
	79	4790.0	2335.0	2335.5	5.0	2341.8	2341.0	2343.0	2342.2		19.3		2336.69			2340.19				
	80	4840.0	2337.5	2337.5	3.5	2341.3	2341.0	2343.4	2342.0		14.5		2337.04			2340.54				
10th bri.	81	4870.0	2337.6	2338.0	4.2	2342.2	2342.2			2342.2	12.0		2337.26			2340.76				
	82	4912.0	2337.7	2338.0	3.0	2343.0	2341.0			2343.0	17.5		2337.56			2341.00				
	83	4944.0	2337.9	2338.0	3.8	2342.0	2341.8		2346.0		13.0		2337.79			2341.29				
	84	4994.0	2337.6	2338.0	3.6	2342.6	2341.6		2343.8		14.0		2338.14			2341.64				
	85	5046.0	2338.5	2339.0	3.5	2343.0	2342.5		2345.0		18.0		2338.51			2342.01				
	86	5096.0	2338.4	2339.0	4.0	2343.0	2343.8		2345.8		14.0		2338.87			2342.37				
	87	5150.0	2338.7	2339.0	4.7	2343.7	2344.0		2346.4		20.0		2339.00			2342.50	2343.10			
	88	5204.0	2339.1	2340.0	4.3	2346.0	2344.3				19.0		2339.40			2342.90				
Fil.bri	89	5262.0	2339.0	2339.0	7.6	2346.7	2346.7			2345.0	11.0		2339.80			2343.30	2343.90			
Fil.bri	90	5296.0	2340.3	2341.0	5.4	2346.4	2346.4			2345.0			2341.00			2345.00	2345.60			
(Kechene	91	5318.0	2340.5	2341.0	3.9	2346.0	2344.9	2346.3			16.0									
river)	92	5402.0	2341.8	2342.0	4.3	2346.5	2346.3	2347.0	2347.5		15.5									
1st bri.	92.1	5466.0	2342.5	2342.5	6.1	2348.6	2348.6			2348.0	9.0		2343.00			2347.00	2347.60			
	93	5480.0	2342.5	2342.5	6.1	2348.6	2348.6				14.0									
	94	5616.0	2344.3	2344.5	3.3	2347.8	2349.2				12.0									
	95	5756.0	2345.7	2346.0	7.0	2353.0	2354.0				13.0	28.0						D.riverbed	DHWL	D.dike/wal
	96	5818.0								2355.0			2347.10			2351.10	2351.70	2347.60	2351.60	2352.20
	97	5964.0	2350.4	2351.0	4.5	2355.5	2357.3				15.0									
	98	6114.0	2352.2	2353.0	7.0	2360.5	2360.0				27.0							2353.50	2357.50	2358.10
	99	6258.0	2353.9	2354.5	7.7	2364.0	2363.8				21.0									
	100	6422.0	2359.2	2359.5	7.7	2368.0	2367.2		2368.3		14.0									
	101	6652.0	2362.0	2365.0	7.0	2372.0	2372.5				18.0									
2nd bri.	102	6768.0	2370.0	2370.5	11.0	2381.5	2381.5			2380.0	8.0									
	103	6882.0	2373.9	2375.0	3.2	2378.2	2378.8				22.0									
4th bri.	104	7000.0	2379.3	2380.0	8.5	2388.5	2389.0			2386.0	9.5									
	105	7098.0	2380.8	2381.0	4.0	2385.0	2386.0				13.5									
	106	7184.0	2381.4	2382.0	3.0	2385.0	2395.0				13.0									
	107	7290.0	2383.8	2384.5	6.5	2391.0	2392.0				27.0									
	108	7450.0	2387.3	2388.0	4.5	2398.0	2392.5				22.0									
	109	7550.0	2388.6	2389.0	8.0	2400.0	2397.0				36.0									
	110	7640.0	2393.0	2393.0	11.0	2404.0	2406.0				33.0									
	111	7774.0	2396.8	2397.0	9.0	2406.0	2402.0				20.0									
	112	7936.0	2399.1	2399.5	7.5	2407.0	2413.0				30.0									
	113	8064.0	2401.2	2401.5	12.5	2413.0	2414.0				33.0									

Table 4.3.2 Proposed Cross Section of Bantyiketu River(1/5)

1.42 k (Intake weir) - 2.056 k (Sect.22), Q=170 cu.m/s

	Gradient	1/140	Freeboard(m)	0.6	Crown width(m)	3.0
	8.452E-02		Water level	2317.00	Q(ql+qhL+qhR.m^3/s)	174.8
Low Water	Width(top.m)	16.5	Total water depth(m)	3.00		
Channel	Width(bottom.m)	10.5	Water depth(m)	2.00	S(m)	17.71
	Depth	2.00	Width(m)	16.5	R(m)	2.456
	Slope gradient	1.5	A(m^2)	43.5	V(m/s)	3.85
	n	0.040				
	Bed elevation(m)	2314.0			ql(m^3/s)	167.3
High Water	Width	2.0	Water depth	1.00	S(m)	3.80
Channel	Slope gradient	1.5	Width(m)	3.5	R(m)	0.723
(left side)	n	0.050	A(m^2)	2.8	V(m/s)	1.36
					qhL(m^3/s)	3.7
High Water	Width	2.0	Water depth	1.00	S(m)	3.80
Channel	Slope gradient	1.5	Width(m)	3.5	R(m)	0.723
(right side)	n	0.050	A(m^2)	2.8	V(m/s)	1.36
					qhR(m^3/s)	3.7

Table 4.3.2 Proposed Cross Section of Bantyiketu River(2/5)

2.056 k (Sect.22) - 3.336 k (Bantyiketu bridge), Q=170cu.m/s

	Gradient	1/140	Freeboard(m)	0.6	Crown width(m)	1.0
	8.452E-02		Water level	2322.00	Q(ql+qhL+qhR.m^3/s)	173.5
Low Water	Width(top.m)	17.5	Total water depth(m)	3.00		
Channel	Width(bottom.m)	12.5	Water depth(m)	2.50	S(m)	19.57
	Depth	2.50	Width(m)	17.5	R(m)	2.363
	Slope gradient	1.0	A(m^2)	46.3	V(m/s)	3.75
	n	0.040				
	Bed elevation(m)	2319.0			ql(m^3/s)	173.4
High Water	Width	0.0	Water depth	0.50	S(m)	0.71
Channel	Slope gradient	1.0	Width(m)	0.5	R(m)	0.177
(left side)	n	0.050	A(m^2)	0.1	V(m/s)	0.53
					qhL(m^3/s)	0.1
High Water	Width	0.0	Water depth	0.50	S(m)	0.71
Channel	Slope gradient	1.0	Width(m)	0.5	R(m)	0.177
(right side)	n	0.050	A(m^2)	0.1	V(m/s)	0.53
					qhR(m^3/s)	0.1

Table 4.3.2 Proposed Cross Section of Bantyiketu River(3/5)

3.374 k (Bantyiketu bridge) - 3.994 k (Finfine bridge), Q=170cu.m/s

	Gradient	1/125	Freeboard(m)	0.6	Crown width(m)	1.0
	8.944E-02		Water level	2331.00	Q(ql+qhL+qhR.m^3/s)	175.7
Low Water	Width(top.m)	14.5	Total water depth(m)	3.00		
Channel	Width(bottom.m)	8.5	Water depth(m)	2.00	S(m)	15.71
	Depth	2.00	Width(m)	14.5	R(m)	2.387
	Slope gradient	1.5	A(m^2)	37.5	V(m/s)	3.99
	n	0.040				
	Bed elevation(m)	2328.0			ql(m^3/s)	149.8
High Water	Width	5.0	Water depth	1.00	S(m)	6.80
Channel	Slope gradient	1.5	Width(m)	6.5	R(m)	0.845
(left side)	n	0.050	A(m^2)	5.8	V(m/s)	1.60
					qhL(m^3/s)	9.2
High Water	Width	10.0	Water depth	1.00	S(m)	11.00
Channel	Slope gradient	0.0	Width(m)	10.0	R(m)	0.909
(right side)	n	0.050	A(m^2)	10.0	V(m/s)	1.68
					qhR(m^3/s)	16.8

Table 4.3.2 Proposed Cross Section of Bantyiketu River(4/5)

3.994 k (Finfine bridge) -5.15 k (Side overflow dike), Q=145cu.m/s

	Gradient	1/140	Freeboard(m)	0.6	Crown width(m)	1.0
	8.452E-02		Water level	2336.50	Q(ql+qhL+qhR.m^3/s)	146.3
Low Water	Width(top,m)	13.6	Total water depth(m)	3.50		
Channel	Width(bottom,m)	7.6	Water depth(m)	3.00	S(m)	16.09
	Depth	3.00	Width(m)	13.6	R(m)	2.400
	Slope gradient	1.0	A(m^2)	38.6	V(m/s)	3.79
	n	0.040				
	Bed elevation(m)	2333.0			ql(m^3/s)	146.2
High Water	Width	0.0	Water depth	0.50	S(m)	0.71
Channel	Slope gradient	1.0	Width(m)	0.5	R(m)	0.177
(left side)	n	0.050	A(m^2)	0.1	V(m/s)	0.53
					qhL(m^3/s)	0.1
High Water	Width	0.0	Water depth	0.50	S(m)	0.71
Channel	Slope gradient	1.0	Width(m)	0.5	R(m)	0.177
(right side)	n	0.050	A(m^2)	0.1	V(m/s)	0.53
					qhR(m^3/s)	0.1

Table 4.3.2 Proposed Cross Section of Bantyiketu River(5/5)

<u>**5.15 k (Side overflow dike) -5.262 k (Filwiha bridge), Q=175cu.m/s**</u>

	Gradient	1/140	Freeboard(m)	0.6	Crown width(m)	1.0
	8.452E-02		Water level	2343.50	Q(ql+qhL+qhR.m^3/s)	177.0
Low Water	Width(top.m)	15.5	Total water depth(m)	3.50		
Channel	Width(bottom.m)	9.5	Water depth(m)	3.00	S(m)	17.99
	Depth	3.00	Width(m)	15.5	R(m)	2.516
	Slope gradient	1.0	A(m^2)	45.3	V(m/s)	3.91
	n	0.040				
	Bed elevation(m)	2340.0			ql(m^3/s)	176.9
High Water	Width	0.0	Water depth	0.50	S(m)	0.71
Channel	Slope gradient	1.0	Width(m)	0.5	R(m)	0.177
(left side)	n	0.050	A(m^2)	0.1	V(m/s)	0.53
					qhL(m^3/s)	0.1
High Water	Width	0.0	Water depth	0.50	S(m)	0.71
Channel	Slope gradient	1.0	Width(m)	0.5	R(m)	0.177
(right side)	n	0.050	A(m^2)	0.1	V(m/s)	0.53
					qhR(m^3/s)	0.1

Table 4.3.3 Work Item and Quantity of Priority Project(River Channel Improvement)

Kebena River				
	Slope protection	Left bank;	2,550 sq.m	(length=190m, slope length=13.4m)
		Right bank;	2,280 sq.m	(length=170m, slope length=13.4m)
		Total;	4,830 sq.m	
Bantyiketu River				
	Excavation		20,500 cu.m	
	Embankment	Right bank;	400 cu.m	(length=100m)
	Floodwall	Left bank;	1,180 sq.m	(length=295m)
		Right bank;	1,800 sq.m	(length=810m)
		Total;	3,010 sq.m	
	Slope protection	Left bank;	2,820 sq.m	(length=350m)
		Right bank;	2,190 sq.m	(length=360m)
		Total;	5,010 sq.m	
	Protection of water supply pipe		2 places	
Kechene River				
	Floodwall	Left bank;	360 sq.m	(length=80m,average height=4.5m)
		Right bank;	180 sq.m	(length=40m,average height=4.5m)
		Total;	540 sq.m	

Table 4.3.4 Proposed Cross Section of Lower Kebena River

0.1 k (Sect.1) - 0.696 k (Sect.6), Q=400cu.m/s

	Gradient	1/100	Freeboard(m)	0.8	Crown width(m)	4.0
	1.000E-01		Water level	2299.20	Q(ql+qhL+qhR,m³/s)	422.4
Low Water	Width(top.m)	18.0	Total water depth(m)	5.00		
Channel	Width(bottom.m)	7.5	Water depth(m)	3.50	S(m)	20.12
	Depth	3.50	Width(m)	18.0	R(m)	3.560
	Slope gradient	1.5	A(m²)	71.6		5.83
	n	0.040				
	Bed elevation(m)	2294.2			ql(m³/s)	417.5
High Water	Width	0.0	Water depth	1.50	S(m)	2.70
Channel	Slope gradient	1.5	Width(m)	2.3	R(m)	0.624
(left side)	n	0.050	A(m²)	1.7	V(m/s)	1.46
					qhL(m³/s)	2.5
High Water	Width	0.0	Water depth	1.50	S(m)	2.70
Channel	Slope gradient	1.5	Width(m)	2.3	R(m)	0.624
(right side)	n	0.050	A(m²)	1.7	V(m/s)	1.46
					qhR(m³/s)	2.5

Table 4.3.5 Proposed Cross Section of Lower Kechene River

5.818 k (Sect.96) - 6.114 k (Sect.98), Q=85cu.m/s

	Gradient	1/50	Freeboard(m)	0.6	Crown width(m)	1.0
	1.414E-01		Water level	2354.00	Q(ql+qhL+qhR,m^3/s)	187.5
Low Water	Width(top,m)	8.0	Total water depth(m)	4.00		
Channel	Width(bottom,m)	8.0	Water depth(m)	3.50	S(m)	15.00
	Depth	3.50	Width(m)	8.0	R(m)	2.133
	Slope gradient	0.0	A(m^2)	32.0	V(m/s)	5.86
	n	0.040				
	Bed elevation(m)	2350.0			ql(m^3/s)	187.5
High Water	Width	0.0	Water depth	0.50	S(m)	0.50
Channel	Slope gradient	0.0	Width(m)	0.0	R(m)	0.000
(left side)	n	0.050	A(m^2)	0.0	V(m/s)	0.00
					qhL(m^3/s)	0.0
High Water	Width	0.0	Water depth	0.50	S(m)	0.50
Channel	Slope gradient	0.0	Width(m)	0.0	R(m)	0.000
(right side)	n	0.050	A(m^2)	0.0	V(m/s)	0.00
					qhR(m^3/s)	0.0

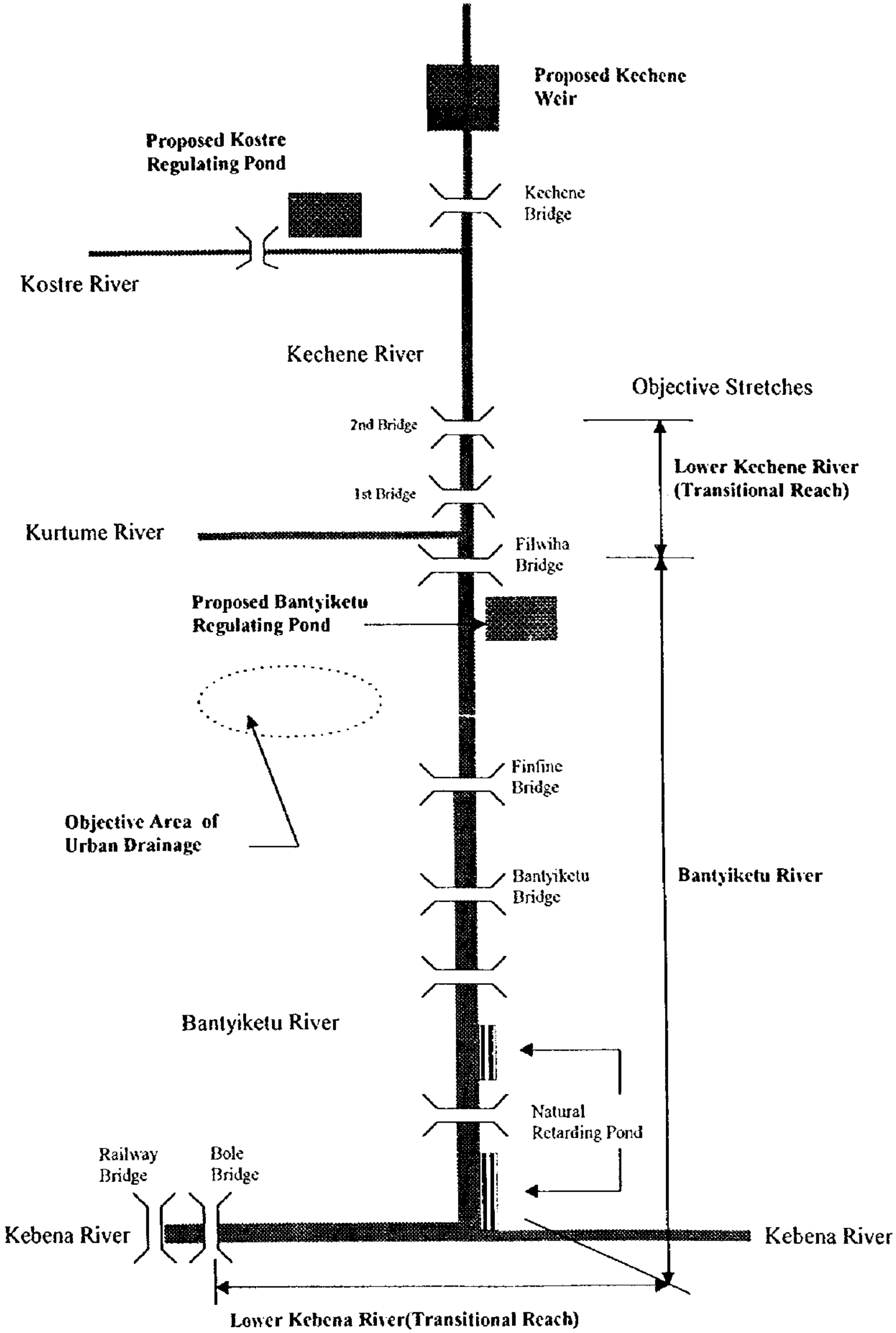
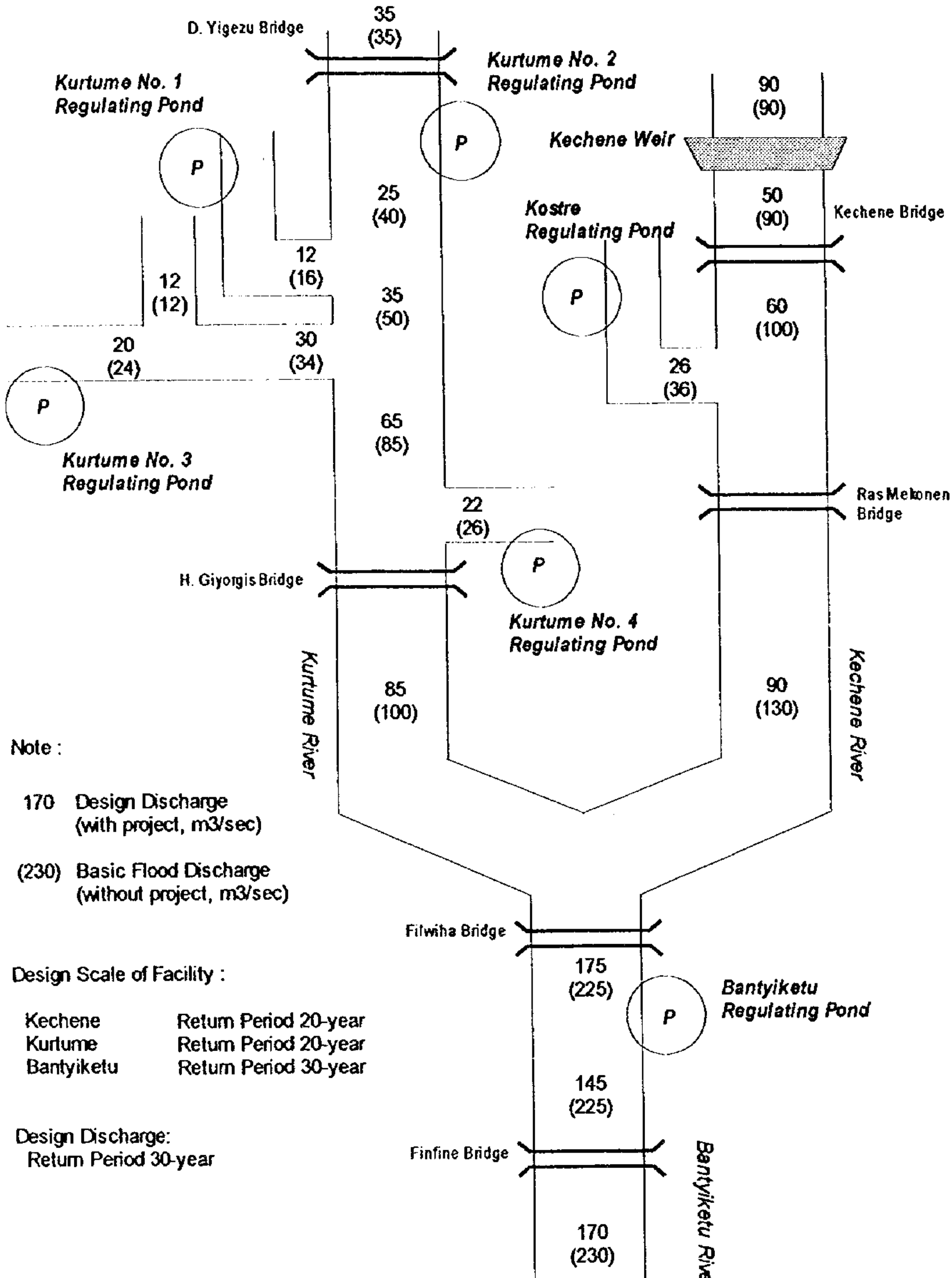


Figure 4.2.1 Objective Rivers and Stretches of Priority Projects



Note :

170 Design Discharge (with project, m3/sec)

(230) Basic Flood Discharge (without project, m3/sec)

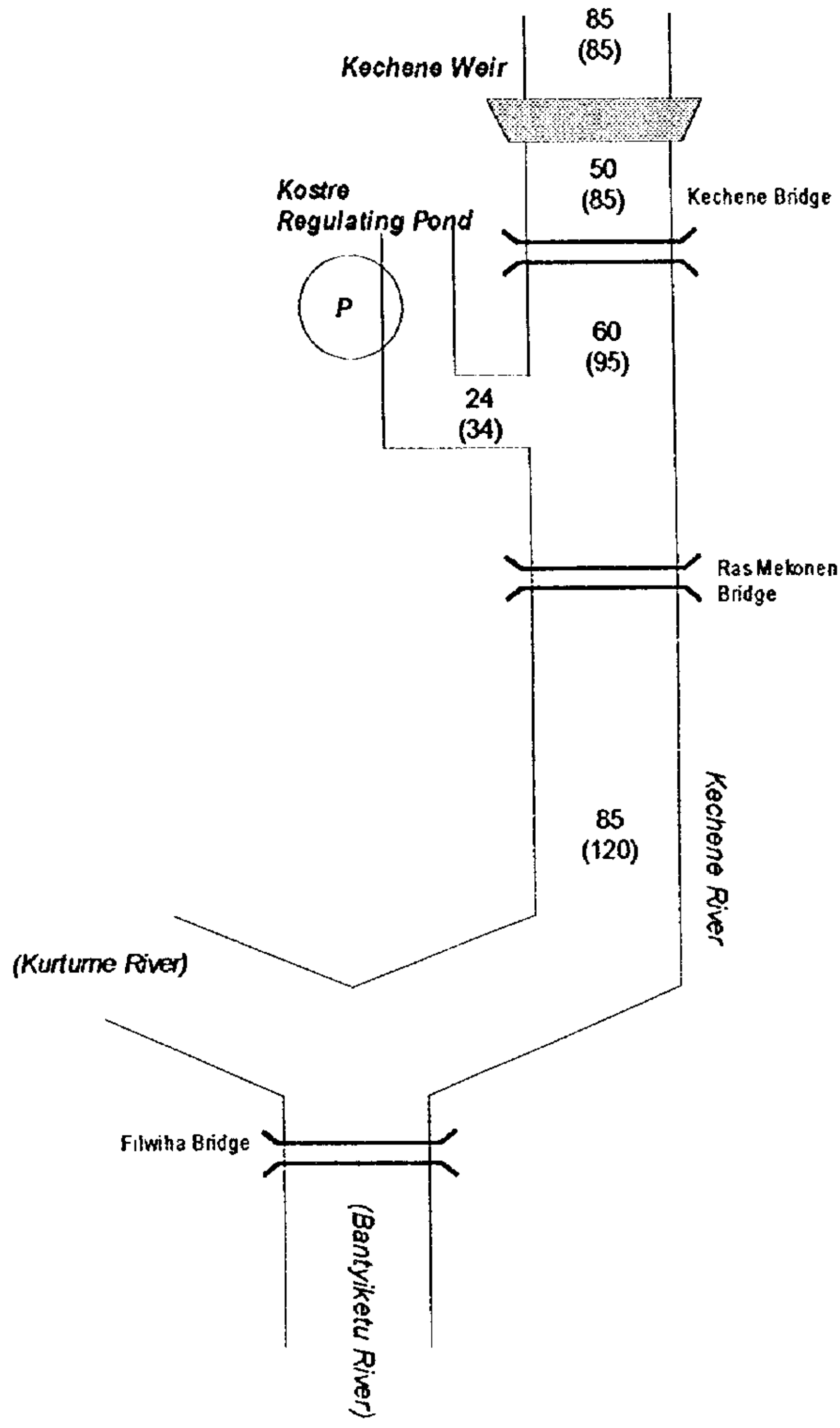
Design Scale of Facility :

Kechene	Return Period 20-year
Kurtume	Return Period 20-year
Bantyiketu	Return Period 30-year

Design Discharge:
Return Period 30-year

Figure 4.2.2 (1/3)

Design Discharge Distribution for Bantyiketu River System
(Return Period 30-year)



Note :

85 Design Discharge
(with project, m3/sec)

(120) Basic Flood Discharge
(without project, m3/sec)

