PART II

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PART II

LIST OF TABLES

Design water depth and level
of Khlong Chawang (F/S area)

	Design probability year			1/50		1/10		1/5		1/2	
	Station	River bed elev (m)	Dist (m)	Depth (m)	Water level (m) ①	Depth (m)	Water level (m) ②	Depth (m)	Water level (m) ③	Depth (m)	Water level (m) ④
	No. 338	66.50	13.517	2.10	68.60	1.87	68.37	1.59	68.09	1.39	67.89
*1	No. 342	69.67	13.957	2.50	72.17	2.17	71.84	1.73	71.40	1.46	71.13
	No. 347	75.22	14.507	1.80	77.02	1.55	76.77	1.23	76.45	1.04	76.26
	No. 352	80.86	15.039	2.32	83.18	2.02	82.88	1.59	82.45	1.32	82.18
	No. 357	86.61	15.547	3.43	90.04	3.08	89.70	2.62	89.23	2.33	88.94
	No. 362	90.93	16.041	3.81	94.74	3.37	94.30	2.80	93.73	2.43	93.36
	No. 365	94.86	16.343	3.84	98.70	3.40	98.26	2.83	97.69	2.47	97.33
*2	No. 367	97.51	16.543	3.57	101.08	2.97	100.48	2.30	99.81	2.03	99.54

	Station	River bed elev (m)	Dist (m)	Difference in water level (m) ①-②	(m) ①-③	(m) ①-④
	No. 338	66.50	13.517	0.23	0.51	0.71
*1	No. 342	69.67	13.957	0.33	0.77	1.04
	No. 347	75.22	14.507	0.25	0.57	0.76
	No. 352	80.86	15.039	0.30	0.73	1.00
	No. 357	86.61	15.547	0.34	0.81	1.10
	No. 362	90.93	16.041	0.44	1.01	1.38
	No. 365	94.86	16.343	0.44	1.01	1.37
*2	No. 367	97.51	16.543	0.60	1.27	1.54

*1.*2 lower boundary and upper boundary of F/S area, respectively
Dist is distance in meter from route 4009

Table 1. Design water level of Khlong Chawang (Ban Na San F/S Area).

Design water depth and level
of Khlong Ta Di (F/S area)

	Design probability year			1/50		1/10		1/5		1/2	
	Station	River bed elev (m)	Dist (m)	Depth (m)	Water level (m) ①	Depth (m)	Water level (m) ②	Depth (m)	Water level (m) ③	Depth (m)	Water level (m) ④
	No. 80	26.62	8.000	6.79	33.41	5.42	32.04	4.60	31.22	3.67	30.29
	No. 85	27.26	8.500	6.59	33.85	5.25	32.51	4.46	31.72	3.53	30.79
*1	No. 90	28.14	9.000	6.02	34.16	4.77	32.91	4.02	32.16	3.15	31.29
	No. 95	28.59	9.500	6.08	34.67	4.85	33.44	4.11	32.70	3.21	31.80
	No. 100	28.41	10.000	6.75	35.16	5.55	33.96	4.82	33.23	3.92	32.33
	No. 105	30.33	10.500	5.40	35.73	4.25	34.58	3.55	33.88	2.70	33.03
	No. 110	31.25	11.000	5.42	36.67	4.37	35.62	3.73	34.98	2.97	34.22
	No. 115	32.45	11.500	5.11	37.56	4.12	36.57	3.47	35.92	2.65	35.10
	No. 120	33.63	12.000	5.08	38.71	4.03	37.66	3.34	36.97	2.41	36.04
	No. 125	34.57	12.500	5.07	39.64	3.92	38.49	3.19	37.76	2.28	36.85
	No. 130	35.64	13.000	4.67	40.31	3.58	39.22	2.89	38.53	2.05	37.69
*2	No. 135	37.27	13.500	3.99	41.26	3.13	40.40	2.57	39.84	1.88	39.15

	Station	River bed elev (m)	Dist (m)	Difference in water level (m) ①-②	(m) ①-③	(m) ①-④
	No. 80	26.62	8.000	1.37	2.19	3.12
	No. 85	27.26	8.500	1.34	2.13	3.06
*1	No. 90	28.14	9.000	1.25	2.09	2.87
	No. 95	28.59	9.500	1.23	1.97	2.87
	No. 100	28.41	10.000	1.20	1.93	2.83
	No. 105	30.33	10.500	1.15	1.85	2.70
	No. 110	31.25	11.000	1.05	1.69	2.45
	No. 115	32.45	11.500	0.99	1.64	2.46
	No. 120	33.63	12.000	1.05	1.74	2.67
	No. 125	34.57	12.500	1.15	1.88	2.79
	No. 130	35.64	13.000	1.09	1.78	2.62
*2	No. 135	37.27	13.500	0.86	1.42	2.11

*1.*2 lower boundary and upper boundary of F/S area, respectively
Dist is distance in meter from route 4015

Table 2. Design water level of Khlong Ta Di (Lan Saka F/S Area).

Steady flow F/S 50 UP CHAWANG FR (Non-uniform flow)

	№	x (m)	Q (m³/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
	0RID	0.000	1048.000	4.280	33.780	4.263		3.031	0.535
	1RID	3330.000	1048.000	4.263	40.523		4.263	3.031	0.539
	239III	3334.000	908.000	4.781	40.821	3.868		2.774	0.325
	240III	3420.000	908.000	4.709	40.909		3.554	2.425	0.293
	241III	3520.000	908.000	4.804	41.004	4.029		2.134	0.249
	242III	3626.000	908.000	4.669	40.959		4.655	2.455	0.353
	243III	3734.000	908.000	4.968	41.088	3.120		2.579	0.311
	244III	3824.000	908.000	4.584	41.074	4.392	3.435	2.990	0.431
	245III	3922.000	908.000	4.530	41.160	4.466	4.506	3.298	0.470
	251III	4508.000	908.000	4.491	41.991	3.984	4.241	3.065	0.400
	256III	4982.000	908.000	4.115	42.545	4.308	3.860	2.722	0.458
	261III	5532.000	908.000	4.236	43.366	3.757	4.226	2.733	0.414
	266III	6014.000	908.000	3.856	43.996	3.303	3.432	2.313	0.407
	271III	6516.000	908.000	3.867	45.157	6.462	5.296	3.867	1.000
	276II	7044.000	908.000	6.958	48.758	3.909	4.449	2.558	0.172
	281II	7540.000	908.000	6.268	48.848	3.357	3.940	2.505	0.212
	286II	8038.000	908.000	5.035	49.025	4.642	4.493	3.631	0.510
	291II	8536.000	908.000	4.636	49.846	3.156	3.728	2.740	0.425
	295II	8962.000	908.000	3.343	50.503	4.085	3.367	3.093	0.862
	301II	9482.000	908.000	4.341	52.611	3.050	3.281	2.280	0.319
	304II	9860.000	908.000	3.610	52.940	2.437	3.127	2.356	0.456
	306I	10028.000	713.000	3.205	53.305	2.273	2.093	1.697	0.344
	311I	10552.000	713.000	2.462	54.342	2.538	2.591	2.050	0.700
	315I	10970.000	713.000	2.734	56.154	3.023	2.897	2.413	0.754
	320I	11494.000	713.000	3.064	58.084	2.119	2.496	1.769	0.430
	324I	11968.000	713.000	2.319	59.889	2.773	2.597	2.301	0.985
	329I	12548.000	713.000	3.364	63.324	2.016	2.321	1.866	0.368
	333I	12937.000	713.000	1.762	64.412	1.708	1.688	1.486	0.761
	338I	13517.000	713.000	2.103	68.603	1.976	2.323	2.103	1.000
O	342I	13957.000	544.000	2.504	72.174	2.073	2.244	2.048	0.679
O	347I	14507.000	544.000	1.796	77.016	1.778	1.802	1.796	1.000
O	352I	15039.000	544.000	2.323	83.183	2.158	2.195	2.323	1.000
O	357I	15547.000	544.000	3.428	90.038	3.356	3.172	3.428	1.000
O	362I	16041.000	544.000	3.811	94.741	3.420	3.767	3.811	1.000
O	365I	16343.000	544.000	3.839	98.699	3.549	3.564	3.839	1.000
O	367I	16543.000	544.000	3.567	101.077		2.305	2.467	0.283

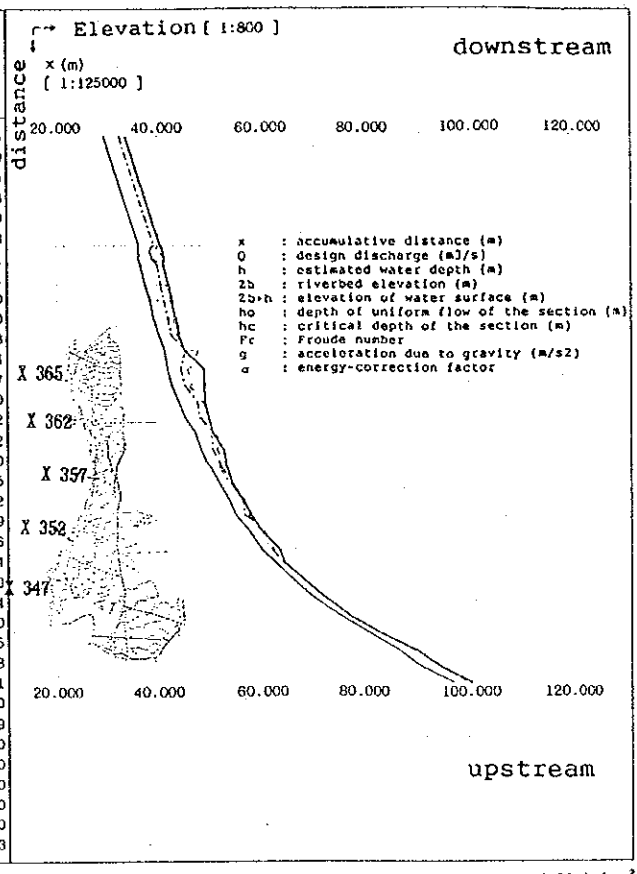


Table 3. Hydraulic profile for 1:50 discharge.

α = 1.000, g = 9.80 (m/sec²)

Steady flow F/S 10 UP CHAWANG FR (Non-uniform flow)

	№	x (m)	Q (m³/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
	0RID	0.000	818.000	3.768	33.268	3.754		2.660	0.524
	1RID	3330.000	818.000	3.754	40.014		3.754	2.660	0.528
	239III	3334.000	710.000	4.224	40.264	3.446		2.503	0.322
	240III	3420.000	710.000	4.151	40.351		3.132	2.153	0.286
	241III	3520.000	710.000	4.239	40.439	3.513		1.871	0.239
	242III	3626.000	710.000	4.120	40.410		4.065	2.106	0.343
	243III	3734.000	710.000	4.409	40.529	2.755		2.257	0.301
	244III	3824.000	710.000	4.019	40.509	3.918	3.059	2.600	0.460
	245III	3922.000	710.000	3.971	40.601	3.996	4.030	2.936	0.497
	251III	4508.000	710.000	3.989	41.489	3.578	3.801	2.773	0.408
	256III	4982.000	710.000	3.641	42.071	3.803	3.415	2.384	0.453
	261III	5532.000	710.000	3.746	42.876	3.329	3.735	2.444	0.409
	266III	6014.000	710.000	3.396	43.506	2.906	3.017	2.010	0.404
	271III	6516.000	710.000	3.410	44.700	5.795	4.680	3.315	0.954
	276II	7044.000	710.000	6.209	48.009	3.435	3.904	2.203	0.163
	281II	7540.000	710.000	5.515	48.095	2.936	3.446	2.159	0.209
	286II	8038.000	710.000	4.351	48.341	4.155	4.020	3.204	0.542
	291II	8536.000	710.000	4.052	49.262	2.767	3.270	2.375	0.412
	295II	8962.000	710.000	2.889	50.049	3.607	2.965	2.548	0.857
	301II	9482.000	710.000	3.902	52.172	2.678	2.877	1.994	0.298
	304II	9860.000	710.000	3.166	52.496	2.149	2.756	2.063	0.452
	306I	10028.000	557.000	2.740	52.840	1.985	1.830	1.461	0.347
	311I	10552.000	557.000	2.131	54.011	2.238	2.285	1.814	0.723
	315I	10970.000	557.000	2.475	55.895	2.707	2.598	2.173	0.738
	320I	11494.000	557.000	2.698	57.718	1.836	2.164	1.510	0.407
	324I	11968.000	557.000	2.049	59.619	2.457	2.304	2.045	0.996
	329I	12548.000	557.000	3.060	63.020	1.765	2.030	1.617	0.337
	333I	12937.000	557.000	1.510	64.160	1.484	1.467	1.276	0.762
	338I	13517.000	557.000	1.873	68.373	1.744	2.043	1.831	0.960
O	342I	13957.000	425.000	2.173	71.843	1.851	1.999	1.614	0.696
O	347I	14507.000	425.000	1.552	76.772	1.557	1.578	1.552	1.000
O	352I	15039.000	425.000	2.017	82.877	1.894	1.927	2.017	1.000
O	357I	15547.000	425.000	3.079	89.689	3.016	2.857	3.079	1.000
O	362I	16041.000	425.000	3.372	94.302	3.046	3.343	3.372	1.000
O	365I	16343.000	425.000	3.401	98.261	3.175	3.187	3.401	1.000
O	367I	16543.000	425.000	2.970	100.480		2.174	2.327	0.384

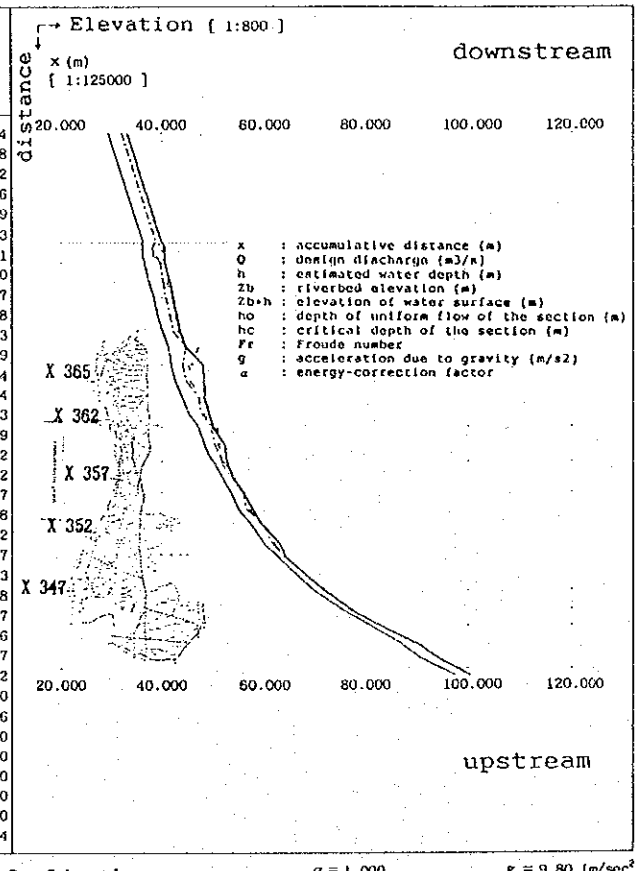


Table 4. Hydraulic profile for 1:10 discharge.

α = 1.000, g = 9.80 (m/sec²)

Steady flow F/S 5 UP CHAWANG P (Non-uniform flow)

	№	x (m)	Q (m³/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
	ORID	0.000	550.000	3.082	32.582	3.070		2.178	0.509
	1RID	3330.000	550.000	3.070	39.330		3.070	2.178	0.513
	239III	3334.000	477.000	3.480	39.520	2.881		2.145	0.319
	240III	3420.000	477.000	3.406	39.606		2.568	1.794	0.274
	241III	3520.000	477.000	3.484	39.684	2.827		1.506	0.222
	242III	3626.000	477.000	3.398	39.676		3.260	1.647	0.316
	243III	3734.000	477.000	3.656	39.776	2.258		1.835	0.286
	244III	3824.000	477.000	3.270	39.760	3.253	2.531	2.109	0.451
	245III	3922.000	477.000	3.221	39.851	3.348	3.377	2.323	0.558
	251III	4508.000	477.000	3.334	40.834	3.027	3.207	2.341	0.422
	256III	4982.000	477.000	3.015	41.445	3.122	2.807	1.930	0.436
	261III	5532.000	477.000	3.089	42.219	2.753	3.076	1.990	0.405
	266III	6014.000	477.000	2.742	42.852	2.365	2.455	1.618	0.397
	271III	6516.000	477.000	2.867	44.157	4.799	3.785	2.641	0.865
	276II	7044.000	477.000	5.008	46.808	2.790	3.168	1.733	0.158
	281II	7540.000	477.000	4.320	46.900	2.363	2.774	1.702	0.214
	286II	8088.000	477.000	3.355	47.345	3.462	3.350	2.618	0.614
	291II	8536.000	477.000	3.314	48.524	2.237	2.644	1.689	0.380
	295II	8962.000	477.000	2.302	49.462	2.939	2.392	1.966	0.775
	301II	9482.000	477.000	3.220	51.490	2.180	2.338	1.592	0.280
	304II	9860.000	477.000	2.513	51.843	1.762	2.250	1.676	0.467
	306I	10028.000	375.000	2.095	52.195	1.601	1.475	1.153	0.366
	311I	10552.000	375.000	1.710	53.590	1.839	1.876	1.460	0.760
	315I	10970.000	375.000	2.124	55.544	2.283	2.195	1.860	0.712
	320I	11494.000	375.000	2.191	57.211	1.461	1.720	1.173	0.377
	324I	11968.000	375.000	1.711	59.281	2.034	1.911	1.711	1.000
	329I	12548.000	375.000	2.549	62.509	1.429	1.641	1.291	0.310
	333I	12937.000	375.000	1.169	63.819	1.189	1.175	1.005	0.777
	338I	13517.000	375.000	1.585	68.085	1.433	1.672	1.478	0.877
O	342I	13957.000	285.000	1.731	71.401	1.557	1.672	1.508	0.740
O	347I	14507.000	285.000	1.231	76.451	1.262	1.278	1.231	1.000
O	352I	15039.000	285.000	1.594	82.454	1.536	1.562	1.594	1.000
O	357I	15547.000	285.000	2.624	89.234	2.561	2.435	2.624	1.000
O	362I	16041.000	285.000	2.802	93.732	2.547	2.781	2.802	1.000
O	365I	16343.000	285.000	2.832	97.692	2.681	2.691	2.832	1.000
O	367I	16543.000	285.000	2.302	99.812		1.989	2.152	0.705

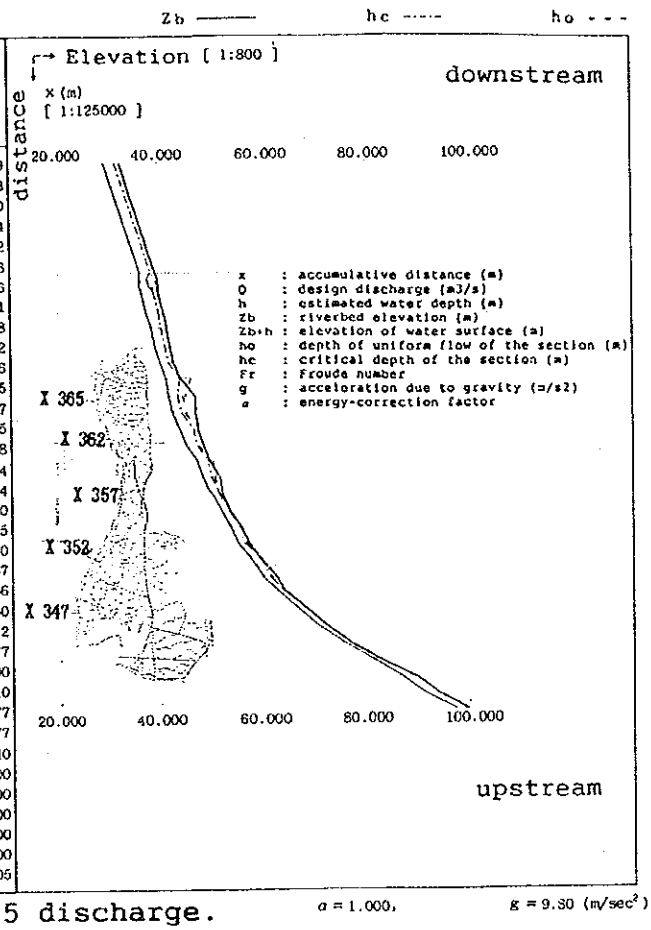


Table 5. Hydraulic profile for 1: 5 discharge.

$\alpha = 1.000$, $g = 9.80$ (m/sec²)

Steady flow F/S 2 UP CHAWANG P (Non-uniform flow)

	№	x (m)	Q (m³/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
	ORID	0.000	397.000	2.620	32.120	2.611		1.865	0.500
	1RID	3330.000	397.000	2.611	38.871		2.611	1.865	0.503
	239III	3334.000	344.000	2.983	39.023	2.505		1.891	0.321
	240III	3420.000	344.000	2.908	39.108		2.193	1.529	0.265
	241III	3520.000	344.000	2.980	39.180	2.374		1.239	0.209
	242III	3626.000	344.000	2.894	39.184		2.717	1.350	0.291
	243III	3734.000	344.000	3.150	39.270	1.925		1.563	0.270
	244III	3824.000	344.000	2.775	39.265	2.786	2.167	1.791	0.431
	245III	3922.000	344.000	2.728	39.358	2.888	2.914	1.666	0.551
	251III	4508.000	344.000	2.886	40.386	2.637	2.798	1.988	0.442
	256III	4982.000	344.000	2.590	41.020	2.659	2.393	1.633	0.416
	261III	5532.000	344.000	2.642	41.772	2.365	2.636	1.652	0.408
	266III	6014.000	344.000	2.306	42.416	2.002	2.077	1.365	0.381
	271III	6516.000	344.000	2.481	43.771	4.030	3.182	2.205	0.807
	276II	7044.000	344.000	4.243	46.043	2.350	2.673	1.424	0.153
	281II	7540.000	344.000	3.560	46.140	1.978	2.321	1.392	0.213
	286II	8038.000	344.000	2.767	46.757	2.982	2.886	2.222	0.647
	291II	8536.000	344.000	2.866	48.076	1.879	2.220	1.525	0.351
	295II	8962.000	344.000	1.919	49.079	2.465	1.999	1.610	0.750
	301II	9482.000	344.000	2.737	51.007	1.838	1.974	1.325	0.270
	304II	9860.000	344.000	2.071	51.401	1.496	1.908	1.401	0.481
	306I	10028.000	270.000	1.674	51.774	1.338	1.234	0.950	0.387
	311I	10552.000	270.000	1.441	53.321	1.564	1.596	1.242	0.738
	315I	10970.000	270.000	1.870	55.290	1.993	1.920	1.653	0.710
	320I	11494.000	270.000	1.856	56.876	1.209	1.423	0.953	0.351
	324I	11968.000	270.000	1.489	59.059	1.747	1.644	1.489	1.000
	329I	12548.000	270.000	2.134	62.004	1.201	1.377	1.070	0.301
	333I	12937.000	270.000	0.947	63.597	0.992	0.981	0.828	0.796
	338I	13517.000	270.000	1.394	67.894	1.229	1.423	1.248	0.805
O	342I	13957.000	206.000	1.459	71.129	1.364	1.459	1.314	0.779
O	347I	14507.000	206.000	1.039	76.259	1.069	1.082	1.027	0.979
O	352I	15039.000	206.000	1.320	82.180	1.297	1.320	1.320	1.000
O	357I	15547.000	206.000	2.332	88.942	2.259	2.152	2.332	1.000
O	362I	16041.000	206.000	2.431	93.361	2.218	2.412	2.431	1.000
O	365I	16343.000	206.000	2.471	97.331	2.363	2.371	2.471	1.000
O	367I	16543.000	206.000	2.034	99.544		1.852	2.034	1.000

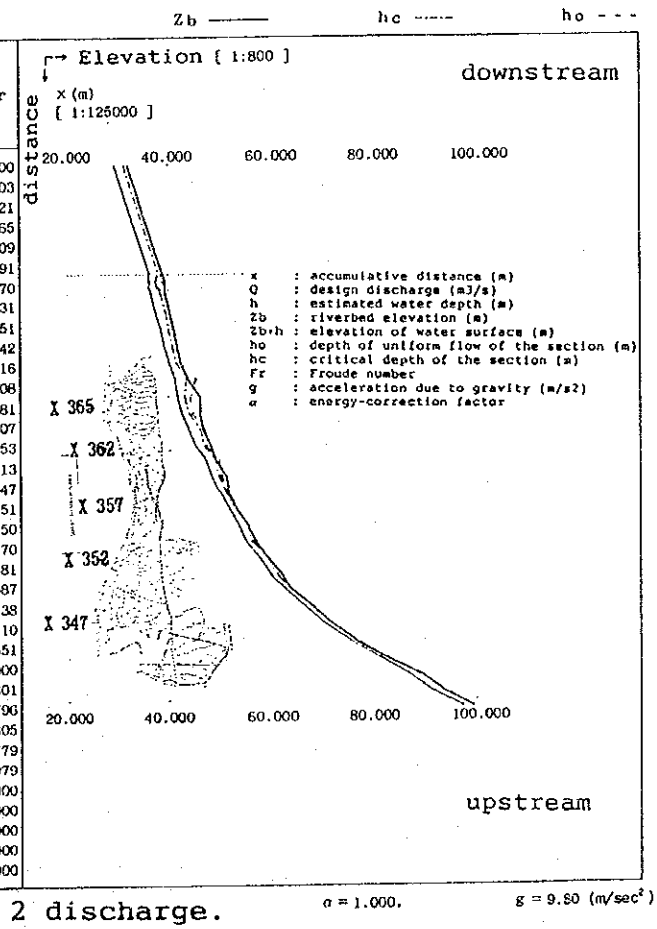


Table 6. Hydraulic profile for 1: 2 discharge.

$\alpha = 1.000$, $g = 9.80$ (m/sec²)

Non-uniform flow F/S 50 UP CHAWANG PR (1/2) $Fr = v / \{ g \cdot A / (D \cdot B) \}^{1/2}$

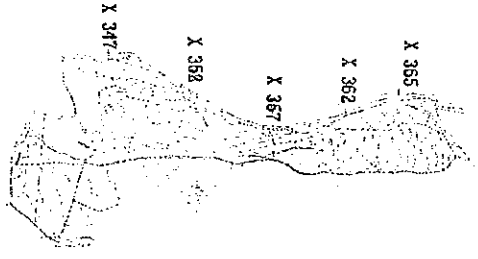
Station No	No	Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m³/sec)	D	N	B (m)	v (m/s)	Fr	A (m²)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-③ (m)
ORID			29.500	33.780	4.280	1048.000	1.064	0.0350	101.400	3.010	0.535	348.196	3.615	0.492	0.333		34.605	
	1	333.000	30.176	34.446	4.270	1048.000	1.064	0.0350	101.349	3.019	0.521	347.157	3.606	0.495	0.336	0.336	35.277	34.604
	2	333.000	30.852	35.118	4.266	1048.000	1.064	0.0350	101.328	3.022	0.522	346.738	3.603	0.496	0.337	0.337	35.951	35.276
	3	333.000	31.528	35.792	4.264	1048.000	1.064	0.0350	101.320	3.024	0.522	346.572	3.601	0.496	0.338	0.338	36.626	35.951
	4	333.000	32.204	36.467	4.263	1048.000	1.064	0.0350	101.317	3.024	0.522	346.506	3.601	0.497	0.338	0.338	37.302	36.626
	5	333.000	32.880	37.143	4.263	1048.000	1.064	0.0350	101.315	3.025	0.523	346.480	3.600	0.497	0.338	0.338	37.978	37.302
	6	333.000	33.556	37.819	4.263	1048.000	1.064	0.0350	101.315	3.025	0.523	346.469	3.600	0.497	0.338	0.338	38.654	37.978
	7	333.000	34.232	38.495	4.263	1048.000	1.064	0.0350	101.315	3.025	0.523	346.465	3.600	0.497	0.338	0.338	39.330	38.653
	8	333.000	34.908	39.171	4.263	1048.000	1.064	0.0350	101.315	3.025	0.523	346.464	3.600	0.497	0.338	0.338	40.006	39.329
	9	333.000	35.584	39.847	4.263	1048.000	1.064	0.0350	101.315	3.025	0.523	346.463	3.600	0.497	0.338	0.338	40.682	40.005
1RID		333.000	36.260	40.523	4.263	1048.000	1.064	0.0350	101.317	3.024	0.539	346.516	3.601	0.497	0.004	0.338	41.024	40.682
239III		4.000	36.040	40.821	4.781	908.000	1.047	0.0350	120.000	1.955	0.325	464.413	3.826	0.204	0.034	0.002	41.059	41.024
240III		86.000	36.200	40.909	4.709	908.000	1.038	0.0350	120.000	1.832	0.293	495.547	4.015	0.178	0.032	0.028	41.119	41.059
241III		100.000	36.200	41.004	4.804	908.000	1.029	0.0350	126.000	1.620	0.249	560.323	4.331	0.138	0.024	0.023	41.166	41.119
242III		106.000	36.290	40.959	4.669	908.000	1.059	0.0350	104.000	2.158	0.353	420.711	4.207	0.252	0.045	0.045	41.256	41.166
243III		108.000	36.120	41.068	4.968	908.000	1.049	0.0350	110.000	1.954	0.311	464.780	4.238	0.204	0.031	0.037	41.323	41.256
244III		90.000	36.490	41.074	4.584	908.000	1.102	0.0350	120.000	2.321	0.431	391.232	3.613	0.303	0.058	0.054	41.435	41.323
245III		98.000	36.630	41.160	4.530	908.000	1.142	0.0350	120.479	2.427	0.470	374.119	3.428	0.343	0.409	0.068	41.913	41.435
251III		586.000	37.500	41.991	4.491	908.000	1.091	0.0350	130.000	2.158	0.400	420.695	3.315	0.259	0.274	0.338	42.524	41.913
256III		474.000	38.430	42.545	4.115	908.000	1.068	0.0350	110.000	2.514	0.458	361.152	3.359	0.344	0.423	0.365	43.312	42.524
261III		550.000	39.130	43.366	4.236	908.000	1.066	0.0350	114.000	2.323	0.414	390.897	3.462	0.293	0.304	0.347	43.963	43.312
266III		482.000	40.110	43.996	3.886	908.000	1.034	0.0350	120.000	2.281	0.407	398.092	3.346	0.274	0.320	0.307	44.590	43.963
271III		502.000	41.290	45.157	3.867	908.000	1.041	0.0350	53.183	5.437	1.000	166.995	3.146	1.570	2.074	1.972	48.801	44.754
276II		528.000	41.800	48.758	6.958	908.000	1.051	0.0350	110.000	1.317	0.172	689.693	6.114	0.093	0.047	0.050	48.898	48.801
281II		496.000	42.580	48.848	6.268	908.000	1.067	0.0350	117.000	1.476	0.212	615.004	5.467	0.119	0.069	0.069	49.036	48.898
286II		498.000	43.990	49.025	5.035	908.000	1.117	0.0350	97.437	2.772	0.510	327.573	3.585	0.438	0.427	0.427	49.890	49.036
291II		498.000	45.210	49.846	4.636	908.000	1.085	0.0350	111.692	2.366	0.425	393.838	4.033	0.310	0.227	0.266	50.383	49.890
295II		426.000	47.160	50.503	3.343	908.000	1.098	0.0350	96.326	3.970	0.862	228.708	2.882	0.883	1.224	1.003	52.610	50.383
301II		520.000	48.270	52.611	4.341	908.000	1.034	0.0350	120.000	1.938	0.319	468.520	3.828	0.198	0.145	0.200	52.955	52.610
304II		378.000	49.330	52.940	3.610	908.000	1.045	0.0350	120.000	2.454	0.456	369.939	3.116	0.321	0.136	0.306	53.397	52.955
306I		168.000	50.100	53.305	3.205	713.000	1.017	0.0350	130.000	1.843	0.344	386.771	2.916	0.176	0.262	0.084	53.743	53.397
311I		524.000	51.880	54.342	2.462	713.000	1.065	0.0350	120.000	2.993	0.700	238.246	2.075	0.487	0.866	1.086	55.695	53.743
315I		418.000	53.420	56.154	2.734	713.000	1.085	0.0350	120.000	3.124	0.754	228.223	1.988	0.541	1.253	0.999	57.947	55.695
320I		524.000	55.020	58.084	3.064	713.000	1.022	0.0350	116.282	2.215	0.430	321.855	2.836	0.256	0.355	0.392	58.695	57.947
324I		474.000	57.570	59.889	2.319	713.000	1.075	0.0350	105.026	3.916	0.985	182.096	1.799	0.841	2.490	2.035	63.219	58.694
329I		580.000	59.960	63.324	3.364	713.000	1.036	0.0350	120.000	1.968	0.368	362.299	3.066	0.205	0.207	0.309	63.735	63.219
333I		389.000	62.650	64.412	1.762	713.000	1.006	0.0350	140.000	3.063	0.761	232.777	1.637	0.482	1.727	1.158	66.621	63.735
338I		580.000	66.500	68.603	2.103	713.000	1.020	0.0350	97.447	4.127	1.000	172.745	1.773	0.886	2.139	2.820	71.629	66.669
○342I		440.000	69.670	72.174	2.504	544.000	1.007	0.0350	90.000	3.005	0.679	181.020	1.936	0.464	1.261	1.009	73.899	71.629
○347I		550.000	75.220	77.016	1.796	544.000	1.013	0.0350	88.763	3.900	1.000	139.472	1.570	0.786	2.717	2.808	80.519	74.994

$\alpha = 1.000$, $g = 9.80$ (m/sec²)

Non-uniform flow F/S 50 UP CHAWANG PR (2/2) $Fr = v / \{ g \cdot A / (D \cdot B) \}^{1/2}$

Station No	No	Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m³/sec)	D	N	B (m)	v (m/s)	Fr	A (m²)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-③ (m)
○352I		532.000	80.860	83.183	2.323	544.000	1.063	0.0350	69.443	4.165	1.000	130.598	1.984	0.941	2.166	2.268	86.289	81.856
○357I		508.000	86.610	90.038	3.428	544.000	1.108	0.0350	50.000	4.583	1.000	118.700	2.414	1.187	1.962	2.018	93.188	89.208
○362I		494.000	90.930	94.741	3.811	544.000	1.092	0.0350	36.000	5.137	1.000	105.896	2.761	1.470	1.260	2.061	97.471	94.150
○365I		302.000	94.860	98.699	3.839	544.000	1.031	0.0350	36.000	5.238	1.000	103.864	2.582	1.442	0.949	1.433	101.090	98.709
○367I		200.000	97.510	101.077	3.567	544.000	1.073	0.0350	220.000	1.218	0.283	446.478	2.086	0.081		0.068		101.090

$\alpha = 1.000$, $g = 9.80$ (m/sec²)



△X:distance D:compound energy correction factor
N:coefficient of compound roughness B:width of water surface
V:velocity A:flow section R:hydraulic mean depth
② velocity head ③ frictional loss

Table 7. Calculation output for 1:50 discharge.

Non-uniform flow F/S 10 UP CHAWANG PR (1/2) $Fr = v / (g \cdot A / (D \cdot B))^{1/2}$,

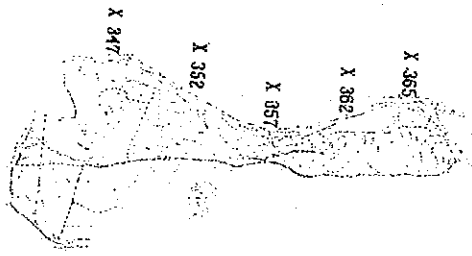
Station No	No	Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m^3/sec)	D	N	B (m)	v (m/s)	Fr	A (m^2)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-④ (m)
ORID			29.500	33.268	3.768	818.000	1.066	0.0350	98.840	2.755	0.524	296.935	3.165	0.413	0.333		34.014	
	1	333.000	30.176	33.934	3.758	818.000	1.066	0.0350	98.792	2.764	0.510	295.977	3.157	0.415	0.336	0.336	34.686	34.013
	2	333.000	30.852	34.607	3.755	818.000	1.066	0.0350	98.775	2.767	0.511	295.643	3.154	0.416	0.338	0.338	35.361	34.686
	3	333.000	31.528	35.282	3.754	818.000	1.066	0.0350	98.769	2.768	0.511	295.528	3.153	0.417	0.338	0.338	36.036	35.360
	4	333.000	32.204	35.957	3.753	818.000	1.066	0.0350	98.767	2.768	0.511	295.488	3.152	0.417	0.338	0.338	36.712	36.036
	5	333.000	32.880	36.633	3.753	818.000	1.066	0.0350	98.766	2.768	0.511	295.475	3.152	0.417	0.338	0.338	37.388	36.712
	6	333.000	33.556	37.309	3.753	818.000	1.066	0.0350	98.766	2.768	0.511	295.470	3.152	0.417	0.338	0.338	38.064	37.388
	7	333.000	34.232	37.985	3.753	818.000	1.066	0.0350	98.766	2.768	0.511	295.469	3.152	0.417	0.338	0.338	38.740	38.064
	8	333.000	34.908	38.661	3.753	818.000	1.066	0.0350	98.766	2.768	0.511	295.468	3.152	0.417	0.338	0.338	39.416	38.740
	9	333.000	35.584	39.337	3.753	818.000	1.066	0.0350	98.766	2.768	0.511	295.468	3.152	0.417	0.338	0.338	40.092	39.416
1RID		333.000	36.260	40.014	3.754	818.000	1.066	0.0350	98.769	2.768	0.528	295.527	3.153	0.417	0.004	0.338	40.434	40.092
239III		4.000	36.040	40.264	4.224	710.000	1.054	0.0350	120.000	1.786	0.322	397.588	3.319	0.171	0.034	0.002	40.470	40.434
240III		86.000	36.200	40.351	4.151	710.000	1.040	0.0350	120.000	1.657	0.286	428.597	3.510	0.146	0.032	0.027	40.528	40.470
241III		100.000	36.200	40.439	4.239	710.000	1.030	0.0350	126.000	1.451	0.239	489.176	3.813	0.111	0.023	0.022	40.573	40.528
242III		106.000	36.290	40.410	4.120	710.000	1.058	0.0350	104.000	1.952	0.343	363.652	3.726	0.206	0.044	0.043	40.659	40.573
243III		108.000	36.120	40.529	4.409	710.000	1.050	0.0350	110.000	1.761	0.301	403.204	3.736	0.166	0.029	0.035	40.724	40.659
244III		90.000	36.490	40.509	4.019	710.000	1.109	0.0350	120.000	2.195	0.450	323.436	3.148	0.273	0.063	0.058	40.845	40.724
245III		98.000	36.630	40.601	3.971	710.000	1.168	0.0350	119.185	2.312	0.497	307.069	2.980	0.319	0.448	0.075	41.367	40.845
251III		686.000	37.500	41.489	3.989	710.000	1.115	0.0350	130.000	1.998	0.408	355.399	2.881	0.227	0.283	0.349	41.999	41.367
256III		474.000	38.430	42.071	3.641	710.000	1.069	0.0350	110.000	2.297	0.453	309.061	2.963	0.288	0.418	0.360	42.777	41.999
261III		550.000	39.130	42.876	3.746	710.000	1.074	0.0350	114.000	2.119	0.409	335.076	3.025	0.246	0.303	0.346	43.425	42.777
266III		482.000	40.110	43.506	3.396	710.000	1.035	0.0350	120.000	2.092	0.404	339.313	2.905	0.231	0.325	0.312	44.062	43.425
271III		502.000	41.290	44.700	3.410	710.000	1.038	0.0350	50.198	4.952	0.954	143.390	2.771	1.299	2.038	1.937	48.037	44.062
276II		528.000	41.800	48.009	6.209	710.000	1.051	0.0350	110.000	1.169	0.163	607.342	5.456	0.073	0.043	0.046	48.126	48.037
281II		496.000	42.580	48.095	5.515	710.000	1.072	0.0350	116.323	1.347	0.209	526.983	4.799	0.099	0.068	0.068	48.262	48.126
286II		498.000	43.990	48.341	4.351	710.000	1.121	0.0350	92.350	2.703	0.542	262.639	3.083	0.418	0.497	0.497	49.256	48.262
291II		498.000	45.210	49.262	4.052	710.000	1.069	0.0350	102.336	2.210	0.412	321.293	3.579	0.266	0.233	0.272	49.761	49.256
295II		426.000	47.160	50.049	2.889	710.000	1.061	0.0350	87.116	3.811	0.857	186.287	2.574	0.786	1.312	1.075	52.147	49.760
301II		520.000	48.270	52.172	3.902	710.000	1.036	0.0350	120.000	1.707	0.298	415.816	3.429	0.154	0.131	0.180	52.457	52.147
304II		378.000	49.330	52.496	3.166	710.000	1.051	0.0350	120.000	2.242	0.452	316.674	2.705	0.270	0.137	0.309	52.903	52.457
306I		168.000	50.100	52.840	2.740	557.000	1.019	0.0350	130.000	1.706	0.347	326.412	2.484	0.151	0.278	0.089	53.270	52.903
311I		524.000	51.880	54.011	2.131	557.000	1.077	0.0350	120.000	2.806	0.723	198.521	1.777	0.433	0.937	1.174	55.380	53.270
315I		418.000	53.420	55.895	2.475	557.000	1.103	0.0350	119.391	2.825	0.738	197.134	1.758	0.449	1.208	0.964	57.552	55.380
320I		524.000	55.020	57.718	2.698	557.000	1.019	0.0350	113.022	1.989	0.407	279.986	2.511	0.206	0.337	0.372	58.261	57.552
324I		474.000	57.570	59.619	2.049	557.000	1.096	0.0350	104.208	3.620	0.996	153.849	1.567	0.733	2.558	2.091	62.910	58.261
329I		580.000	59.960	63.020	3.060	557.000	1.038	0.0350	120.000	1.709	0.337	325.907	2.781	0.155	0.178	0.265	63.353	62.910
333I		389.000	62.650	64.160	1.510	557.000	1.008	0.0350	140.000	2.821	0.762	197.474	1.395	0.409	1.813	1.216	66.382	63.353
338I		580.000	66.500	68.373	1.873	557.000	1.021	0.0350	96.952	3.705	0.960	150.343	1.555	0.715	2.053	2.706	71.140	66.382
O 342I		440.000	69.670	71.843	2.173	425.000	1.009	0.0350	90.000	2.810	0.696	151.233	1.630	0.406	1.386	1.109	73.636	71.140
O 347I		550.000	75.220	76.772	1.552	425.000	1.012	0.0350	87.859	3.604	1.000	117.924	1.343	0.671	2.857	2.953	80.299	74.489

$\alpha = 1.000$, $g = 9.80$ (m/sec^2)

Non-uniform flow F/S 10 UP CHAWANG PR (2/2) $Fr = v / (g \cdot A / (D \cdot B))^{1/2}$

Station No	No	Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m^3/sec)	D	N	B (m)	v (m/s)	Fr	A (m^2)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-④ (m)
O 352I		532.000	80.860	82.877	2.017	425.000	1.060	0.0350	67.354	3.878	1.000	109.604	1.723	0.813	2.266	2.373	85.956	81.317
O 357I		508.000	86.610	89.689	3.079	425.000	1.126	0.0350	50.000	4.198	1.000	101.250	2.118	1.013	1.960	2.016	92.662	88.686
O 362I		494.000	90.930	94.302	3.372	425.000	1.101	0.0350	36.000	4.717	1.000	90.092	2.411	1.251	1.273	2.082	96.826	93.470
O 365I		302.000	94.860	98.261	3.401	425.000	1.031	0.0350	36.000	4.824	1.000	88.096	2.238	1.224	0.974	1.471	100.459	98.014
O 367I		200.000	97.510	100.480	2.970	425.000	1.137	0.0350	220.000	1.349	0.384	315.066	1.531	0.106		0.126		100.459

$\alpha = 1.000$, $g = 9.80$ (m/sec^2)



△X:distance D:compound energy correction factor
N:coefficient of compound roughness B:width of water surface
V:velocity A:flow section R:hydraulic mean depth
② velocity head ③ frictional loss

Table 8. Calculation output for 1:10 discharge.

Non-uniform flow F/S 5 UP CHAWANG P (1/2) $Fr = v / \{ g \cdot A / (D \cdot B) \}^{1/2}$,

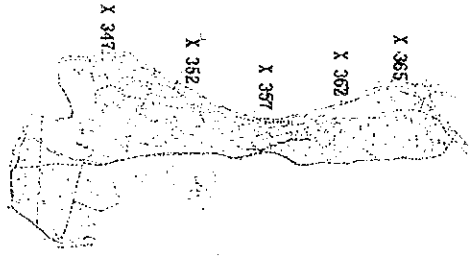
Station No	No	Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m^3/sec)	D	N	B (m)	v (m/s)	Fr	A (m^2)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-④ (m)
ORID			29.500	32.582	3.082	550.000	1.074	0.0350	95.410	2.388	0.509	230.307	2.556	0.312	0.333		33.227	
	1	333.000	30.176	33.249	3.073	550.000	1.074	0.0350	95.363	2.397	0.494	229.416	2.548	0.315	0.337	0.337	33.900	33.227
	2	333.000	30.852	33.922	3.070	550.000	1.074	0.0350	95.351	2.400	0.494	229.188	2.546	0.316	0.338	0.338	34.576	33.900
	3	333.000	31.528	34.598	3.070	550.000	1.074	0.0350	95.348	2.400	0.495	229.130	2.545	0.316	0.338	0.338	35.252	34.575
	4	333.000	32.204	35.274	3.070	550.000	1.074	0.0350	95.348	2.401	0.495	229.116	2.545	0.316	0.338	0.338	35.928	35.251
	5	333.000	32.880	35.949	3.069	550.000	1.074	0.0350	95.347	2.401	0.495	229.112	2.545	0.316	0.338	0.338	36.603	35.927
	6	333.000	33.556	36.625	3.069	550.000	1.074	0.0350	95.347	2.401	0.495	229.111	2.545	0.316	0.338	0.338	37.279	36.603
	7	333.000	34.232	37.301	3.069	550.000	1.074	0.0350	95.347	2.401	0.495	229.111	2.545	0.316	0.338	0.338	37.955	37.279
	8	333.000	34.908	37.977	3.069	550.000	1.074	0.0350	95.347	2.401	0.495	229.111	2.545	0.316	0.338	0.338	38.631	37.955
	9	333.000	35.584	38.653	3.069	550.000	1.074	0.0350	95.347	2.401	0.495	229.111	2.545	0.316	0.338	0.338	39.307	38.631
1RID		333.000	36.260	39.330	3.070	550.000	1.074	0.0350	95.349	2.400	0.513	229.151	2.546	0.316	0.004	0.338	39.650	39.308
239III		4.000	36.040	39.520	3.480	477.000	1.071	0.0350	120.000	1.547	0.319	308.298	2.639	0.131	0.035	0.002	39.686	39.650
240III		86.000	36.200	39.606	3.406	477.000	1.048	0.0350	120.000	1.466	0.274	339.161	2.830	0.106	0.030	0.026	39.742	39.686
241III		100.000	36.200	39.684	3.484	477.000	1.033	0.0350	126.000	1.210	0.222	394.060	3.113	0.077	0.021	0.020	39.783	39.742
242III		106.000	36.290	39.676	3.386	477.000	1.047	0.0350	98.886	1.651	0.316	288.901	3.094	0.146	0.040	0.039	39.862	39.783
243III		108.000	36.120	39.776	3.656	477.000	1.051	0.0350	110.000	1.489	0.286	320.384	3.068	0.119	0.027	0.033	39.922	39.862
244III		90.000	36.490	39.760	3.270	477.000	1.083	0.0350	107.060	2.017	0.451	236.441	2.595	0.225	0.069	0.063	40.054	39.922
245III		98.000	36.630	39.851	3.221	477.000	1.187	0.0350	117.451	2.185	0.558	218.355	2.453	0.289	0.518	0.087	40.658	40.053
251III		586.000	37.500	40.834	3.334	477.000	1.164	0.0350	130.000	1.765	0.422	270.234	2.333	0.185	0.292	0.361	41.312	40.658
256III		474.000	38.430	41.445	3.015	477.000	1.068	0.0350	106.685	1.983	0.436	240.597	2.439	0.214	0.403	0.348	42.062	41.311
261III		550.000	39.130	42.219	3.089	477.000	1.092	0.0350	114.000	1.834	0.405	260.140	2.444	0.187	0.302	0.344	42.708	42.062
266III		482.000	40.110	42.852	2.742	477.000	1.027	0.0350	117.418	1.827	0.397	261.076	2.328	0.175	0.333	0.319	43.360	42.708
271III		502.000	41.290	44.157	2.867	477.000	1.037	0.0350	49.090	4.095	0.865	116.472	2.314	0.887	1.772	1.685	46.817	43.360
276II		528.000	41.800	46.808	5.008	477.000	1.054	0.0350	110.000	1.004	0.158	475.148	4.385	0.054	0.043	0.045	46.905	46.816
281II		496.000	42.580	46.900	4.320	477.000	1.070	0.0350	110.248	1.222	0.214	390.477	3.790	0.081	0.077	0.077	47.058	46.904
286II		498.000	43.990	47.345	3.355	477.000	1.106	0.0350	80.158	2.708	0.614	176.146	2.389	0.414	0.700	0.700	48.459	47.058
291II		498.000	45.210	48.524	3.314	477.000	1.060	0.0350	91.813	1.907	0.380	250.080	2.953	0.197	0.224	0.262	48.945	48.459
295II		426.000	47.160	49.462	2.302	477.000	1.034	0.0350	70.200	3.382	0.775	141.054	2.084	0.603	1.368	1.121	51.434	48.945
301II		520.000	48.270	51.490	3.220	477.000	1.044	0.0350	120.000	1.429	0.280	333.909	2.804	0.109	0.119	0.164	51.718	51.434
304II		378.000	49.330	51.843	2.513	477.000	1.067	0.0350	119.380	2.001	0.467	238.383	2.105	0.218	0.153	0.344	52.214	51.718
306I		168.000	50.100	52.195	2.095	375.000	1.026	0.0350	130.000	1.547	0.366	242.493	1.878	0.125	0.331	0.106	52.651	52.214
311I		524.000	51.880	53.590	1.710	375.000	1.088	0.0350	120.000	2.533	0.760	148.043	1.416	0.356	1.033	1.295	54.980	52.651
315I		418.000	53.420	55.544	2.124	375.000	1.135	0.0350	117.366	2.409	0.712	155.675	1.455	0.336	1.129	0.901	57.010	54.979
320I		524.000	55.020	57.211	2.191	375.000	1.017	0.0350	100.242	1.676	0.377	223.727	2.046	0.146	0.314	0.347	57.671	57.010
324I		474.000	57.570	59.281	1.711	375.000	1.133	0.0350	103.185	3.156	1.000	118.824	1.298	0.576	2.525	2.063	62.382	57.793
329I		580.000	59.960	62.509	2.549	375.000	1.041	0.0350	119.223	1.417	0.310	264.644	2.304	0.107	0.157	0.234	62.773	62.382
333I		389.000	62.650	63.819	1.169	375.000	1.011	0.0350	140.000	2.503	0.777	149.830	1.067	0.323	2.042	1.369	66.184	62.773
338I		580.000	66.500	68.085	1.585	375.000	1.024	0.0350	96.333	3.060	0.877	122.532	1.282	0.489	1.813	2.390	70.387	66.184
○ 342I		440.000	69.670	71.401	1.731	285.000	1.016	0.0350	90.000	2.557	0.740	111.475	1.219	0.339	1.691	1.353	73.431	70.337
○ 347I		550.000	75.220	76.451	1.231	285.000	1.012	0.0350	86.670	3.170	1.000	89.912	1.041	0.519	3.105	3.210	80.075	73.760

$\alpha = 1.000$, $g = 9.80$ (m/sec^2)

Non-uniform flow F/S 5 UP CHAWANG P (2/2) $Fr = v / \{ g \cdot A / (D \cdot B) \}^{1/2}$

Station No	No	Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m^3/sec)	D	N	B (m)	v (m/s)	Fr	A (m^2)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-④ (m)
○ 352I		532.000	80.860	82.454	1.594	285.000	1.050	0.0350	63.297	3.477	1.000	81.971	1.361	0.648	2.495	2.613	85.596	80.489
○ 357I		508.000	86.610	89.234	2.624	285.000	1.166	0.0350	50.000	3.631	1.000	78.500	1.736	0.784	1.911	1.965	91.929	88.053
○ 362I		494.000	90.930	93.732	2.802	285.000	1.129	0.0350	36.000	4.096	1.000	69.572	1.947	0.967	1.277	2.089	95.976	92.610
○ 365I		302.000	94.860	97.692	2.832	285.000	1.036	0.0350	36.000	4.215	1.000	67.612	1.772	0.939	1.015	1.532	99.646	97.098
○ 367I		200.000	97.510	99.812	2.302	285.000	1.382	0.0350	209.800	1.686	0.705	169.080	0.961	0.200		0.367		99.646

$\alpha = 1.000$, $g = 9.80$ (m/sec^2)



△X:distance D:compound energy correction factor
N:coefficient of compound roughness B:width of water surface
V:velocity A:flow section R:hydraulic mean depth
② velocity head ③ frictional loss

Table 9. Calculation output for 1: 5 discharge.