Figure 4.2.2 (2/3)

Design Discharge Distribution for Kechene River
(Return Period 20-year)

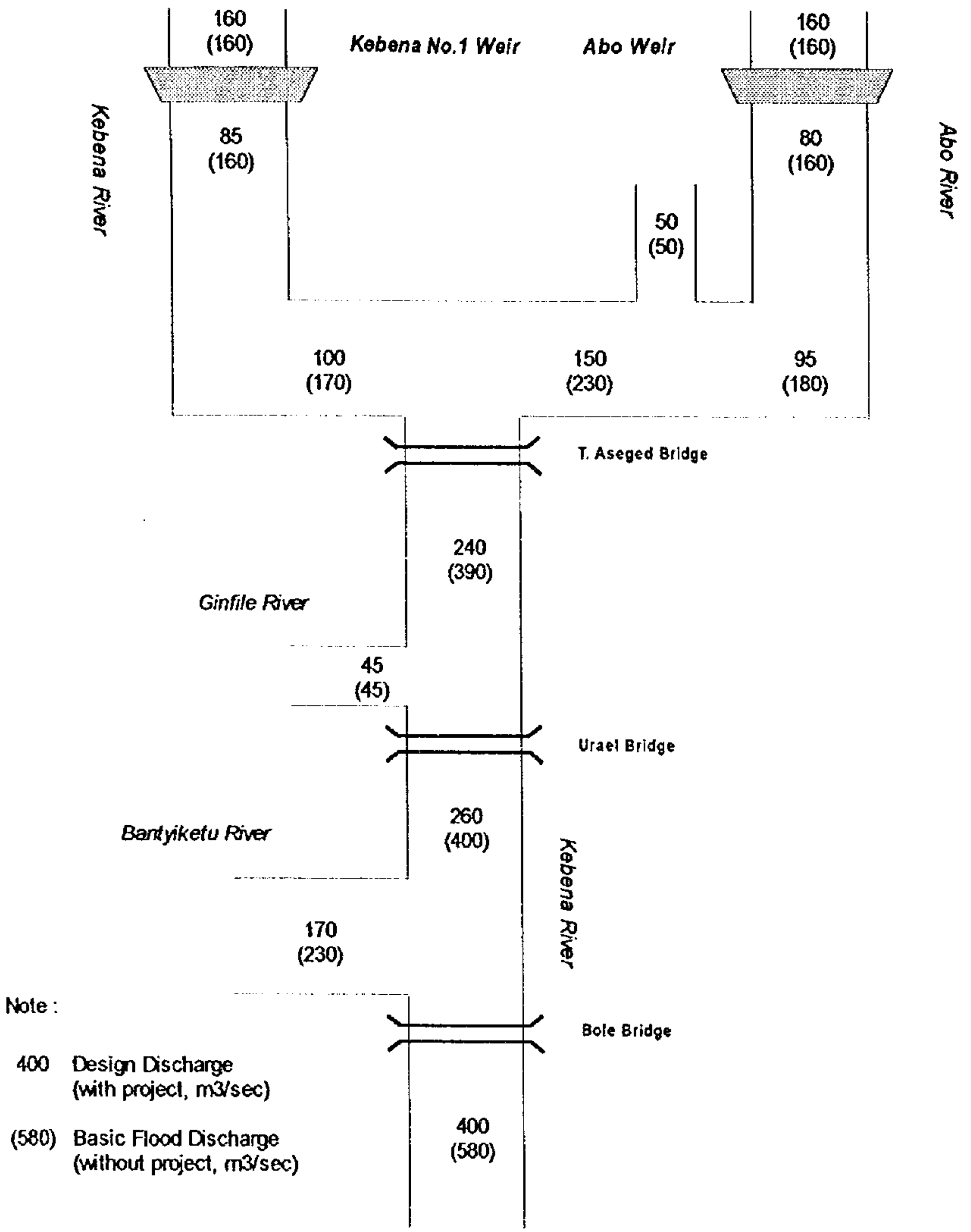


Figure 4.2.2 (3/3)

Design Discharge Distribution for Kebena River System
(Return Period 30-year)

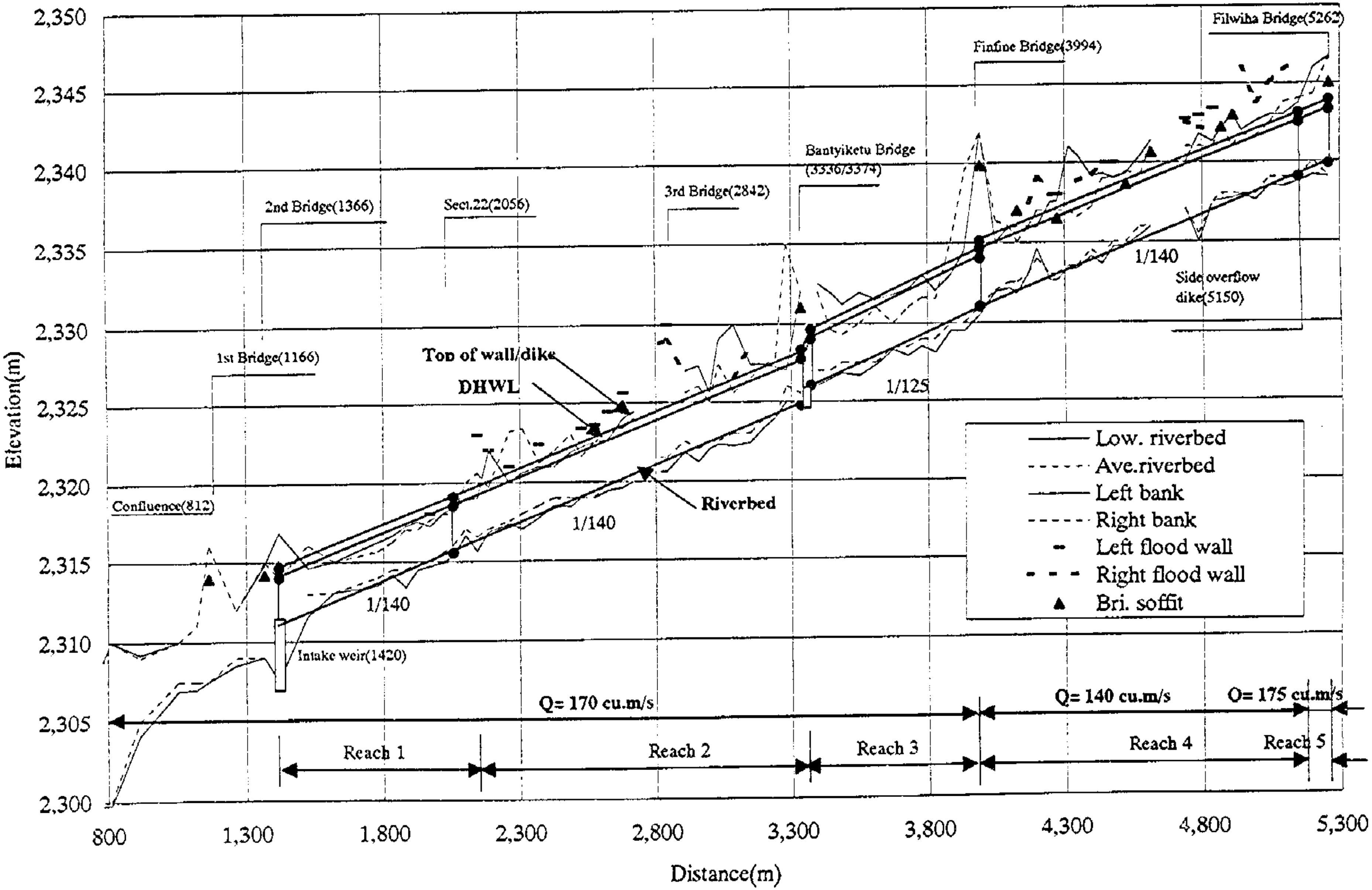


Figure 4.3.1 **Longitudinal Profile of the Bantyiketu River**

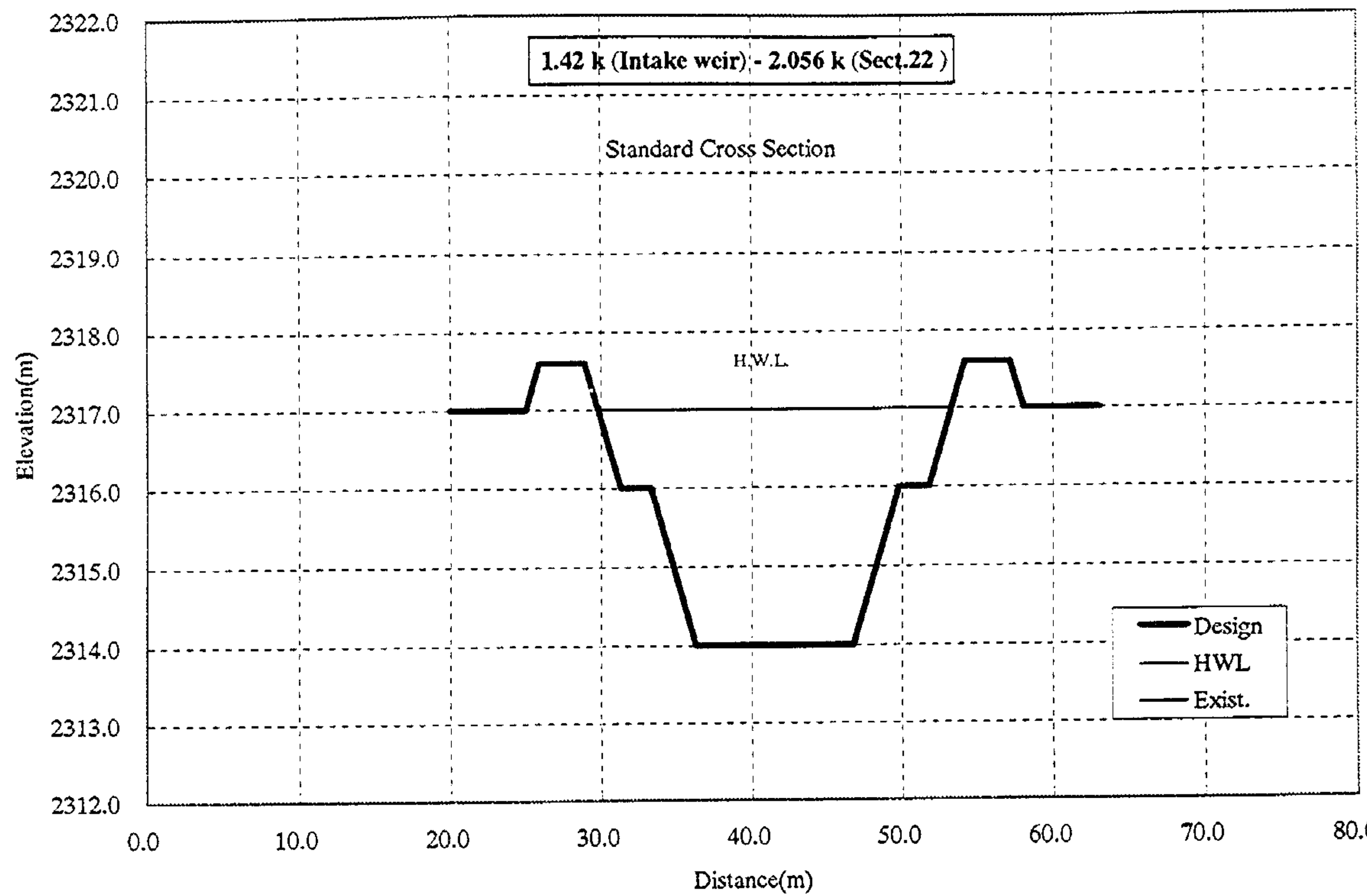


Figure 4.3.2 Section of Bantyiketu River(1/30)

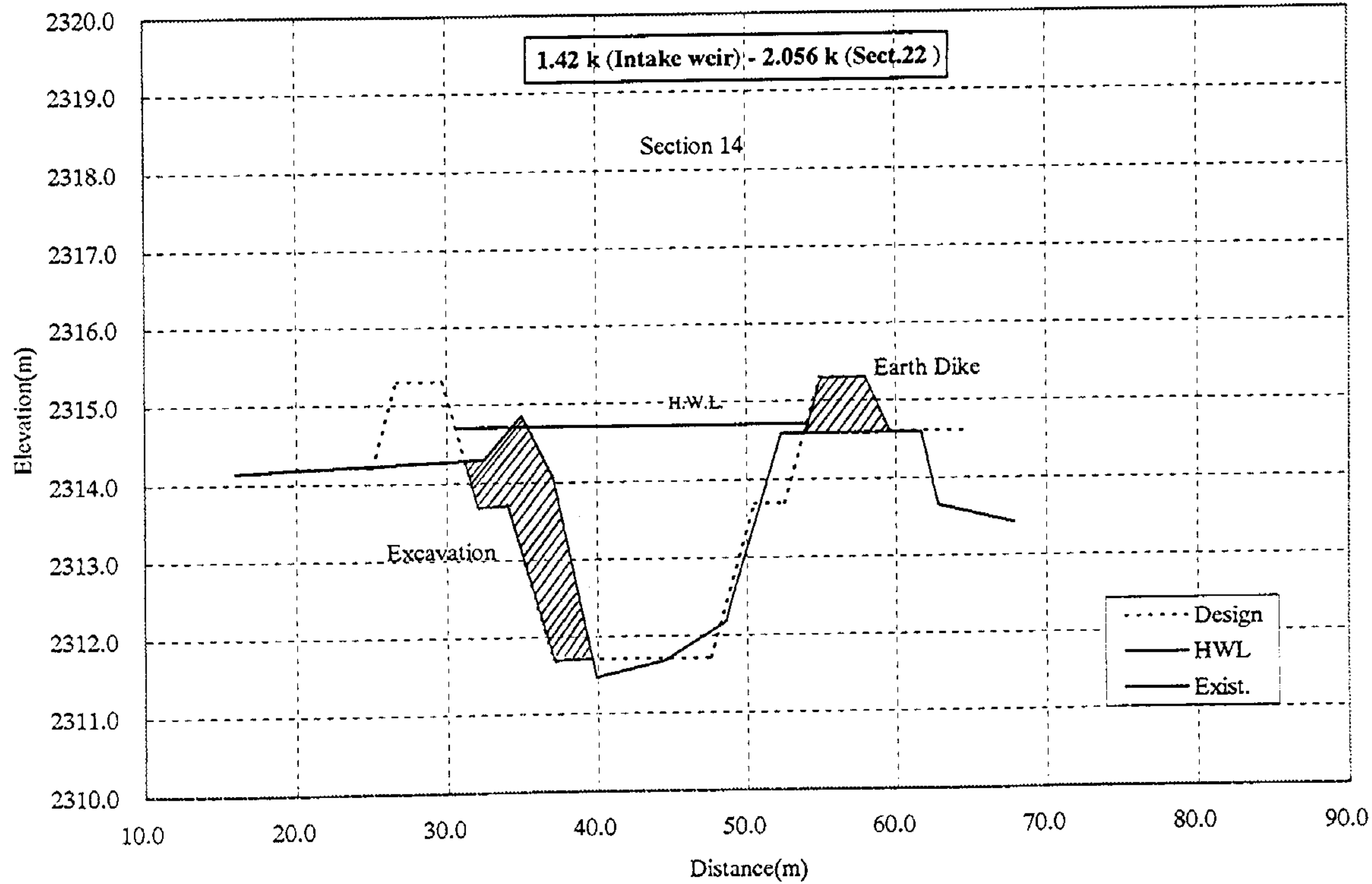


Figure 4.3.2 Section of Bantyiketu River(2/30)

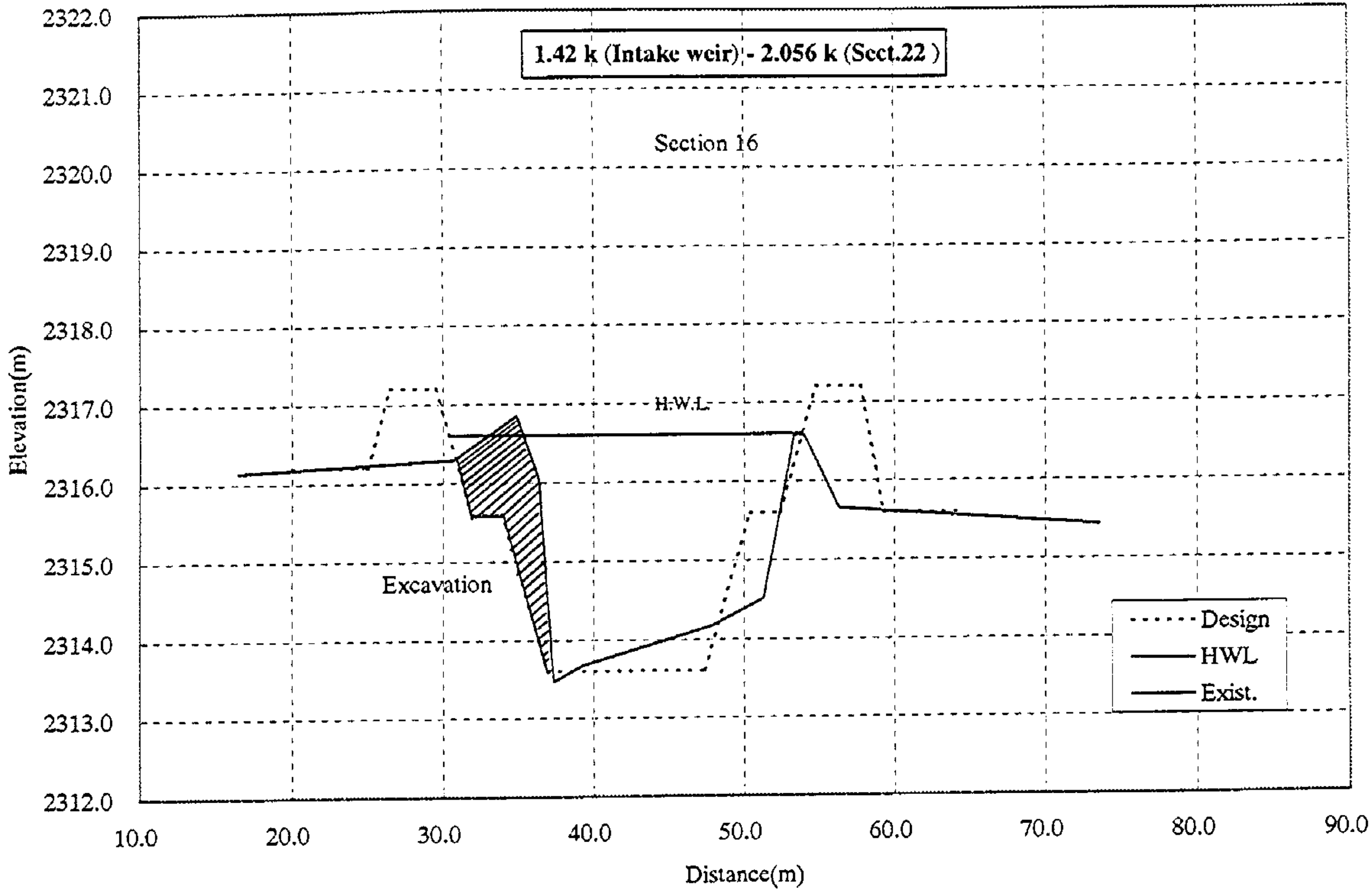


Figure 4.3.2 Section of Bantyiketu River(3/30)

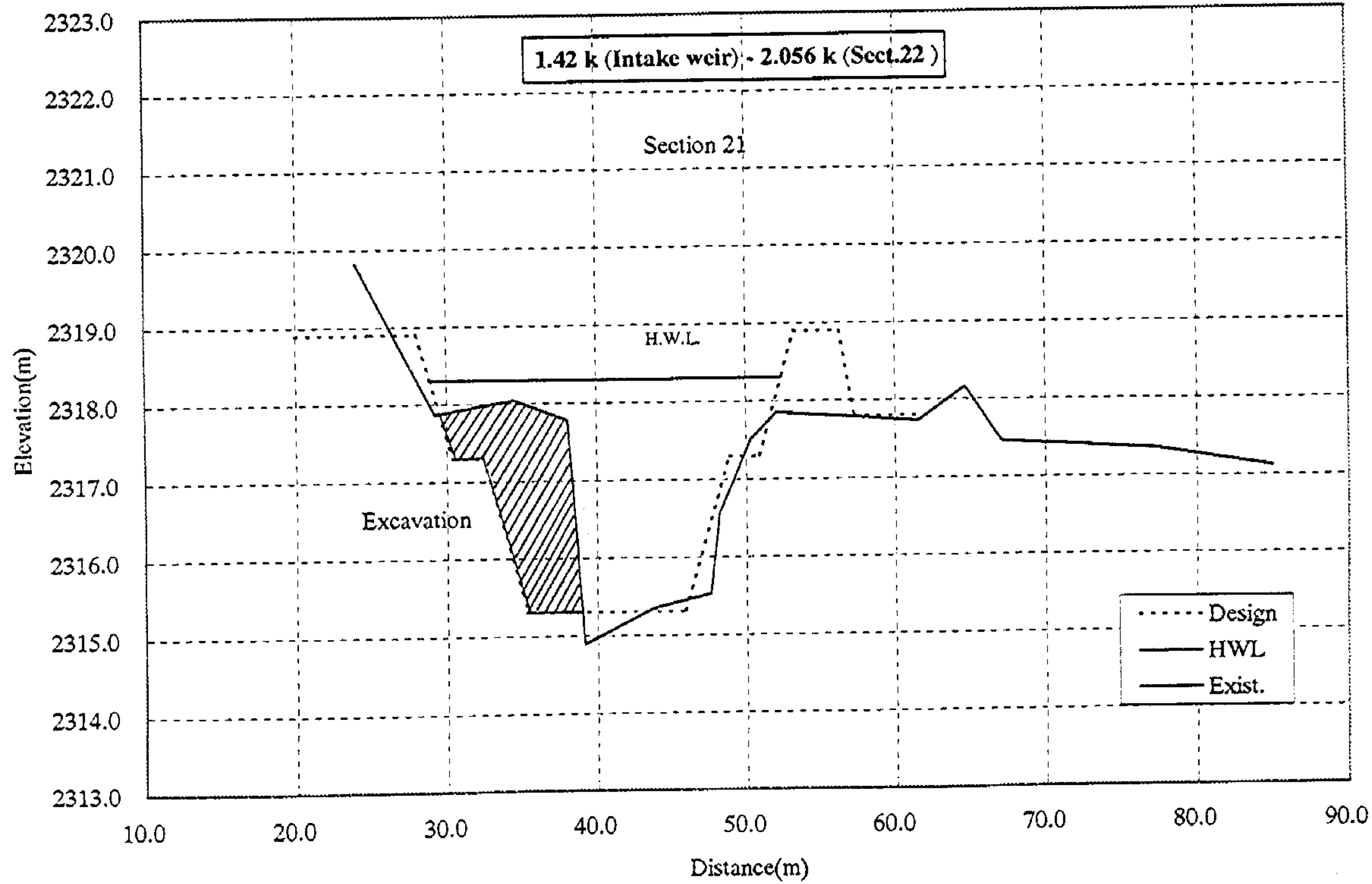


Figure 4.3.2 Section of Bantyiketu River(4/30)

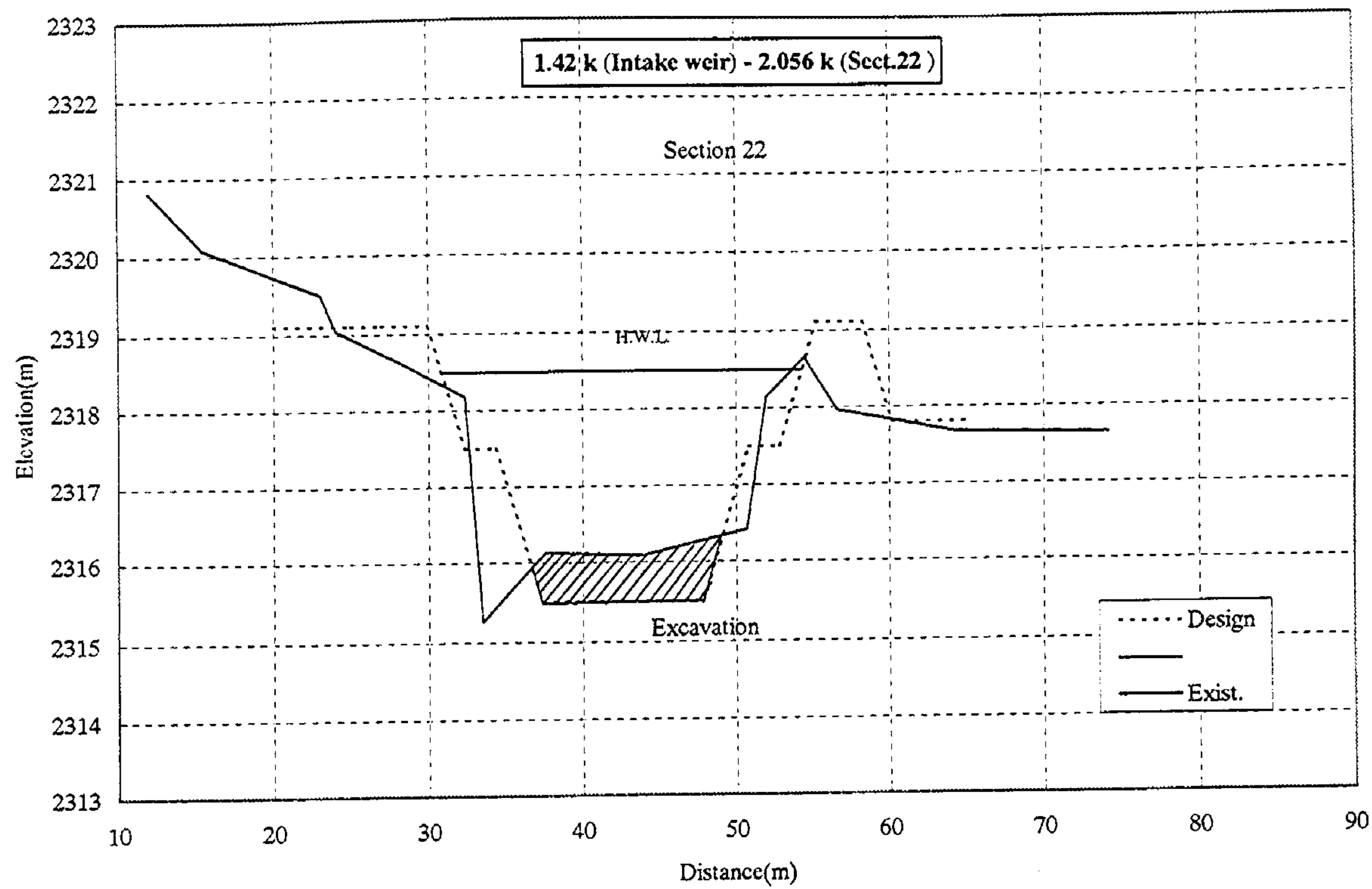


Figure 4.3.2 Section of Bantyiketu River(5/30)