Non-uniform flow F/S 2 UP CHAWANG P (1/2) $Fr=v/(g\cdot A/(D\cdot B))^{1/2}$

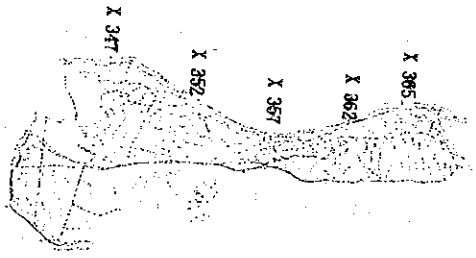
Station No.	No.	Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m³/sec)	D	N	B (m)	v (m/s)	Fr	A (m²)	R (m)	$\frac{D\cdot Q^2}{2g\cdot A^2}$ ② (m)	$\frac{N^2\cdot Q^2\cdot \Delta x}{2R^{4/3}\cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-④ (m)
ORID			29.500	32.120	2.620	397.000	1.087	0.0350	93.100	2.126	0.500	186.761	2.145	0.251	0.333		32.704	
	1	333.000	30.176	32.788	2.612	397.000	1.087	0.0350	93.060	2.134	0.492	186.012	2.138	0.253	0.337	0.337	33.378	32.703
	2	333.000	30.852	33.463	2.611	397.000	1.088	0.0350	93.053	2.136	0.493	185.883	2.137	0.253	0.338	0.338	34.054	33.378
	3	333.000	31.528	34.138	2.610	397.000	1.088	0.0350	93.052	2.136	0.493	185.861	2.136	0.253	0.338	0.338	34.730	34.053
	4	333.000	32.204	34.814	2.610	397.000	1.088	0.0350	93.051	2.136	0.493	185.857	2.136	0.253	0.338	0.338	35.406	34.729
	5	333.000	32.880	35.490	2.610	397.000	1.088	0.0350	93.051	2.136	0.483	185.857	2.136	0.253	0.338	0.338	36.082	35.405
	6	333.000	33.556	36.166	2.610	397.000	1.088	0.0350	93.051	2.136	0.483	185.857	2.136	0.253	0.338	0.338	36.758	36.081
	7	333.000	34.232	36.842	2.610	397.000	1.088	0.0350	93.051	2.136	0.483	185.857	2.136	0.253	0.338	0.338	37.434	36.757
	8	333.000	34.908	37.518	2.610	397.000	1.088	0.0350	93.051	2.136	0.483	185.857	2.136	0.253	0.338	0.338	38.110	37.433
	9	333.000	35.584	38.194	2.610	397.000	1.088	0.0350	93.051	2.136	0.483	185.857	2.136	0.253	0.338	0.338	38.786	38.109
1RID		333.000	36.260	38.871	2.611	397.000	1.088	0.0350	93.053	2.136	0.503	185.887	2.137	0.253	0.004	0.338	39.128	38.786
239III		4.000	36.040	39.023	2.983	344.000	1.093	0.0350	120.000	1.384	0.321	248.555	2.187	0.107	0.036	0.002	39.165	39.128
240III		86.000	36.200	39.108	2.908	344.000	1.059	0.0350	120.000	1.231	0.265	279.425	2.375	0.082	0.029	0.025	39.219	39.165
241III		100.000	36.200	39.180	2.980	344.000	1.038	0.0350	126.000	1.041	0.209	330.509	2.642	0.057	0.019	0.018	39.257	39.219
242III		106.000	36.290	39.184	2.894	344.000	1.042	0.0350	94.786	1.426	0.291	241.259	2.656	0.108	0.037	0.036	39.329	39.257
243III		108.000	36.120	39.270	3.150	344.000	1.045	0.0350	107.349	1.298	0.270	264.958	2.632	0.090	0.026	0.031	39.385	39.329
244III		90.000	36.490	39.265	2.775	344.000	1.071	0.0350	93.962	1.840	0.431	186.936	2.197	0.185	0.071	0.065	39.522	39.385
245III		98.000	36.630	39.358	2.728	344.000	1.153	0.0350	97.560	2.089	0.551	164.705	2.173	0.257	0.556	0.093	40.171	39.522
251III		586.000	37.500	40.386	2.886	344.000	1.201	0.0350	128.053	1.623	0.442	211.990	1.996	0.161	0.304	0.376	40.851	40.171
256III		474.000	38.430	41.020	2.590	344.000	1.072	0.0350	101.166	1.751	0.416	196.430	2.075	0.168	0.390	0.336	41.578	40.851
261III		550.000	39.130	41.772	2.642	344.000	1.106	0.0350	114.000	1.644	0.408	209.193	2.064	0.153	0.304	0.347	42.228	41.578
266III		482.000	40.110	42.416	2.306	344.000	1.023	0.0350	110.702	1.628	0.381	211.284	1.930	0.138	0.339	0.326	42.893	42.228
271III		502.000	41.290	43.771	2.481	344.000	1.037	0.0350	48.404	3.524	0.807	97.622	1.981	0.657	1.614	1.534	46.041	42.893
276II		528.000	41.800	46.043	4.243	344.000	1.059	0.0350	110.000	0.880	0.153	391.025	3.700	0.042	0.041	0.044	46.126	46.041
281II		496.000	42.580	46.140	3.560	344.000	1.061	0.0350	104.140	1.113	0.213	309.037	3.157	0.067	0.082	0.081	46.289	46.126
286II		498.000	43.990	46.757	2.767	344.000	1.089	0.0350	72.112	2.618	0.647	131.380	1.966	0.381	0.849	0.849	47.987	46.289
291II		498.000	45.210	48.076	2.866	344.000	1.057	0.0350	88.830	1.641	0.351	209.590	2.560	0.145	0.201	0.235	48.422	47.987
295II		426.000	47.160	49.079	1.919	344.000	1.030	0.0350	68.041	3.002	0.750	114.605	1.731	0.474	1.381	1.131	50.933	48.422
301II		520.000	48.270	51.007	2.737	344.000	1.055	0.0350	120.000	1.246	0.270	276.019	2.360	0.084	0.114	0.157	51.205	50.933
304II		378.000	49.330	51.401	2.071	344.000	1.071	0.0350	115.800	1.846	0.481	186.390	1.721	0.186	0.170	0.382	51.757	51.205
306I		168.000	50.100	51.774	1.674	270.000	1.033	0.0350	120.324	1.438	0.387	187.774	1.485	0.109	0.392	0.126	52.275	51.757
311I		524.000	51.880	53.321	1.441	270.000	1.099	0.0350	109.082	2.292	0.738	117.823	1.187	0.295	1.070	1.341	54.686	52.275
315I		418.000	53.420	55.290	1.870	270.000	1.170	0.0350	115.897	2.142	0.710	126.036	1.244	0.274	1.101	0.873	56.665	54.686
320I		524.000	55.020	56.876	1.856	270.000	1.014	0.0350	107.742	1.441	0.351	187.423	1.738	0.107	0.288	0.319	57.272	56.665
324I		474.000	57.570	59.059	1.489	270.000	1.159	0.0350	102.512	2.813	1.000	95.991	1.120	0.468	2.417	1.976	61.944	57.551
329I		580.000	59.960	62.094	2.134	270.000	1.042	0.0350	117.083	1.252	0.301	215.585	1.921	0.083	0.156	0.233	62.334	61.944
333I		389.000	62.650	63.597	0.947	270.000	1.015	0.0350	140.000	2.276	0.796	118.629	0.851	0.268	2.283	1.531	66.148	62.334
338I		580.000	66.500	67.894	1.394	270.000	1.028	0.0350	95.924	2.590	0.805	104.242	1.100	0.352	1.592	2.099	69.838	66.148
○ 342I		440.000	69.670	71.129	1.459	206.000	1.028	0.0350	90.000	2.367	0.779	87.033	0.964	0.294	1.981	1.585	73.404	69.838
○ 347I		550.000	75.220	76.259	1.039	206.000	1.014	0.0350	85.958	2.810	0.979	73.305	0.858	0.409	3.157	3.263	79.824	73.404

$\alpha = 1.000$, $g = 9.80$ (m/sec²)

Non-uniform flow F/S 2 UP CHAWANG P (2/2) $Fr=v/(g\cdot A/(D\cdot B))^{1/2}$

Station No.	No.	Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m³/sec)	D	N	B (m)	v (m/s)	Fr	A (m²)	R (m)	$\frac{D\cdot Q^2}{2g\cdot A^2}$ ② (m)	$\frac{N^2\cdot Q^2\cdot \Delta x}{2R^{4/3}\cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-④ (m)
○ 352I		532.000	80.860	82.180	1.320	206.000	1.045	0.0350	60.670	3.170	1.000	64.987	1.120	0.535	2.689	2.816	85.404	79.900
○ 357I		508.000	86.610	88.942	2.332	206.000	1.205	0.0350	50.000	3.224	1.000	63.900	1.503	0.639	1.826	1.878	91.407	87.703
○ 362I		494.000	90.930	93.361	2.431	206.000	1.162	0.0350	35.510	3.659	1.000	56.299	1.647	0.793	1.274	2.083	95.428	92.071
○ 365I		302.000	94.860	97.331	2.471	206.000	1.045	0.0350	36.000	3.772	1.000	54.616	1.465	0.758	1.047	1.581	99.136	96.508
○ 367I		200.000	97.510	99.544	2.034	206.000	1.641	0.0350	204.240	1.820	1.000	113.200	0.778	0.277		0.567		99.255

$\alpha = 1.000$, $g = 9.80$ (m/sec²)

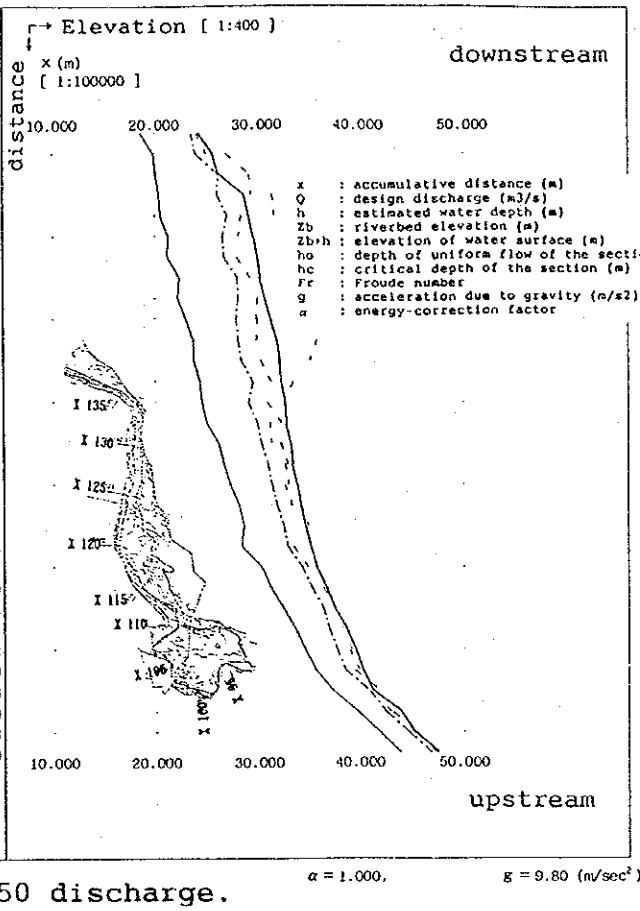


△X:distance D:compound energy correction factor
N:coefficient of compound roughness B:width of water surface
V:velocity A:flow section R:hydraulic mean depth
② velocity head ③ frictional loss

Table 10. Calculation output for 1: 2 discharge.

Steady flow F/S 50 UP TA DI FRE (Non-uniform flow)

	No	x (m)	Q (m³/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
	0	0.000	1364.000	5.649	24.229	5.405		4.969	0.705
	5	500.000	1184.000	5.787	25.567	7.088	5.179	4.131	0.462
	10	1000.000	1184.000	6.084	26.164	9.127	9.191	6.030	0.973
	15	1500.000	1184.000	8.307	28.697	11.100	9.031	5.625	0.374
	20	2000.000	1184.000	8.642	29.162	7.860	11.130	6.489	0.396
	25	2500.000	1184.000	8.328	29.608		6.867	5.282	0.335
	30	3000.000	1184.000	8.743	29.973	6.683		5.461	0.301
	35	3500.000	1184.000	7.869	30.199		6.968	5.696	0.439
	40	4000.000	1184.000	8.496	30.736	7.759		5.813	0.424
	45	4500.000	1184.000	8.345	31.325	6.990	6.918	4.892	0.363
	50	5000.000	1184.000	8.159	31.849	12.137	6.208	4.343	0.287
	55	5500.000	1184.000	8.397	32.137	6.522	11.352	4.662	0.240
	60	6000.000	1184.000	7.962	32.282	9.158	7.008	5.216	0.322
	65	6500.000	1184.000	8.173	32.663	6.447	8.009	4.566	0.215
	70	7000.000	1184.000	7.810	32.780	6.203	7.377	4.978	0.320
	75	7500.000	1184.000	7.081	33.181	6.142	5.253	4.221	0.279
	80	8000.000	1184.000	6.794	33.424	6.098	6.340	4.337	0.343
	85	8500.000	1184.000	6.586	33.846	5.373	5.771	4.110	0.317
	90	9000.000	1184.000	6.015	34.155	6.174	5.221	3.703	0.379
O	95	9500.000	1184.000	6.078	34.668		6.306	3.892	0.385
O	100	10000.000	1184.000	6.749	35.159	5.070		4.483	0.393
O	105	10500.000	1184.000	5.398	35.728	5.430	4.550	3.939	0.513
O	110	11000.000	1184.000	5.420	36.670	5.100	5.426	3.971	0.519
O	115	11500.000	1184.000	5.105	37.555	5.093	5.071	3.938	0.592
O	120	12000.000	1184.000	5.080	38.710	5.024	4.706	3.322	0.497
O	125	12500.000	1184.000	5.073	39.643	4.417	4.578	3.113	0.432
O	130	13000.000	1184.000	4.674	40.314	3.832	4.323	2.916	0.470
	135	13500.000	1184.000	3.989	41.259	4.083	4.629	3.634	0.856
	140	14000.000	1184.000	4.130	43.930	3.358	3.181	2.766	0.540
	145	14500.000	1184.000	3.312	45.212	3.393	3.355	2.764	0.758
	150	15000.000	1184.000	3.596	47.516		3.344	2.900	0.559

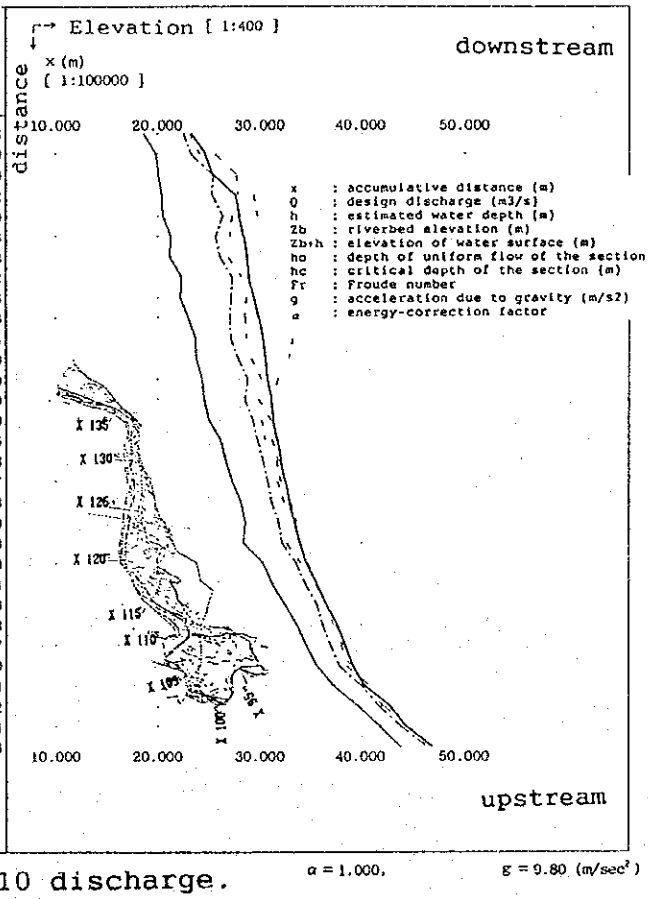


α = 1.000, g = 9.80 (m/sec²)

Table 11. Hydraulic profile for 1:50 discharge.

Steady flow F/S 10 UP TA DI FRE (Non-uniform flow)

	No	x (m)	Q (m³/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
	0	0.000	872.000	4.746	23.326	4.518		3.935	0.716
	5	500.000	757.000	4.827	24.607	5.770	4.298	3.469	0.439
	10	1000.000	757.000	5.260	25.340	7.600	7.650	5.260	1.000
	15	1500.000	757.000	7.197	27.587	8.979	7.420	4.878	0.332
	20	2000.000	757.000	7.419	27.939	6.743	9.258	5.743	0.400
	25	2500.000	757.000	7.087	28.367		5.683	4.328	0.308
	30	3000.000	757.000	7.438	28.668	5.656		4.772	0.278
	35	3500.000	757.000	6.579	28.909		5.850	4.937	0.432
	40	4000.000	757.000	7.203	29.443	6.364		4.907	0.386
	45	4500.000	757.000	6.937	29.917	5.607	5.551	3.973	0.323
	50	5000.000	757.000	6.611	30.301	9.583	5.006	3.392	0.284
	55	5500.000	757.000	6.826	30.566	5.465	9.174	4.061	0.239
	60	6000.000	757.000	6.420	30.740	7.514	5.867	4.512	0.350
	65	6500.000	757.000	6.648	31.138	5.444	6.634	4.010	0.220
	70	7000.000	757.000	6.345	31.315	5.267	6.157	4.352	0.330
	75	7500.000	757.000	5.637	31.737	5.113	4.433	3.678	0.296
	80	8000.000	757.000	5.417	32.047	5.028	5.213	3.720	0.363
	85	8500.000	757.000	5.250	32.510	4.484	4.789	3.559	0.337
	90	9000.000	757.000	4.766	32.906	4.944	4.216	3.053	0.378
O	95	9500.000	757.000	4.849	33.439		5.083	3.265	0.390
O	100	10000.000	757.000	5.552	33.962	4.240		3.786	0.383
O	105	10500.000	757.000	4.250	34.580	4.385	3.713	3.267	0.540
O	110	11000.000	757.000	4.371	35.621	4.166	4.423	3.237	0.524
O	115	11500.000	757.000	4.116	36.566	4.066	4.049	3.188	0.583
O	120	12000.000	757.000	4.032	37.662	3.894	3.653	2.564	0.463
O	125	12500.000	757.000	3.924	38.494	3.460	3.583	2.389	0.427
O	130	13000.000	757.000	3.576	39.216	2.976	3.350	2.223	0.460
	135	13500.000	757.000	3.126	40.396	3.176	3.591	2.769	0.824
	140	14000.000	757.000	3.044	42.844	2.588	2.451	2.063	0.552
	145	14500.000	757.000	2.502	44.402	2.616	2.587	2.062	0.744
	150	15000.000	757.000	2.909	46.829		2.861	2.521	0.633



α = 1.000, g = 9.80 (m/sec²)

Table 12. Hydraulic profile for 1:10 discharge.

Steady flow F/S 5 UP TA DI PRE (Non-uniform flow)

No	x (m)	Q (m³/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
0	0.000	607.000	4.079	22.659	3.865		3.308	0.653
5	500.000	527.000	4.128	23.908	4.928	3.731	3.012	0.446
10	1000.000	527.000	4.702	24.782	6.617	6.658	4.702	1.000
15	1500.000	527.000	6.398	26.788	7.651	6.405	4.347	0.311
20	2000.000	527.000	6.565	27.085	6.004	8.072	5.097	0.426
25	2500.000	527.000	6.238	27.518		4.883	3.675	0.293
30	3000.000	527.000	6.551	27.781	5.002		4.284	0.265
35	3500.000	527.000	5.705	28.035		5.134	4.433	0.443
40	4000.000	527.000	6.340	28.580	5.470		4.170	0.360
45	4500.000	527.000	5.999	28.979	4.719	4.673	3.353	0.296
50	5000.000	527.000	5.597	29.287	7.978	4.201	2.763	0.278
55	5500.000	527.000	5.799	29.539	4.789	7.788	3.684	0.245
60	6000.000	527.000	5.423	29.743	6.472	5.128	3.938	0.394
65	6500.000	527.000	5.692	30.182	4.804	5.766	3.645	0.228
70	7000.000	527.000	5.436	30.406	4.674	5.389	3.968	0.344
75	7500.000	527.000	4.761	30.861	4.459	3.908	3.338	0.316
80	8000.000	527.000	4.594	31.224	4.343	4.494	3.305	0.381
85	8500.000	527.000	4.455	31.715	3.916	4.164	3.213	0.355
90	9000.000	527.000	4.022	32.162	4.164	3.576	2.650	0.372
O 95	9500.000	527.000	4.104	32.694		4.312	2.876	0.393
O 100	10000.000	527.000	4.815	33.225	3.698		3.336	0.372
O 105	10500.000	527.000	3.547	33.877	3.722	3.176	2.844	0.569
O 110	11000.000	527.000	3.733	34.983	3.553	3.764	2.773	0.508
C 115	11500.000	527.000	3.472	35.922	3.397	3.383	2.401	0.581
O 120	12000.000	527.000	3.338	36.968	3.184	2.992	2.093	0.442
C 125	12500.000	527.000	3.188	37.758	2.844	2.946	1.938	0.428
C 130	13000.000	527.000	2.886	38.526	2.435	2.735	1.790	0.453
135	13500.000	527.000	2.569	39.839	2.591	2.932	2.210	0.785
140	14000.000	527.000	2.375	42.175	2.094	1.982	1.625	0.562
145	14500.000	527.000	2.012	43.912	2.117	2.092	1.625	0.723
150	15000.000	527.000	2.516	46.436		2.552	2.286	0.701

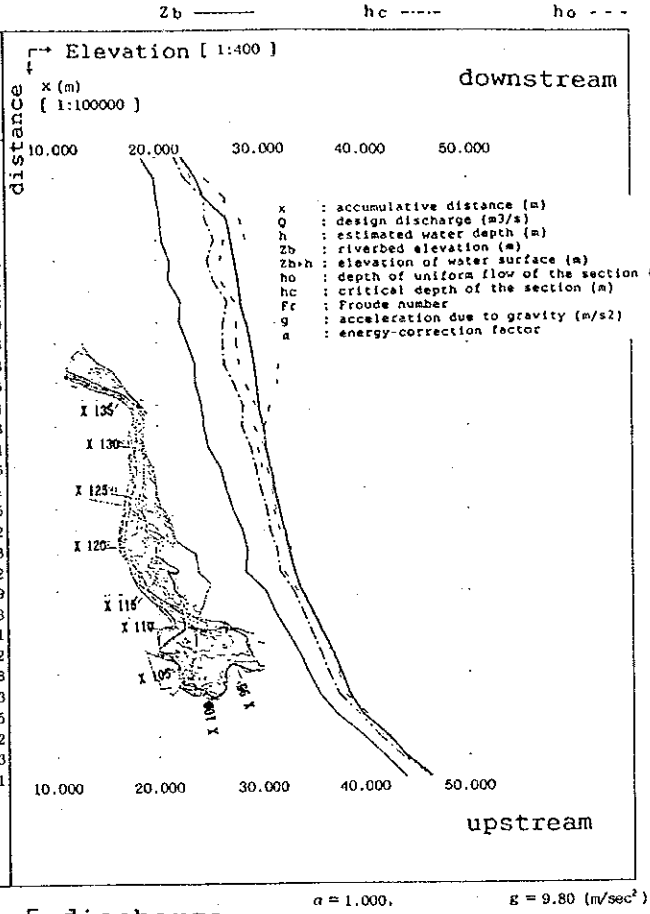


Table 13. Hydraulic profile for 1: 5 discharge.

Steady flow F/S 2 UP TA DI PRE (Non-uniform flow)

No	x (m)	Q (m³/sec)	h (m)	Zb+h (m)	ho (m) up	ho (m) down	hc (m)	Fr
0	0.000	339.000	3.143	21.723	2.975		2.509	0.622
5	500.000	294.000	3.171	22.951	3.891	2.983	2.444	0.487
10	1000.000	294.000	3.802	23.882	5.370	5.401	3.512	0.865
15	1500.000	294.000	5.281	25.671	6.048	5.167	3.611	0.301
20	2000.000	294.000	5.406	25.926	4.947	6.606	4.011	0.466
25	2500.000	294.000	5.094	26.374		3.817	2.779	0.270
30	3000.000	294.000	5.362	26.592	4.144		3.675	0.263
35	3500.000	294.000	4.551	26.881		4.228	3.784	0.510
40	4000.000	294.000	5.248	27.488	4.310		3.113	0.323
45	4500.000	294.000	4.806	27.786	3.605	3.572	2.414	0.258
50	5000.000	294.000	4.322	28.012	6.013	3.138	1.986	0.251
55	5500.000	294.000	4.507	28.247	3.948	6.094	3.158	0.275
60	6000.000	294.000	4.202	28.522	5.184	4.140	2.904	0.470
65	6500.000	294.000	4.545	29.035	4.001	4.703	3.194	0.252
70	7000.000	294.000	4.367	29.337	3.947	4.456	3.501	0.383
75	7500.000	294.000	3.762	29.862	3.655	3.253	2.915	0.359
80	8000.000	294.000	3.659	30.289	3.484	3.597	2.529	0.409
85	8500.000	294.000	3.533	30.793	3.208	3.389	2.733	0.398
90	9000.000	294.000	3.149	31.289	3.210	2.789	2.160	0.360
C 95	9500.000	294.000	3.211	31.801		3.372	2.400	0.407
C 100	10000.000	294.000	3.918	32.328	2.997		2.581	0.354
C 105	10500.000	294.000	2.700	33.030	2.902	2.490	2.183	0.643
C 110	11000.000	294.000	2.969	34.219	2.788	2.943	2.194	0.475
C 115	11500.000	294.000	2.648	35.098	2.502	2.491	1.724	0.472
C 120	12000.000	294.000	2.409	36.039	2.326	2.191	1.512	0.434
O 125	12500.000	294.000	2.282	36.852	2.079	2.152	1.394	0.420
O 130	13000.000	294.000	2.053	37.693	1.774	1.986	1.279	0.443
135	13500.000	294.000	1.879	39.149	1.869	2.113	1.546	0.726
140	14000.000	294.000	1.598	41.398	1.485	1.405	1.105	0.572
145	14500.000	294.000	1.434	43.334	1.501	1.484	1.105	0.674
150	15000.000	294.000	2.071	45.991		2.166	1.959	0.824

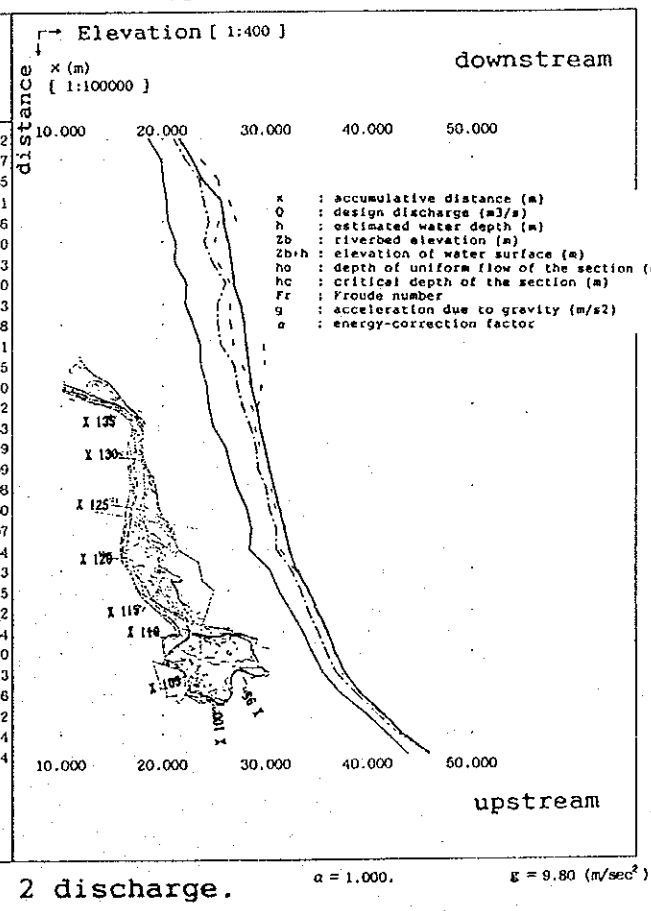


Table 14. Hydraulic profile for 1: 2 discharge.

Non-uniform flow F/S 50 UP TA DI PRE (1/1) $Fr = v / \{g \cdot A / (D \cdot B)\}^{1/2}$

Station No.		Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m³/sec)	D	N	B (m)	v (m/s)	Fr	A (m²)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②−④ (m)
0			18.580	24.229	5.649	1364.000	1.220	0.0350	125.000	3.520	0.705	387.475	3.814	0.771	0.637		25.637	
5		500.000	19.780	25.567	5.787	1184.000	1.091	0.0350	99.000	2.839	0.462	417.010	4.083	0.449	0.378	0.378	26.394	25.637
10		500.000	20.080	26.164	6.084	1184.000	1.250	0.0350	79.404	4.800	0.973	246.671	3.684	1.470	1.240	1.240	28.874	26.394
15		500.000	20.390	28.697	8.307	1184.000	1.102	0.0350	77.000	2.673	0.374	443.014	5.511	0.402	0.225	0.225	29.324	28.874
20		500.000	20.520	29.162	8.642	1184.000	1.182	0.0350	94.000	2.540	0.396	466.152	5.663	0.389	0.227	0.227	29.778	29.323
25		500.000	21.280	29.608	8.328	1184.000	1.134	0.0350	84.000	2.390	0.335	495.438	5.998	0.330	0.161	0.161	30.099	29.778
30		500.000	21.230	29.973	8.743	1184.000	1.088	0.0350	86.000	2.240	0.301	528.503	5.640	0.278	0.153	0.153	30.405	30.099
35		500.000	22.330	30.199	7.869	1184.000	1.118	0.0350	74.000	3.000	0.439	394.617	5.174	0.514	0.308	0.308	31.021	30.405
40		500.000	22.240	30.736	8.496	1184.000	1.201	0.0350	62.000	3.040	0.424	389.534	5.650	0.566	0.281	0.281	31.583	31.021
45		500.000	22.980	31.325	8.345	1184.000	1.154	0.0350	60.000	2.803	0.363	422.392	6.366	0.463	0.204	0.204	31.991	31.583
50		500.000	23.690	31.849	8.159	1184.000	1.109	0.0350	89.000	2.132	0.287	555.328	6.478	0.257	0.115	0.115	32.222	31.991
55		500.000	23.740	32.137	8.397	1184.000	1.064	0.0350	109.257	1.791	0.240	660.997	6.006	0.174	0.090	0.090	32.402	32.221
60		500.000	24.320	32.282	7.962	1184.000	1.125	0.0350	100.000	2.202	0.322	537.573	5.347	0.278	0.159	0.159	32.719	32.401
65		500.000	24.490	32.663	8.173	1184.000	1.056	0.0350	130.000	1.577	0.215	750.566	5.550	0.134	0.078	0.078	32.874	32.719
70		500.000	24.970	32.780	7.810	1184.000	1.055	0.0350	96.000	2.272	0.320	521.124	5.019	0.278	0.184	0.184	33.242	32.874
75		500.000	26.100	33.181	7.081	1184.000	1.057	0.0350	120.000	1.923	0.279	615.734	4.825	0.199	0.139	0.139	33.520	33.242
80		500.000	26.630	33.424	6.794	1184.000	1.086	0.0350	104.000	2.294	0.343	516.053	4.855	0.292	0.196	0.196	33.912	33.520
85		500.000	27.260	33.846	6.586	1184.000	1.071	0.0350	118.000	2.098	0.317	564.284	4.635	0.240	0.174	0.174	34.261	33.912
90		500.000	28.140	34.155	6.015	1184.000	1.065	0.0350	94.000	2.555	0.379	463.318	4.766	0.355	0.249	0.249	34.759	34.261
C 95		500.000	28.590	34.668	6.078	1184.000	1.069	0.0350	98.000	2.542	0.385	465.694	4.568	0.353	0.261	0.261	35.282	34.759
C100		500.000	28.410	35.159	6.749	1184.000	1.073	0.0350	90.000	2.650	0.393	446.853	4.849	0.384	0.262	0.262	35.805	35.281
C105		500.000	30.330	35.728	5.398	1184.000	1.079	0.0350	90.000	3.156	0.513	375.142	4.059	0.548	0.471	0.471	36.748	35.805
C110		500.000	31.250	36.670	5.420	1184.000	1.073	0.0350	94.000	3.140	0.519	377.109	4.085	0.540	0.462	0.462	37.672	36.747
C115		500.000	32.450	37.555	5.105	1184.000	1.104	0.0350	84.000	3.527	0.592	335.703	4.081	0.701	0.584	0.584	38.840	37.672
C120		500.000	33.630	38.710	5.080	1184.000	1.045	0.0350	76.000	3.306	0.497	358.100	4.487	0.583	0.452	0.452	39.745	38.840
C125		500.000	34.570	39.643	5.073	1184.000	1.051	0.0350	92.000	2.820	0.432	419.862	4.529	0.426	0.325	0.325	40.395	39.745
C130		500.000	35.640	40.314	4.674	1184.000	1.033	0.0350	88.000	3.043	0.470	389.059	4.283	0.488	0.408	0.408	41.210	40.395
135		500.000	37.270	41.259	3.989	1184.000	1.053	0.0350	66.000	4.966	0.856	238.426	3.591	1.325	1.374	1.374	43.957	41.210
140		500.000	39.800	43.930	4.130	1184.000	1.047	0.0350	100.235	3.181	0.540	372.152	3.854	0.541	0.513	0.513	44.983	43.957
145		500.000	41.900	45.212	3.312	1184.000	1.039	0.0350	96.561	4.049	0.758	292.394	3.127	0.869	1.098	1.098	47.180	44.983
150		500.000	43.920	47.516	3.596	1184.000	1.042	0.0350	208.000	2.557	0.559	463.083	2.237	0.347		0.684		47.179

$\alpha = 1.000$, $g = 9.80$ (m/sec²)

△×:distance D:compound energy correction factor N:coefficient of compound roughness
B:width of water surface V:velocity A:flow section R:hydraulic mean depth
② velocity head ③ frictional loss

Table 15. Calculation output for 1:50 discharge.

Non-uniform flow F/S 10 UP TA DI PRE (1/1) $Fr = v / \{g \cdot A / (D \cdot B)\}^{1/2}$

Station No.		Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m³/sec)	D	N	B (m)	v (m/s)	Fr	A (m²)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②−④ (m)
0			18.580	23.326	4.746	872.000	1.224	0.0350	114.696	3.148	0.716	277.042	3.270	0.618	0.625		24.570	
5		500.000	19.780	24.607	4.827	757.000	1.113	0.0350	99.000	2.351	0.439	321.988	3.253	0.314	0.351	0.351	25.272	24.569
10		500.000	20.080	25.340	5.260	757.000	1.317	0.0350	77.993	4.164	1.000	181.800	3.132	1.165	1.159	1.159	27.664	25.347
15		500.000	20.390	27.587	7.197	757.000	1.122	0.0350	77.000	2.118	0.332	357.495	4.601	0.257	0.179	0.179	28.023	27.664
20		500.000	20.520	27.939	7.419	757.000	1.262	0.0350	94.000	2.155	0.400	351.210	4.117	0.299	0.216	0.216	28.454	28.022
25		500.000	21.230	28.367	7.087	757.000	1.158	0.0350	84.000	1.935	0.308	391.175	4.991	0.221	0.134	0.134	28.723	28.454
30		500.000	21.230	28.668	7.438	757.000	1.107	0.0350	86.000	1.819	0.278	416.233	4.602	0.187	0.132	0.132	28.987	28.722
35		500.000	22.330	28.909	6.579	757.000	1.153	0.0350	74.000	2.531	0.432	299.146	4.098	0.377	0.299	0.299	29.585	28.987
40		500.000	22.240	29.443	7.203	757.000	1.217	0.0350	62.000	2.447	0.386	309.384	4.742	0.372	0.230	0.230	30.045	29.585
45		500.000	22.980	29.917	6.937	757.000	1.150	0.0350	60.000	2.240	0.323	337.965	5.289	0.294	0.167	0.167	30.379	30.045
50		500.000	23.690	30.301	6.611	757.000	1.126	0.0350	89.000	1.813	0.284	417.586	5.201	0.189	0.112	0.112	30.602	30.379
55		500.000	23.740	30.565	6.826	757.000	1.074	0.0350	107.686	1.543	0.239	490.599	4.605	0.130	0.095	0.095	30.792	30.602
60		500.000	24.320	30.740	6.420	757.000	1.181	0.0350	100.000	1.975	0.350	383.352	4.089	0.235	0.183	0.183	31.157	30.792
65		500.000	24.490	31.138	6.648	757.000	1.077	0.0350	130.000	1.370	0.220	552.378	4.228	0.103	0.084	0.084	31.325	31.157
70		500.000	24.970	31.315	6.345	757.000	1.070	0.0350	96.000	1.990	0.330	380.439	3.785	0.216	0.206	0.206	31.737	31.325
75		500.000	26.100	31.737	5.637	757.000	1.085	0.0350	120.000	1.711	0.296	442.457	3.592	0.162	0.163	0.163	32.062	31.736
80		500.000	26.630	32.047	5.417	757.000	1.123	0.0350	104.000	2.030	0.363	372.885	3.693	0.236	0.221	0.221	32.505	32.062
85		500.000	27.260	32.510	5.250	757.000	1.107	0.0350	118.000	1.861	0.337	406.672	3.480	0.196	0.201	0.201	32.907	32.504
90		500.000	28.140	32.906	4.766	757.000	1.076	0.0350	94.000	2.189	0.378	345.877	3.640	0.263	0.262	0.262	33.431	32.907
C 95		500.000	28.590	33.439	4.849	757.000	1.091	0.0350	98.000	2.192	0.390	345.289	3.511	0.267	0.276	0.276	33.982	33.431
C100		500.000	28.410	33.962	5.552	757.000	1.085	0.0350	90.000	2.232	0.383	339.133	3.817	0.276	0.256	0.256	34.494	33.982
C105		500.000	30.330	34.580	4.250	757.000	1.112	0.0350	90.000	2.785	0.540	271.856	3.095	0.440	0.526	0.526	35.547	34.494
C110		500.000	31.250	35.621	4.371	757.000	1.090	0.0350	93.118	2.718	0.524	278.535	3.174	0.411	0.485	0.485	36.516	35.547
C115		500.000	32.450	36.566	4.116	757.000	1.116	0.0350	84.000	2.997	0.583	252.601	3.293	0.512	0.561	0.561	37.639	36.516
C120		500.000	33.630	37.662	4.032	757.000	1.041	0.0350	76.000	2.718	0.463	278.470	3.567	0.392	0.415	0.415	38.470	37.639
C125		500.000	34.570	38.494	3.924	757.000	1.053	0.0350	92.000	2.410	0.427	314.131	3.486	0.312	0.336	0.336	39.143	38.470
C130		500.000	35.640	39.216	3.576	757.000	1.026	0.0350	88.000	2.589	0.460	292.428	3.260	0.351	0.425	0.425	39.992	39.142
135		500.000	37.270	40.396	3.126	757.000	1.052	0.0350	66.978	4.172	0.824	181.467	2.818	0.934	1.339	1.339	42.669	39.992
140		500.000	39.800	42.844	3.044	757.000	1.036	0.0350	94.915	2.844	0.552	266.213	2.889	0.427	0.602	0.602	43.873	42.669
145		500.000	41.900	44.402	2.502	757.000	1.030	0.0350	92.512	3.507	0.744	215.853	2.394	0.647	1.176	1.176	46.225	43.873
150		500.000	43.920	46.829	2.909	757.000	1.081	0.0350	208.000	2.364	0.633	320.205	1.602	0.308		0.913		46.225

$\alpha = 1.000$, $g = 9.80$ (m/sec²)

△×:distance D:compound energy correction factor N:coefficient of compound roughness
B:width of water surface V:velocity A:flow section R:hydraulic mean depth
② velocity head ③ frictional loss

Table 16. Calculation output for 1:10 discharge.

Non-uniform flow F/S 5 UP TA DI PRE (1/1)　　$Fr = v / \{g \cdot A / (D \cdot B)\}^{1/2}$

Station No		Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m^3/sec)	D	N	B (m)	v (m/s)	Fr	A (m^2)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-④ (m)
0			18.580	22.659	4.079	607.000	1.178	0.0350	85.753	2.930	0.653	207.195	2.937	0.516	0.625		23.800	
5		500.000	19.780	23.908	4.128	527.000	1.145	0.0350	99.000	2.085	0.446	252.791	2.654	0.254	0.362	0.362	24.524	23.800
10		500.000	20.080	24.782	4.702	527.000	1.327	0.0350	72.265	3.776	1.000	139.572	2.869	0.965	1.071	1.071	26.818	24.676
15		500.000	20.390	26.788	6.398	527.000	1.150	0.0350	77.000	1.780	0.311	296.002	3.941	0.186	0.156	0.156	27.130	26.818
20		500.000	20.520	27.085	6.565	527.000	1.355	0.0350	94.000	1.945	0.426	270.962	3.512	0.262	0.217	0.217	27.564	27.130
25		500.000	21.280	27.518	6.238	527.000	1.184	0.0350	84.000	1.648	0.293	319.853	4.327	0.164	0.118	0.118	27.800	27.564
30		500.000	21.230	27.781	6.551	527.000	1.135	0.0350	86.000	1.550	0.265	339.946	3.881	0.139	0.121	0.121	28.041	27.799
35		500.000	22.330	28.035	5.705	527.000	1.207	0.0350	74.000	2.248	0.443	234.437	3.379	0.311	0.305	0.305	28.651	28.041
40		500.000	22.240	28.580	6.340	527.000	1.237	0.0350	62.000	2.060	0.360	255.820	4.130	0.268	0.196	0.196	29.043	28.651
45		500.000	22.980	28.979	5.999	527.000	1.152	0.0350	60.000	1.871	0.296	281.679	4.560	0.206	0.142	0.142	29.327	29.043
50		500.000	23.690	29.287	5.597	527.000	1.127	0.0350	85.938	1.603	0.278	328.744	4.427	0.148	0.108	0.108	29.543	29.327
55		500.000	23.740	29.539	5.799	527.000	1.096	0.0350	106.659	1.385	0.245	380.508	3.685	0.107	0.103	0.103	29.750	29.543
60		500.000	24.320	29.743	5.423	527.000	1.253	0.0350	100.000	1.858	0.394	283.650	3.317	0.221	0.214	0.214	30.177	29.750
65		500.000	24.490	30.182	5.692	527.000	1.110	0.0350	130.000	1.231	0.228	428.110	3.391	0.086	0.091	0.091	30.359	30.177
70		500.000	24.970	30.406	5.436	527.000	1.099	0.0350	96.000	1.797	0.344	293.229	3.002	0.181	0.228	0.228	30.816	30.359
75		500.000	26.100	30.861	4.761	527.000	1.128	0.0350	120.000	1.562	0.316	337.323	2.839	0.140	0.186	0.186	31.188	30.816
80		500.000	26.630	31.224	4.594	527.000	1.169	0.0350	104.000	1.834	0.381	287.284	3.008	0.201	0.237	0.237	31.662	31.188
85		500.000	27.260	31.715	4.455	527.000	1.158	0.0350	118.000	1.684	0.355	312.913	2.793	0.168	0.221	0.221	32.104	31.662
90		500.000	28.140	32.162	4.022	527.000	1.094	0.0350	94.000	1.910	0.372	275.931	2.971	0.204	0.262	0.262	32.627	32.104
O 95		500.000	28.590	32.694	4.104	527.000	1.121	0.0350	98.000	1.935	0.393	272.314	2.864	0.214	0.282	0.282	33.191	32.627
O100		500.000	28.410	33.225	4.815	527.000	1.102	0.0350	90.000	1.932	0.372	272.799	3.179	0.210	0.244	0.244	33.679	33.191
O105		500.000	30.330	33.877	3.547	527.000	1.151	0.0350	90.000	2.527	0.569	208.580	2.511	0.375	0.573	0.573	34.825	33.679
O110		500.000	31.250	34.983	3.733	527.000	1.094	0.0350	89.085	2.390	0.508	220.496	2.648	0.319	0.477	0.477	35.780	34.825
O115		500.000	32.450	35.922	3.472	527.000	1.108	0.0350	84.000	2.655	0.581	198.480	2.825	0.399	0.541	0.541	36.861	35.780
O120		500.000	33.630	36.968	3.338	527.000	1.041	0.0350	76.000	2.335	0.442	225.694	2.942	0.290	0.396	0.396	37.653	36.861
O125		500.000	34.570	37.758	3.188	527.000	1.055	0.0350	91.556	2.139	0.428	246.409	2.824	0.246	0.351	0.351	38.355	37.653
O130		500.000	35.640	38.526	2.886	527.000	1.022	0.0350	88.000	2.275	0.453	231.686	2.610	0.270	0.441	0.441	39.237	38.355
135		500.000	37.270	39.839	2.569	527.000	1.045	0.0350	63.875	3.626	0.785	145.335	2.330	0.701	1.303	1.303	41.843	39.237
140		500.000	39.800	42.175	2.375	527.000	1.028	0.0350	91.638	2.586	0.562	203.828	2.279	0.351	0.683	0.683	43.209	41.843
145		500.000	41.900	43.912	2.012	527.000	1.025	0.0350	90.061	3.080	0.723	171.105	1.941	0.496	1.200	1.200	45.608	43.208
150		500.000	43.920	46.436	2.516	527.000	1.131	0.0350	208.000	2.211	0.701	238.388	1.251	0.282		1.110		45.608

$\alpha = 1.000$,　　$g = 9.80$ (m/sec²)

△X:distance　D:compound energy correction factor　N:coefficient of compound roughness
B:width of water surface　V:velocity　A:flow section　R:hydraulic mean depth
② velocity head　③ frictional loss

Table 17. Calculation output for 1: 5 discharge.

Non-uniform flow F/S 2 UP TA DI PRE (1/1)　　$Fr = v / \{g \cdot A / (D \cdot B)\}^{1/2}$

Station No		Δx (m)	Zb (m)	Zb+h ① (m)	h (m)	Q (m^3/sec)	D	N	B (m)	v (m/s)	Fr	A (m^2)	R (m)	$\frac{D \cdot Q^2}{2g \cdot A^2}$ ② (m)	$\frac{N^2 \cdot Q^2 \cdot \Delta x}{2R^{4/3} \cdot A^2}$ ③ (m)	④ (m)	Φ ①+②+③ (m)	Ψ ①+②-④ (m)
0			18.580	21.723	3.143	339.000	1.171	0.0350	69.793	2.505	0.622	135.324	2.323	0.375	0.625		22.722	
5		500.000	19.780	22.951	3.171	294.000	1.193	0.0350	92.193	1.839	0.487	159.898	1.917	0.206	0.435	0.435	23.592	22.722
10		500.000	20.080	23.882	3.802	294.000	1.186	0.0350	42.229	3.503	0.865	83.925	2.635	0.743	1.033	1.033	25.657	23.592
15		500.000	20.390	25.671	5.281	294.000	1.235	0.0350	77.000	1.400	0.301	209.981	3.030	0.124	0.137	0.137	25.931	25.657
20		500.000	20.520	25.926	5.406	294.000	1.448	0.0350	78.323	1.767	0.466	166.358	2.959	0.231	0.225	0.225	26.381	25.931
25		500.000	21.230	26.374	5.094	294.000	1.201	0.0350	78.343	1.306	0.270	225.121	3.543	0.104	0.097	0.097	26.575	26.381
30		500.000	21.230	26.592	5.362	294.000	1.224	0.0350	86.000	1.237	0.263	237.687	2.910	0.096	0.113	0.113	26.800	26.575
35		500.000	22.330	26.881	4.551	294.000	1.357	0.0350	72.188	1.970	0.510	149.274	2.504	0.269	0.349	0.349	27.499	26.800
40		500.000	22.240	27.488	5.248	294.000	1.274	0.0350	62.000	1.563	0.323	188.141	3.376	0.159	0.148	0.148	27.794	27.499
45		500.000	22.980	27.786	4.806	294.000	1.163	0.0350	60.000	1.400	0.258	210.055	3.628	0.116	0.108	0.108	28.009	27.794
50		500.000	23.690	28.012	4.322	294.000	1.118	0.0350	74.026	1.298	0.251	226.523	3.467	0.096	0.098	0.098	28.206	28.009
55		500.000	23.740	28.247	4.507	294.000	1.178	0.0350	105.367	1.208	0.275	243.463	2.547	0.088	0.128	0.128	28.463	28.206
60		500.000	24.320	28.522	4.202	294.000	1.290	0.0350	87.181	1.782	0.470	164.990	2.628	0.209	0.268	0.268	28.999	28.462
65		500.000	24.490	29.035	4.545	294.000	1.204	0.0350	130.000	1.054	0.252	279.033	2.413	0.068	0.105	0.105	29.209	28.999
70		500.000	24.970	29.337	4.367	294.000	1.202	0.0350	96.000	1.542	0.383	190.605	2.079	0.146	0.275	0.275	29.758	29.209
75		500.000	26.100	29.862	3.762	294.000	1.253	0.0350	120.000	1.352	0.359	217.452	2.005	0.117	0.221	0.221	30.201	29.758
80		500.000	26.630	30.289	3.659	294.000	1.251	0.0350	104.000	1.547	0.409	190.041	2.300	0.153	0.241	0.241	30.683	30.201
85		500.000	27.260	30.793	3.533	294.000	1.294	0.0350	118.000	1.441	0.398	204.055	2.034	0.137	0.247	0.247	31.177	30.683
90		500.000	28.140	31.289	3.149	294.000	1.141	0.0350	94.000	1.516	0.360	193.879	2.201	0.134	0.246	0.246	31.669	31.177
O 95		500.000	28.590	31.801	3.211	294.000	1.205	0.0350	98.000	1.592	0.407	184.717	2.104	0.156	0.288	0.288	32.244	31.669
O100		500.000	28.410	32.328	3.918	294.000	1.133	0.0350	88.932	1.530	0.354	192.198	2.431	0.135	0.219	0.219	32.682	32.244
O105		500.000	30.330	33.030	2.700	294.000	1.208	0.0350	90.000	2.222	0.643	132.320	1.879	0.304	0.652	0.652	33.986	32.682
O110		500.000	31.250	34.219	2.969	294.000	1.115	0.0350	84.250	1.906	0.475	154.280	2.005	0.207	0.440	0.440	34.866	33.986
O115		500.000	32.450	35.098	2.648	294.000	1.048	0.0350	62.190	2.143	0.472	137.219	2.249	0.246	0.477	0.477	35.820	34.866
O120		500.000	33.630	36.039	2.409	294.000	1.049	0.0350	76.000	1.895	0.434	155.120	2.092	0.192	0.411	0.411	36.643	35.820
O125		500.000	34.570	36.852	2.282	294.000	1.050	0.0350	86.657	1.775	0.420	165.652	2.020	0.169	0.378	0.378	37.398	36.612
O130		500.000	35.640	37.693	2.053	294.000	1.018	0.0350	87.192	1.854	0.443	158.589	1.820	0.178	0.474	0.474	38.345	37.398
135		500.000	37.270	39.149	1.879	294.000	1.036	0.0350	61.392	2.830	0.726	102.099	1.710	0.439	1.242	1.242	40.829	38.345
140		500.000	39.800	41.398	1.598	294.000	1.020	0.0350	87.830	2.193	0.572	134.090	1.553	0.250	0.818	0.818	42.466	40.830
145		500.000	41.900	43.334	1.434	294.000	1.018	0.0350	87.170	2.453	0.674	119.853	1.397	0.313	1.180	1.180	44.826	42.467
150		500.000	43.920	45.991	2.071	294.000	1.203	0.0350	199.621	2.012	0.824	146.125	0.906	0.248		1.413		44.826

$\alpha = 1.000$,　　$g = 9.80$ (m/sec²)

△X:distance　D:compound energy correction factor　N:coefficient of compound roughness
B:width of water surface　V:velocity　A:flow section　R:hydraulic mean depth
② velocity head　③ frictional loss

Table 18. Calculation output for 1: 2 discharge.