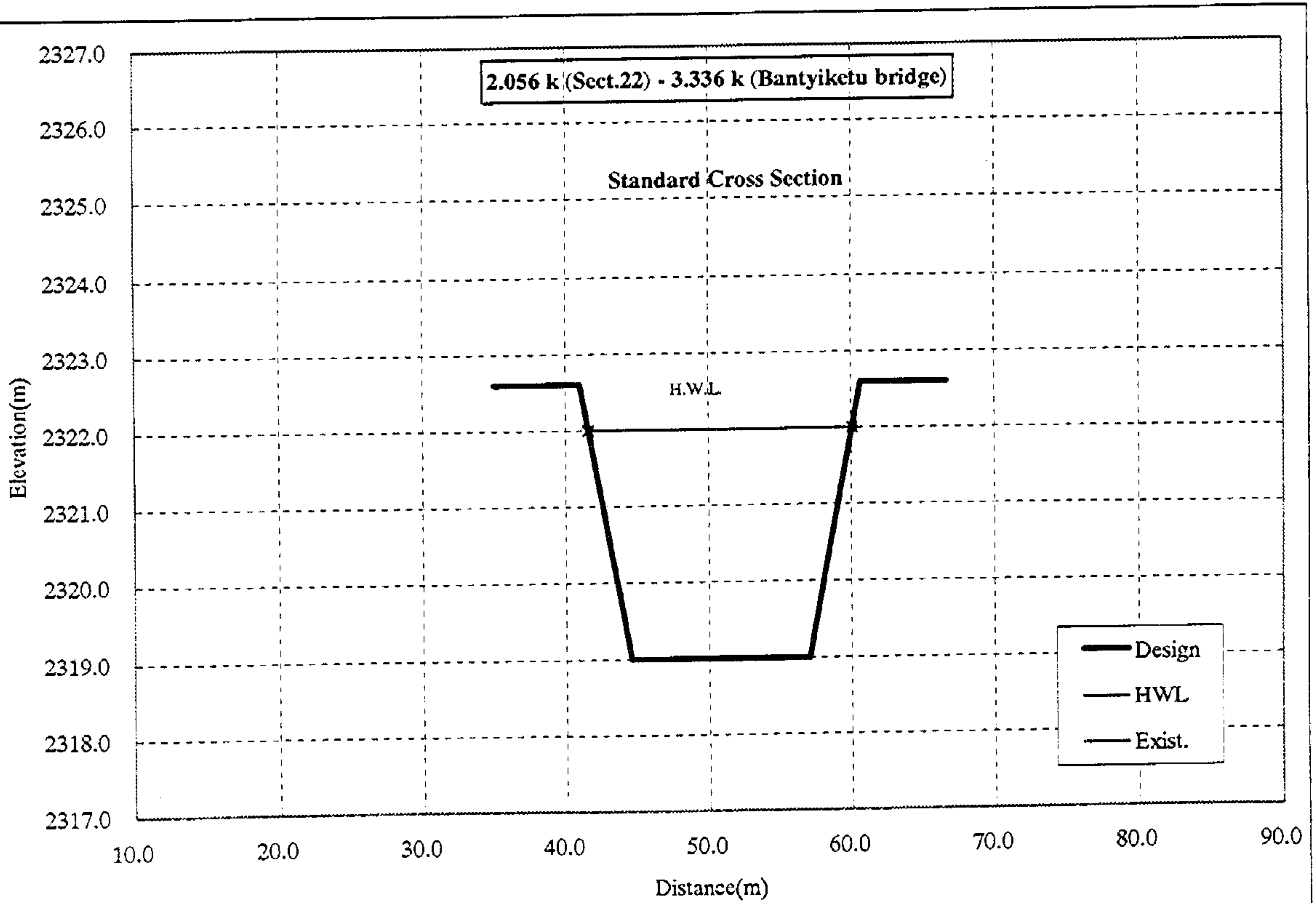


Figure 4.3.2 Section of Bantyiketu River(6/30)

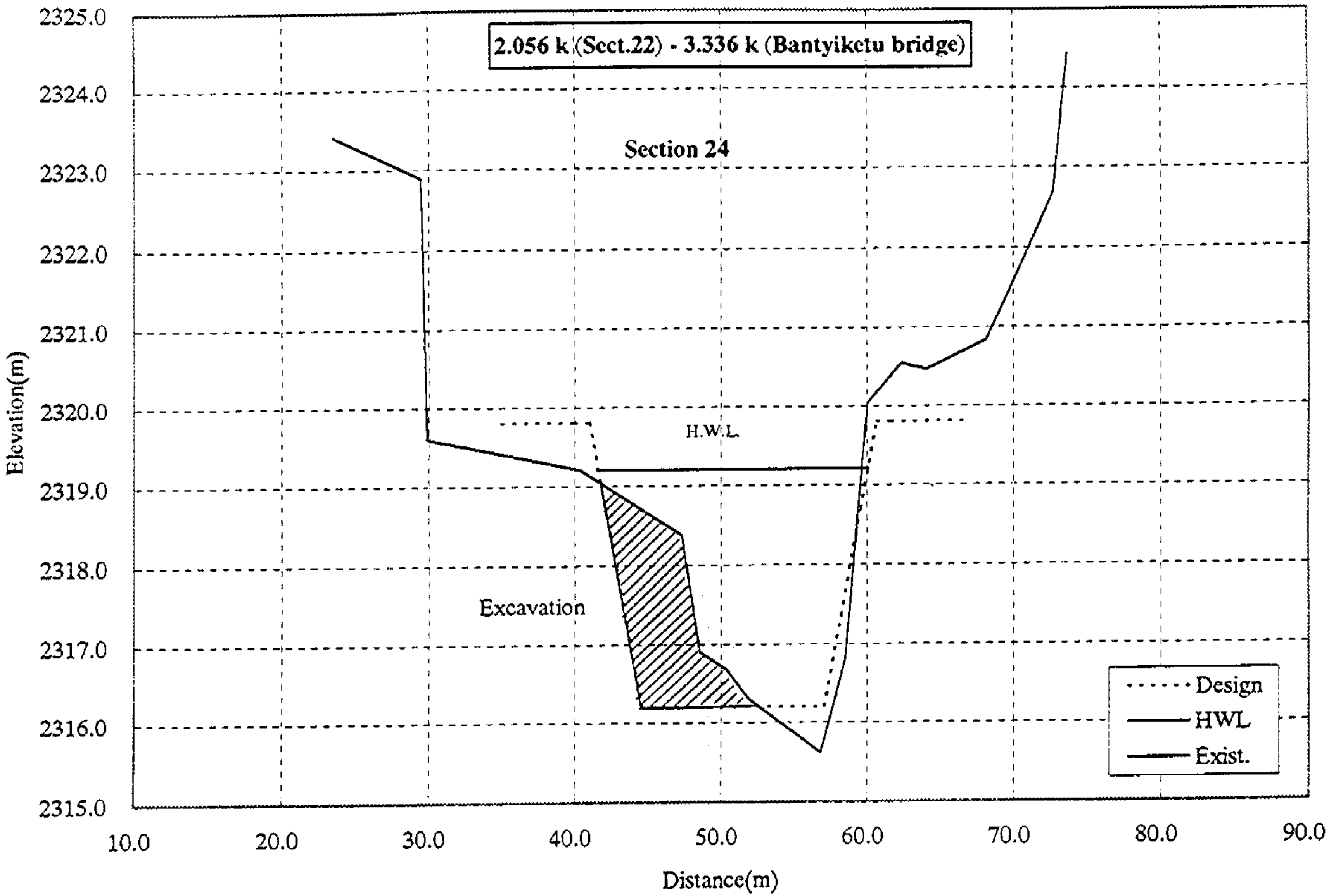


Figure 4.3.2 Section of Bantyiketu River(7/30)

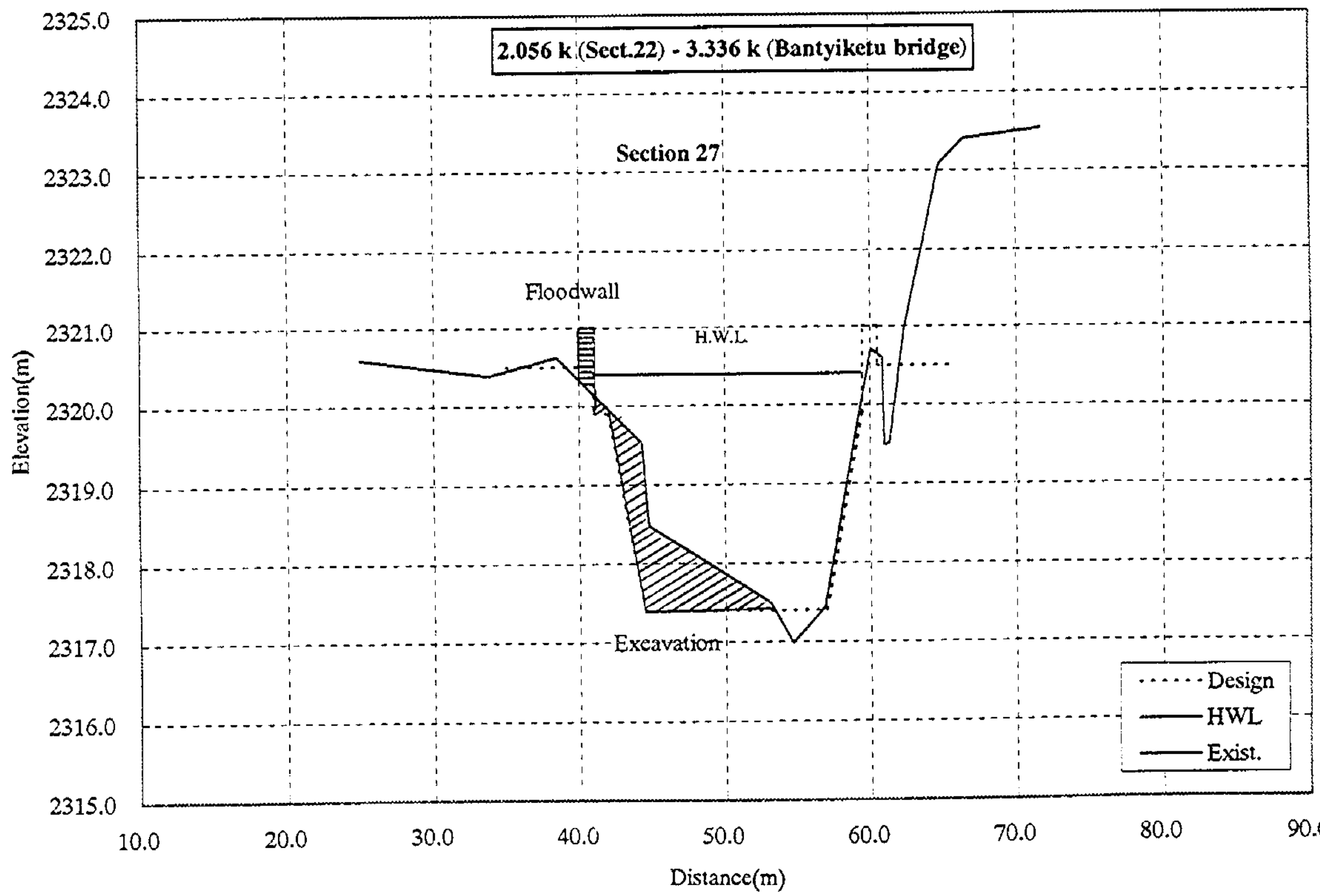


Figure 4.3.2 Section of Bantyiketu River(8/30)

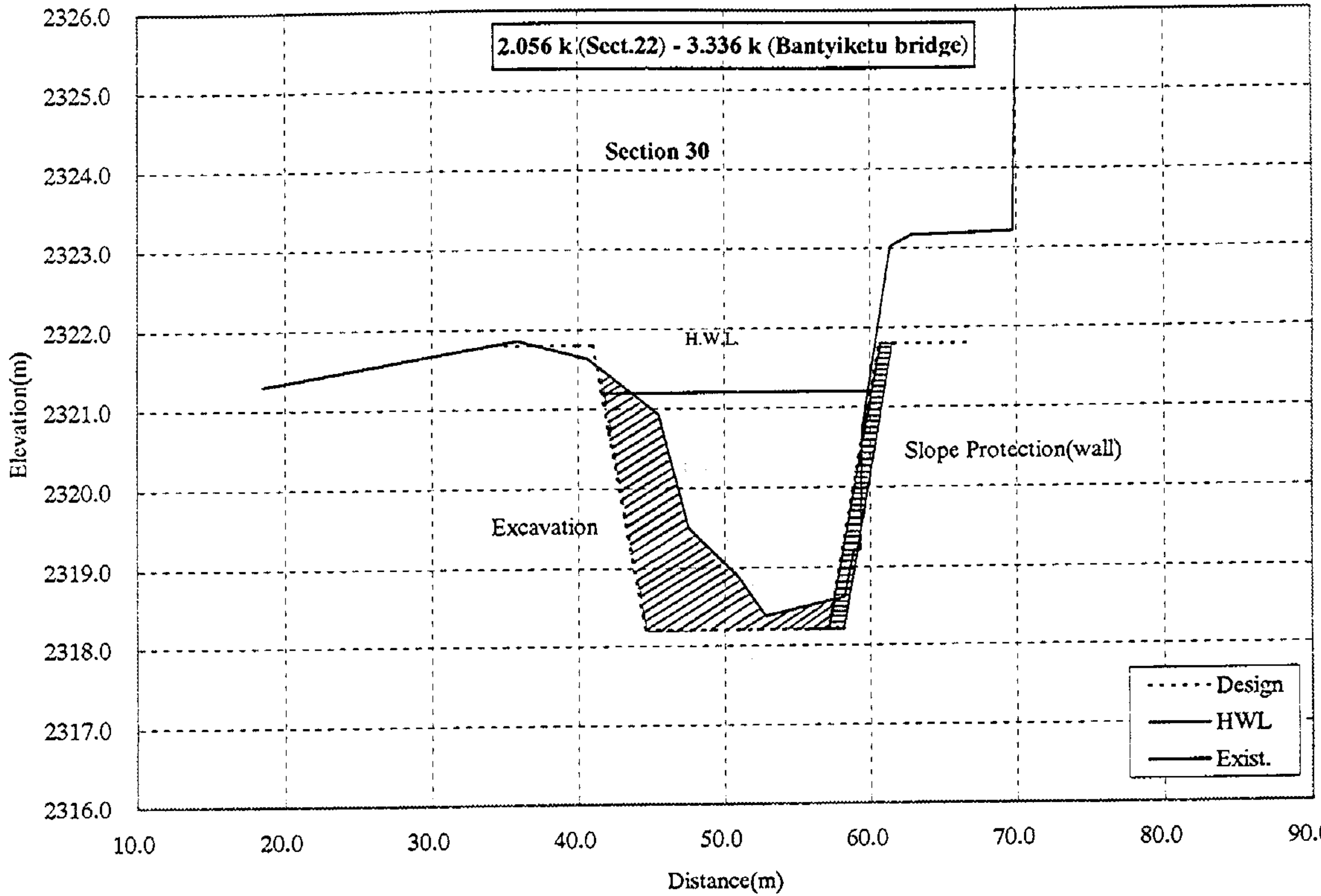


Figure 4.3.2 Section of Bantyiketu River(9/30)

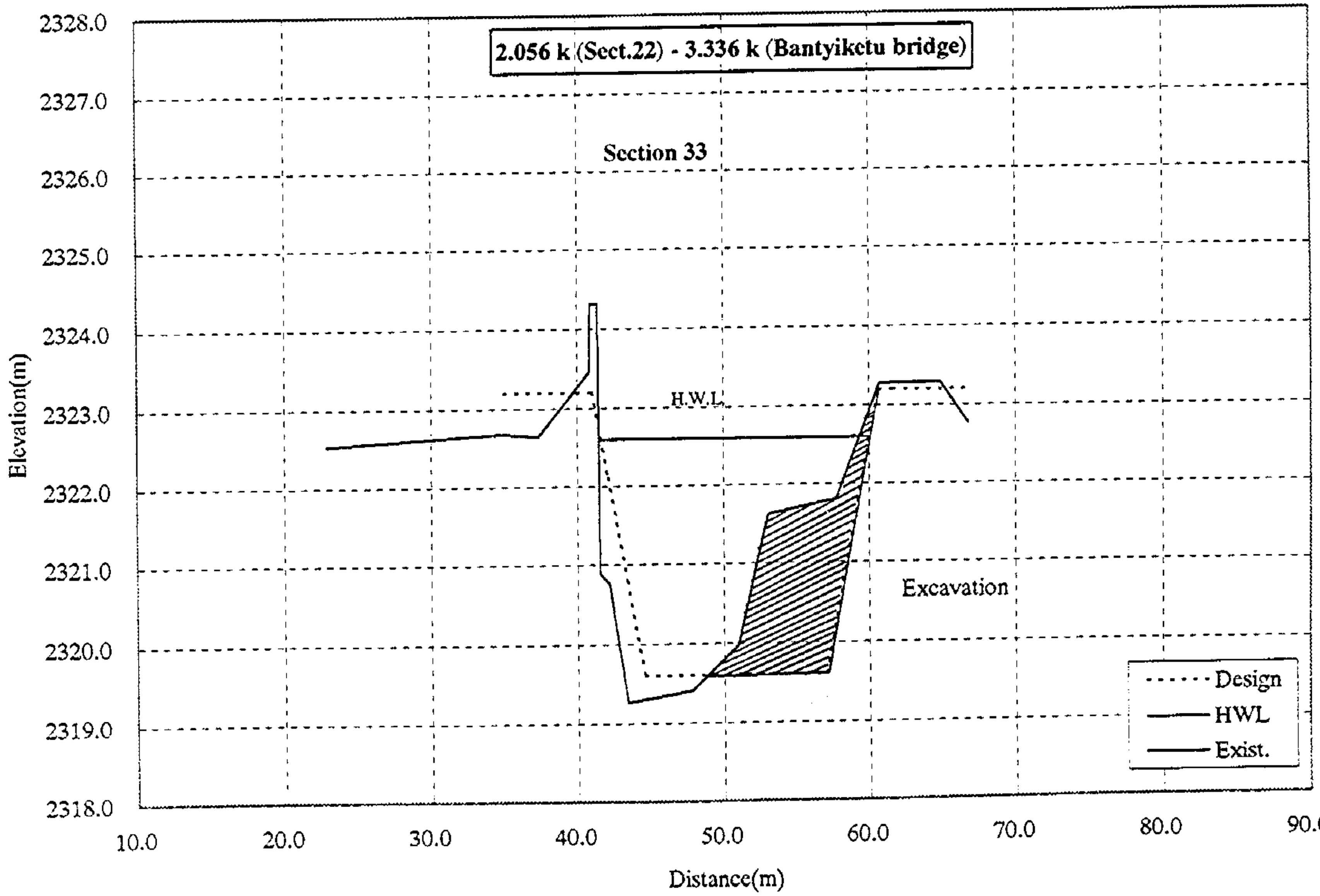


Figure 4.3.2 Section of Bantyiketu River(10/30)

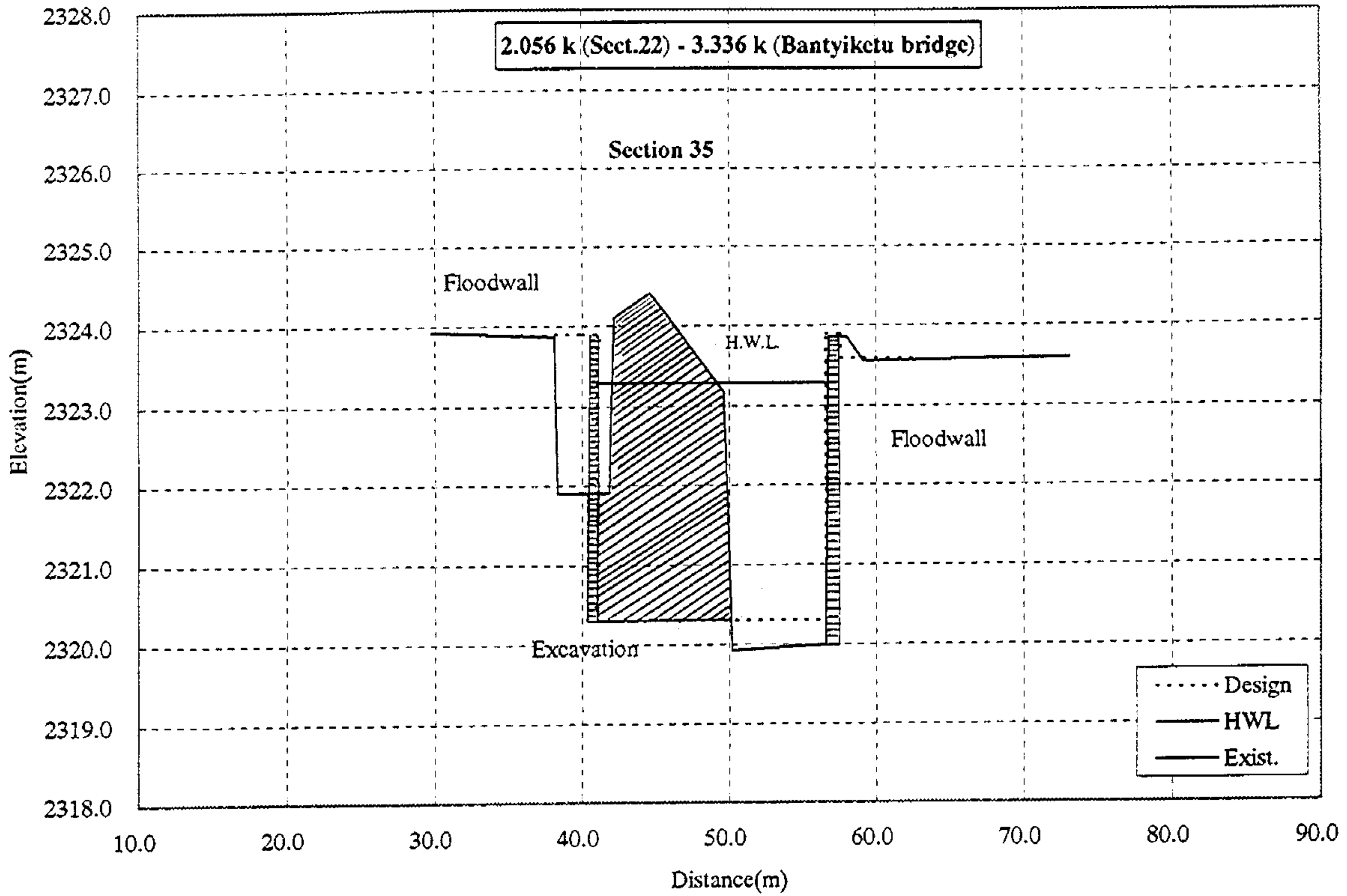


Figure 4.3.2 Section of Bantyiketu River(11/30)