Hydraulic of trapezoidal open channel

Side slope 1/i= 1.5
Roughness coefficient n= 0.035

Canal type	B (m)	H (m)	h (m)	L (m)	S (m)	A=B*h (m2)	P=S+B (m)	R=A/P (m)	R^(2/3)	(1/n)*R^(2/3)
Type-I	0.7	0.7	0.5	2.8	1.80	0.73	2.50	0.29	0.44	12.51
Type-II	1.0	1.0	0.7	4.0	2.52	1.44	3.52	0.41	0.55	15.70
Type-III	1.5	1.5	1.2	6.0	4.33	3.96	5.83	0.68	0.77	22.09
Type-IV	2.0	2.0	1.7	8.0	6.13	7.74	8.13	0.95	0.97	27.64
Type-V	2.5	2.5	2.1	10.0	7.57	11.87	10.07	1.18	1.12	31.87

Velocity (m/s) V = (1/n)*R^(2/3)*I^(1/2)

i	100	200	300	400	500	600	700	800	900	1000
Type-I	1.25	0.88	0.72	0.63	0.56	0.51	0.47	0.44	0.42	0.40
Type-II	1.57	1.11	0.91	0.78	0.70	0.64	0.59	0.55	0.52	0.50
Type-III	2.21	1.56	1.28	1.10	0.99	0.90	0.83	0.78	0.74	0.70
Type-IV	2.76	1.95	1.60	1.38	1.24	1.13	1.04	0.98	0.92	0.87
Type-V	3.19	2.25	1.84	1.59	1.43	1.30	1.20	1.13	1.06	1.01
i	1200	1500	2000	2500	3000	3500	4000	4500	5000	10000
Type-I	0.36	0.32	0.28	0.25	0.23	0.21	0.20	0.19	0.18	0.13
Type-II	0.45	0.41	0.35	0.31	0.29	0.27	0.25	0.23	0.22	0.16
Type-III	0.64	0.57	0.49	0.44	0.40	0.37	0.35	0.33	0.31	0.22
Type-IV	0.80	0.71	0.62	0.55	0.50	0.47	0.44	0.41	0.39	0.28
Type-V	0.92	0.82	0.71	0.64	0.58	0.54	0.50	0.48	0.45	0.32

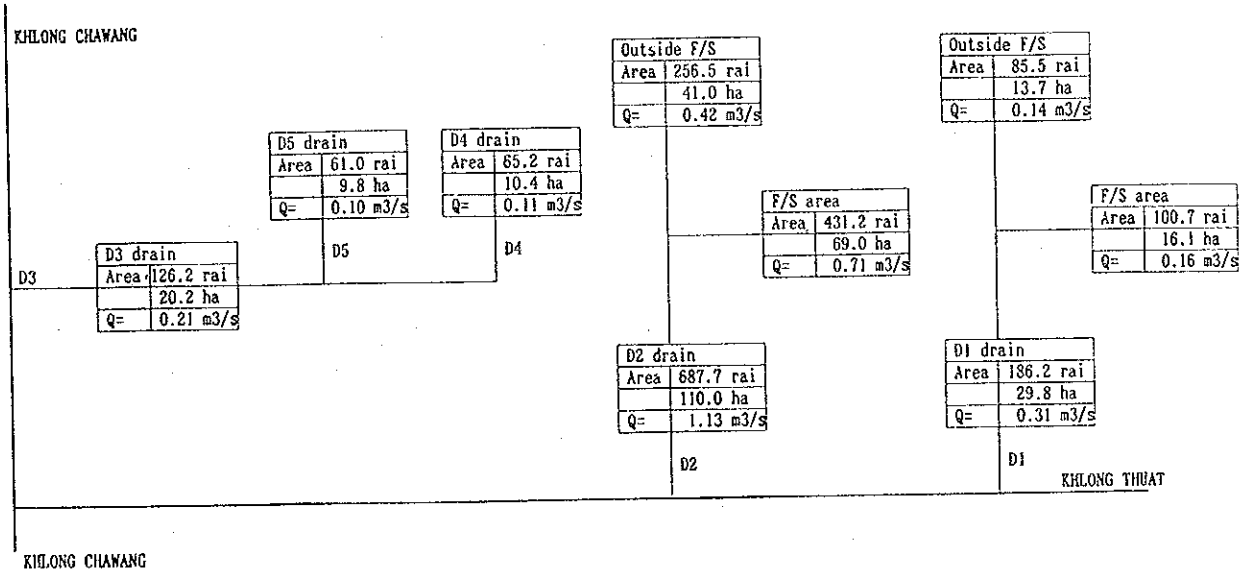
Discharge (m3/s) Q = V*A

i	100	200	300	400	500	600	700	800	900	1000
Type-I	0.91	0.64	0.52	0.45	0.41	0.37	0.34	0.32	0.30	0.29
Type-II	2.25	1.59	1.30	1.13	1.01	0.92	0.85	0.80	0.75	0.71
Type-III	8.75	6.18	5.05	4.37	3.91	3.57	3.31	3.09	2.92	2.77
Type-IV	21.38	15.12	12.34	10.69	9.56	8.73	8.08	7.56	7.13	6.76
Type-V	37.81	26.74	21.83	18.91	16.91	15.44	14.29	13.37	12.60	11.96
i	1200	1500	2000	2500	3000	3500	4000	4500	5000	10000
Type-I	0.26	0.23	0.20	0.18	0.17	0.15	0.14	0.14	0.13	0.09
Type-II	0.65	0.58	0.50	0.45	0.41	0.38	0.36	0.34	0.32	0.23
Type-III	2.52	2.26	1.96	1.75	1.60	1.48	1.38	1.30	1.24	0.87
Type-IV	6.17	5.52	4.78	4.28	3.90	3.61	3.38	3.19	3.02	2.14
Type-V	10.92	9.76	8.46	7.56	6.90	6.39	5.98	5.64	5.35	3.78

B= Bottom width
H= Channel depth
h= Depth of water
L= Length of channel
S= Length of slope (both banks)=2*(h^2+(h*i)^2)^(1/2)

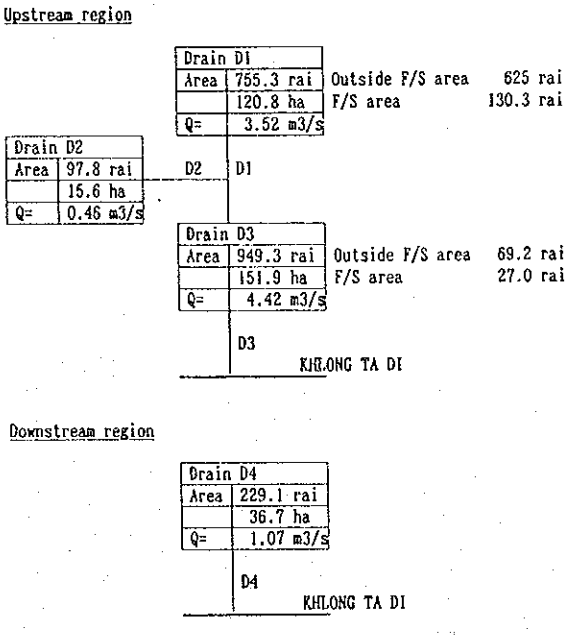
Table 19. Hydraulic of trapezoidal open channel.

Flow-chart of drainage canal (Ban Na San F/S Area)



Note: 1/10 probability daily rainfall drained daily is adopted.
Q(m3/s)=(1/3.6)*f*r*A(km2)=1.024*A(km2), f=0.64, r=5.763mm/hr(138.3mm/24hr)

Flow-chart of drainage canal (Lan Saka F/S Area)



Note: 1/10 probability daily rainfall drained daily is adopted.
Q(m3/s)=(1/3.6)*f*r*A(km2)=2.909*A(km2), f=0.86, r=12.179mm/hr(292.3mm/24hr)

Figure 1. Flow chart of drainage canals (Ban Na San and Lan Saka F/S area).

Drainage canal – Ban Na San F/S Area

Canal D1

Distance from downstream (m)	0	20	35	100	170	275	340	490
Elevation	76.5	77	78	79	80	81	82	83

Existing surface gradient= 0.013 or 1/ 75
Design canal bed gradient 1/ 400

Distance from downstream (m)	0	123	123	245	245	368	368	496	490
Elevation	75.8	76.1	77.6	77.9	79.4	79.7	81.2	81.5	82.5
Drop structure			d3		d3		d3		d3

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=0.31m3/s<0.45m3/s for canal Type-I (V=0.63m/s, Q=0.45m3/s, 1/400)

Canal D2

Distance from downstream (m)	0	60	120	215	400	490	600	720	810	870
Elevation	83	84	84	84	85	86	87	88	89	90

Existing surface gradient= 0.008 or 1/ 124
Design canal bed gradient 1/ 400

Distance from downstream (m)	0	174	174	348	348	522	522	696	696	870	870
Elevation	82.0	82.4	83.1	83.8	84.3	84.7	85.7	86.1	87.1	87.6	89.1
Drop structure			d1		d1		d2		d2		d3

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=1.13m3/s≦1.13m3/s for canal Type-II (V=0.78m/s, Q=1.13m3/s, 1/400)

Canal D3

Distance from downstream (m)	0	110	240	360
Elevation	77	78.2	79.7	81

Existing surface gradient= 0.011 or 1/ 90
Design canal bed gradient 1/ 400

Distance from downstream (m)	0	90	90	180	180	270	270	360	360
Elevation	76.3	76.5	77.2	77.4	78.2	78.4	79.1	79.3	80.3
Drop structure			d1		d1		d1		d2

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=0.21m3/s<0.45m3/s for canal Type-I (V=0.63m/s, Q=0.45m3/s, 1/400)

Canal D4

Distance from downstream (m)	0	135
Elevation	79.7	81

Existing surface gradient= 0.01 or 1/ 104
Design canal bed gradient 1/ 400

Distance from downstream (m)	0	68	68	135	135
Elevation	79.0	79.2	80.2	80.3	80.3
Drop structure			d2		

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=0.11m3/s<0.45m3/s for canal Type-I (V=0.63m/s, Q=0.45m3/s, 1/400)

Canal D5

Distance from downstream (m)	0	190
Elevation	78.2	80

Existing surface gradient= 0.009 or 1/ 105
Design canal bed gradient 1/ 400

Distance from downstream (m)	0	63	63	127	127	190	190
Elevation	77.5	77.7	78.4	78.5	79.2	79.4	79.4
Drop structure			d1		d1		

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=0.10m3/s<0.45m3/s for canal Type-I (V=0.63m/s, Q=0.45m3/s, 1/400)

Drainage canal – Lan Saka F/S Area

Canal D1

Distance from downstream (m)	0	125	600	1000
Elevation	33.5	35	36	37

Existing surface gradient= 0.004 or 1/ 286
Design canal bed gradient 1/ 1000

Distance from downstream (m)	0	250	250	500	500	750	750	1000	1000
Elevation	31.5	31.8	32.5	32.7	33.4	33.7	34.4	34.6	35.3
Drop structure			d1		d1		d1		d1

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=3.52m3/s<3.89m3/s for canal Type-IV (V=0.76m/s, Q=3.89m3/s, h=1.3m, 1/1000)

Canal D2

Distance from downstream (m)	0	225	425	600
Elevation	33.5	34	35	36

Existing surface gradient= 0.004 or 1/ 240
Design canal bed gradient 1/ 300

Distance from downstream (m)	0	300	300	600	600
Elevation	32.8	33.8	33.8	34.8	35.5
Drop structure					d1

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=0.46m3/s<0.52m3/s for canal Type-I (V=0.72m/s, Q=0.52m3/s, h=0.5m, 1/300)

Canal D3

Distance from downstream (m)	0	300
Elevation	33	33.5

Existing surface gradient= 0.002 or 1/ 600
Design canal bed gradient 1/ 1000

Distance from downstream (m)	0	300	300
Elevation	31.0	31.3	31.3
Drop structure			

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=4.42m3/s<4.52m3/s for canal Type-IV (V=0.79m/s, Q=4.52m3/s, h=1.4m, 1/1000)

Canal D4

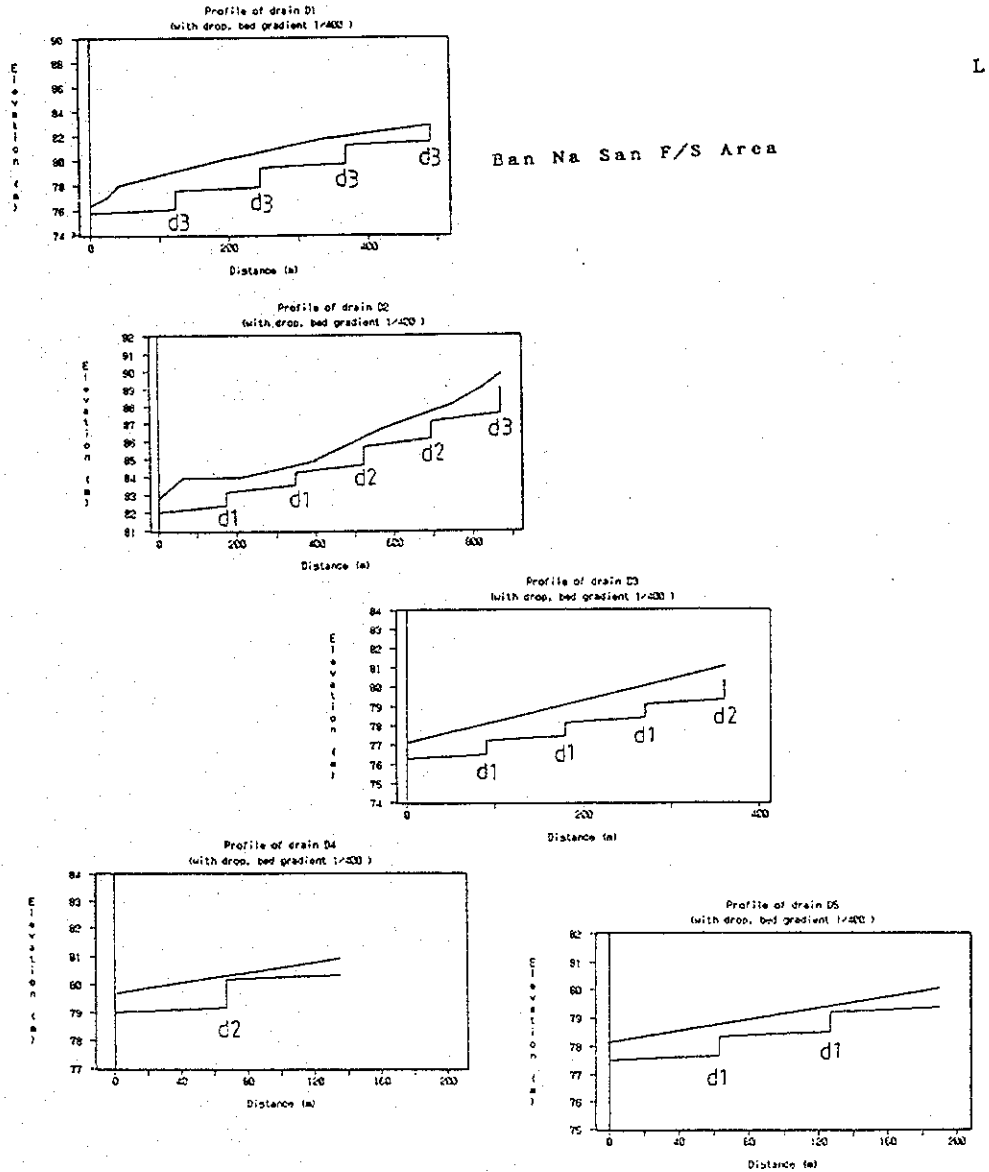
Distance from downstream (m)	0	50	300	500	625
Elevation	30	31	32	33	34

Existing surface gradient= 0.006 or 1/ 156
Design canal bed gradient 1/ 400

Distance from downstream (m)	0	208	208	417	417	625	625
Elevation	29.0	29.5	30.2	30.7	31.4	32.0	33.0
Drop structure			d1		d1		d2

d3=drop Type III (H=1.5m), d2=drop Type II (H=1.0m), d1=drop Type I (H=0.7m)
Design Q=1.07m3/s<1.13m3/s for canal Type-II (V=0.78m/s, Q=1.13m3/s, h=0.7m, 1/400)

Table 20 Canal and drop structure design (Ban Na San and Lan Saka F/S area).



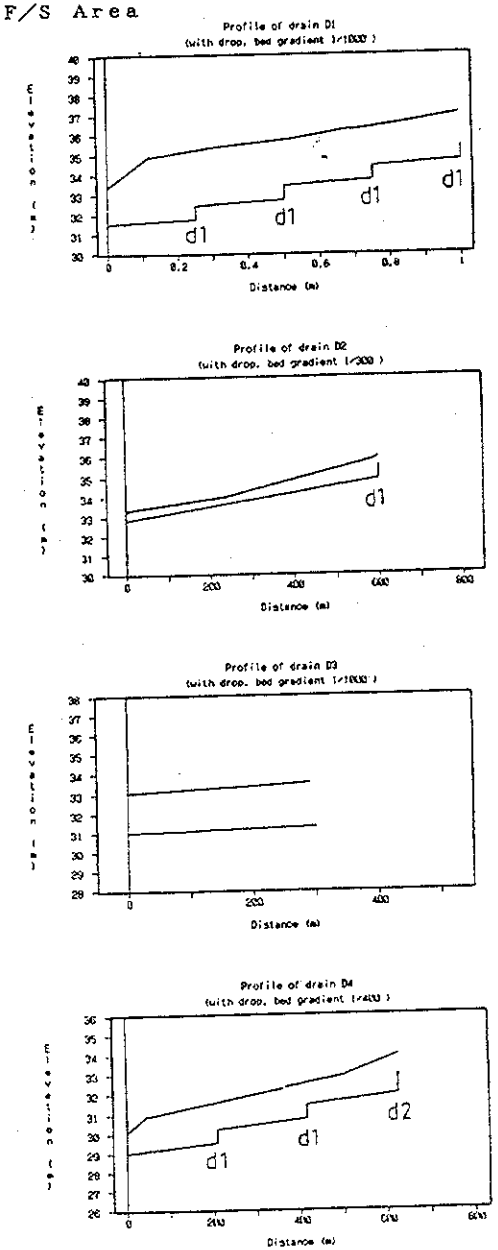


Figure 2. Profile of drainage canals (Ban Na San and Lan Saka F/S area).

Ban Na San : Estimated irrigable area of water diverted from Khlong Mui.

Probability year	Estimated irrigable area for April Efficiency 0.7-0.85, duration 8-12hr min (ha)	max (ha)	Remarks
1/2	60	110	No irrigation water shortage
1/5	20	40	Need to store water in tanks. Pump water from pipeline during non-irrigation hours to be stored in the existing tanks.
1/10	10	20	Need to store water in tanks. Pump water from pipeline during non-irrigation hrs. Need to supplement water by pumping from Khlong Chawang.

Note: Effective rainfall is considered

Estimation of utilizable water from Khlong Chawang + Mui

Total available water (m3/day) = 4,800

Utilizable discharge (1/10 probability dry year)	(m3/s) ①	(m3/day) ②=①*86400	(m3/day) ③=②*0.7	(m3/day)
Khlong Chawang+Mui	0.08	6,912	4,838	4,800
Khlong Mui	0.03	2,592	1,814	1,800
Khlong Chawang	0.05	4,320	3,024	3,000

Note 1) Utilizable discharge = Discharge - release requirement (droughty discharge)
2) Irrigation efficiency = 0.7 is assumed

Water requirement estimation

Water requirement (mm/day)		4
Total area a) with dike (ha)	=	102
b) without dike (ha)	=	87
Rotation (days/cycle)	=	7
Irrigated area for a) (ha/day)	≒	15
for b) (ha/day)	≒	13
Water requirement for a) (m3/day)	=	4,200
for b) (m3/day)	=	3,640

Estimated irrigation area

Total area = 658.05rai
=(652.45+5.6)rai
Test plot=5.6rai
or ≒ 105.3ha
Irrigation area
a) with dike =101.7≒102ha
(unusable land=3.62ha)
b) without dike =86.58≒87ha
(unusable land=3.62ha)
(sand=110.09rai=17.61ha)

Storage capacity of the existing tanks

Average depth (m)	=	1.5
Average width & length (m)	=	15
Average volume (m3)	≒	350
Existing storage capacity	=	3,850 ~ 4,900 (11~14tanks)

Since water in Khlong Chawang + Mui (4,800m3/day) is greater than irrigation requirement (3,640~4,200m3/day), it is necessary to extract daily water from Khlong Chawang to supplement daily water shortage in the dry years.
Since storage capacity of the existing tanks (3,850~4,900m3) ≒ daily irrigation requirement with proper irrigation practice and close cooperation among the farmers, water shortage can be met by using water from the pipeline & Khlong Chawang (farmers without tank) and tanks (farmer with tanks) during daytime and pump water from pipeline & Khlong Chawang, to be stored in the tanks for next day use, during non-irrigation hours (e.g. in the early morning or evening and/or nighttime).

Table 21. Estimation of storage capacity of the existing tanks, Ban Na San F/S area.

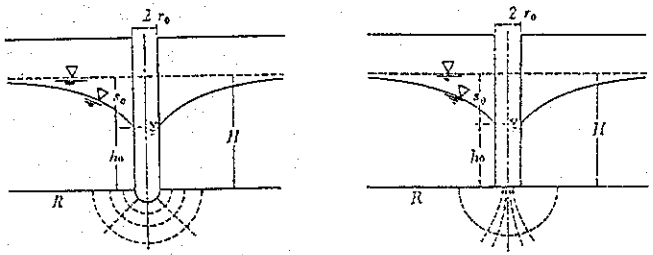
Yield of shallow well

No yield from side of wells

Permeability (k)	=	0.073 cm/s
Circle of influence (R)	=	400 m
Radius of well (ro)	=	0.5 m

Drawdown (so) (m)	Groundwater yield Q1 (m3/s)	Q2 (m3/s)
0.5	0.0011	0.0007
1.0	0.0023	0.0015
1.5	0.0034	0.0022
2.0	0.0046	0.0029

Note:
Q1: Semi-circle bottom Q1=2*PI*k*so/(1/ro-1/R)
Q2: Flat bottom Q2=2*PI*k*ro*so/(tan-1(R/ro)) Forchheimer



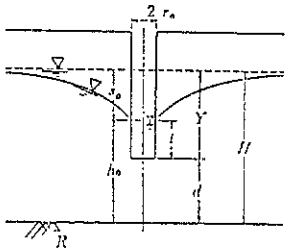
Yield from side and bottom of wells

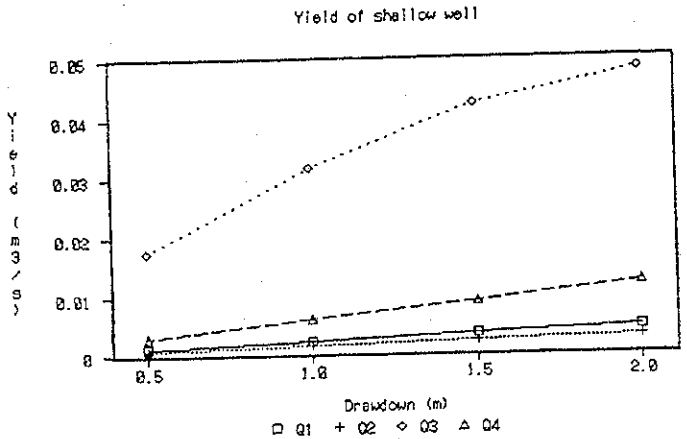
Permeability (k)	=	0.073 cm/s
Circle of influence (R)	=	400 m
Radius of well (ro)	=	0.5 m
Groundwater thickness (H)	=	10 m
Depth of well from groundwater level (Y)	=	3 m

Drawdown (so) (m)	Groundwater yield ho (m)	t (m)	Q3 (m3/s)	Q4 (m3/s)
0.5	9.50	2.50	0.0174	0.0030
1.0	9.00	2.00	*0.0318	0.0061
1.5	8.50	1.50	0.0424	0.0091
2.0	8.00	1.00	0.0482	0.0121

Note:
Q3: Forchheimer $Q=\frac{\pi k(H^2-h_o^2)}{2.3\log_{10}\frac{R}{r_o}}\frac{1}{\left(\frac{h_o}{t+0.5r_o}\right)^{0.5}\left(\frac{h_o}{2h_o-t}\right)^{0.25}}$

Q4: de Glee $Q=\frac{4\pi k(H-h_o)}{\frac{4.6}{Y}\log_{10}\frac{\pi Y}{2r_o}+\frac{0.20}{H}}$



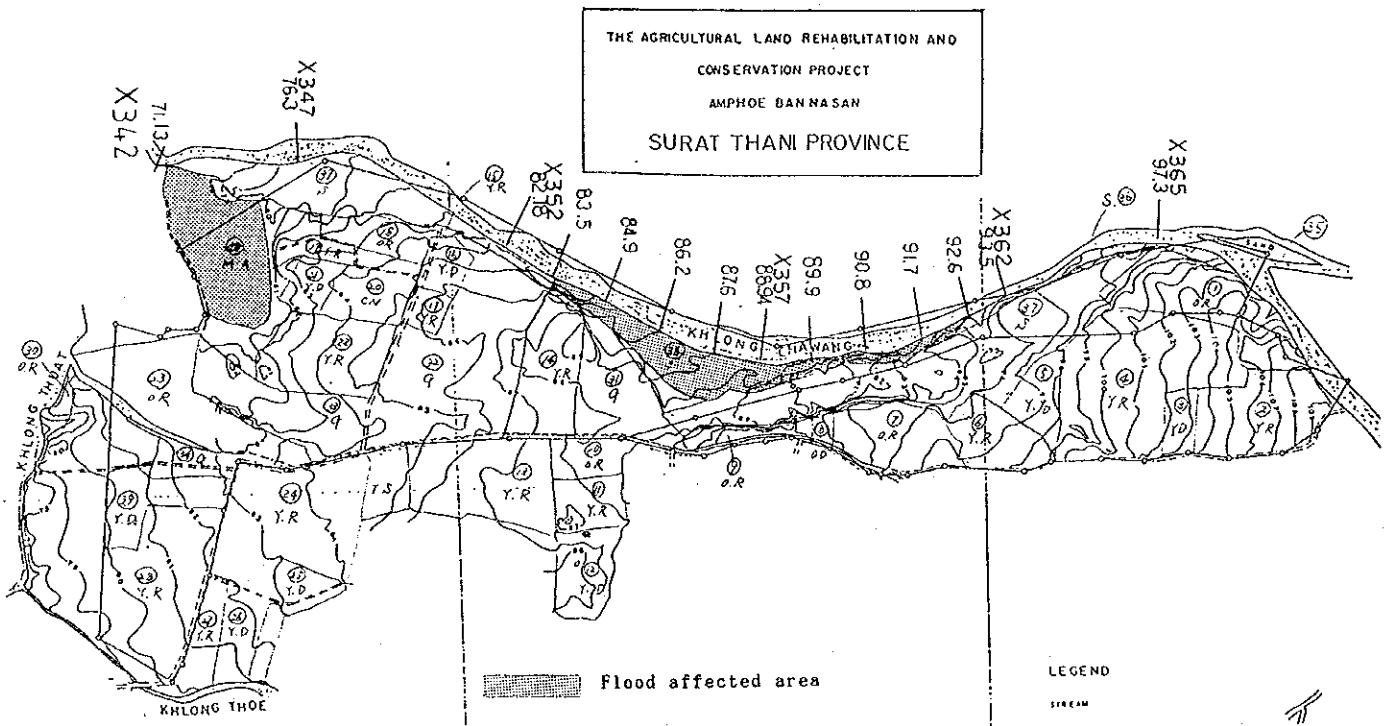


Command area of shallow well

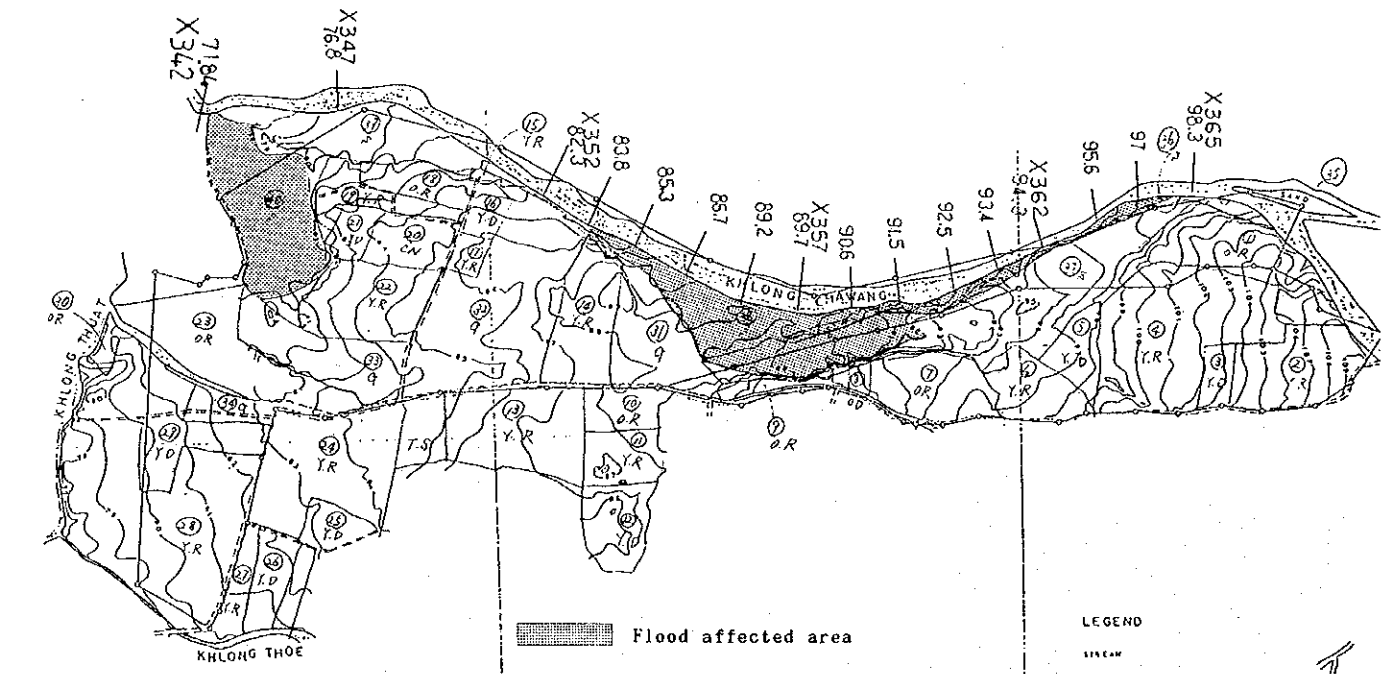
Water requirement (ETo in March, April)	=	5.3 mm/day
or	=	53 m3/ha/day
Available groundwater (Q3 for drawdown 1.0m)	=	114.31 m3/hr
Irrigable area per hour per well	=	2.16 ha/hr
Irrigable area per day per well	=	8.63 ha/day
or	=	8 ha/day

Note:
Intermittent pumping. 1 hr pumping follow by 1hr intermission is adopted.
4 cycles per day (8hr/2hr per cycle) is possible.
Drawdown=1.0m. Q3=0.0318m3/s is adopted.

Figure 3. Groundwater yield and command area of shallow wells (Lan Saka F/S area)

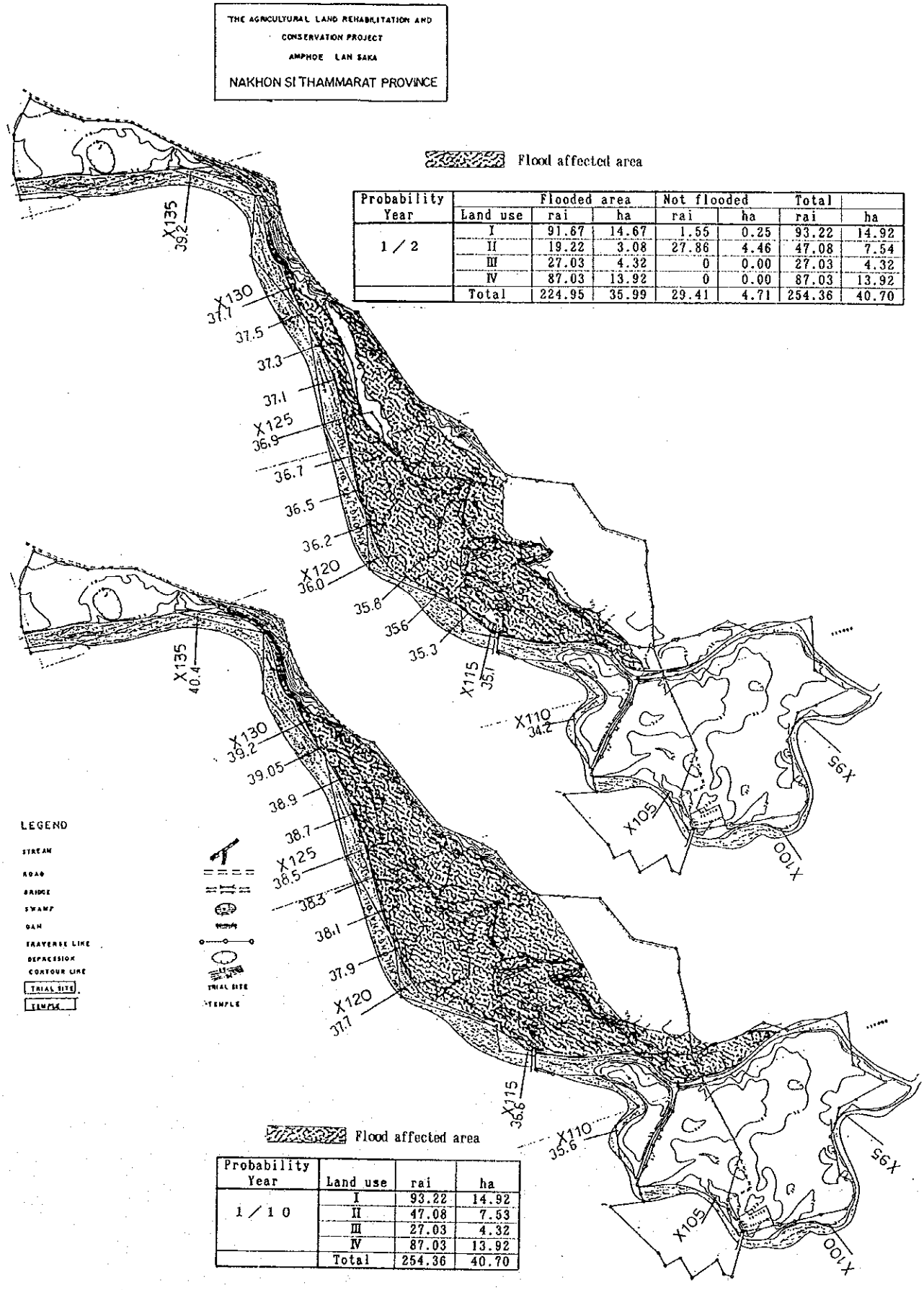


Probability year	Block number	Flood affected/not affected				Total	
		Flood affected		Not affected			
		rai	ha	rai	ha	rai	ha
1/2	36	1.30	0.21	7.80	1.25	9.10	1.46
	38	18.37	2.94	3.06	0.49	21.43	3.43
	40	24.32	3.89	11.61	1.86	35.93	5.75
	Total	43.99	7.04	22.47	3.60	66.46	10.63



Probability year	Block number	Flood affected/not affected				Total	
		Flood affected		Not affected			
		rai	ha	rai	ha	rai	ha
1/10	36	6.50	1.04	2.60	0.42	9.10	1.46
	37	14.57	2.33	41.46	6.63	56.03	8.96
	38	21.43	3.43	0.00	0.00	21.43	3.43
	40	29.30	4.69	6.63	1.06	35.93	5.75
	Total	71.80	11.49	50.69	8.11	122.49	19.60

Figure 4. Flood affected area of 1/2 & 1/10 probability rainfall (without dike), Ban Na San F/S area.

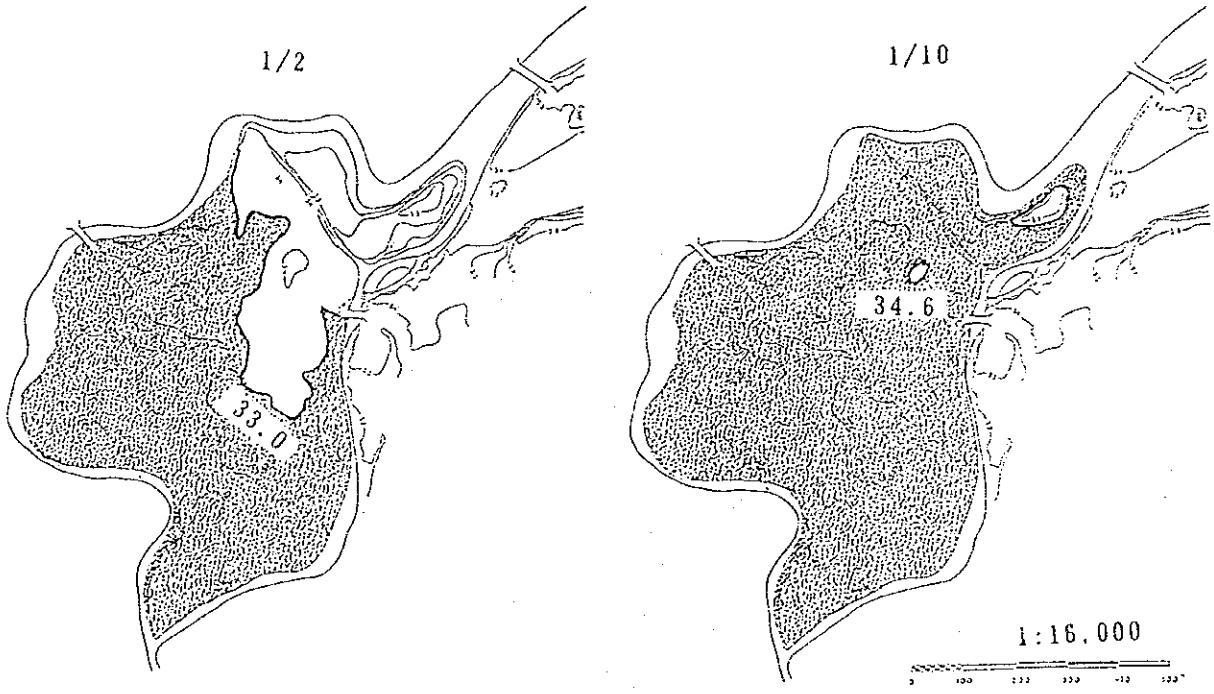


Probability Year	Land use	Flooded area rai	ha	Not flooded rai	ha	Total rai	ha
1/2	I	91.67	14.67	1.55	0.25	93.22	14.92
	II	19.22	3.08	27.86	4.46	47.08	7.54
	III	27.03	4.32	0	0.00	27.03	4.32
	IV	87.03	13.92	0	0.00	87.03	13.92
	Total	224.95	35.99	29.41	4.71	254.36	40.70

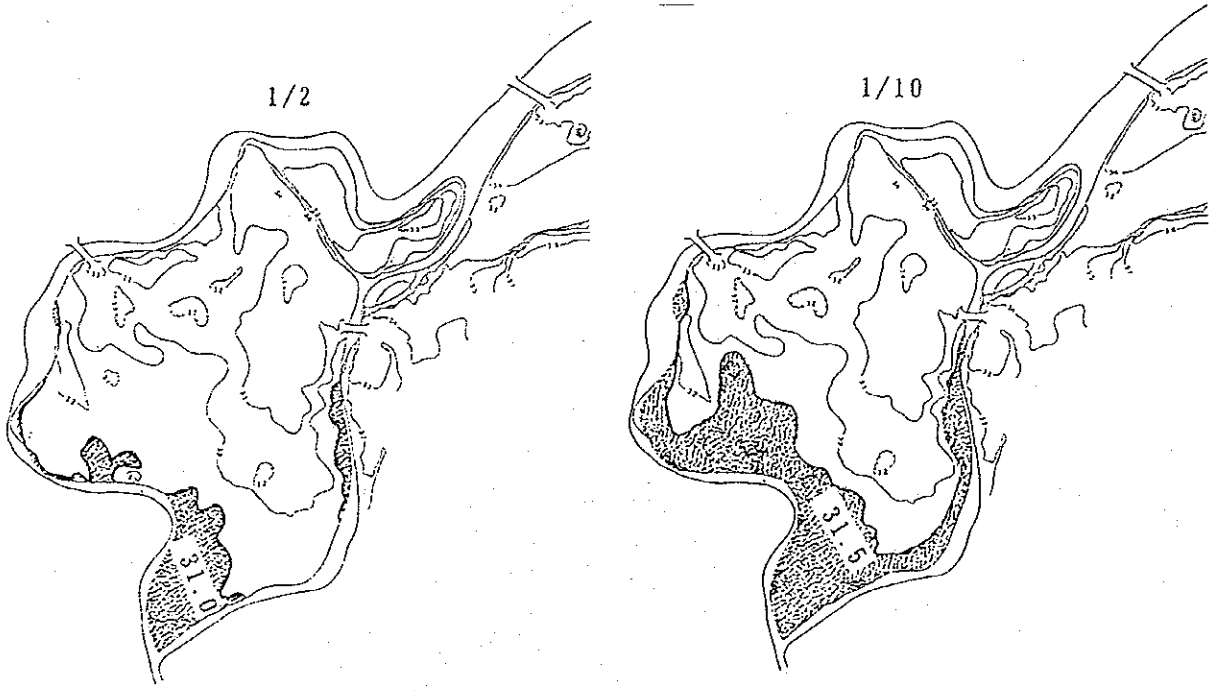
Probability Year	Land use	rai	ha
1/10	I	93.22	14.92
	II	47.08	7.53
	III	27.03	4.32
	IV	87.03	13.92
	Total	254.36	40.70

Figure 5. Flood affected area of 1/2 and 1/10 probability rainfall (without dike), upstream region, Lan Saka F/S area.

without ring dike



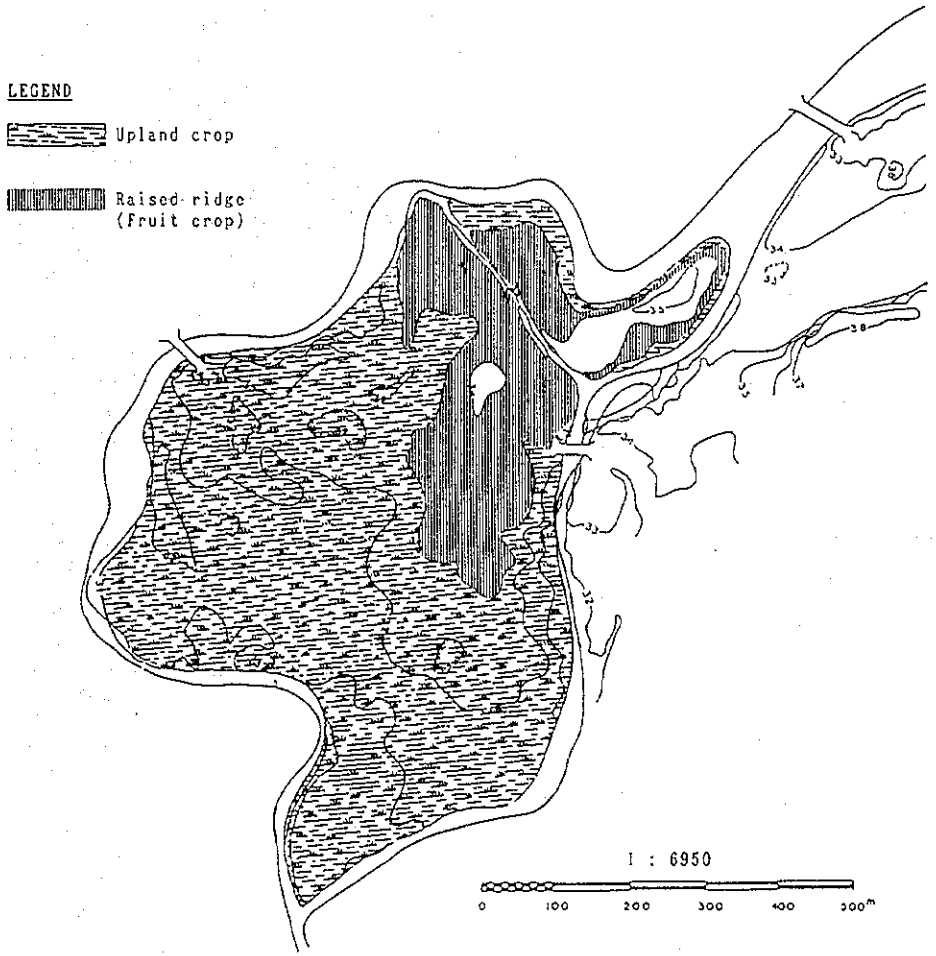
with ring dike



Probability year	Without ring dike			With ring dike		
	Elevation (m)	Area		Elevation (m)	Area	
		rai	ha		rai	ha
1/2	33.0	170.8	27.32	31.0	29.6	4.74
1/10	34.6	225.4	36.06	31.5	65.4	10.46

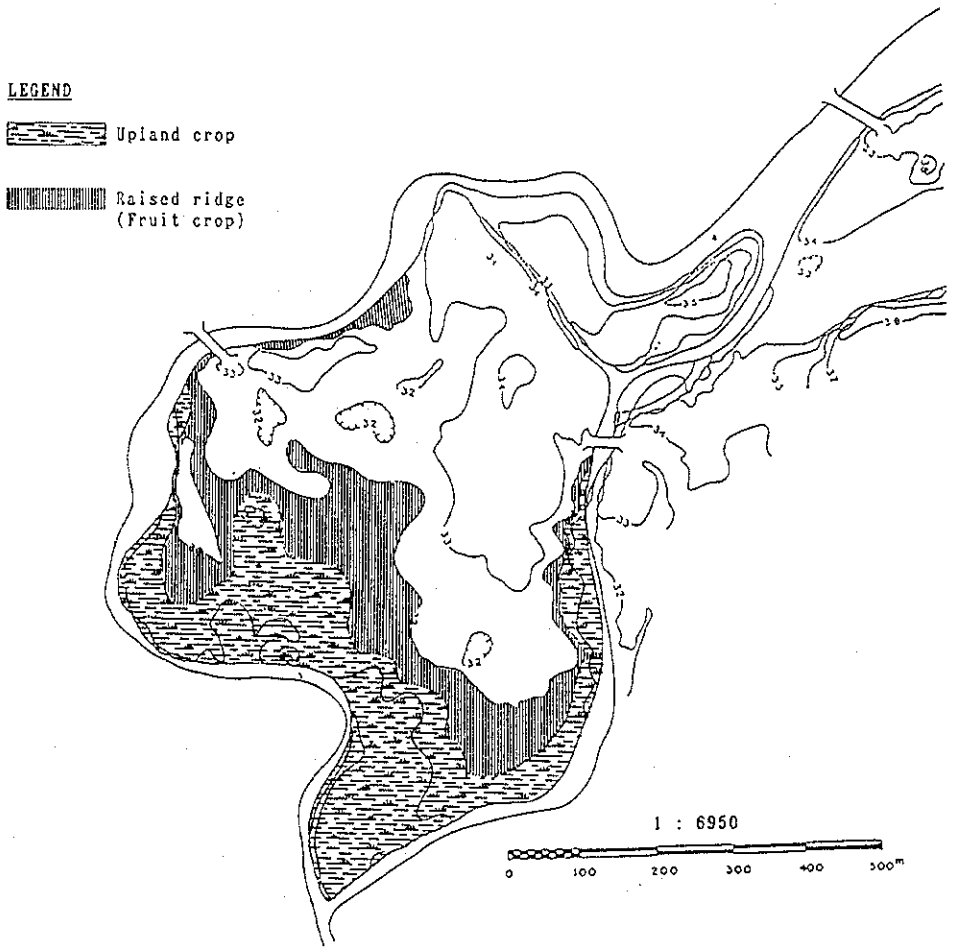
Note: Without ring dike = limited dike at the upper edge of islet

Figure 6. Flood affected area of 1/2 & 1/10 probability rainfall (without and with ring dike), downstream region , Lan Saka F/S area.



	Elevation (m)	Unusable land rai	Unusable land ha	Farmland rai	Farmland ha	Total rai	Total ha
Orchard	>34	0.0	0.00	8.1	1.29	8.1	1.29
Raised ridge	33~34	4.4	0.70	46.2	7.39	50.6	8.09
Upland crop	<33	17.9	2.87	152.8	24.45	170.8	27.32
Total		22.3	3.57	207.1	33.13	229.4	36.70

Note: Unusable land = dike area only
Without ring dike = limited dike at upper region
Land use for 1/2 probability rainfall without ring dike



	Elevation (m)	Unusable land rai	Unusable land ha	Farmland rai	Farmland ha	Total rai	Total ha
Orchard	>32	25.0	4.00	103.3	16.53	128.3	20.53
Raised ridge	31.5~32	6.9	1.11	28.8	4.61	35.8	5.72
Upland crop	<31.5	12.8	2.04	52.6	8.41	65.3	10.45
Total		44.7	7.15	184.7	29.55	229.4	36.70

Note: Unusable land = dike area only
Land use for 1/2 probability rainfall with ring dike

Figure 7. Land use of 1/2 probability rainfall, with and without ring dike.

Water level outside and inside the ring dike

Probability	Without dike Flood level of Khlong Ta Di See Note 1) (m)	With ring dike Water level inside ring dike resulting from rainfall		
		No drainage		Drained by D4 See note 2)
		1-day rainfall (m)	3-day rainfall (m)	
1/2	33.03	31.31	31.67	31.0
1/5	33.88	31.58	32.06	-
1/10	34.58	31.80	32.25	31.5
1/25	-	32.06	32.54	-
1/50	35.73	32.18	32.78	-

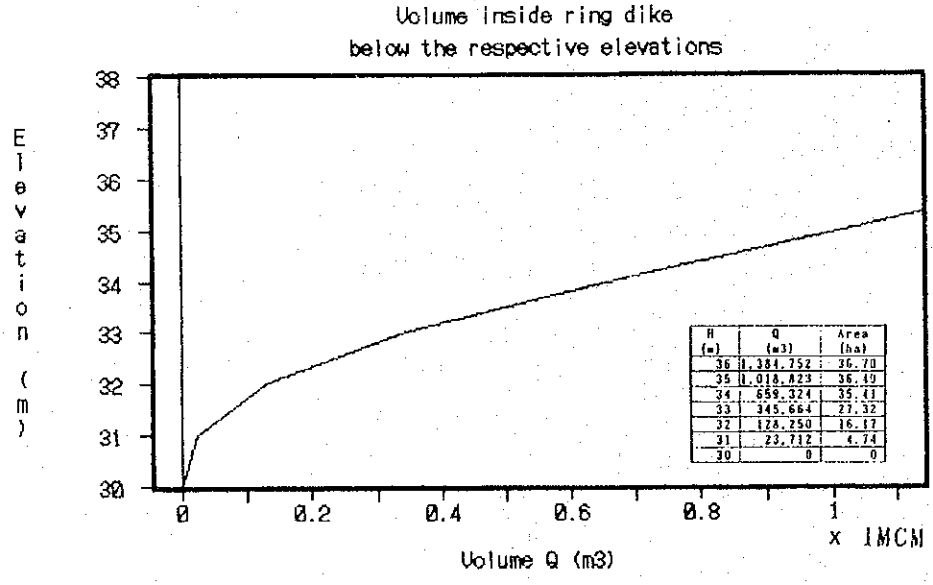
Note: 1) Flood level of Ta Di are the results of non-uniform flow calculation. The data are water levels at X105. Flood is assumed to intrude near X105 when there is no dike.