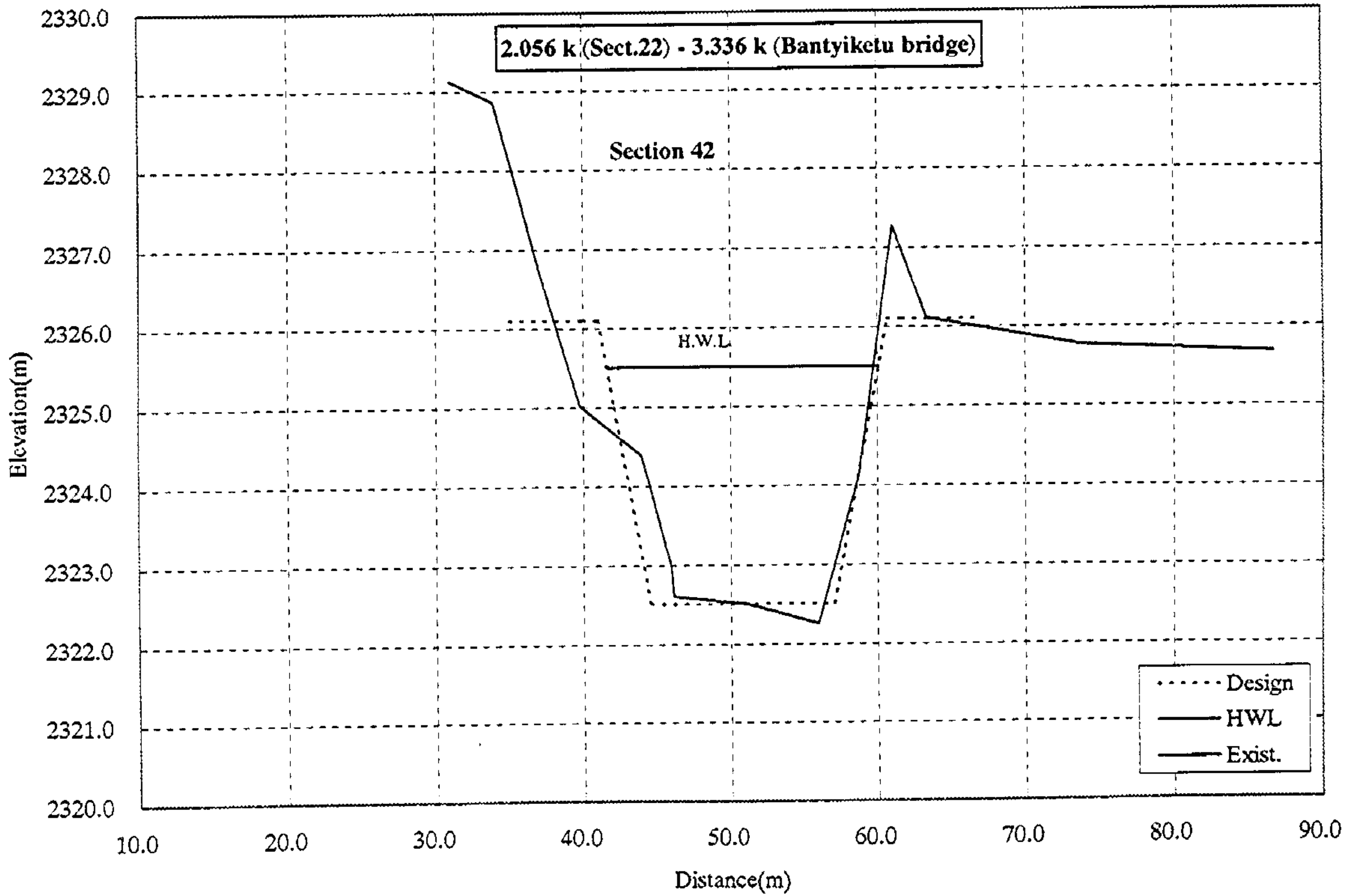


Figure 4.3.2 Section of Bantyiketu River(12/30)

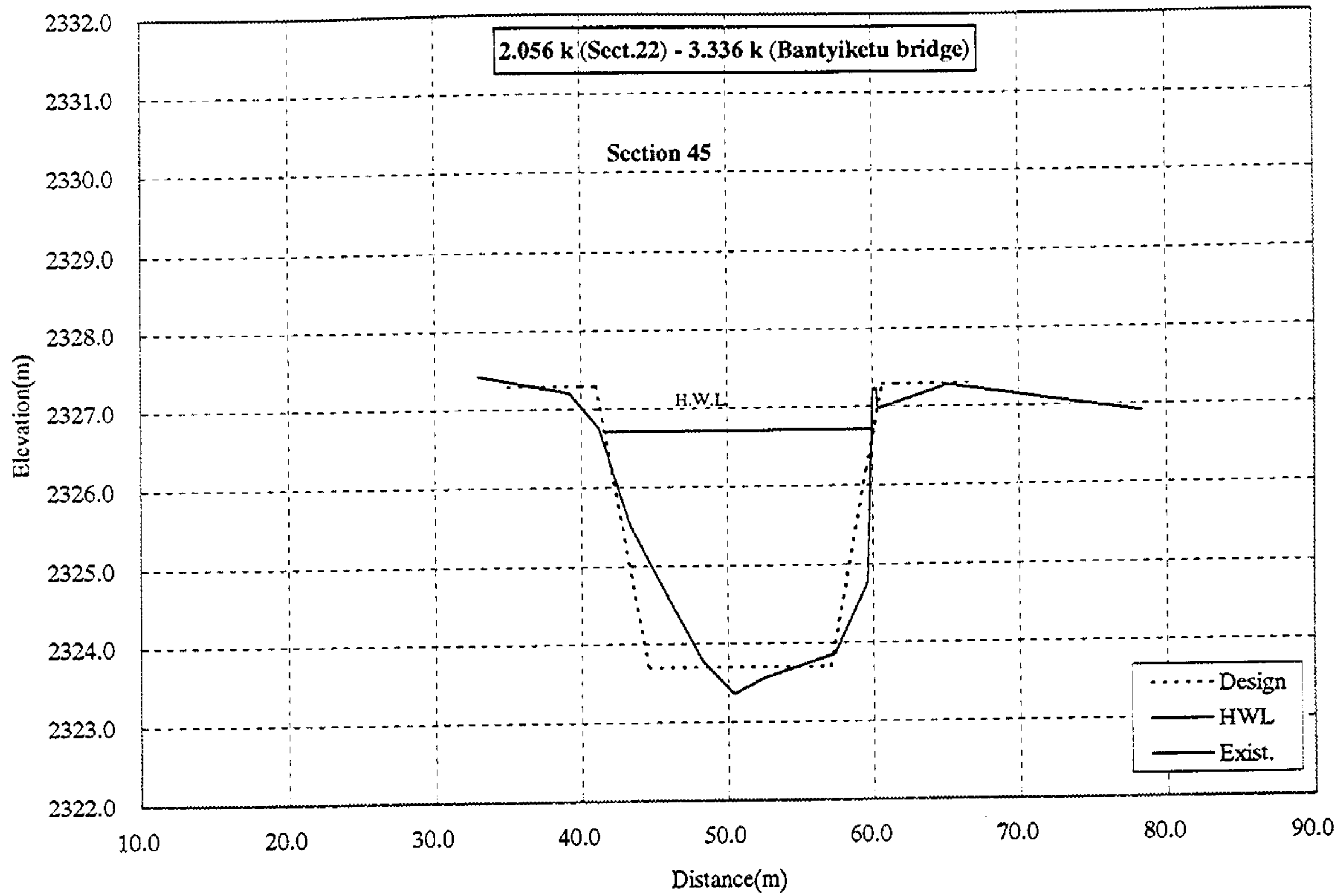


Figure 4.3.2 Section of Bantyiketu River(13/30)

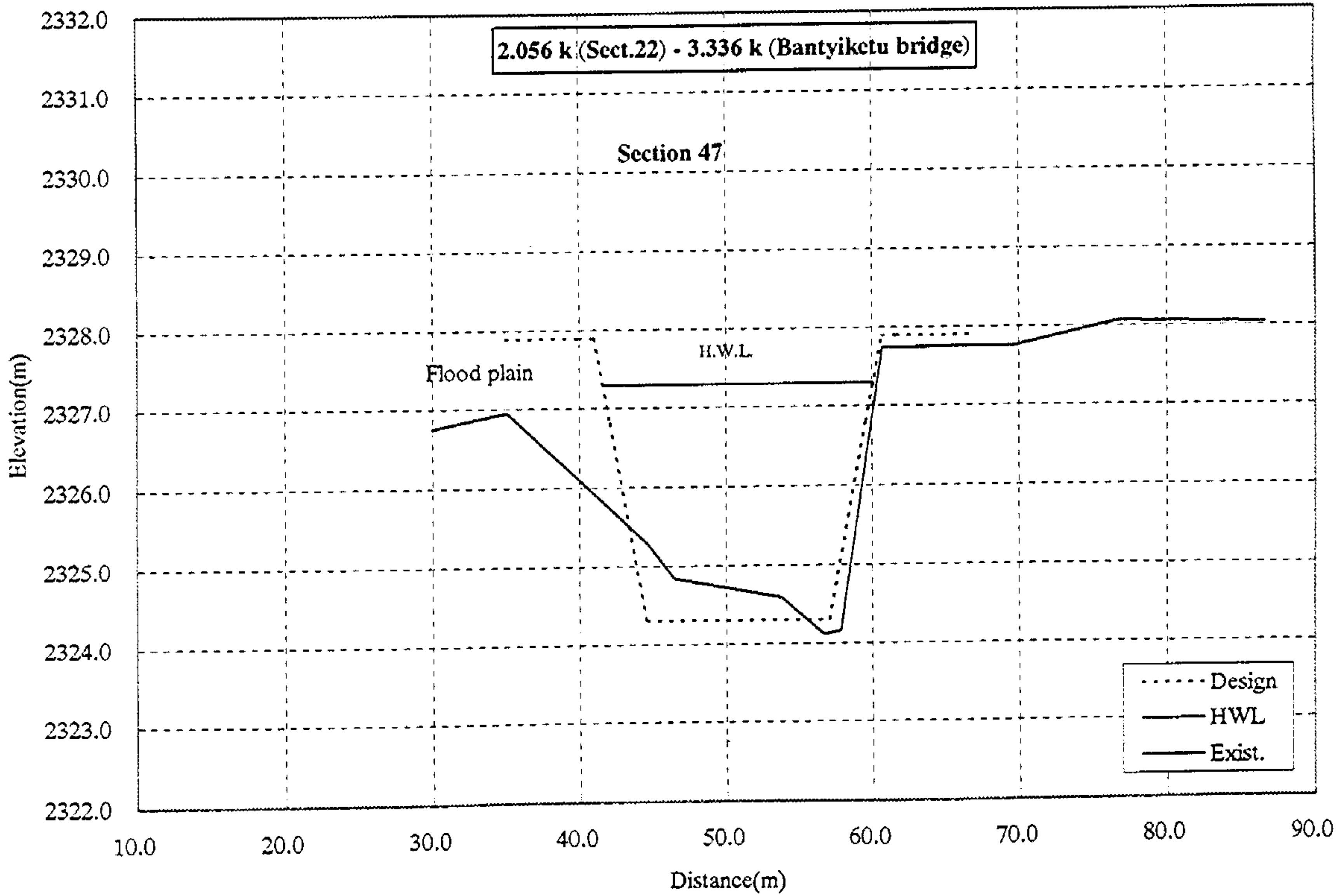


Figure 4.3.2 Section of Bantyiketu River(14/30)

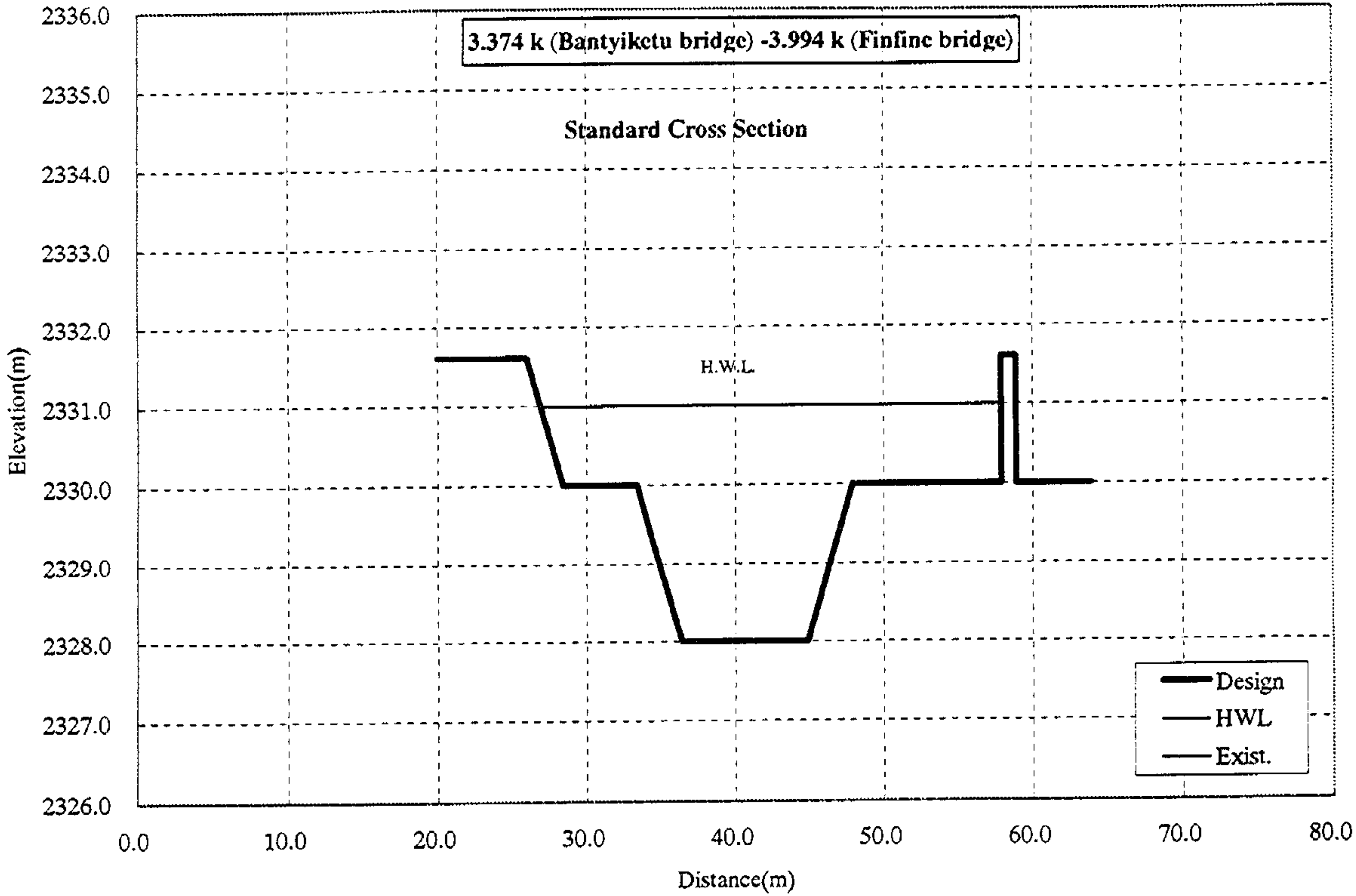


Figure 4.3.2 Section of Bantyiketu River(15/30)

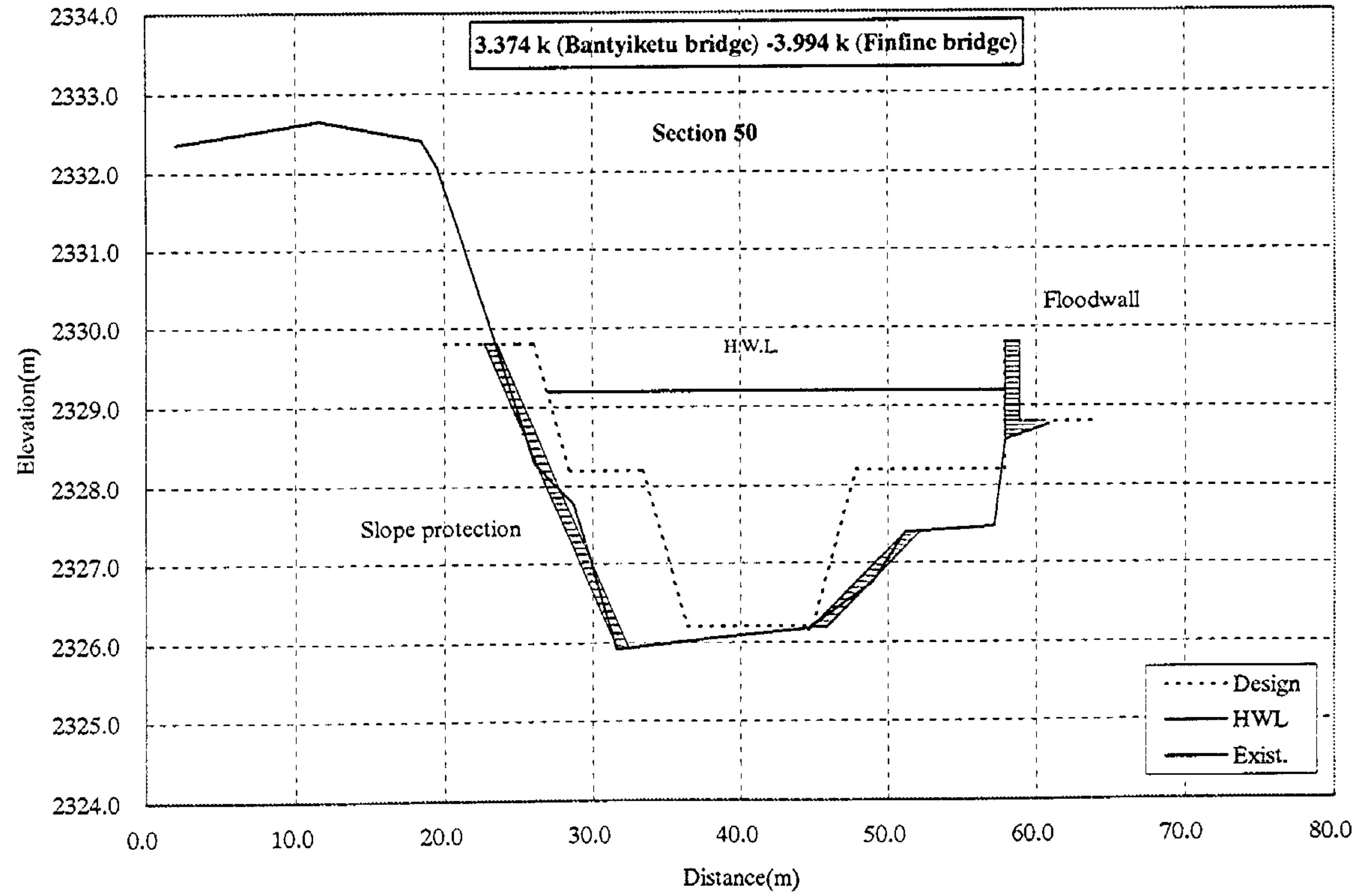


Figure 4.3.2 Section of Bantyiketu River(16/30)

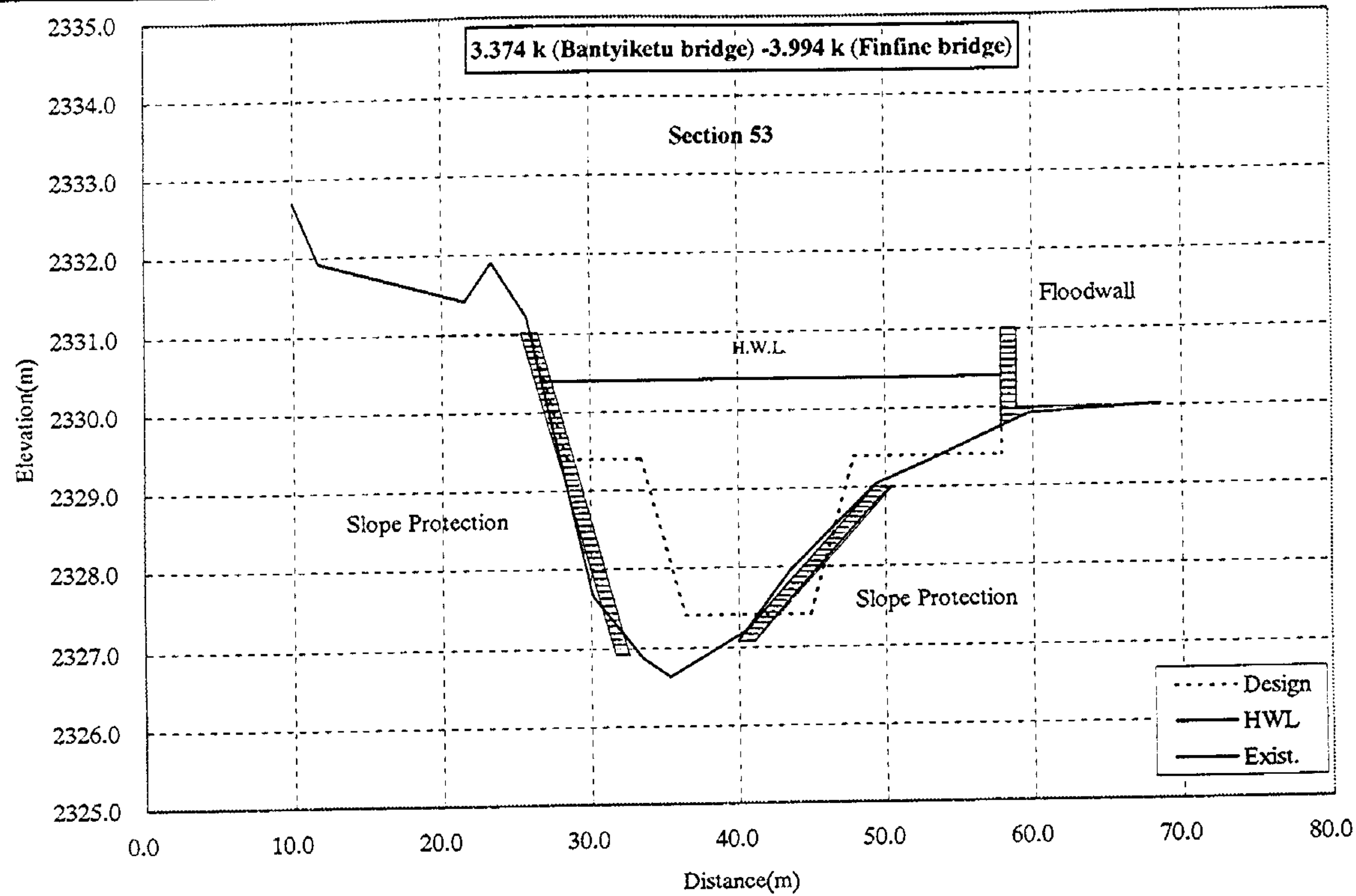


Figure 4.3.2 Section of Bantyiketu River(17/30)

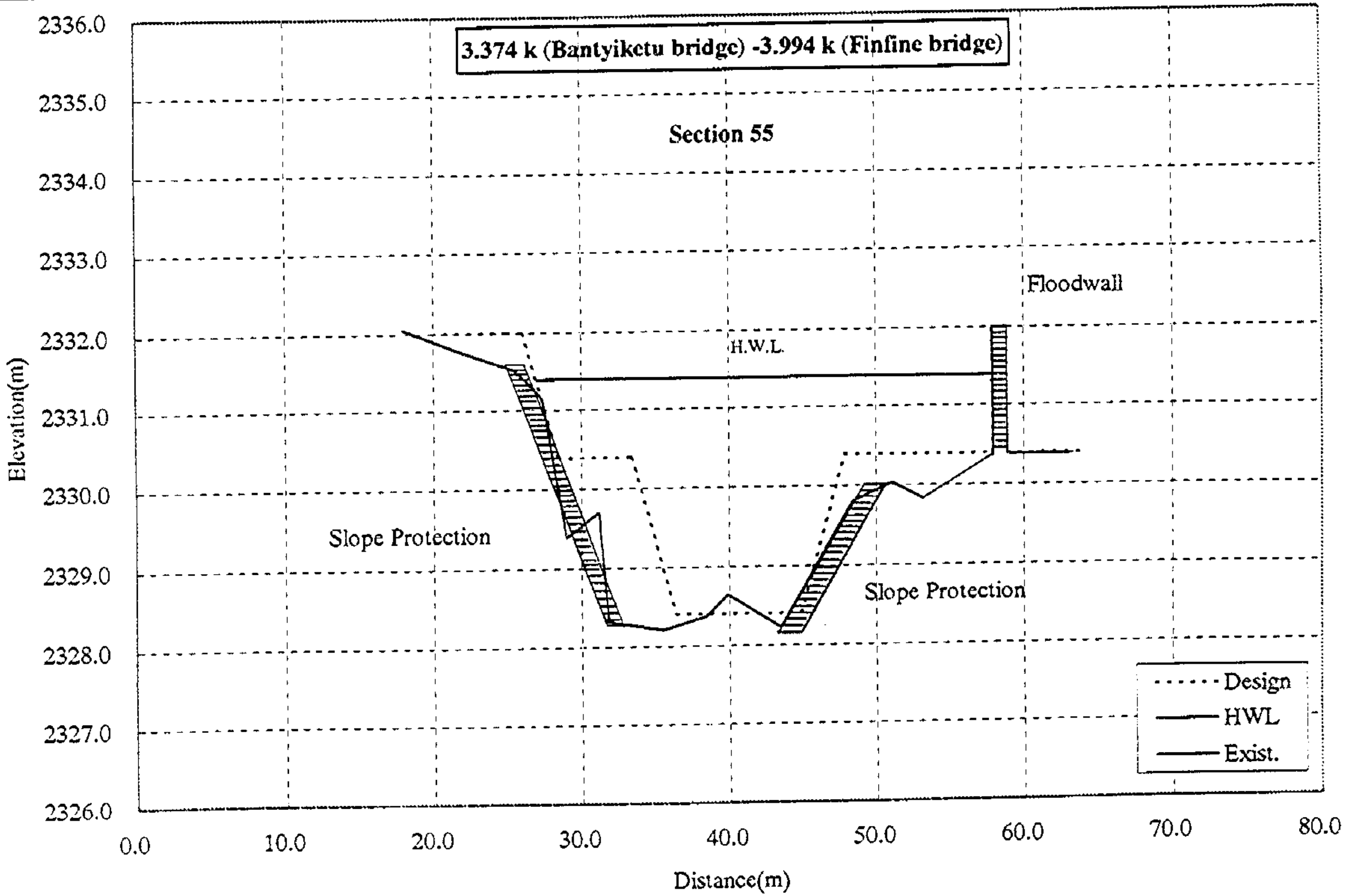


Figure 4.3.2 Section of Bantyiketu River(18/30)

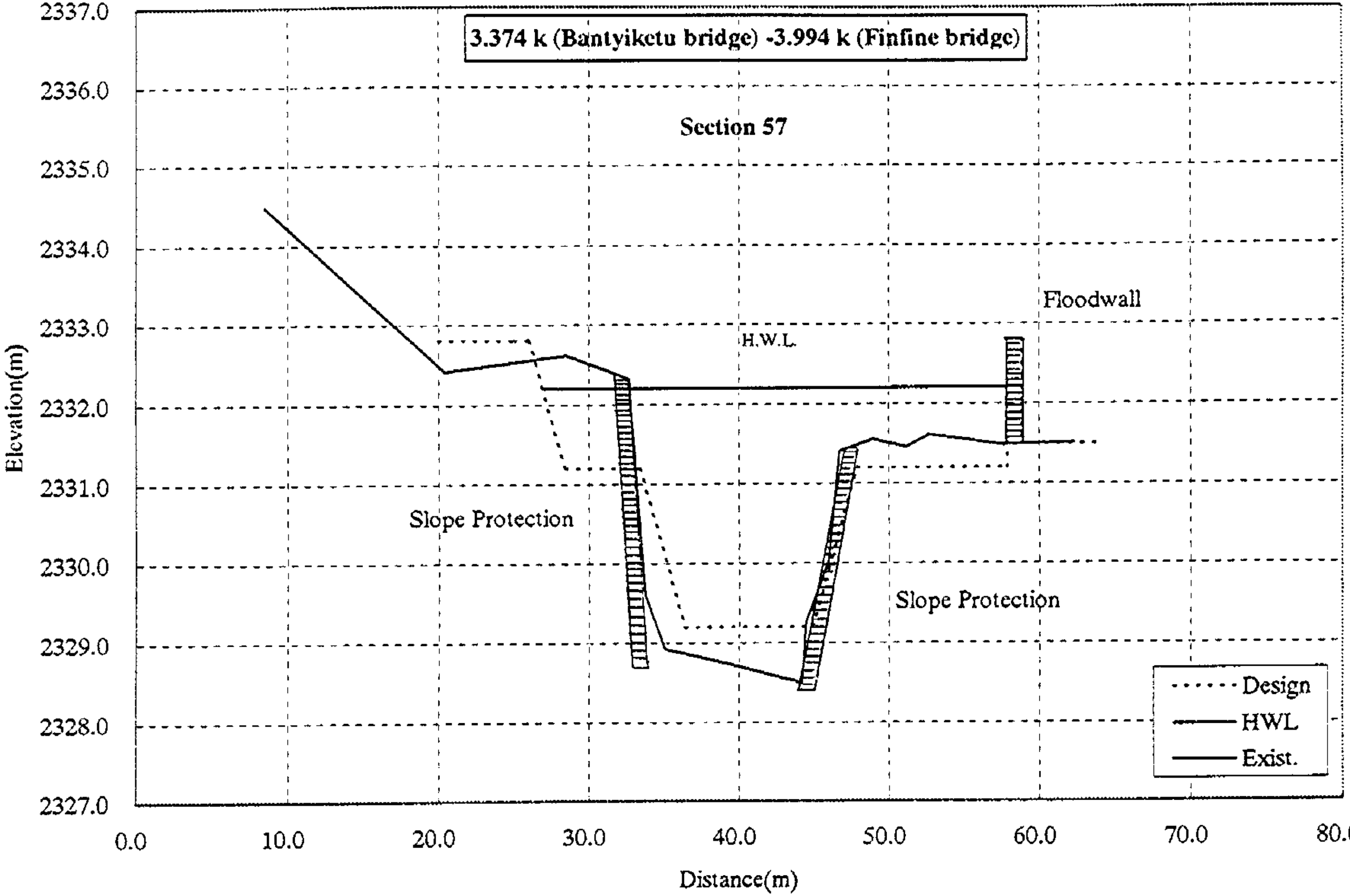


Figure 4.3.2 Section of Bantyiketu River(19/30)

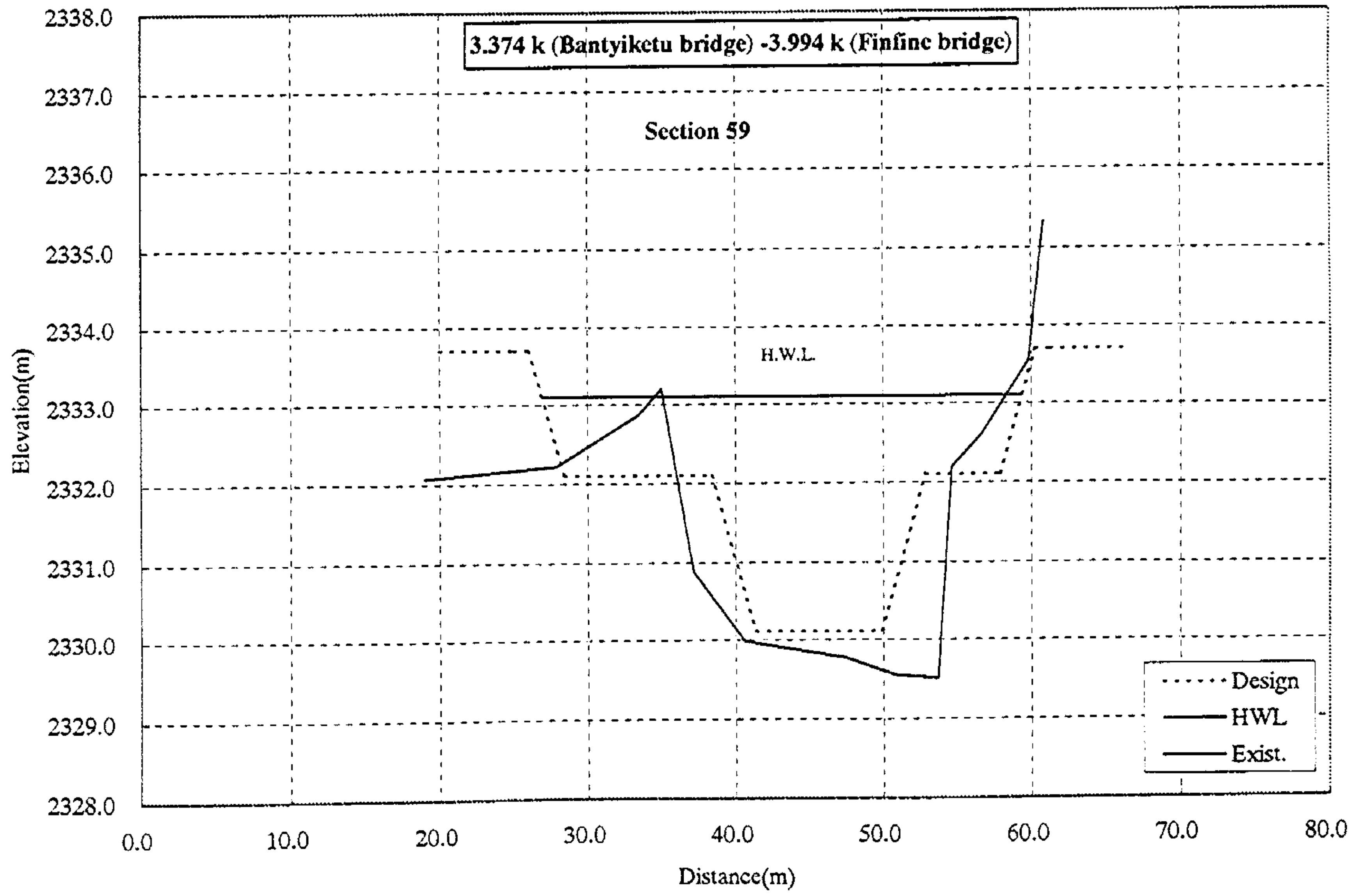


Figure 4.3.2 Section of Bantyiketu River(20/30)

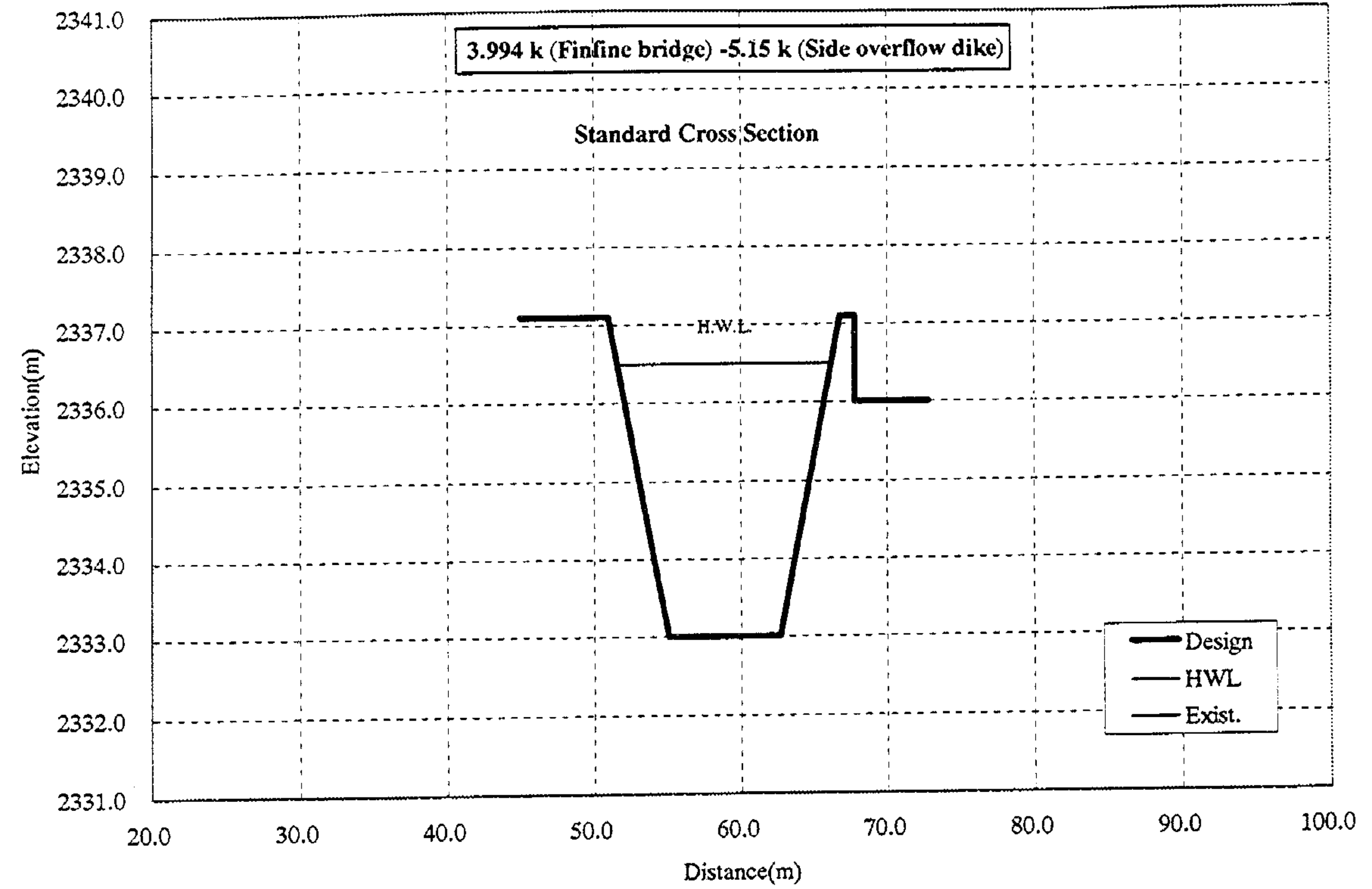


Figure 4.3.2 Section of Bantyiketu River(21/30)

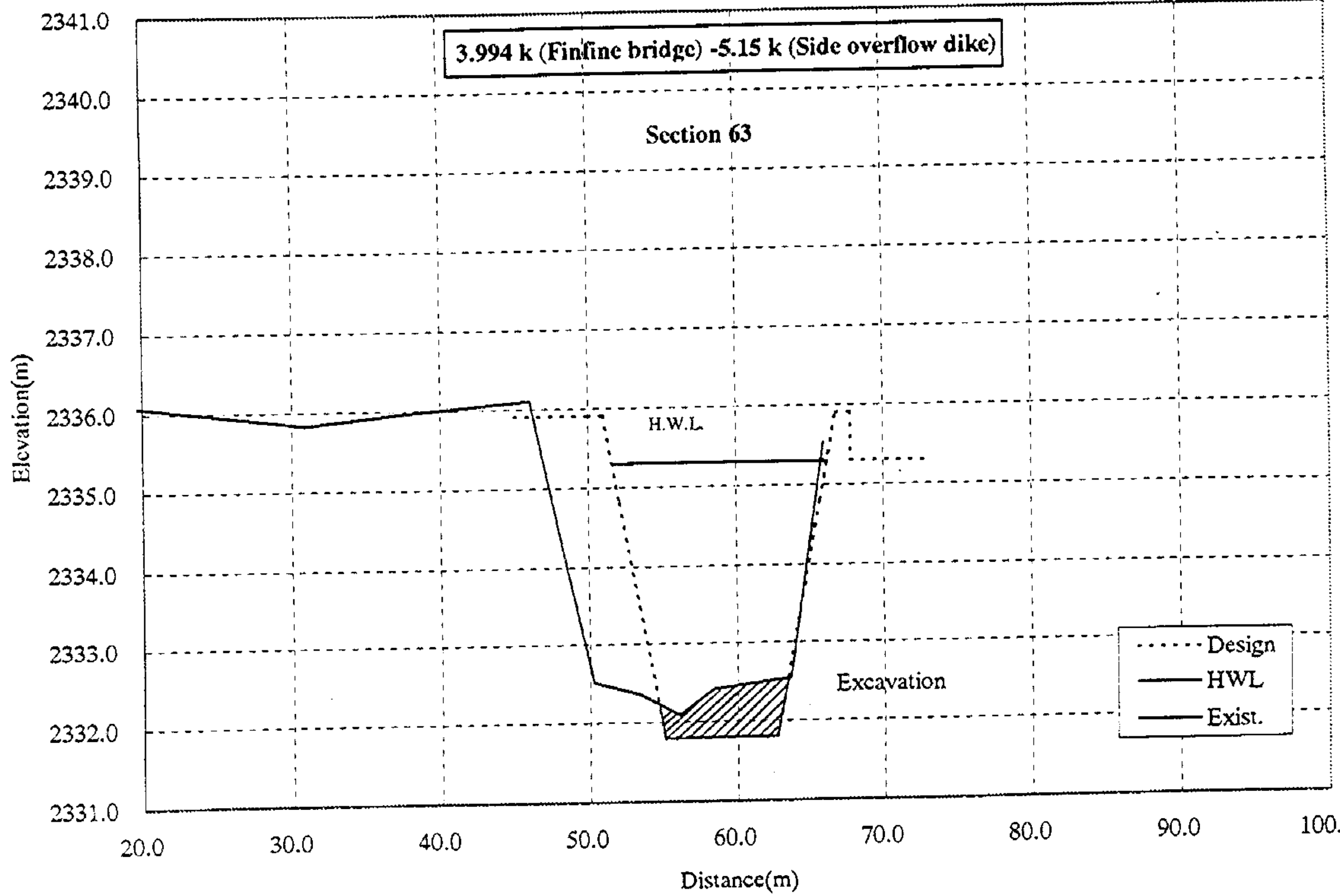


Figure 4.3.2 Section of Bantyiketu River(22/30)

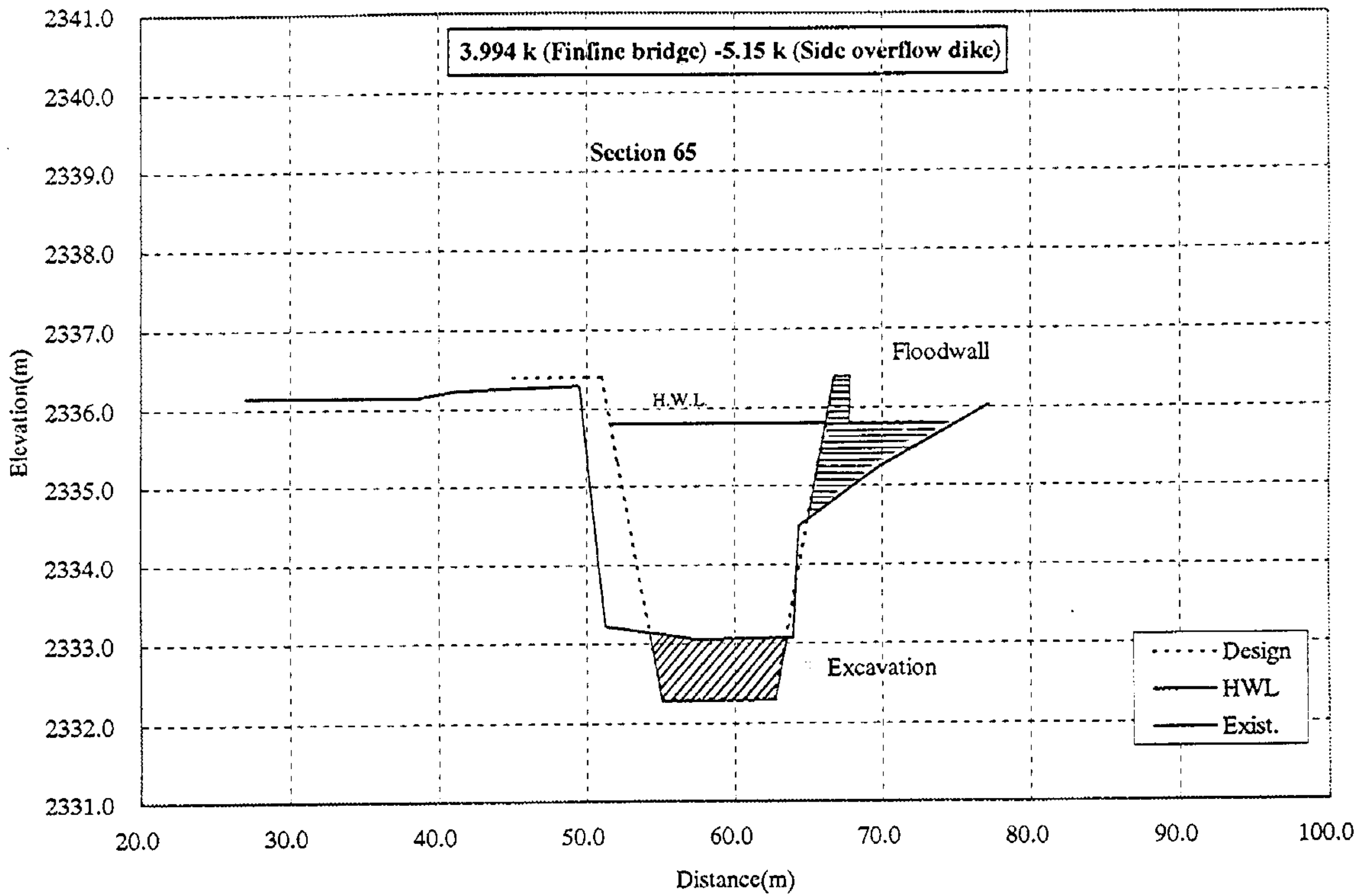


Figure 4.3.2 Section of Bantyiketu River(23/30)

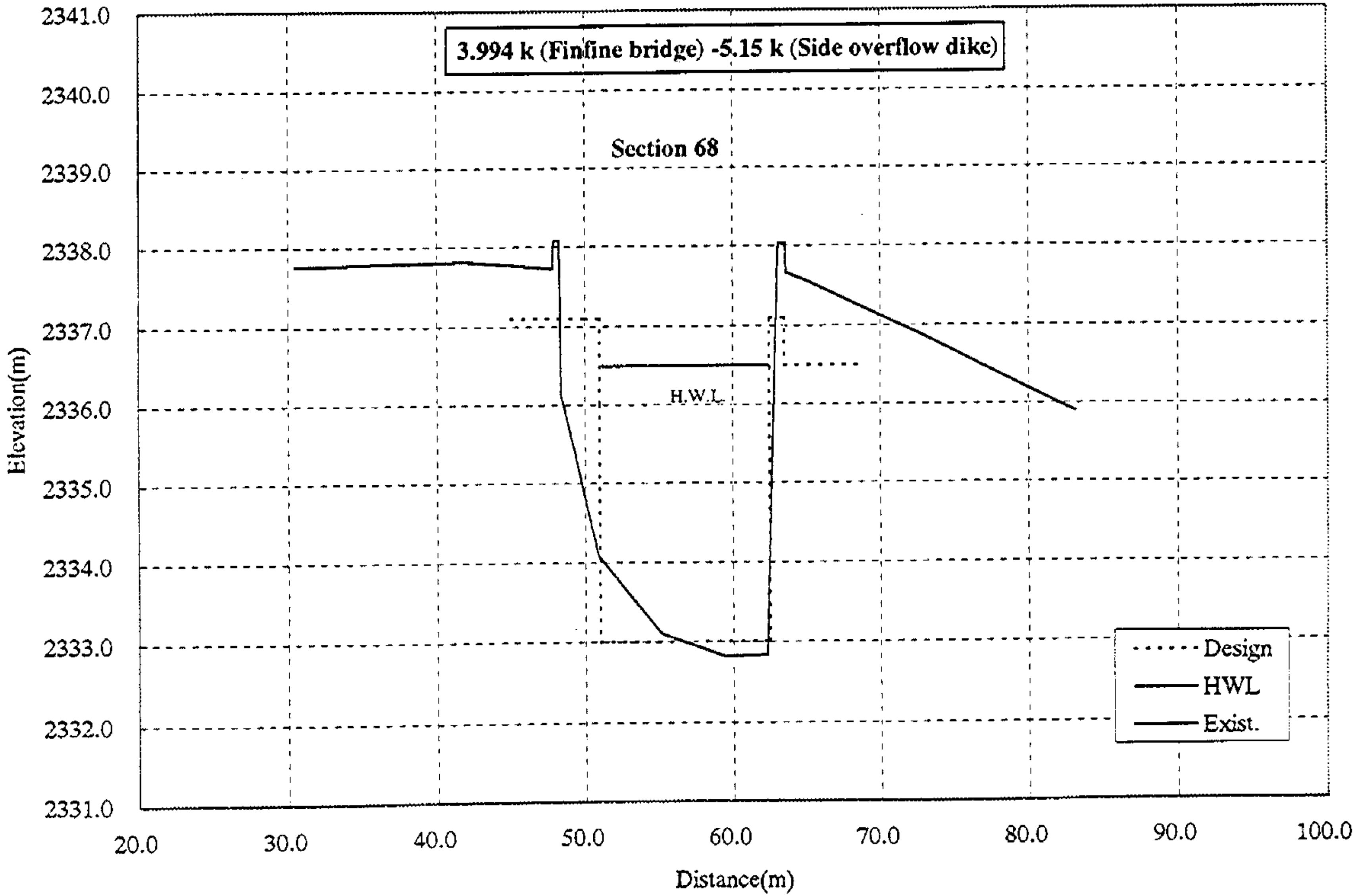


Figure 4.3.2 Section of Bantyiketu River(24/30)

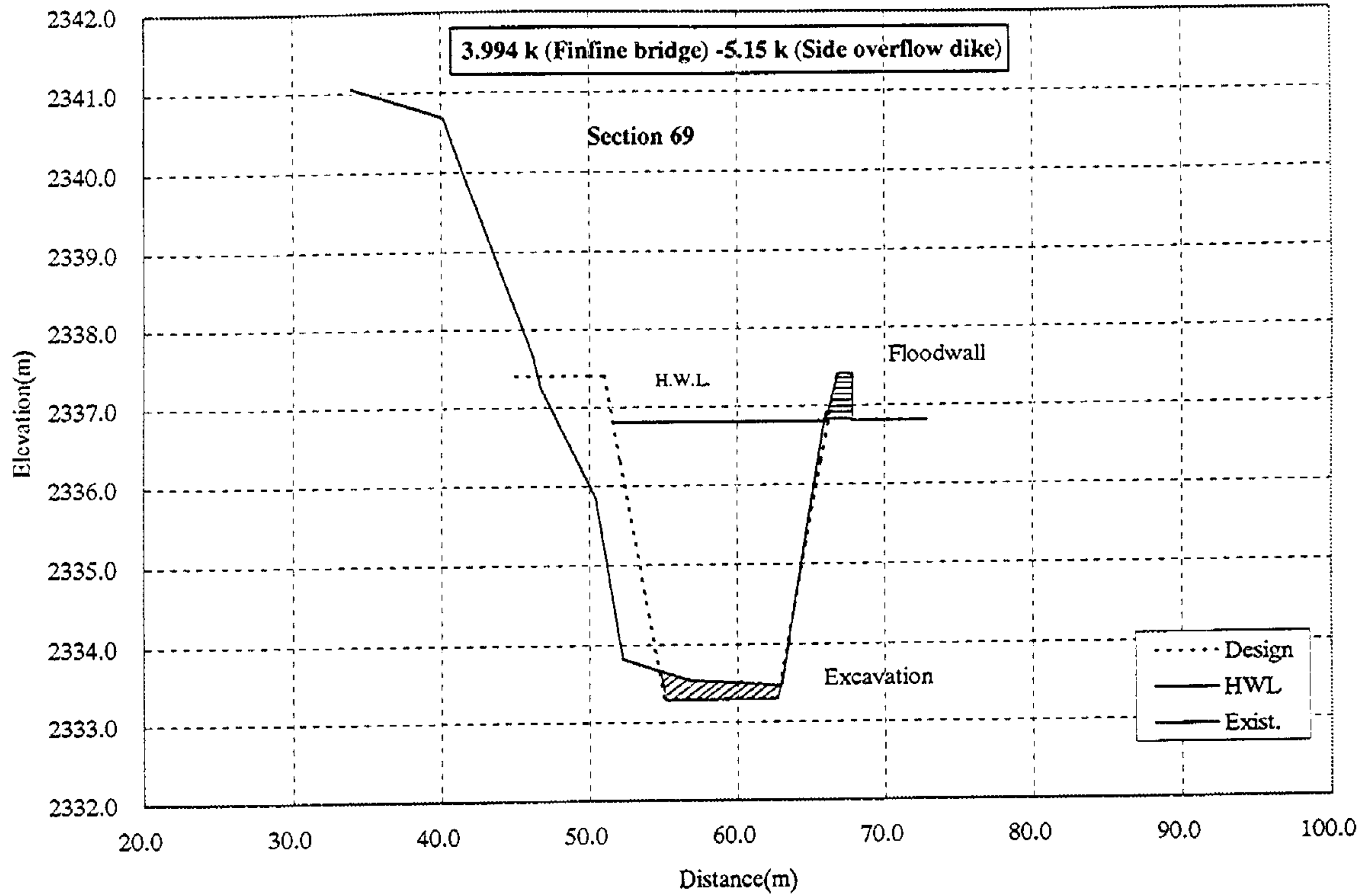


Figure 4.3.2 Section of Bantyiketu River(25/30)