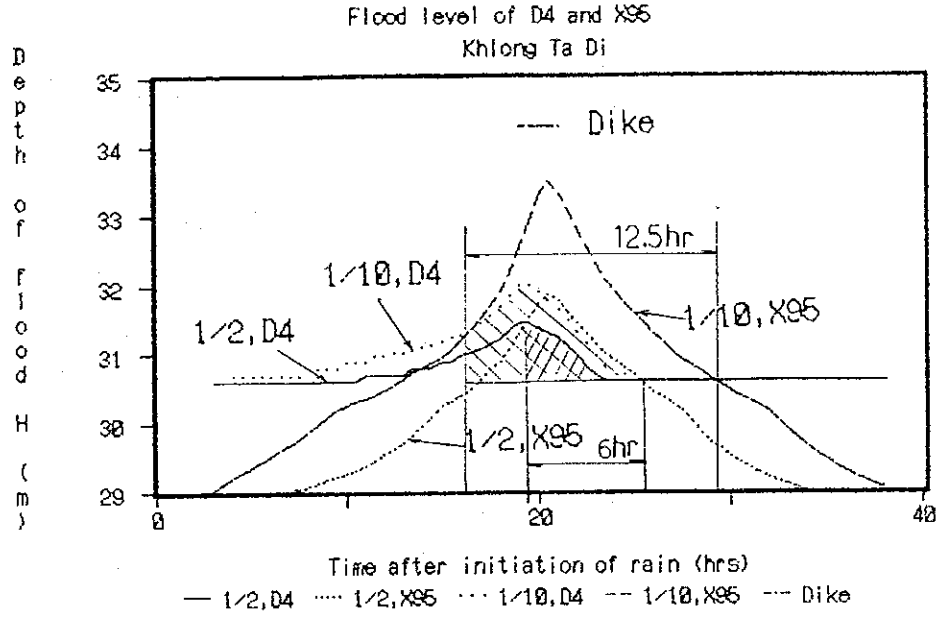
2) Drainage by D4 is subject to flood level changes at X95. Volume of water inundated after gate closure are 14,580 and 66,780m3 for 1/2 and 1/10 probability, respectively. Inundation duration are 6 and 12.5 hours, respectively. Drainage gate is closed when outside water level equals inside level.

Volume in m3 of the respective rainfalls

Probability	1-day rainfall (mm)	Volume (m3)	3-day rainfall (mm)	Volume (m3)
1/2	152.7	56,041	254.4	93,365
1/5	230.4	84,557	387.0	142,029
1/10	292.3	107,274	498.8	183,060
1/25	382.2	140,267	667.5	244,973
1/50	457.3	167,829	813.3	298,481

Note : area inside ring dike (ha) = 36.7

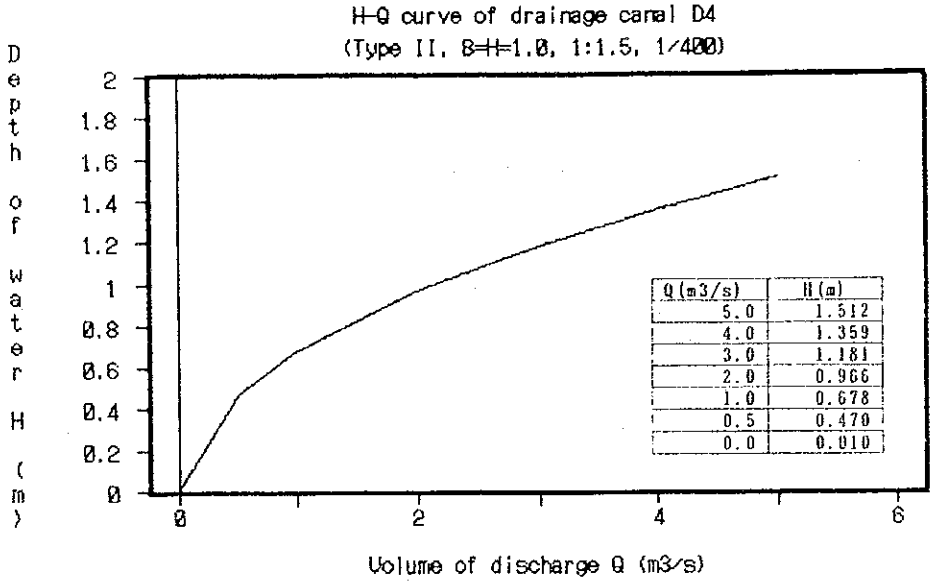


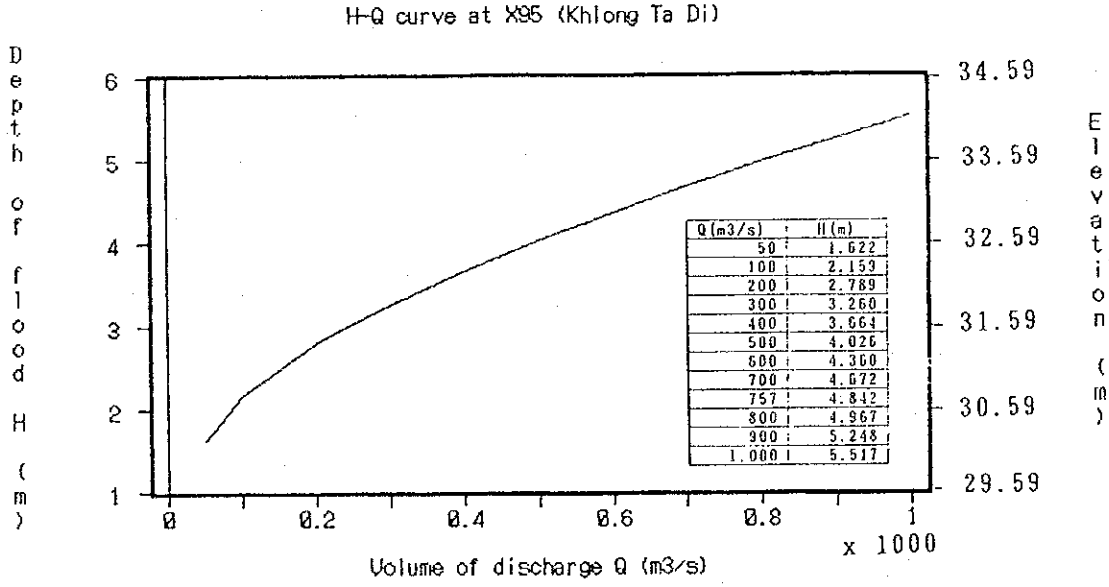


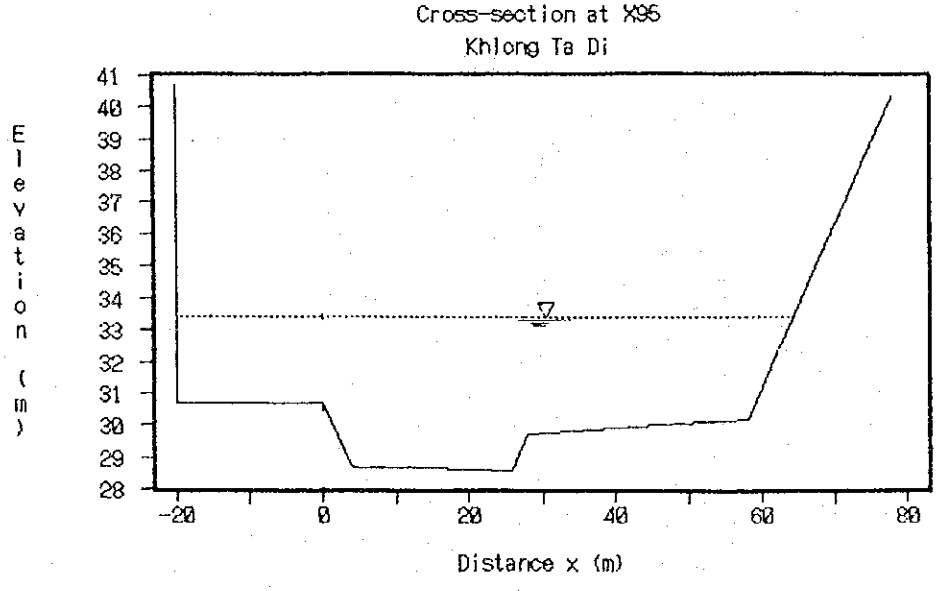
Results and conditions of calculation

Conditions	D4, inside ring dike	X95, Ta Di
Method	Triangular unit hydrograph	Unit hydrograph
Canal/river bed elevation (m)	30.5	28.59
Command area (km2)	0.364	82.8
Concentration time (hr)	0.5	2.0
Results		
Peak discharge (1/2) (m3/s)	(at 19hr) 1.92	(at 20.5hr) 301.70
(1/10) (m3/s)	4.95	776.00
flood level (1/2) (m)	31.47	31.86
(1/10) (m)	32.00	33.49
Flood level of 1/2 at 19.5hr	31.44	31.51
at 25.5hr	30.60	30.56
1/10 at 17.0hr	31.44	31.49
at 29.5hr	30.60	30.54

Note that for 1/2. flood level of D4 < X95 at 19.5hr
D4 > X95 at 25.5hr
1/10. flood level of D4 < X95 at 17.0hr
D4 > X95 at 29.5hr


H-Q curve of drainage canal D4
(Type II, B=H=1.0, 1:1.5, 1/400)
Depth of water H (m)
Volume of discharge Q (m3/s)
Q(m3/s) | H(m)
5.0 | 1.512
4.0 | 1.359
3.0 | 1.181
2.0 | 0.966
1.0 | 0.678
0.5 | 0.470
0.0 | 0.010


H-Q curve at X95 (Khlong Ta Di)
Depth of flood H (m)
Elevation (m)
Volume of discharge Q (m3/s)
x 1000
Q(m3/s) | H(m)
50 | 1.622
100 | 2.159
200 | 2.789
300 | 3.260
400 | 3.664
500 | 4.026
600 | 4.360
700 | 4.672
757 | 4.842
800 | 4.967
900 | 5.248
1,000 | 5.517


Cross-section at X95
Khlong Ta Di
Elevation (m)
Distance x (m)

Ban Na San F/S area (Complete earth dike construction)

	route	Land use type	Land occupied by structure and unusable for cultivation			
			m2	ha	rai	%
Complete earth dike		36	12,150	1.22	7.59	
		38	7,950	0.80	4.97	
		39	6,750	0.68	4.22	
	Total		26,850	2.69	16.78	74.3%
Farm road	R1	5	350	0.04	0.22	
		37	450	0.05	0.28	
	R2	9	100	0.01	0.06	
		37	100	0.01	0.06	
		38	200	0.02	0.13	
	R3	40	550	0.06	0.34	
	R4	28	700	0.07	0.44	
	Total		2,450	0.25	1.53	6.8%
Drainage canal	D1	24	350	0.04	0.22	
		28	1050	0.11	0.66	
	D2	31	350	0.04	0.22	
		14	700	0.07	0.44	
		32	1,250	0.13	0.78	
		33	450	0.05	0.28	
		23	750	0.08	0.47	
	D3	40	1000	0.10	0.63	
	D4	40	400	0.04	0.25	
	D5	40	550	0.06	0.34	
	Total		6,850	0.69	4.28	18.9%
Total			36,150	3.62	22.59	100.0%

Note: Unusable land is shown for the blocks with structure

Ban Na San F/S area (Limited dike construction)

	route	Land use type	Land occupied by structure and unusable for cultivation			
			m2	ha	rai	%
Earth dike		36	12,150	1.22	7.59	
		38	3,120	0.31	1.95	
		39	1,750	0.18	1.09	
	Total		17,020	1.70	10.64	64.7%
Farm road	R1	5	350	0.04	0.22	
		37	450	0.05	0.28	
	R2	9	100	0.01	0.06	
		37	100	0.01	0.06	
		38	200	0.02	0.13	
	R3	40	550	0.06	0.34	
	R4	28	700	0.07	0.44	
	Total		2,450	0.25	1.53	9.3%
Drainage canal	D1	24	350	0.04	0.22	
		28	1050	0.11	0.66	
	D2	31	350	0.04	0.22	
		14	700	0.07	0.44	
		32	1,250	0.13	0.78	
		33	450	0.05	0.28	
		23	750	0.08	0.47	
	D3	40	1000	0.10	0.63	
	D4	40	400	0.04	0.25	
	D5	40	550	0.06	0.34	
	Total		6,850	0.69	4.28	26.0%
Total			26,320	2.63	16.45	100.0%

Note: Unusable land is shown for the blocks with structure

Lan Saka F/S area (Upstream, earth dike construction)

Upstream	route	Land use type	Land occupied by structure and unusable for cultivation			
			m2	ha	rai	%
Dike		I	40,000	4.00	25.00	
		IV	5,000	0.50	3.13	
			45,000	4.50	28.13	74.2%
Farm road	R1	V	100	0.01	0.06	
	R2	II	200	0.02	0.13	
		IV	100	0.01	0.06	
	R3	I	220	0.02	0.14	
		IV	180	0.02	0.11	
	Total		800	0.08	0.50	1.3%
Drainage canal	D1	IV	9,000	0.90	5.63	
	D2	IV	1,400	0.14	0.88	
	D1	III	1,000	0.10	0.63	
	D2	III	400	0.04	0.25	
	D3	III	3,000	0.30	1.88	
	Total		14,800	1.48	9.27	24.5%
Total			60,600	6.06	37.90	100.0%

Note: Unusable land is shown for each land use type.

Lan Saka F/S area (Downstream, ring dike construction)

Downstream	route	Land use type	Land occupied by structure and unusable for cultivation			
			m2	ha	rai	%
Ring dike		I	71,500	7.15	44.69	94.8%
Farm road	R4	I	1,400	0.14	0.88	1.9%
Drainage canal	D4	I	2,500	0.25	1.56	3.3%
Total			75,400	7.54	47.13	100.0%

Note: Unusable land is shown for each land use type.

Lan Saka F/S area (Downstream, semi-ring dike construction)

Downstream	route	Land use type	Land occupied by structure and unusable for cultivation			
			m2	ha	rai	%
Semi-Ring dike		I	35,750	3.58	22.34	90.2%
Farm road	R4	I	1,400	0.14	0.88	3.5%
Drainage canal	D4	I	2,500	0.25	1.56	6.3%
Total			39,650	3.97	24.78	100.0%

Note: Unusable land is shown for each land use type.

Table 22. Unusable land of Ban Na San and Lan Saka F/S area.

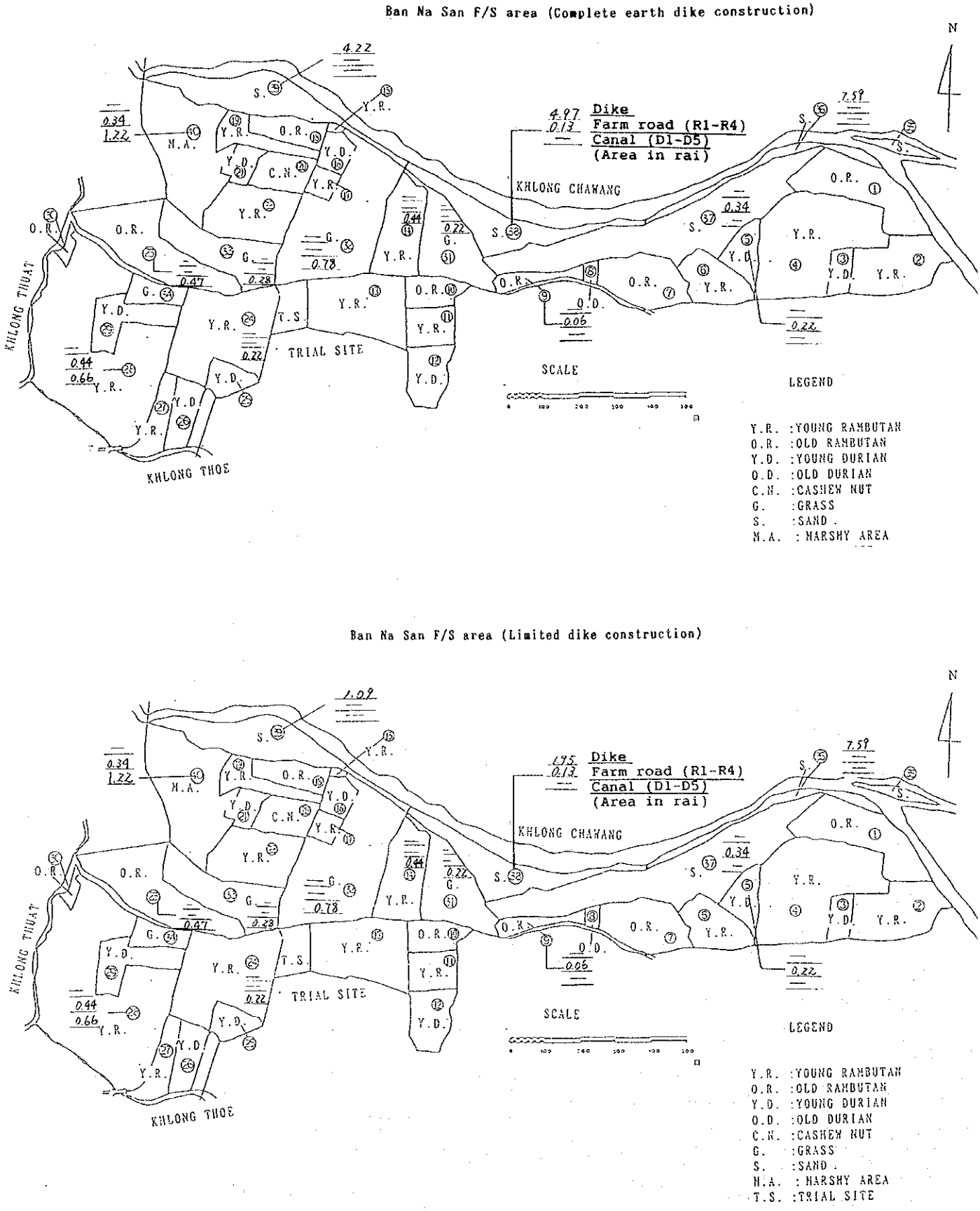


Figure 8. Unusable land of Ban Na San F/S area.

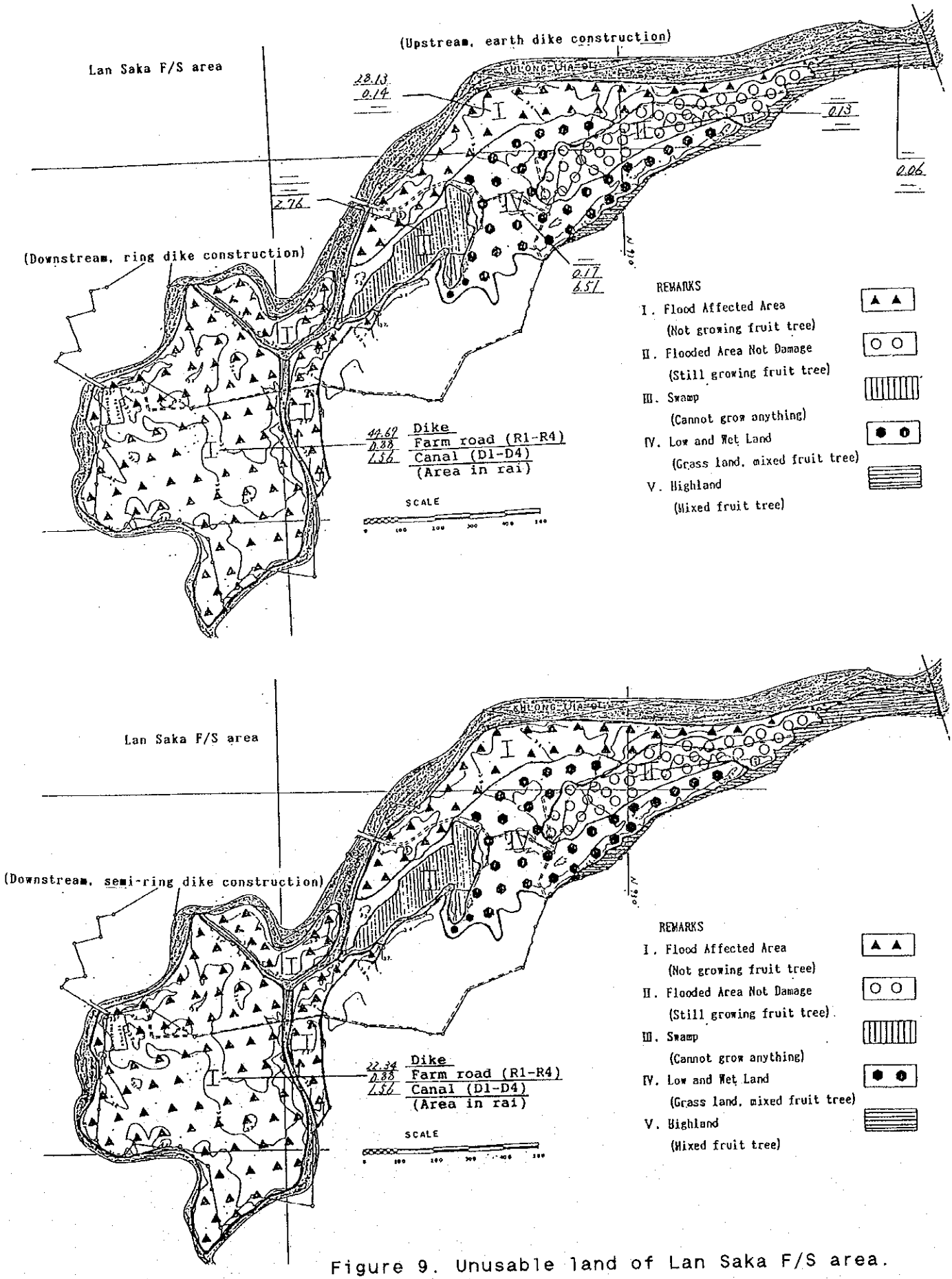


Figure 9. Unusable land of Lan Saka F/S area.

Cross-section elevation of Ban Na San F/S area

Location	X342	X347	X352	X357
Dist (m)	Elev (m)	Elev (m)	Elev (m)	Elev (m)
0	70.33	75.48	80.79	86.81
10	70.41	75.48	80.86	87.27
20	71.37	77.35	83.32	88.83
30	73.07	77.02	83.16	88.89
40	73.91	76.87	83.52	88.87
50	73.86	77.20	83.87	88.72
60	73.33	77.29	84.02	88.60
70	73.09	77.23	84.13	88.65
80	72.87	77.43	84.17	88.42
90	72.67	77.58	84.06	88.29
100	72.76	77.71	83.92	88.30
110	72.44	77.85	83.97	88.28
120	72.37	78.02	83.91	88.26

	X362		X365
Dist (m)	Elev (m)	Dist (m)	Elev (m)
0	92.02	0	96.02
4	92.02	4	95.96
8	90.96	8	94.86
12	90.80	20	96.87
16	90.93	30	97.20
20	93.73	40	97.51
30	93.24	50	97.87
40	93.24	60	97.04
50	93.24	70	97.17
60	93.24	80	97.33
70	93.24	90	97.37
80	93.24	100	97.41
90	93.39	110	97.46
100	93.31	120	97.49
110	93.44		
120	93.63		

Cross-section elevation of Lan Saka F/S area

Location	X95	X100	X105	X110
Dist (m)	Elev (m)	Elev (m)	Elev (m)	Elev (m)
0	28.69	29.33	30.49	31.25
10	28.71	29.41	30.39	31.33
16	28.67	29.80	30.33	32.27
20	30.67	31.48	32.58	33.61
30	30.53	31.25	32.48	35.76
40	30.43	31.36	32.60	35.47
60	30.52	31.21	32.41	33.89
70	30.5	31.27	32.51	33.64
80	30.55	31.18	32.59	33.98
90	30.44	31.33	32.61	34.02
100	30.73	31.33	32.41	33.89
110	30.67	31.33	32.42	32.42
120	30.68	31.33	32.38	32.38

	X115	X120	X125	X130
Dist (m)	Elev (m)	Elev (m)	Elev (m)	Elev (m)
0	32.41	33.72	34.63	35.70
10	32.45	33.78	34.58	35.94
16	32.70	34.5	34.68	35.75
20	33.48	35.09	36.09	36.58
30	34.90	36.07	37.48	38.38
40	35.04	36.39	37.78	38.53
60	35.72	35.94	37.08	39.07
70	35.72	36.46	36.84	40.00
80	35.72	36.33	37.25	41.00
90	35.72	35.91	37.14	42.00
100	35.72	36.06	37.04	43.00
110	35.72	35.82	36.97	44.00
120	32.38	35.82	36.84	36.84

Table 23. Cross section of Khlong Chawang and Khlong Ta Di in the F/S areas.