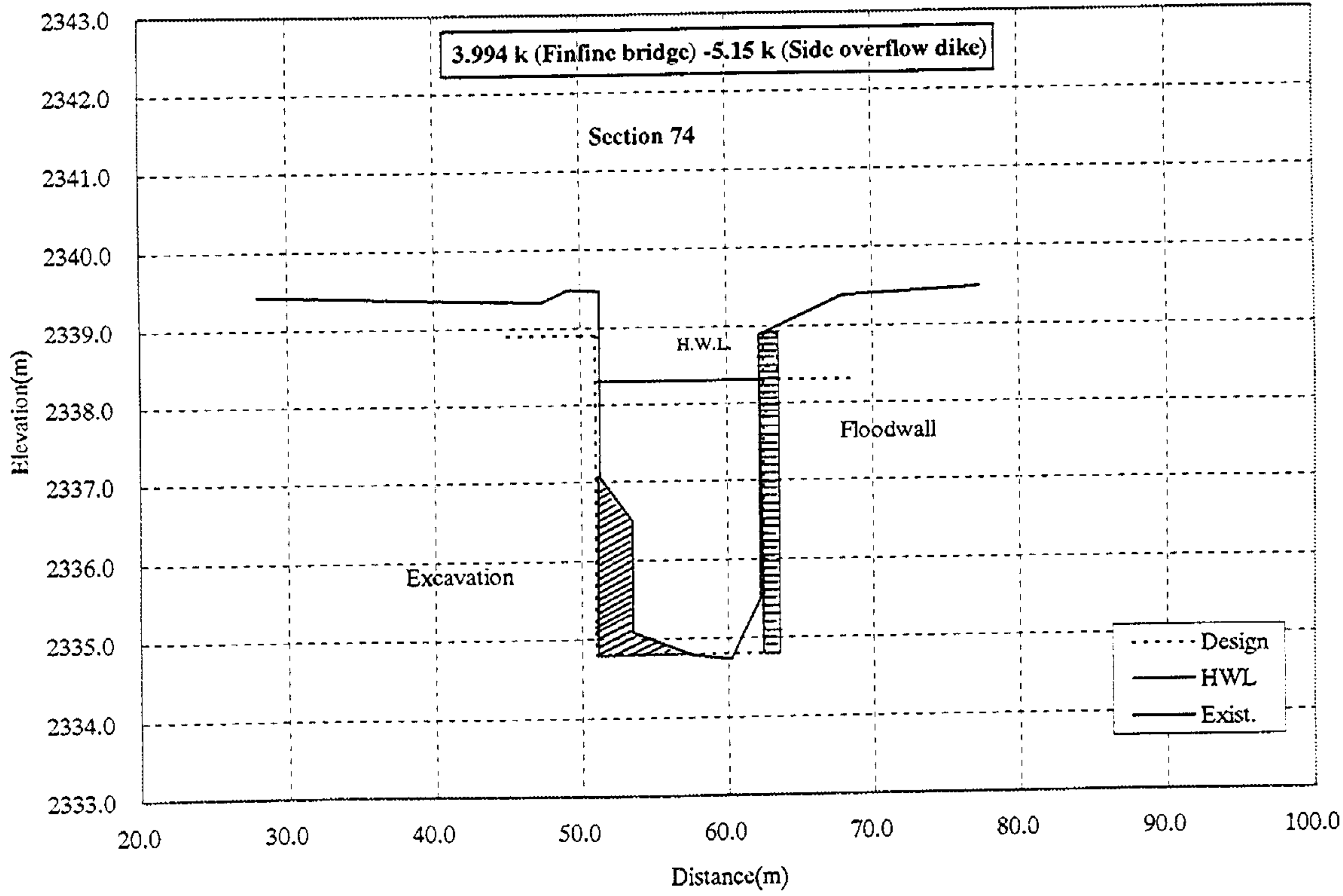


Figure 4.3.2 Section of Bantyiketu River(26/30)

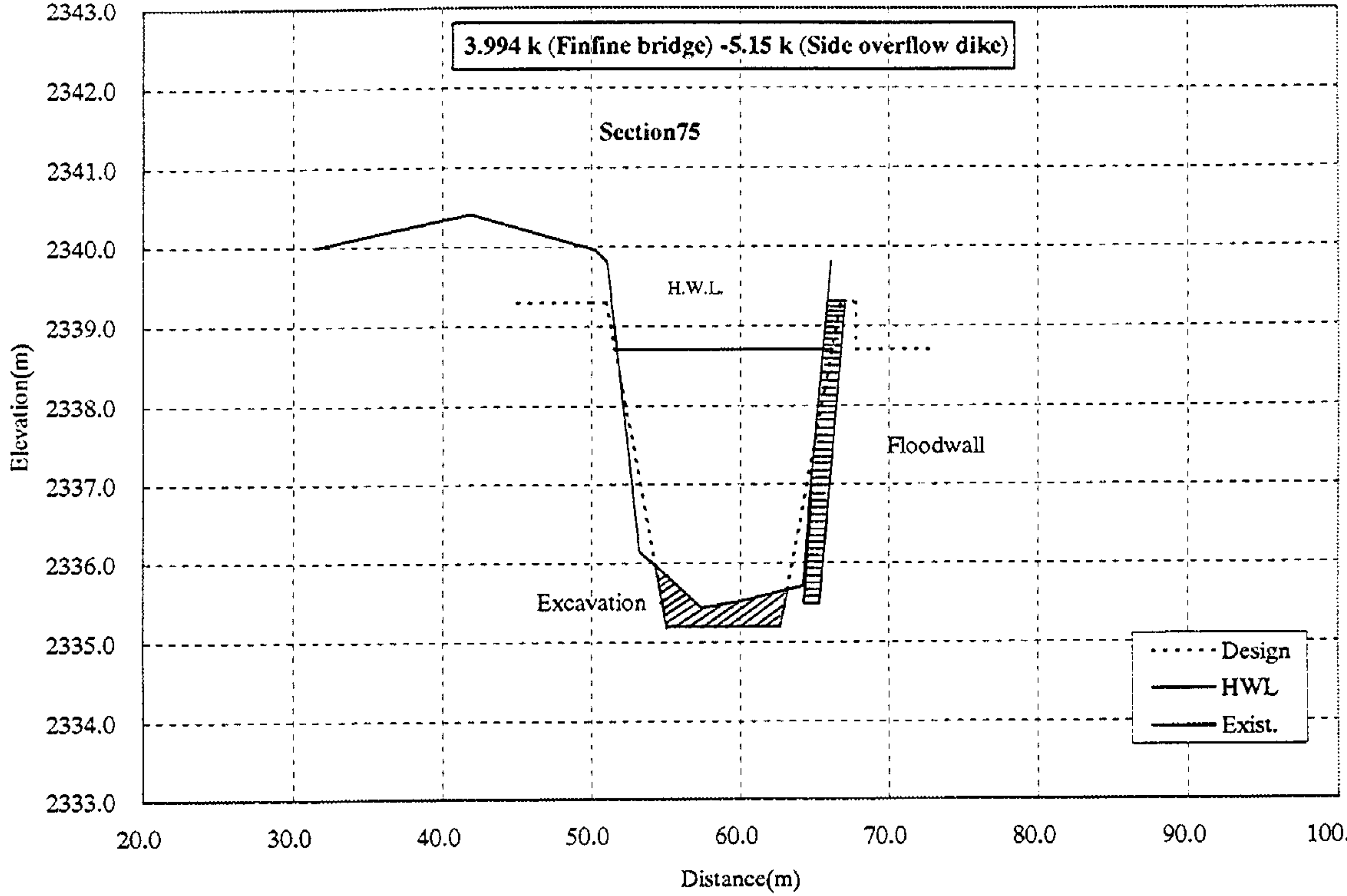


Figure 4.3.2 Section of Bantyiketu River(27/30)

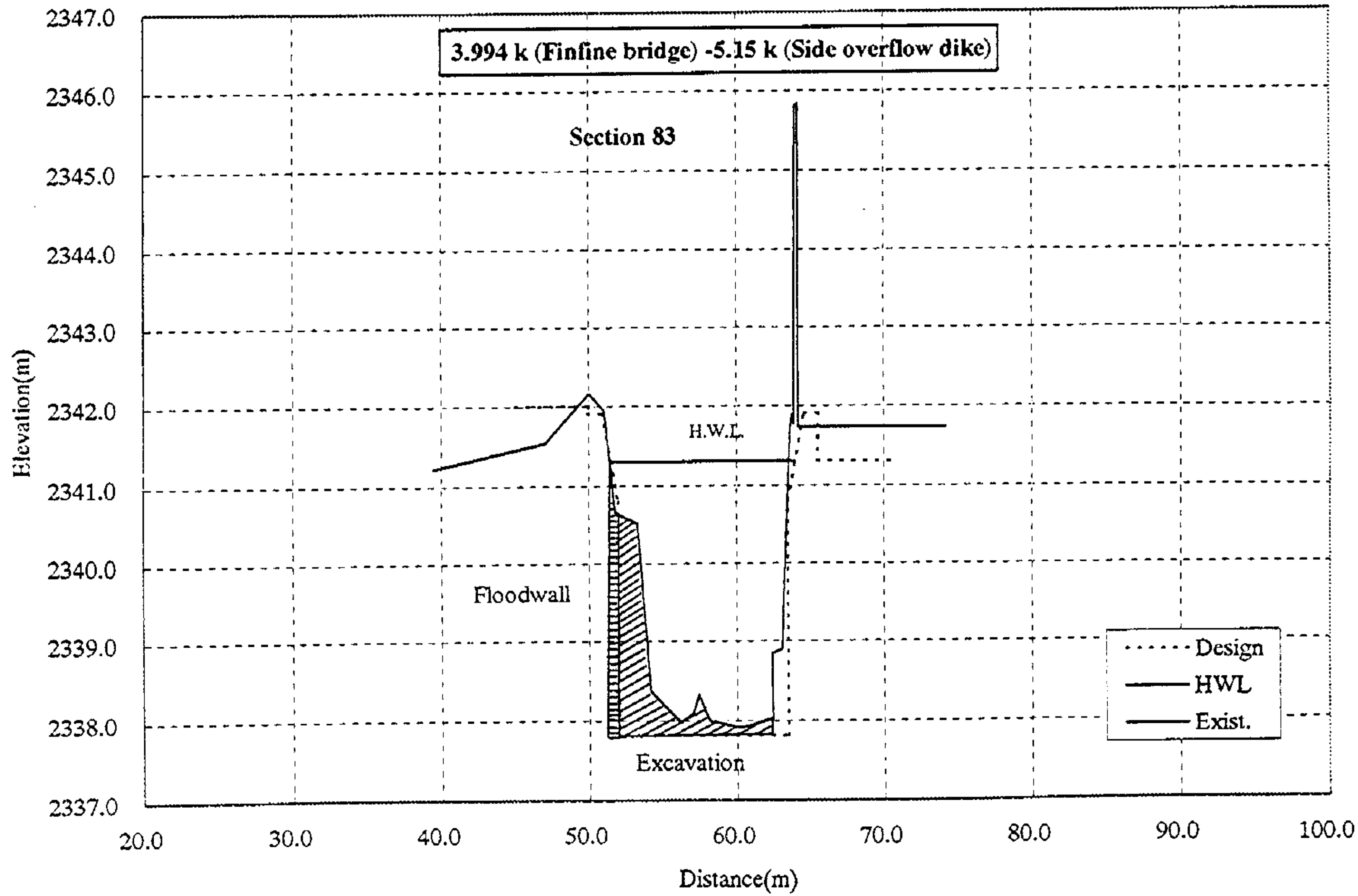


Figure 4.3.2 Section of Bantyiketu River(28/30)

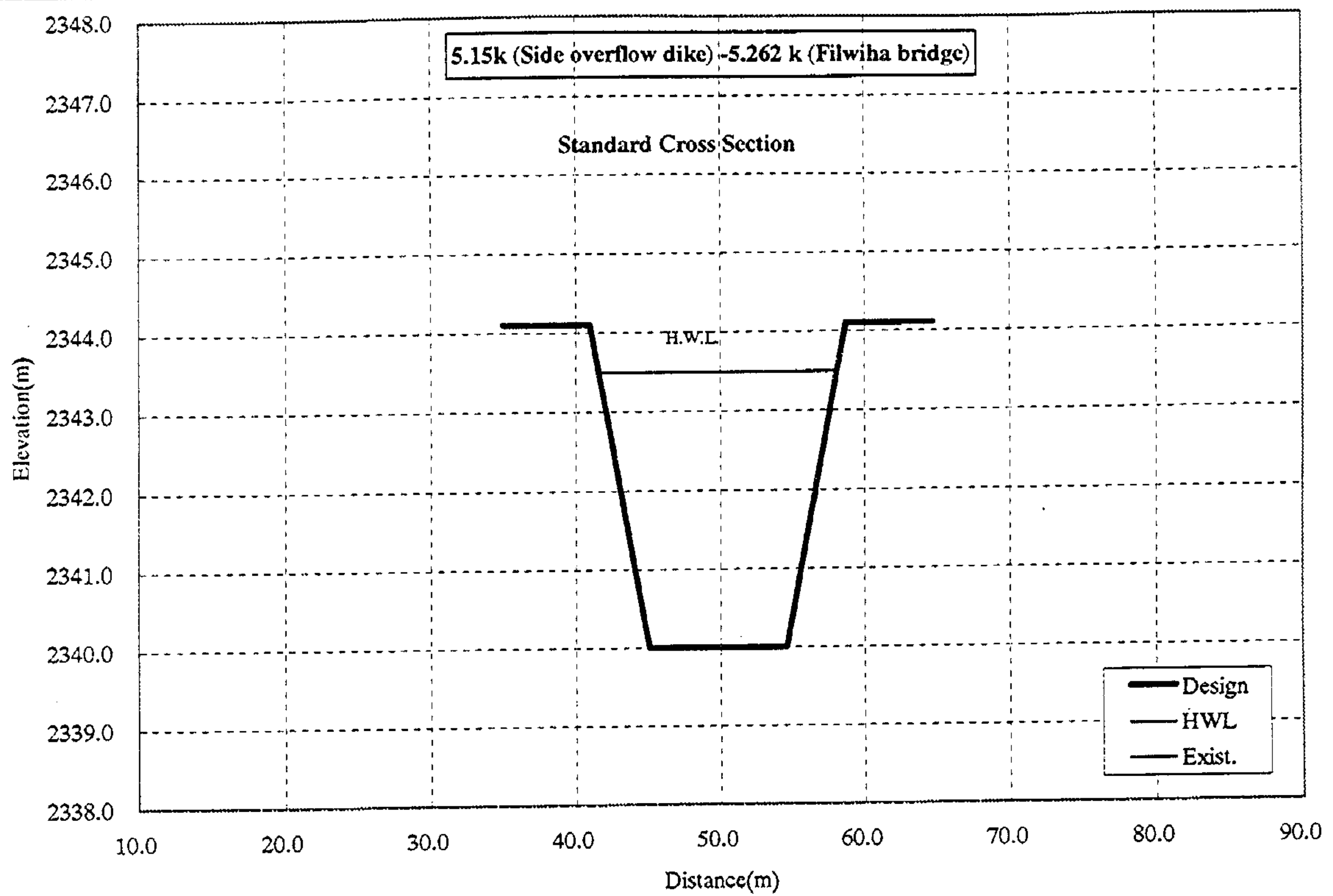


Figure 4.3.2 Section of Bantyiketu River(29/30)

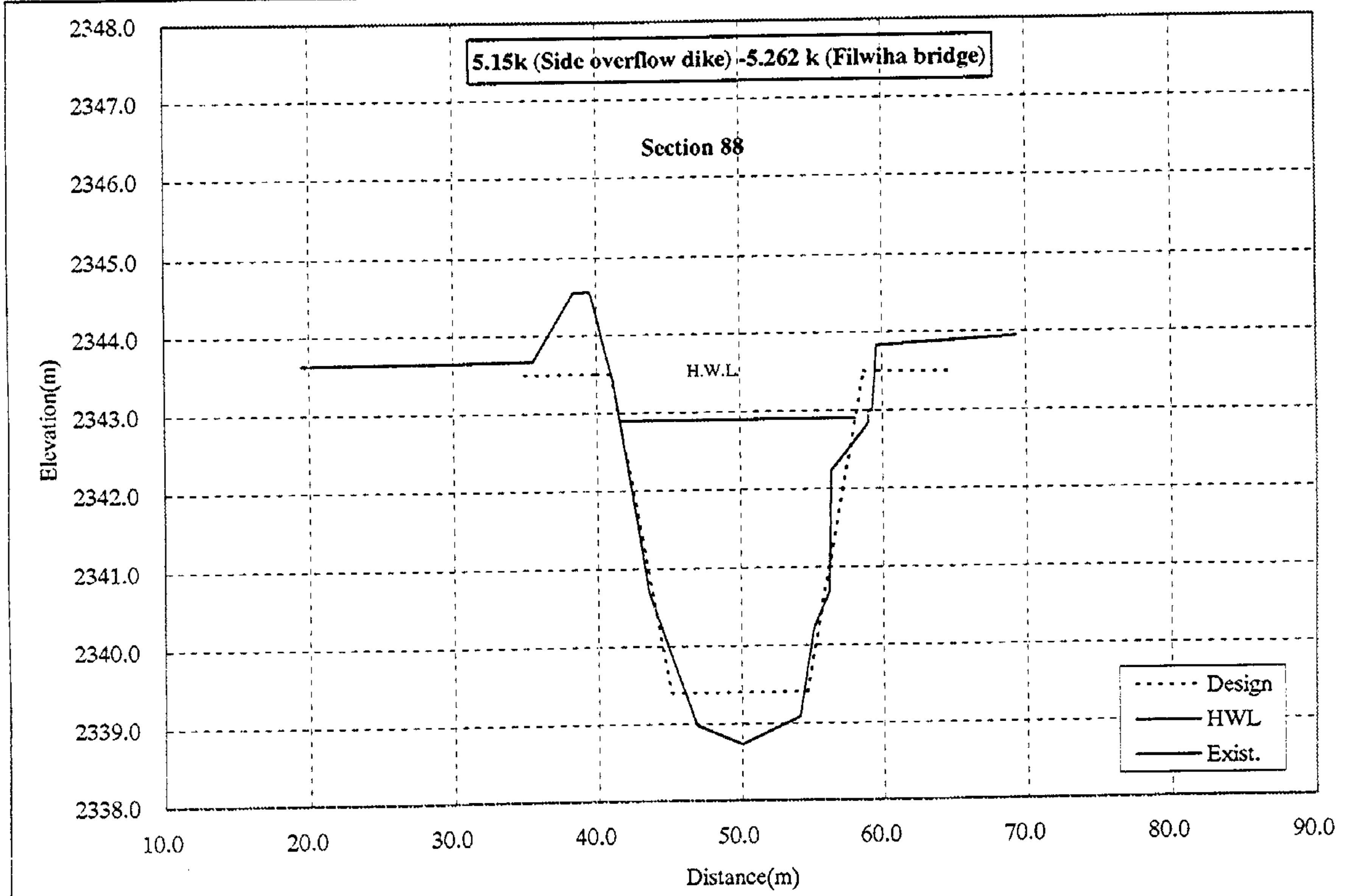


Figure 4.3.2 Section of Bantyiketu River(30/30)

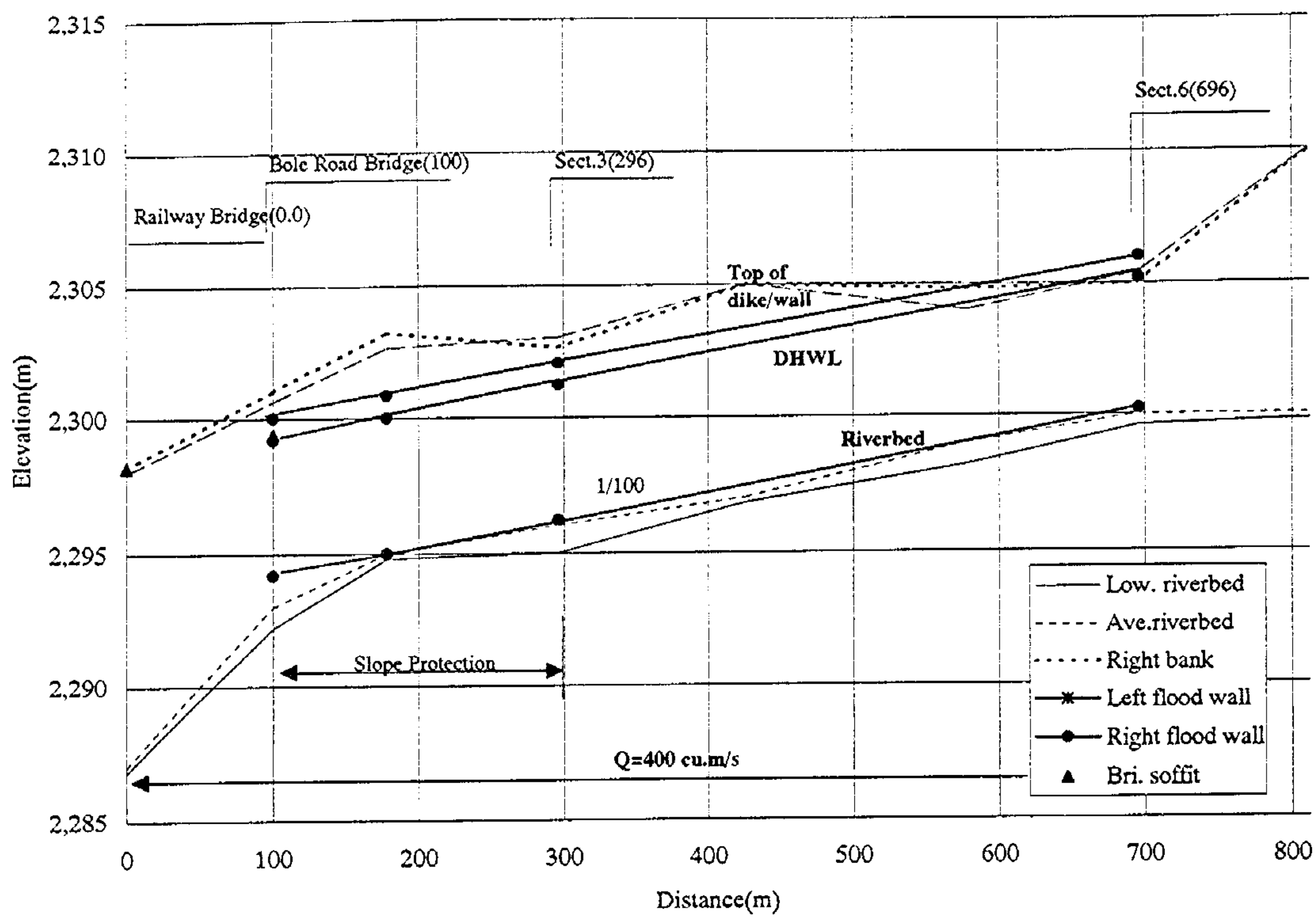


Figure 4.3.4 Longitudinal Profile of the Lower Kebena River

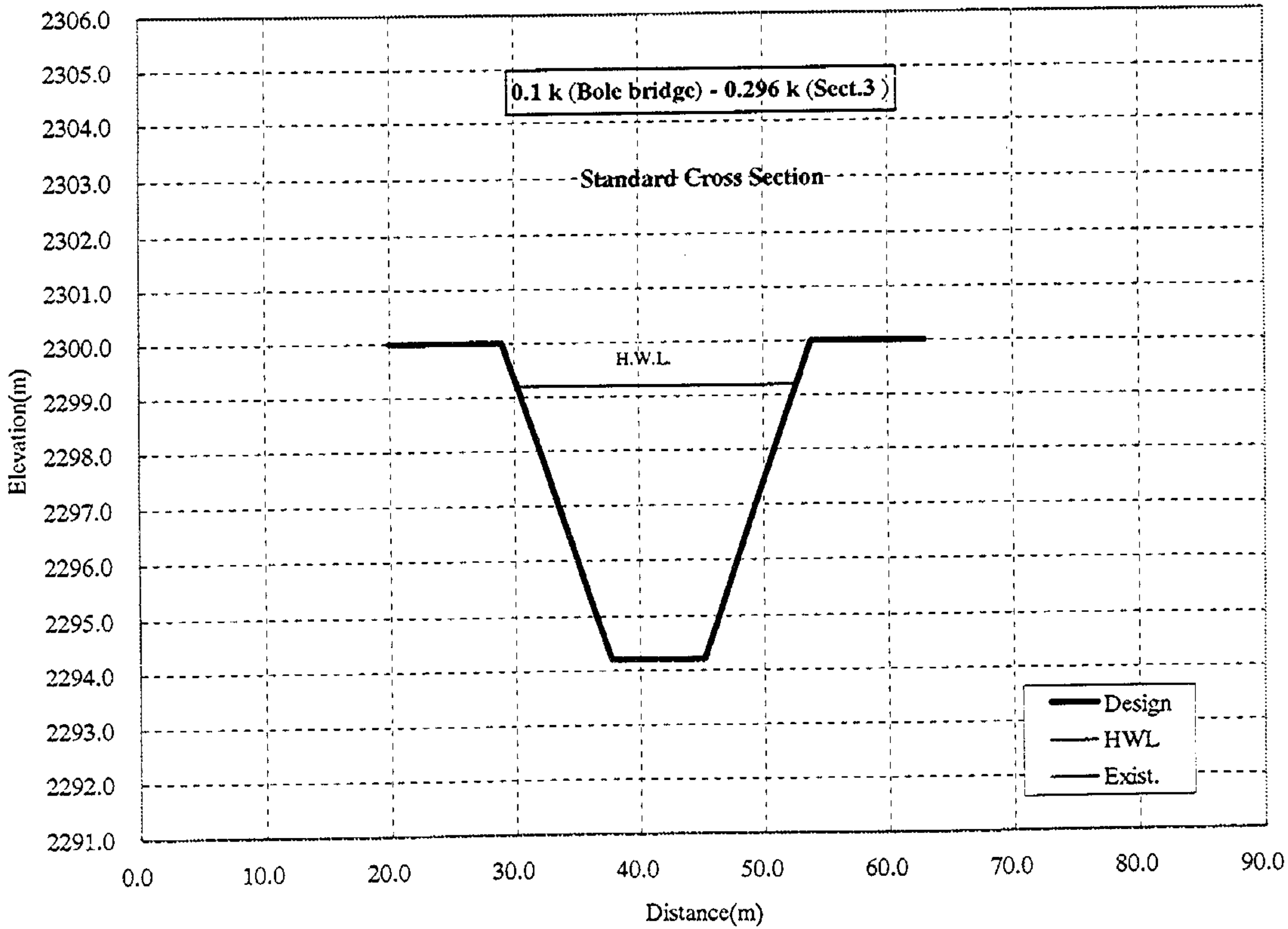


Figure 4.3.5 Section of Lower Kebena River(1/4)

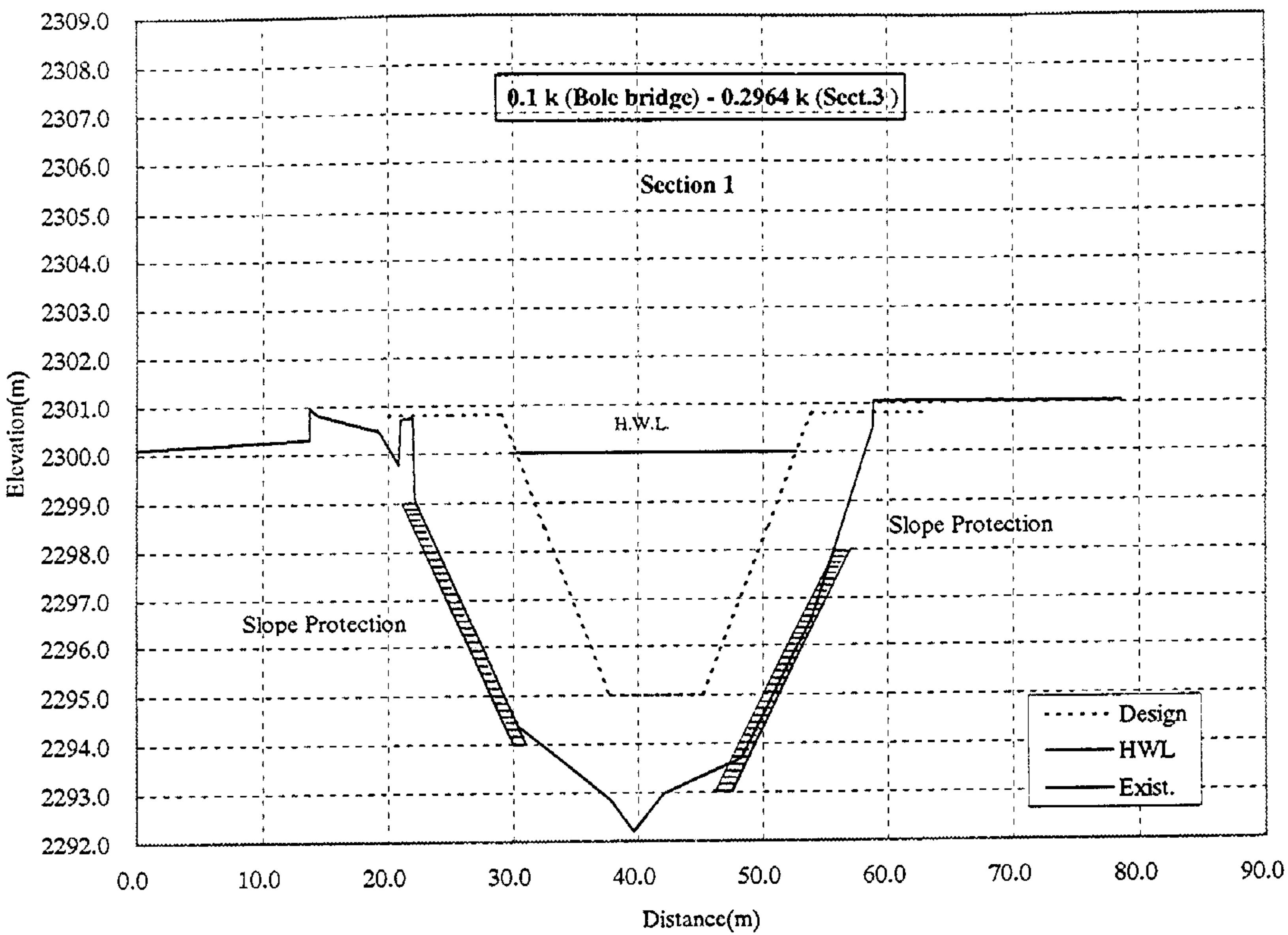


Figure 4.3.5 Section of Lower Kebena River(2/4)

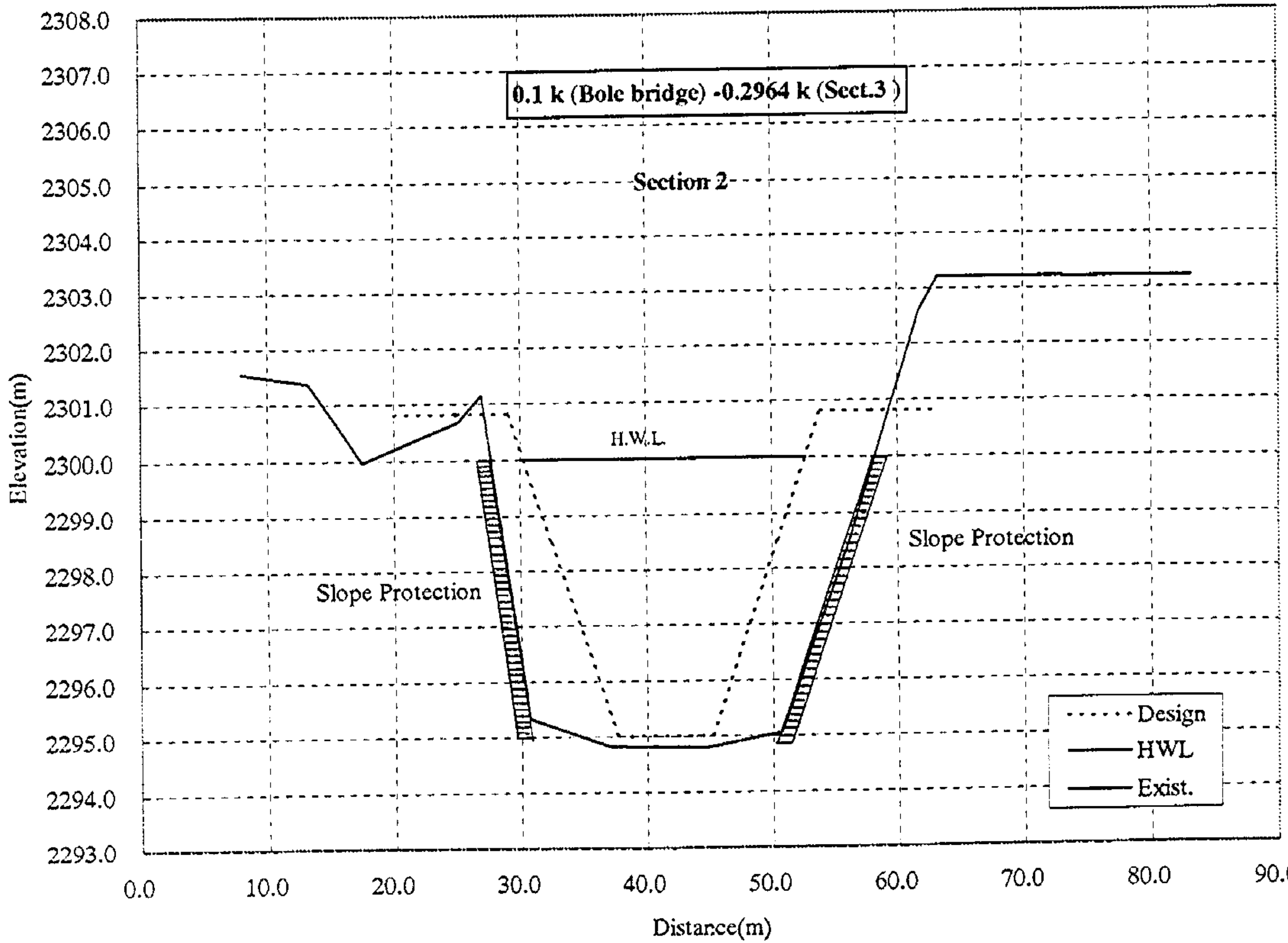


Figure 4.3.5 Section of Lower Kebena River(3/4)

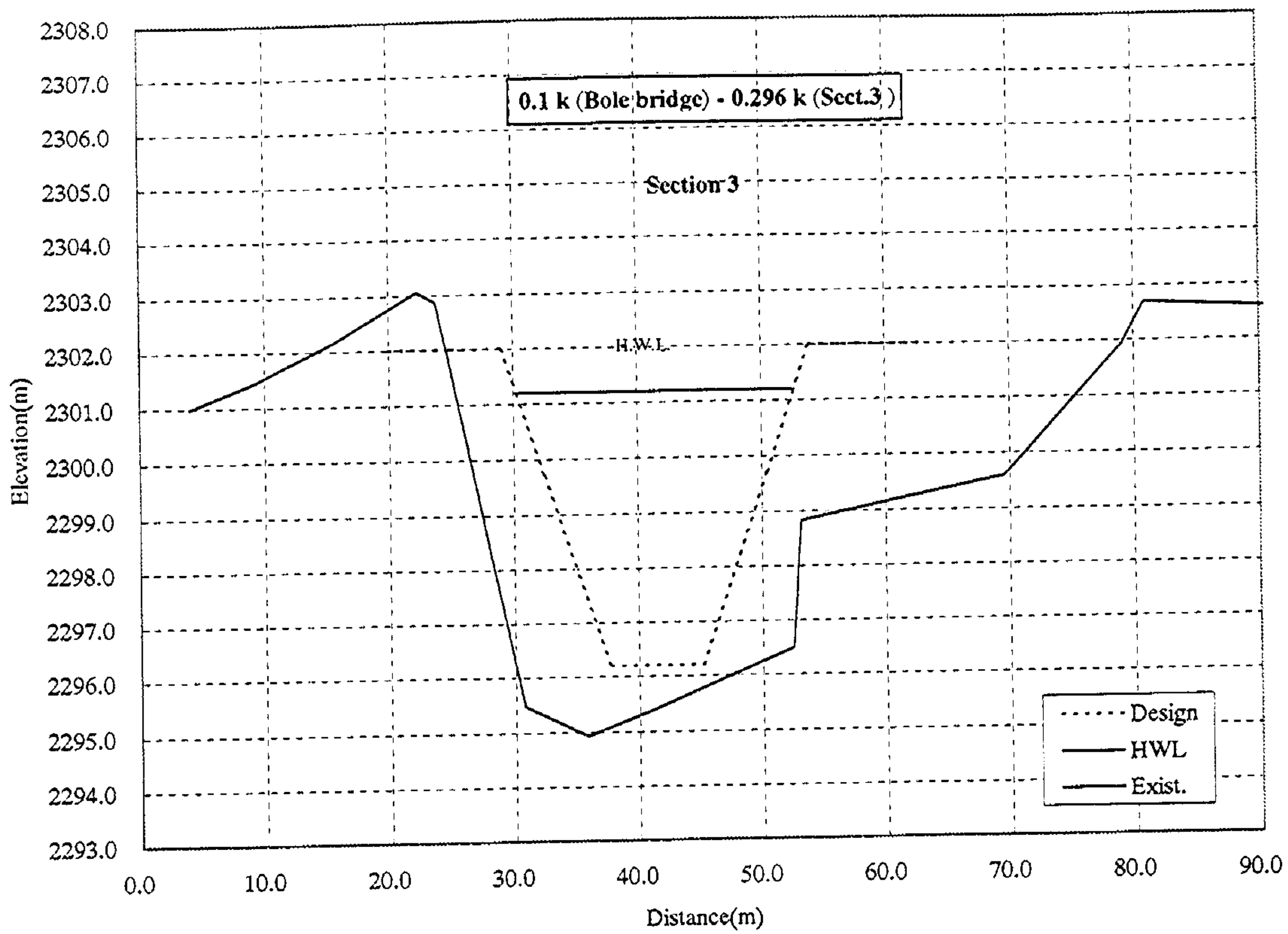


Figure 4.3.5 Section of Lower Kebena River(4/4)

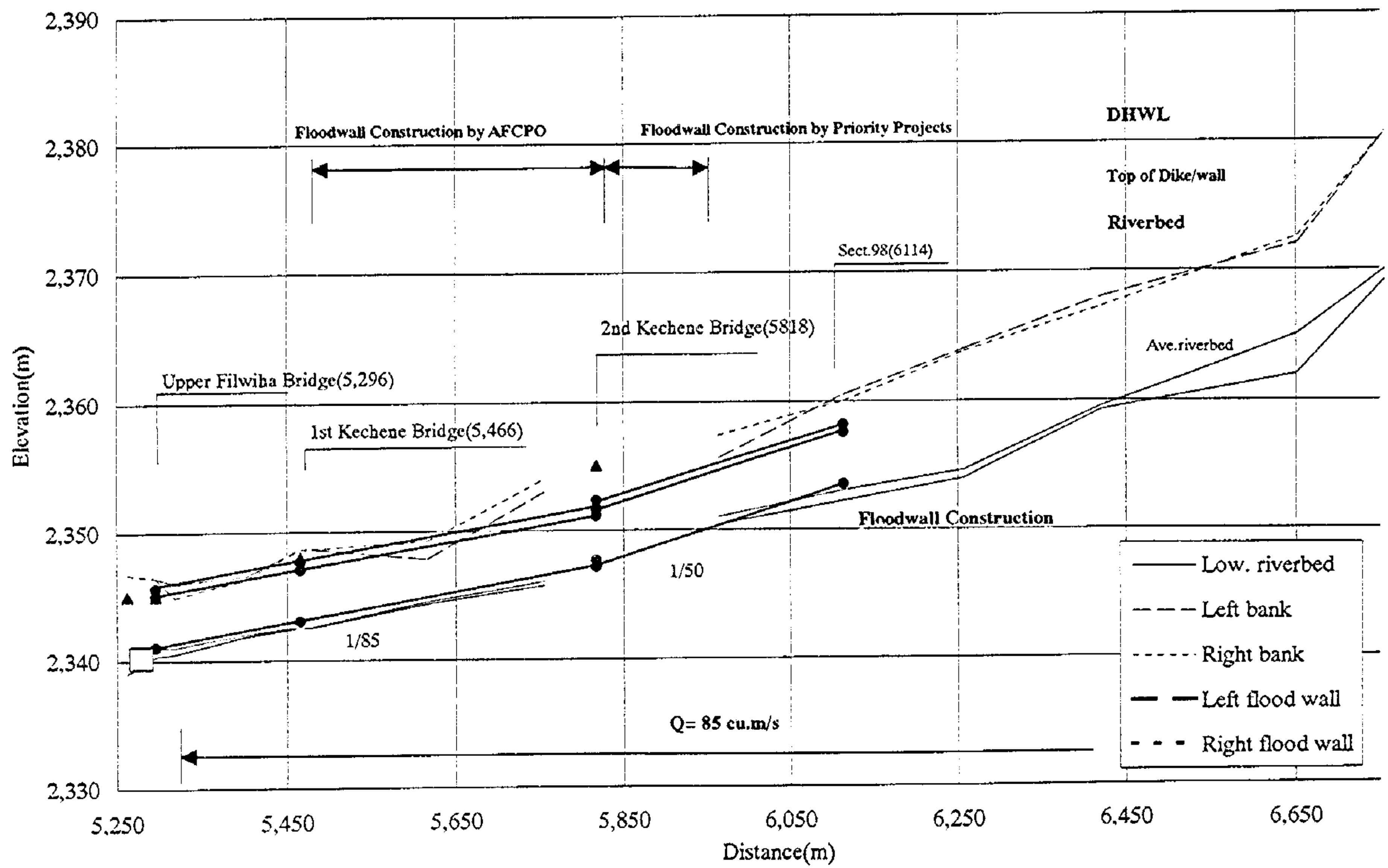


Figure 4.3.6 Longitudinal Profile of the Lower Kechene

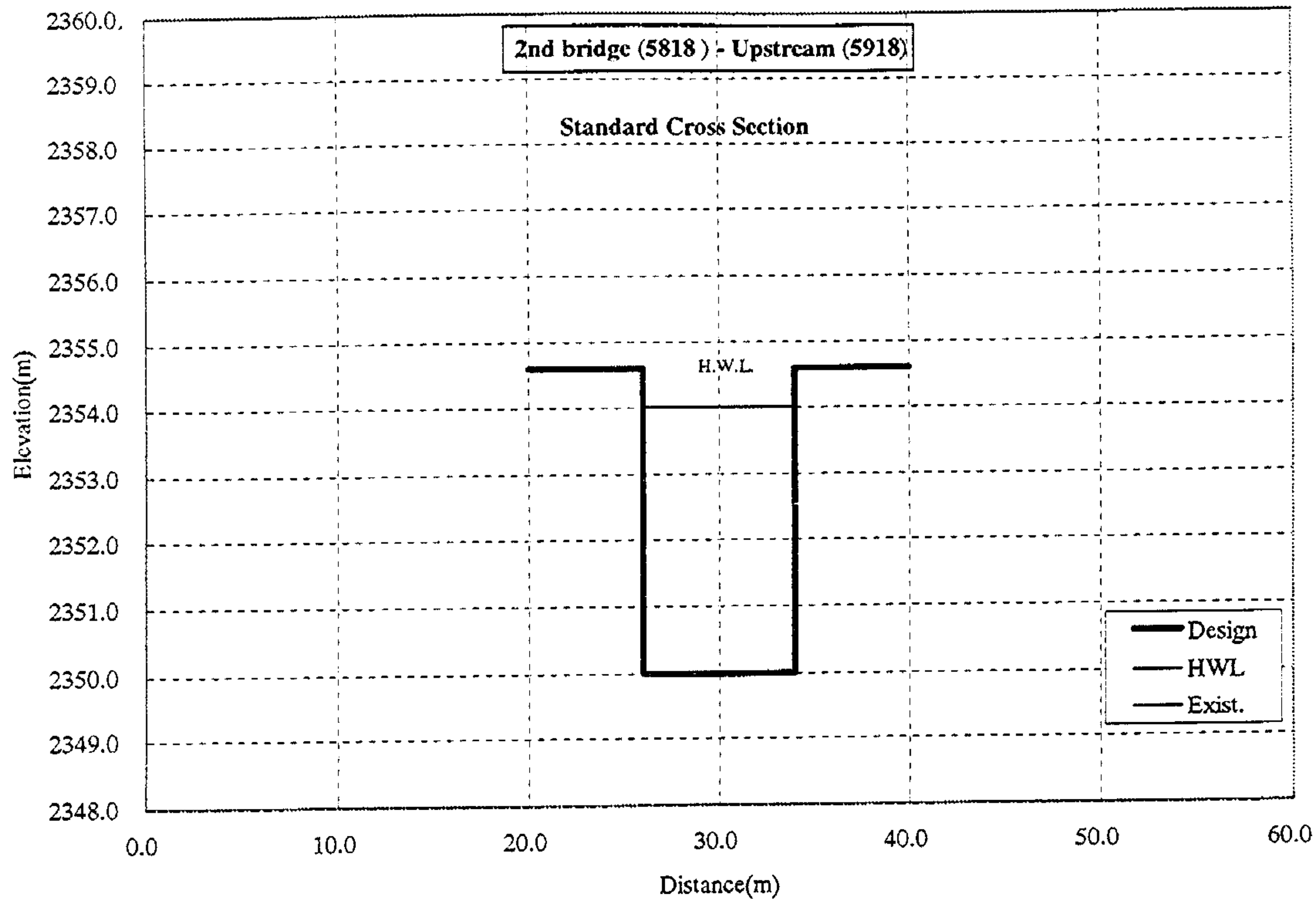


Figure 4.3.7 Section of Lower Kechene River(1/2)

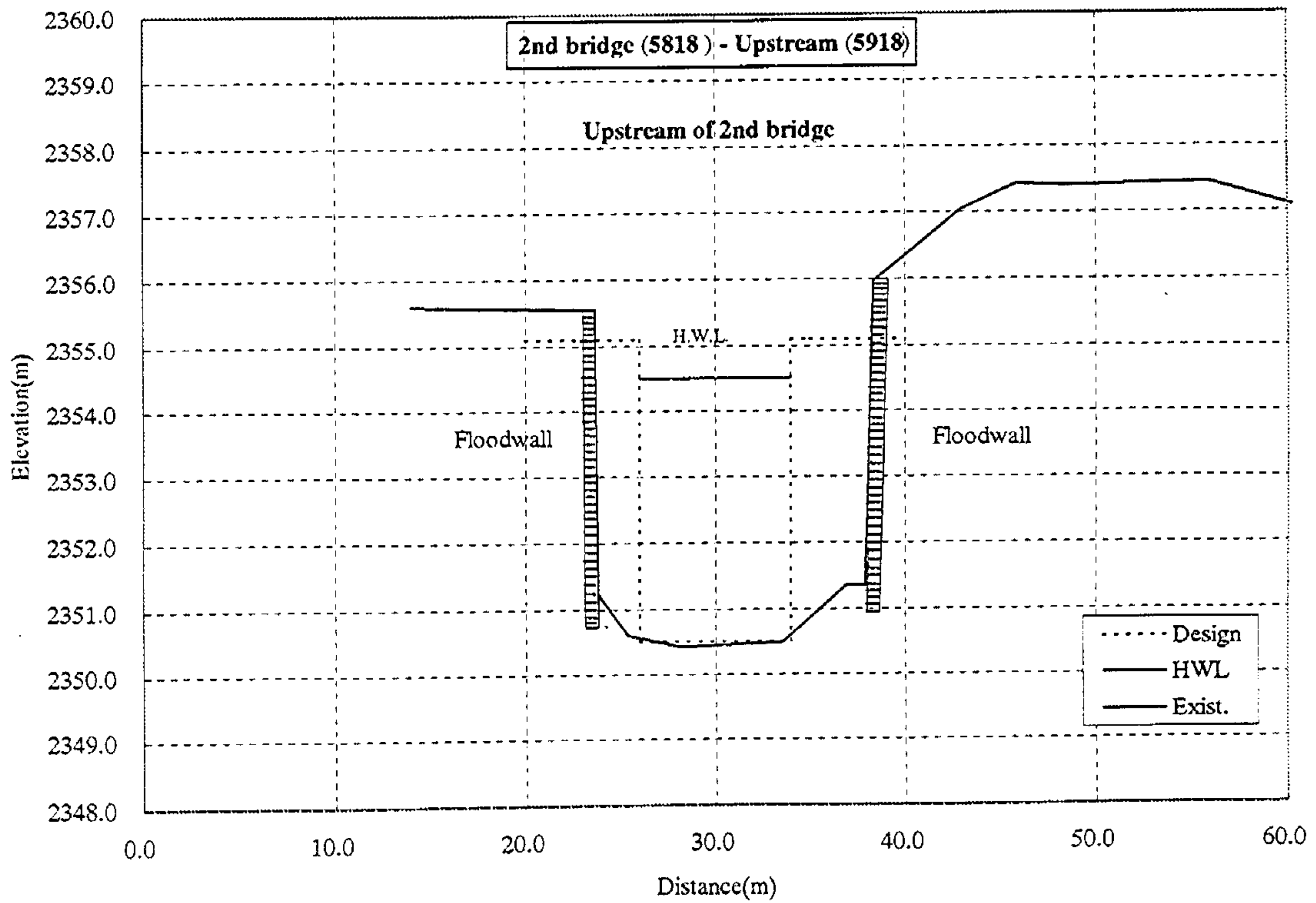
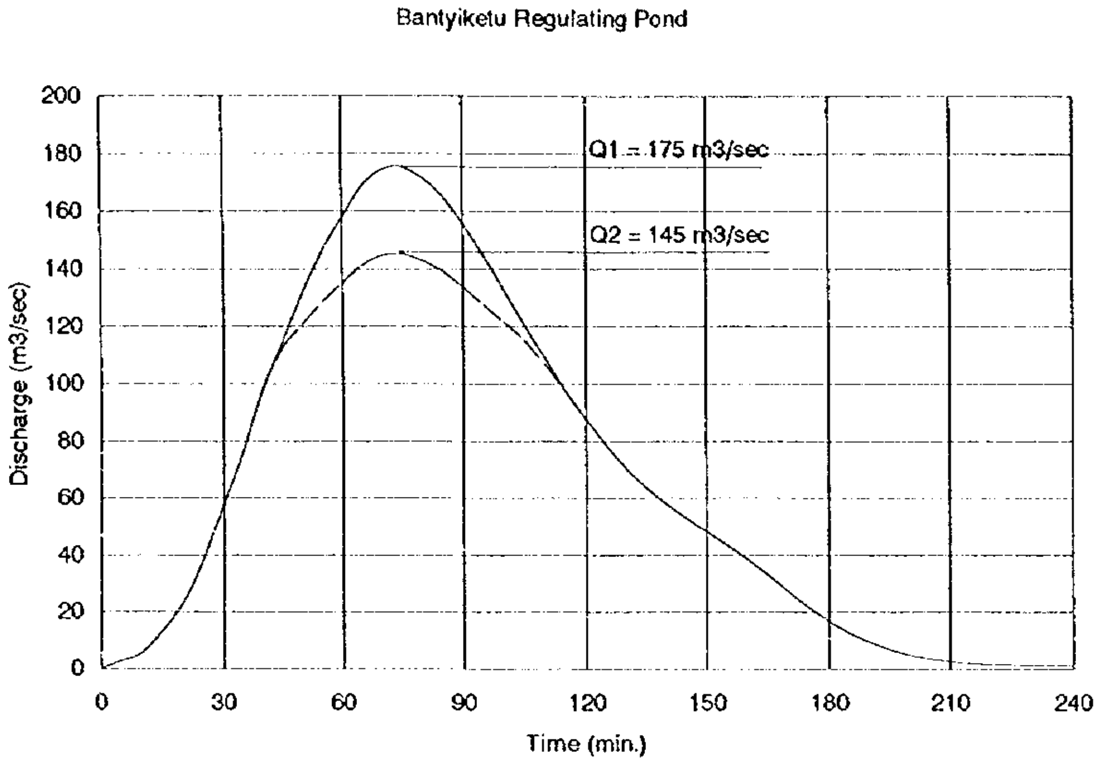


Figure 4.3.7 Section of Lower Kechene River(2/2)



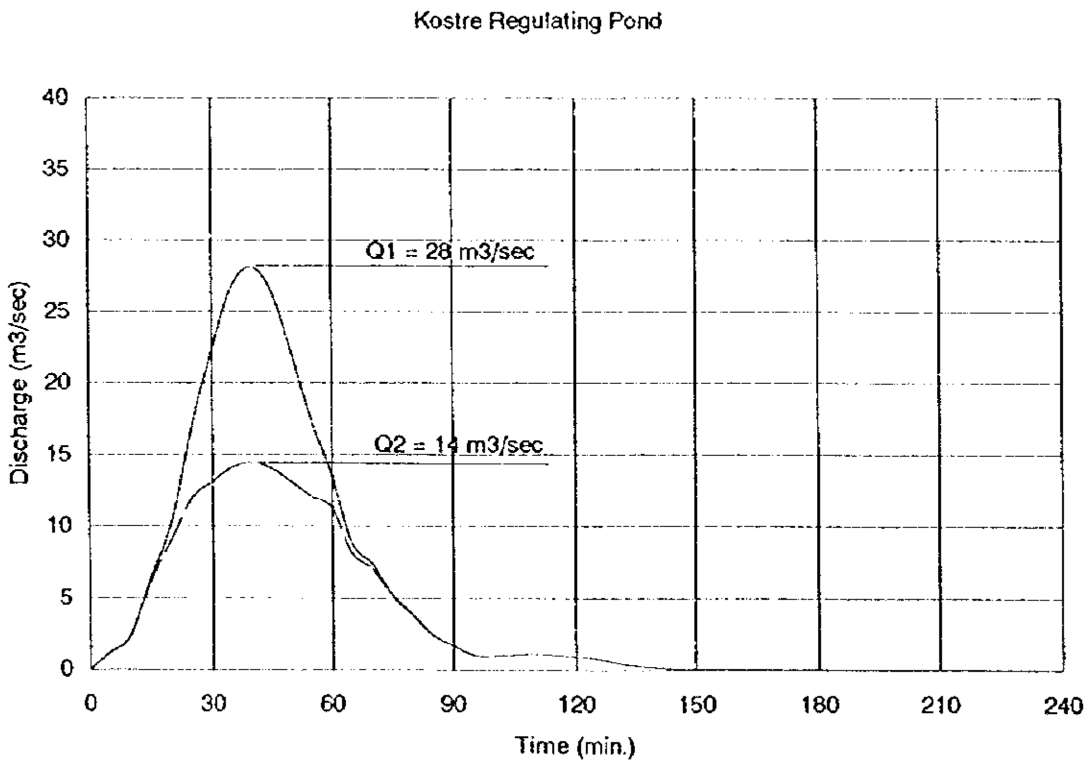


Figure 4.3.8 Flood Control Plan by Regulating Pond

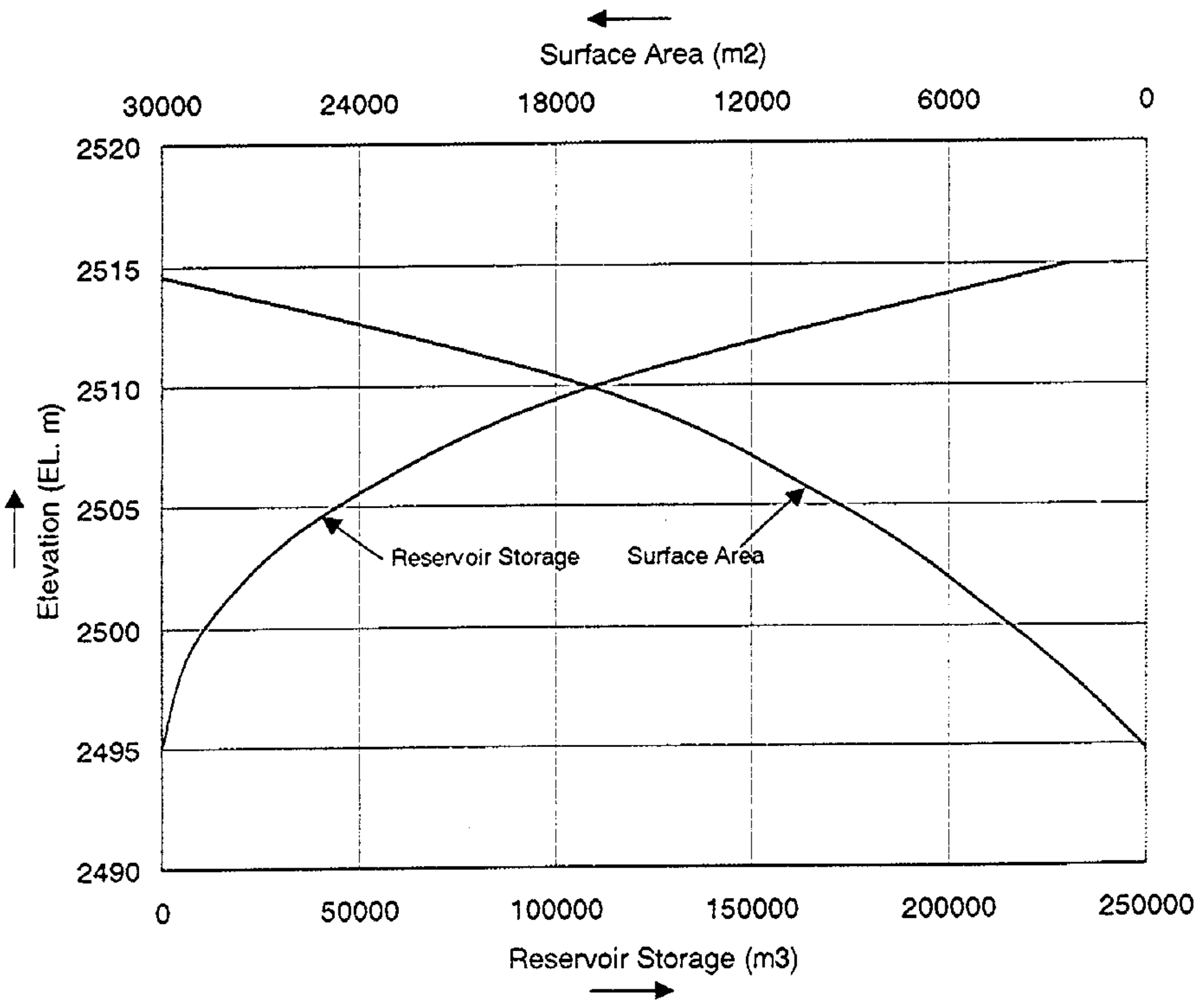
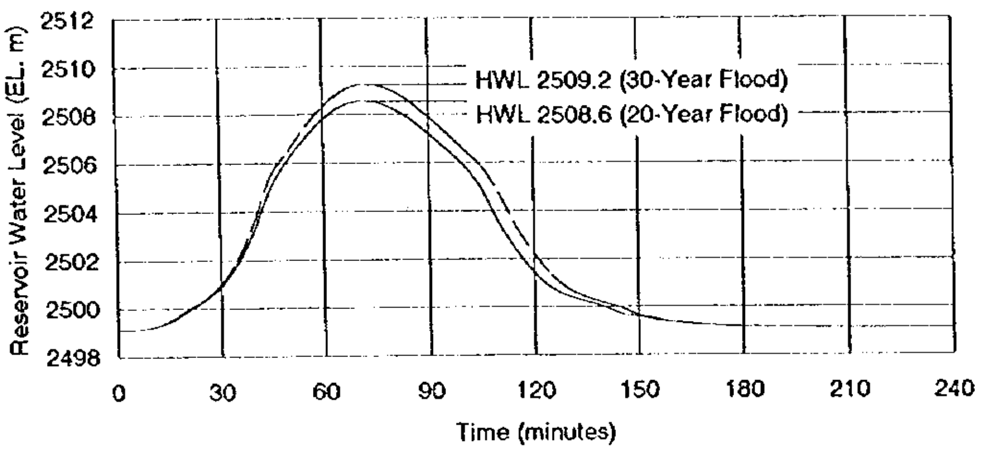
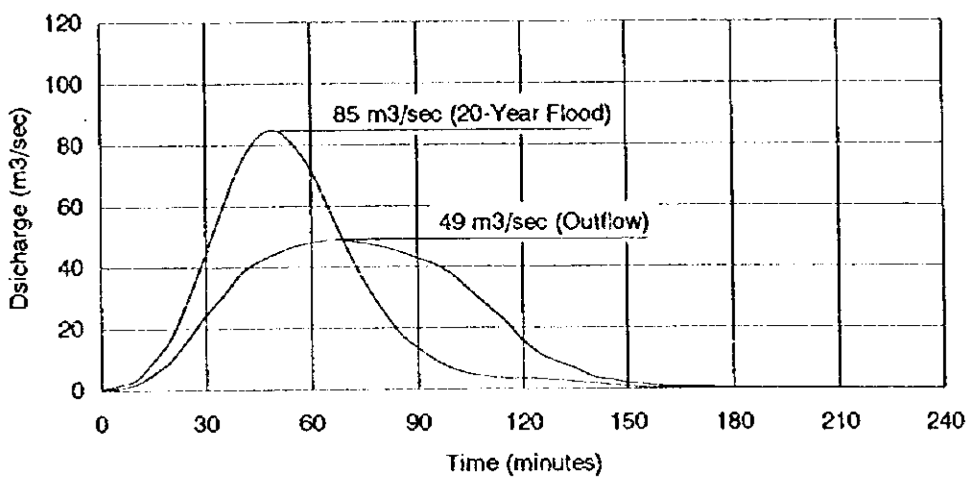


Figure 4.3.9 Elevation, Reservoir Storage and Surface Area of Kechene Weir

Reservoir Water Level



Inflow - Outflow Hydrograph (20-Year Flood)



Inflow - Outflow Hydrograph (30-Year Flood)

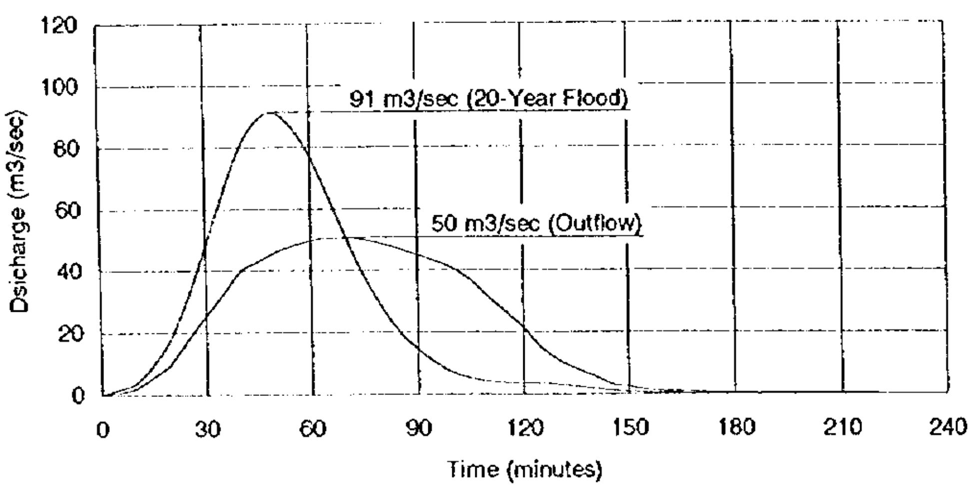


Figure 4.3.10 Flood Control Plan by Kechene Weir

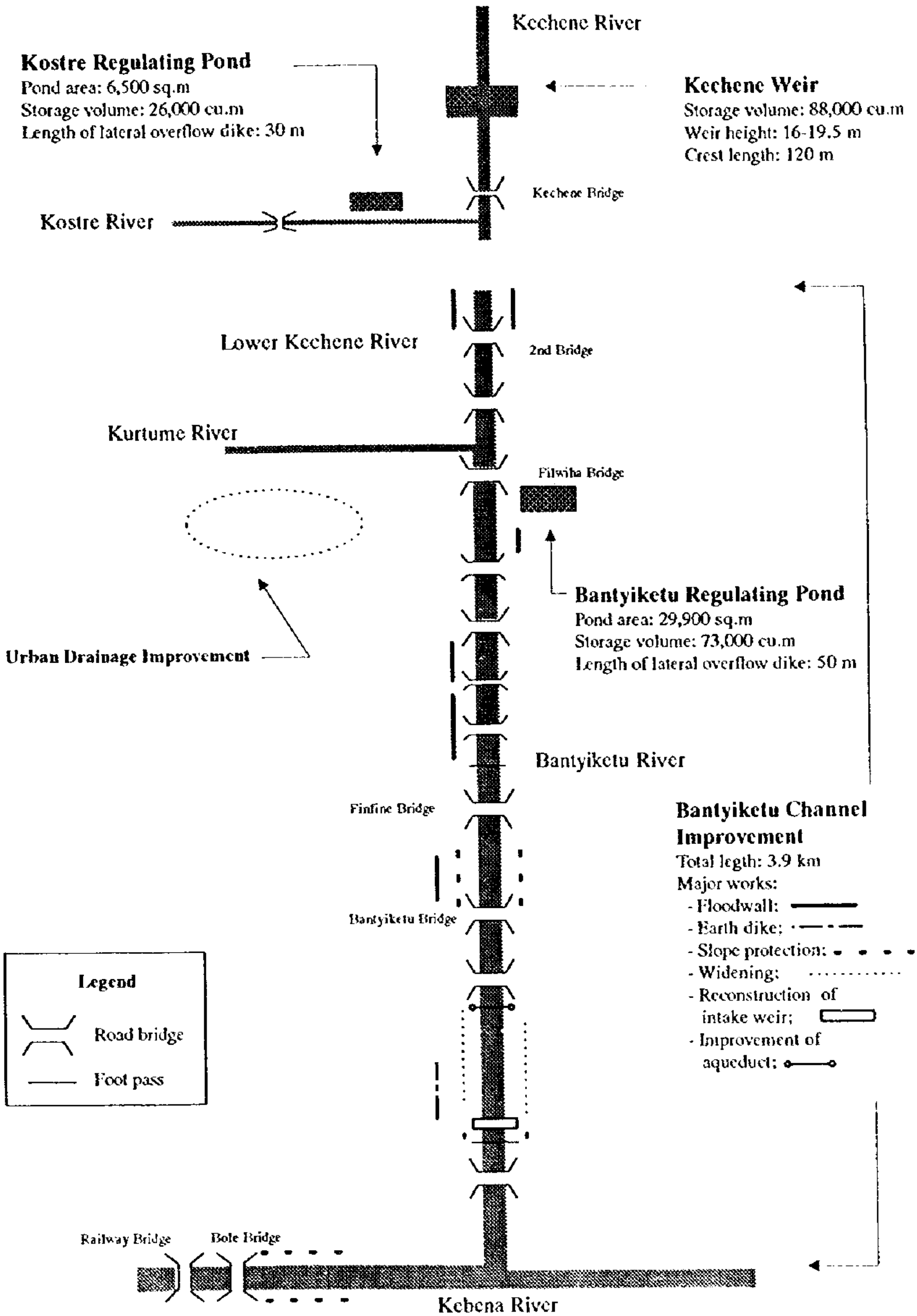


Figure 4.4.1 Outline of Proposed Works of the Priority Projects

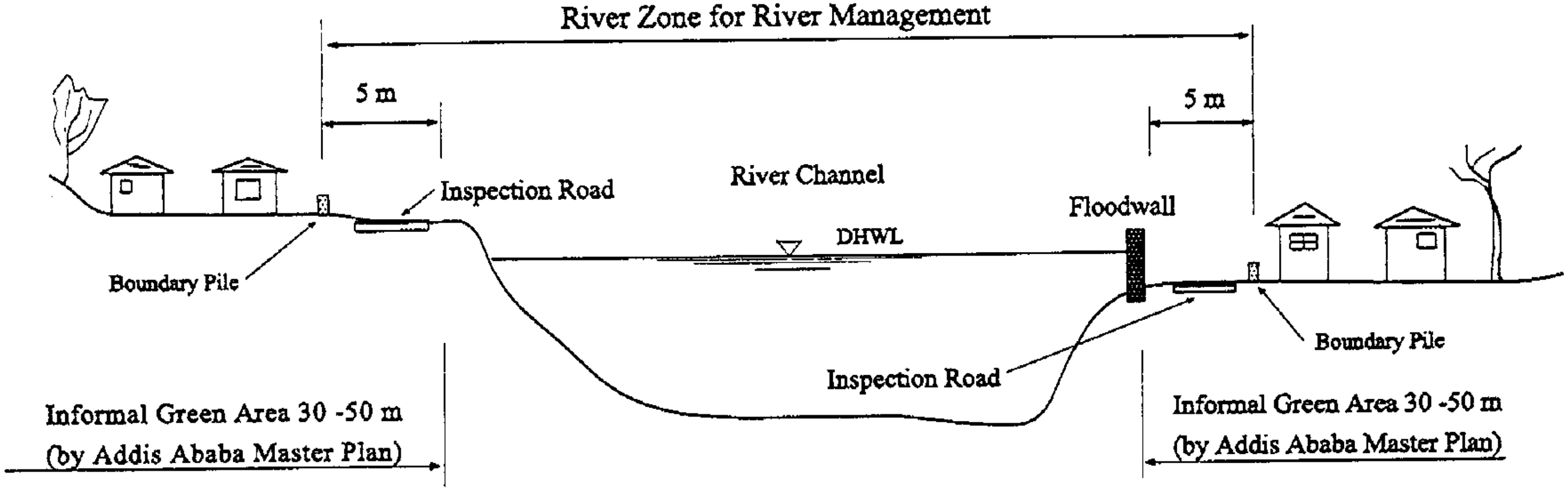


Figure 4.4.2 Concept of River Zone for River Management

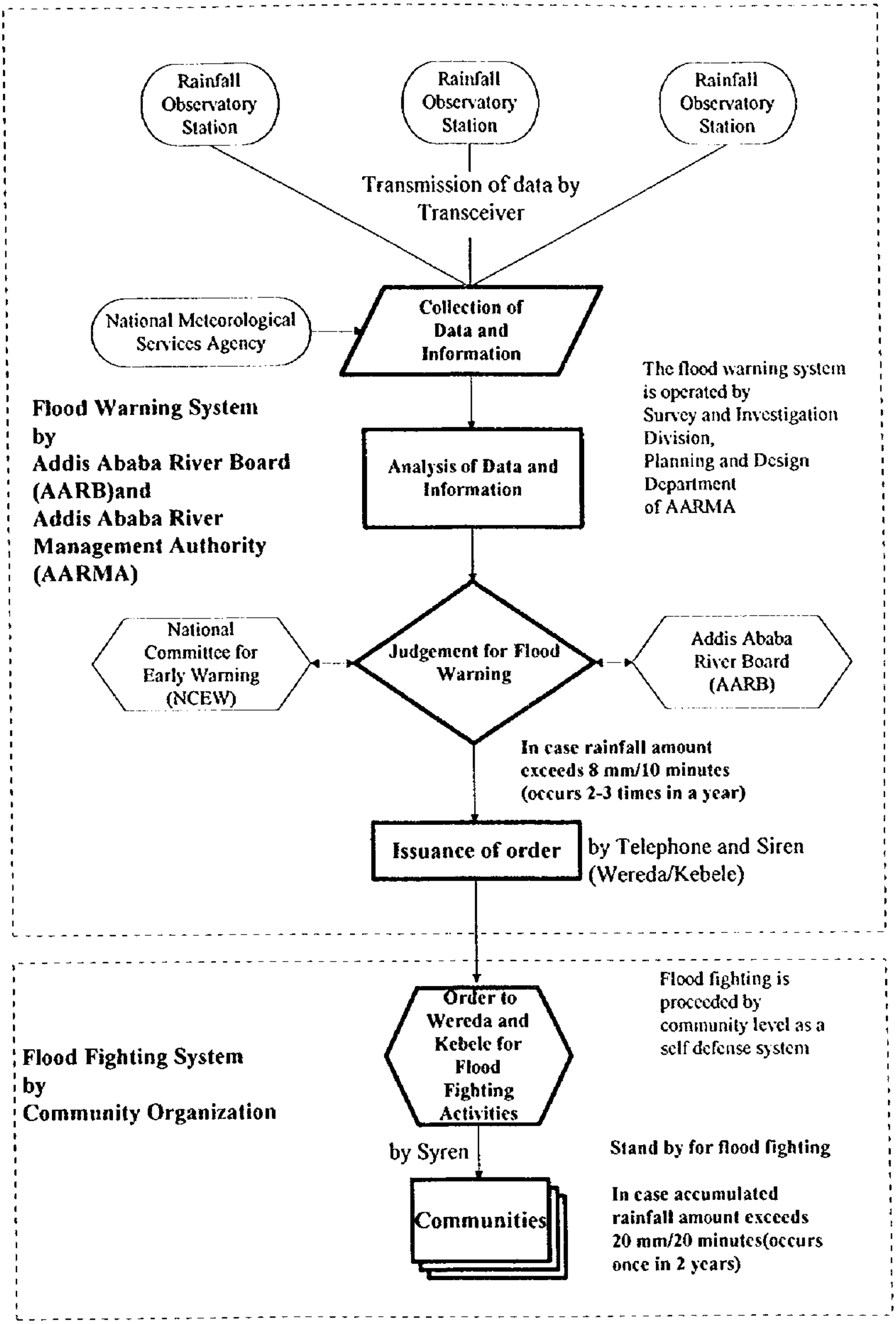


Figure 4.4.3 Outline of the Flood Warning System

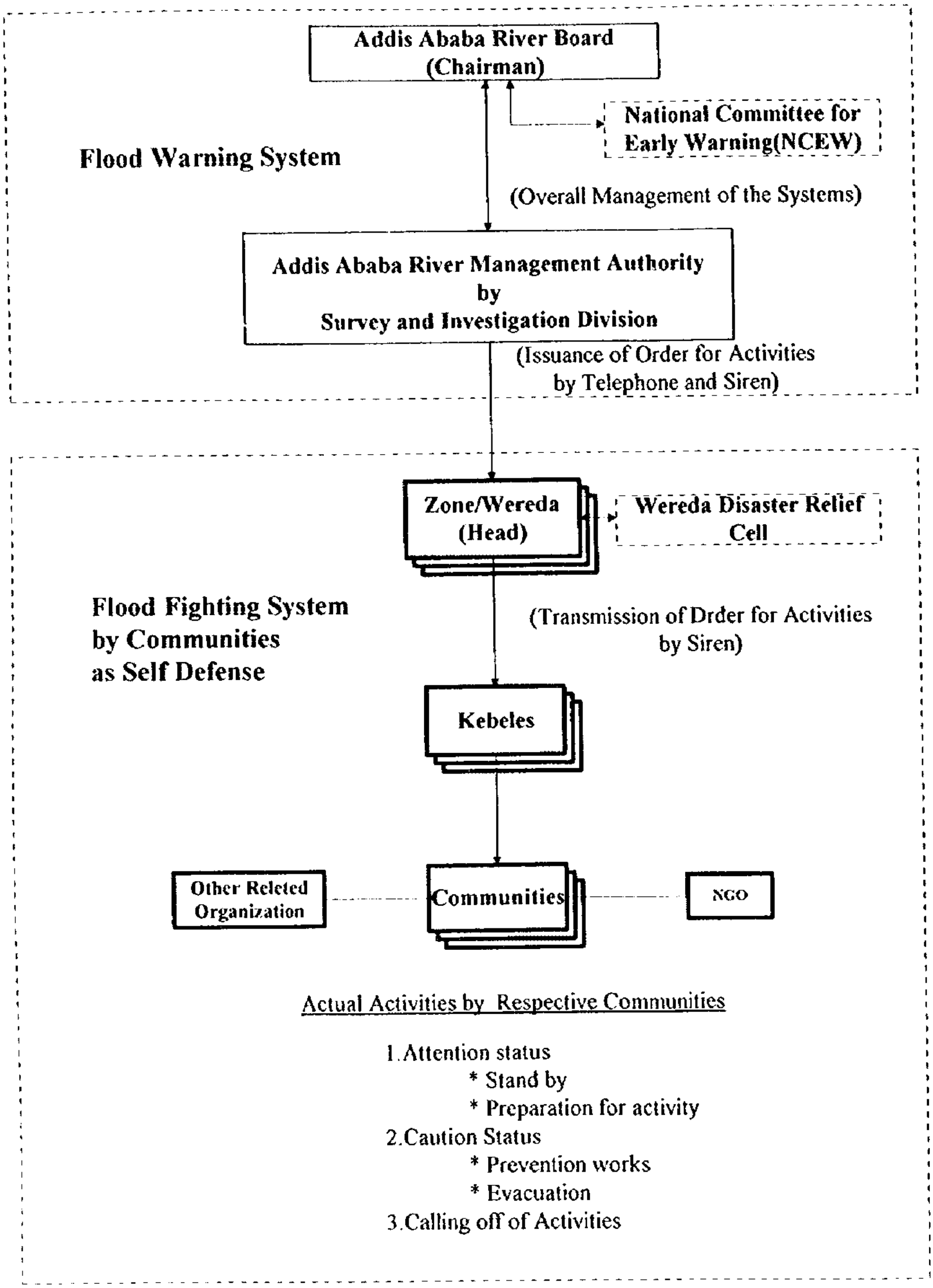


Figure 4.4.4 Community Organization and Communication Chart for Flood Fighting