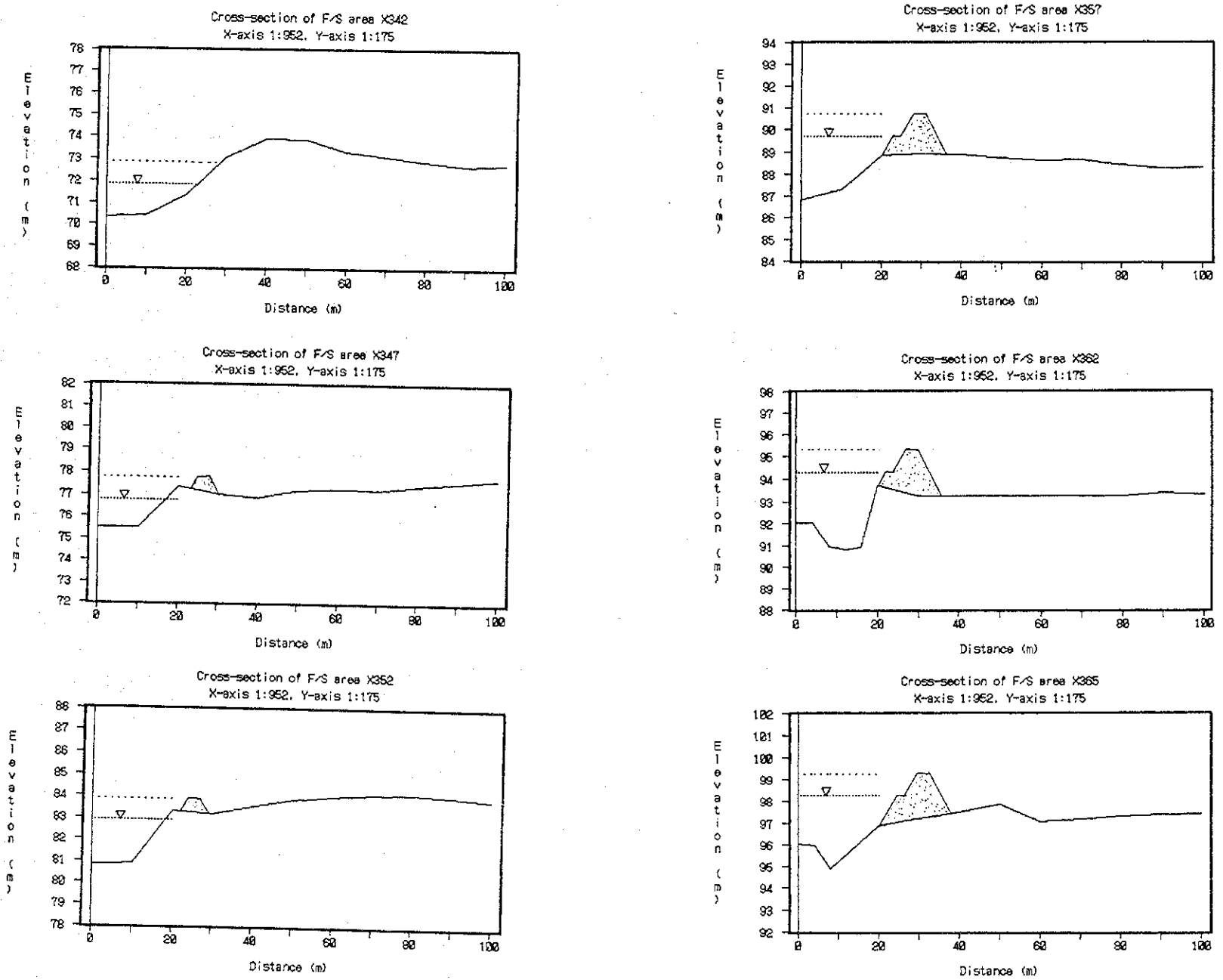


Figure 10. Dike location along Khlong Chawang, (Ban Na San F/S area).

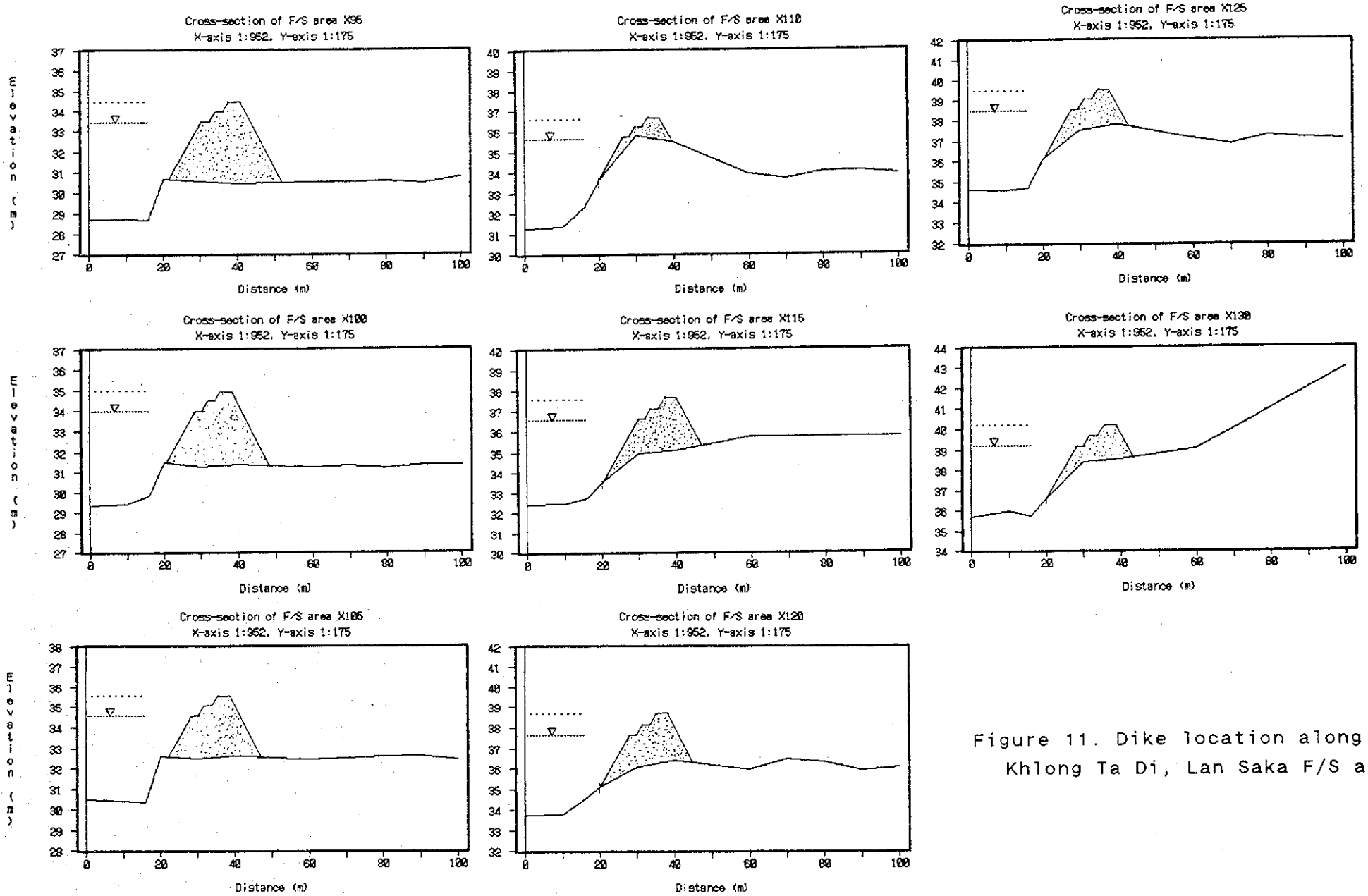
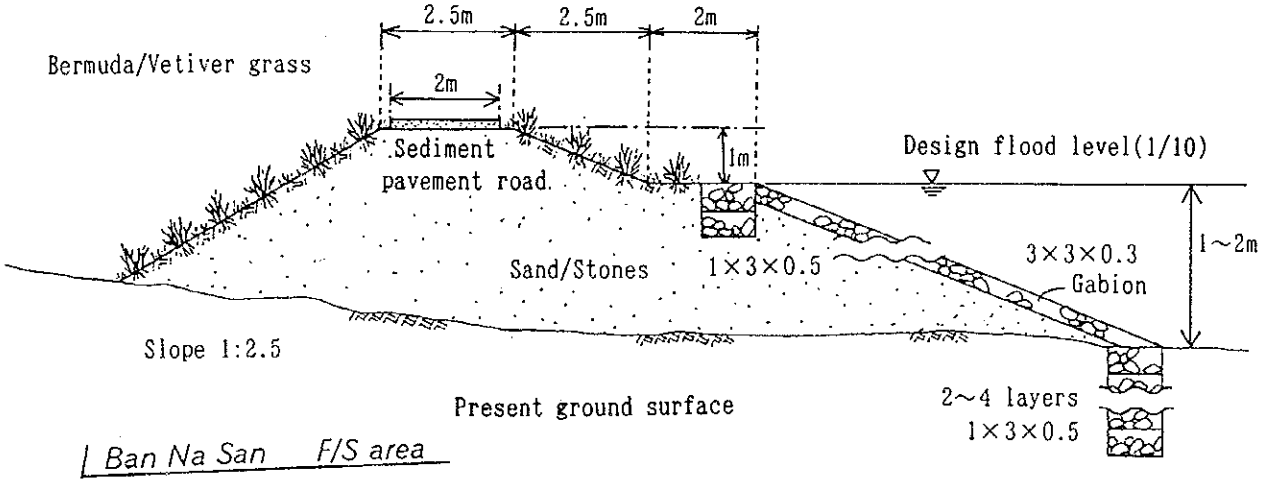


Figure 11. Dike location along Khlong Ta Di, Lan Saka F/S area.



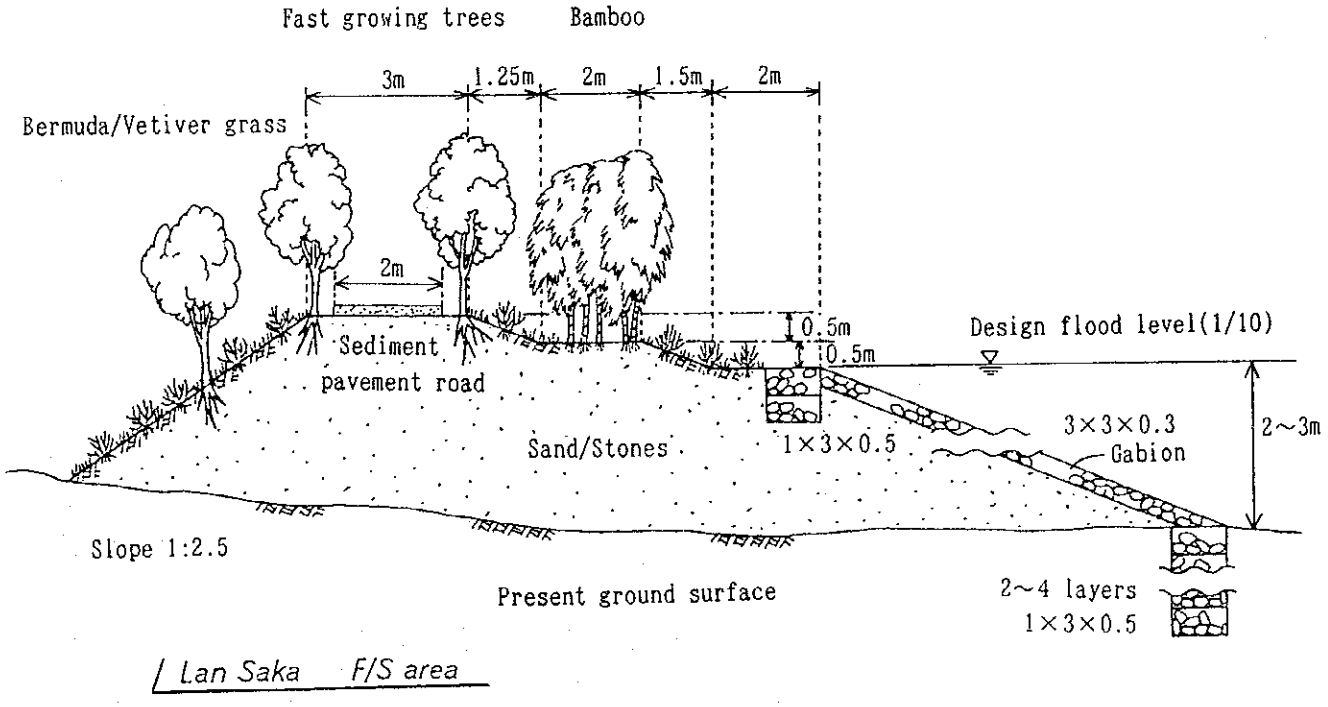


Figure 12. Typical cross-section of dike in Ban Na San and Lan Saka F/S area.

APPENDIX F

SOIL AND LAND USE

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Table F.1 Population growth and forest land in Thailand

Year	Population(million)	Forest area	
		K m^2	%
1961	-	273,628	53.33
1973	-	221,707	43.21
1976	-	198,417	38.67
1978	45.2	175,224	34.15
1982	48.8	156,600	30.52
1983	49.5	154,028	30.02
1984	50.6	151,513	29.53
1985	51.8	150,866	29.40
1988	54.9	143,803	28.03
1989	55.9	143,417	27.95

Source: Royal Forestry Department, MOAC(1990)

Table F.2 Soil distribution of Chawang river basin (Ban Na San)

Type of Soil / Area	Area (Km2)	Percentage (%)
Total Land	119.0	100.0
1.Alluvial Deposits	29.4	24.7
Ruso and Ta Khun Soil	13.6	11.4
Tha Khun Soil	8.3	7.0
Bang Nara and Tha Sala Soil	3.0	2.5
Khok Khain Soil	2.7	2.3
Others	1.8	1.5
2.Residuum and Transported Material from Fine Grained Clastic Rocks	22.5	18.9
Khlong Chak Soil	14.8	12.4
Na Thon / Huai Yot association	6.9	5.8
Others	0.8	0.7
3.Residuum and Transported from Shale Associated with Limestone	3.3	2.8
Krabi Soil	3.3	2.8
4.Residuum and Transported Material from Granite	21.7	18.2
Krathung Soil	6.7	5.6
Phuket Soil	5.9	5.0
Chalong Soil	4.7	3.9
Khlong Nok Krathung Soil	3.5	2.9
Others	0.9	0.8
5.Slope Complex	36.7	30.9
6.Tin Mine Land	4.6	3.9
7.Others	0.8	0.6

Note: Area is calculated by digital planimeter(PLANIX, Japan)

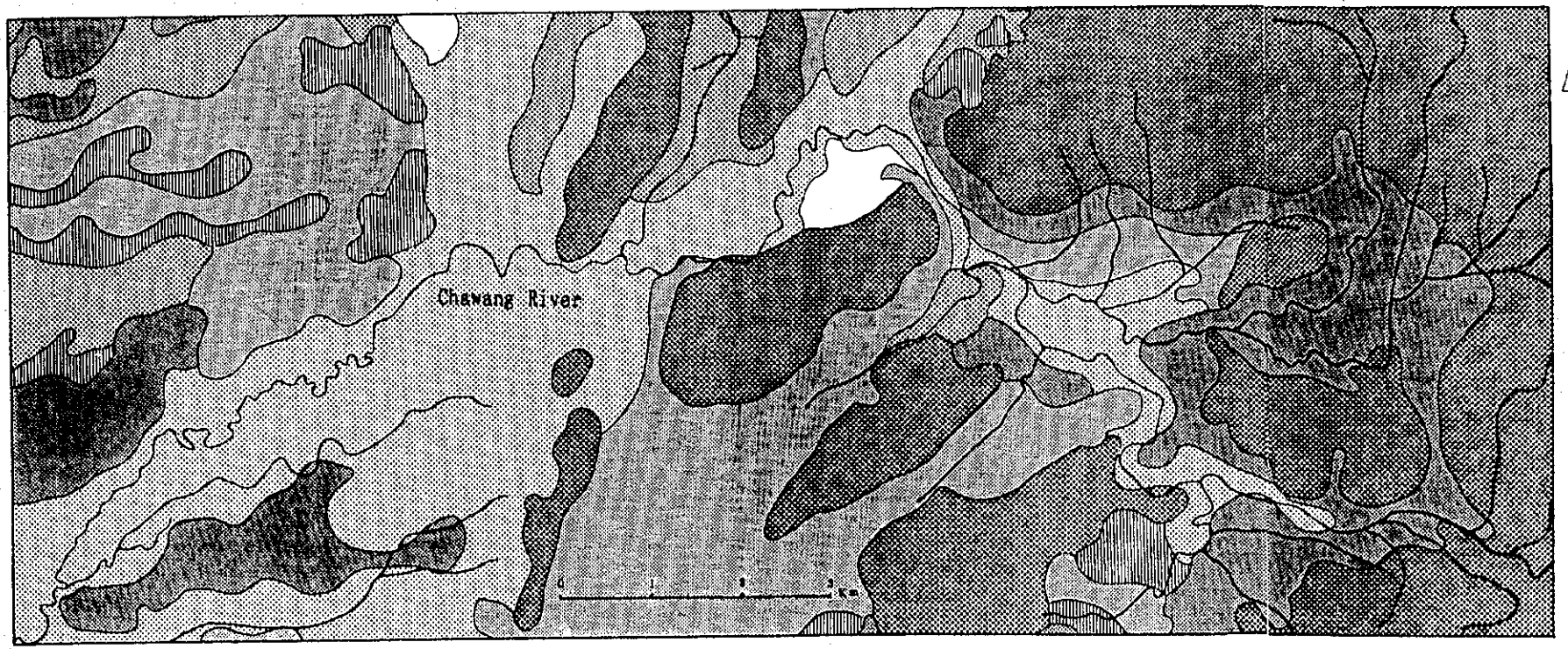

Figure F.1 Soil distribution map of Chawang river basin (Ban Na San)

Explanation of the Legend

Type of Soil	
1.Alluvial Deposits	
2.Residuum and Transported Material from Fine grained Clastic Rocks	
3.Residuum and Transported from Shale Associated with Limestone	
4.Residuum and Transported Material from Granite	
5.Slope Complex	
6.Tin Mine Land	
7.Others	

Table F.3 Description of Ruso series derived from alluvial deposit

RUSO SERIES Field Symbol: Ro

Setting: Ruso series occur on river levee (mostly old levee) at the elevation of 10 to 40 meters above sea level. Relief is undulating. Slope ranges from 2 to 4%. They are formed from riverine alluvium and found under the Tropical Rain Forest Climate (Koppen 'Af') or Tropical Monsoon Climate (Koppen 'Am'). The average annual precipitation is 1,800 to 3,000 mm, average annual air temperature is 26 to 28°C.

Drainage, Permeability and Runoff: Well drained with medium surface runoff. Permeability is estimated to be rapid to moderate. Flooding may occur for short period during flash flood from the river. Ground water table lies below 1 m throughout the year.

Vegetation and Land Use: Exclusively used for rubber, fruit trees, coffee and vegetable growing.

Characteristic Profile Features: Ruso series is a fine-loamy, mixed, isohyperthermic, Typic Paleudults. They are very deep soils which characterized by a dark brown to dark yellowish brown loam or sandy loam overlying a yellowish brown or strong brown loam or clay loam argillic B horizon. Soil reaction of the solum is strongly acid to very strongly acid. Mica flakes are usually present within the soil.

Range of Profile Features: The A horizon ranges between 10 to 15 cm in thickness and values of 3 or 4, chromas of 2 through 4 in hues 10YR or 7.5YR. Soil texture is loam, silt loam or sandy loam with moderate fine to medium subangular. Soil pH ranges from 4.5 to 6.0.

The argillic B horizon has a texture of loam or clay loam and values of 5 or 6, chromas of 6 or 8 in hues 7.5YR and 10YR. The clay texture may occur in the deeper argillic B but usually below 80 cm of the soil surface, yet still in fine loamy family. The soil structure is moderate fine to medium subangular blocky. Soil pH also ranges from 4.5 to 6.0.

Fine mica flakes are commonly present in the soil profile.

Similar Soil Series:
Lamphu La: almost the same in characteristic profile features except they are in fine clayey family.
Tha Sae: same in color profile but much higher in sand fraction.

Principal Associated Soils: These include Lamphu La and Sai Buri series. Lamphu La series have much higher in clay content and Sai Buri series usually occur in the lower part of river levee extended to flood plain or low terrace.

Table F.4 Description of Tha Khun series derived from alluvial deposit

THA KHUN SERIES Field Symbol: Tkn

Setting: Tha Khun series are formed from the recent river deposits on the lower of river levee. Relief is flat or nearly flat, 0-2 % slopes. The climate is Tropical Monsoon (Koppen 'Am'). Average annual precipitation is 2,000 to 2,500 mm and annual air temperature is 26 to 28℃.

Drainage, Permeability and runoff: Tha Khun series is well drained, medium runoff and rapid permeability.

Vegetation and Land Use: coconut, fruit trees and vegetables

Characteristic Profile Features: Tha Khun series is a loamy, mixed, acid, isohyperthermic, Typic Udifluvents. They are deep soils, which characterized by very dark grayish brown to dark brown sandy loam or loamy sand A horizon overlying stratification of brownish yellow, strong brown loam, sandy loam or loamy sand C horizon. Mica flakes and soil reaction is very strongly acid to strongly acid throughout the profile.

Range of profile Features: The surface sandy loam or loamy sand A horizon ranges 10 to 40 cm in thickness which hues 10YR or 7.5YR values of 3 to 5 and chroma 2 to 4. Soil reaction is 5.0 to 5.5.

The Stratification of subsoils C horizon has 10YR to 7.5YR hues, 4 to 5 values and chroma 3 to 6 which loam, sandy loam, loamy sand texture. Soil reaction is very strongly acid to strongly acid.

Mica flakes throughout the profile

Similar Soil Series:
Tha Muang series: ustic soil moisture regime
Lam Kaen series: not stratified. Lighter texture of subsoils (more than 20 %).

Principal Associate soils: Tha Khun series is associated with Ruso, Lam Kaen and Lamphu La. Tha Khun series occurred on the lowest of river levee, some years may be flash flooded by river water. Lam Kean, Ruso and Lamphu La series occurred on higher of river levee.

Table F.5 Description of Khlong Chak series derived from residuum and transported clastic rocks

KHLONG CHAK SERIES Field Symbol: Kc

Setting: The Khlong Chak soils are formed from residuum and colluvium of shale and phyllite and occur on dissected erosion surface and footslopes of shale and phyllite hills. Relief is undulating to hilly. Slopes range from 4 to 12 percent. Elevation is from 20 to 50 meters above sea level. The climate is Tropical Monsoon (Koppen 'Am') Average annual precipitation is from 2,000 to 6,000 mm, Mean annual air temperature is from 26 to 27°C.

Drainage, Permeability and Runoff: is well drained soils. Permeability and surface runoff are rapid. Ground water table falls below 5 meters throughout the year.

Vegetation and Land Use: Tropical Evergreen Forest. Parts have been cleared and planted in rubber trees.

Characteristic Profile Features: The Khlong Chak series is a clayey skeletal, kaolinitic, isohyperthermic, Typic Paleudults. The are deep gravelly soils and characterized by a dark brown or dark reddish brown or dark grayish brown loam or clay loam (gravelly) A horizon overlying a yellowish red gravelly clay loam or gravelly clay argillic B horizon. Coarse fraction consists of angular and subangular shale and phyllite fragments. Reaction is a medium acid to slightly acid at the surface layer and strongly acid to medium acid in the subsoil.

Range of Profile Features: The thickness of the A horizon varies from 10 to 30 cm and has 10YR or 7.5YR or 5YR hues, values of 3 or 4 and chromas of 2 to 4. Texture of silty clay loam may occur. Structures is moderate medium and/or fine blocky with some granular. Field pH values range from 5.5 to 7 0,

The argillic horizon has 5YR Hues, values of 4 or 5 and chromas of 6 to 8. The color of 7.5YR hues may occur at the upper B horizon and the color of 2.5YR hue may occur in the lower part of the B horizon. Structure is moderate blocky. Field pH values range from 4.5 to 5.5. Khlong Chak soils contain gravel of Pseudo-laterite gravel within 50 cm of the surface.

Similar Soil Series:
Trad: Contains gravel or Pseudo-laterite at some depth below 50 cm of the surface.
Nong Khla: has redder color in the subsoil (2.5YR or 10R hue).

Principal Associated Soils:
These include Trad, Saphan Wa, and Slope Complex Soils.

Table F.6 Description of Krabi seeries derived from residuum and transported clastic rocks

KRABI SERIES Field Symbol: Kbi

Setting: The Krabi series are formed from colluvium or residuum of fine grain clastic rocks namely shale, mudstone or other equivalent rocks. They commonly occur on eroded hill, foothill slope or strath terrace. Relief is undulating to rolling with slopes ranging from 3 to 10 percent. Elevation is approximately 20 to 60 m above sea level. The climate is Tropical Monsoon (Koppen 'Am') or Tropical Rain Forest (Koppen 'Af'). Average annual precipitation is above 1,800 mm. Mean annual air temperature is from 26 to 28°C.

Drainage, Permeability and Runoff: The Krabi series are well-drained soils. Permeability is estimated to be moderate. Surface runoff is medium in general ground water table lies below 2 m throughout the year.

Vegetation and Land Use: Originally, under Tropical Rain Forest, but after clearance of climax forest, the soils are use almost exclusively for rubber growing. However, fruit trees such as rambutan, durian are also grown in some parts.

Characteristic Profile Features: The Krabi series is a clayey, kaolinitic, isohyperthermic, Typic Paleudults. They are very deep soils which characterized by a dark brown or dark grayish brown loam or clay loam overlying yellowish red heavy clay loam or clay argillic horizon. Matrix color of strong brown or yellowish brown may occur in upper B horizon and matrix color of red may also occur below 80 cm of the soil surface. Reaction of the solum is strongly acid to very strongly acid.

Range of Profile Features: The A horizon is approximately 10 to 15 cm thick and has 10YR or 7.5YR hues, values and chromas of 3 through 4. Texture of silt loam may also occur. Structure is moderate fine to medium blocky. Field pH range from 5.0 to 6.0.

The argillic horizon commonly has 5YR hue with values of 4 to 5 and chromas of 5 to 6 and rather have a uniformed color throughout the horizons. However, upper argillic horizon may have 5YR hue with values of 5 to 6 and chromas of 6 to 8. Also, lower argillic horizon which approximately below 80 cm of the soil surface may have 2.5YR hues with values of 3 to 4 and chromas of 6 to 8. Structure is moderate to strong subangular blocky. Field pH values are from 5.0 to 5.5.

Similar Soil Series:
Ao Luk: the argillic horizon is redder and more clay.
Khlong Chak: has ironstones within the solum.
Trad: has ironstones within the solum but occur below 50 cm of the soil surface.
Lamphu La: the color of argillic horizon is strong brown or yellowish brown.

Principle Associated Soils: These include Ao Luk and Lamphu La soils. They may also occur in association with Khlong Chak or Trad soils where ironstone layers are developed.

Table F.7 Soil distribution of Tha Di river basin (Lan Saka)

Type of Soil \ Area	Area (Km2)	Percentage (%)
Total Land	70.0	100.0
1.Alluvial Deposits	5.0	7.1
Kho Hong and Tha Sae association	1.5	2.1
Alluvial Soil	1.2	1.7
Ruso Soil	1.1	1.6
Lam Kaen Soil	1.0	1.4
Langu Soil	0.2	0.3
2.Transported Material and Residuum from Sand Stone or Other Equivalent Rocks	0.3	0.4
Ranong Soil	0.3	0.4
3.Residuum and Transported Material from Granite	19.3	27.6
Khlong Nok Krathung Soil	10.0	14.3
Thung Wa Soil	5.9	8.4
Khlong Nok Krathung and Thung Wa Soil	2.0	2.9
Khok Kloi-Shallow phase	1.1	1.6
Khok Kloi Soil	0.3	0.4
4.Slope Complex	45.4	64.9

Note: Area is calculated by digital planimeter(PLANIX, Japan)

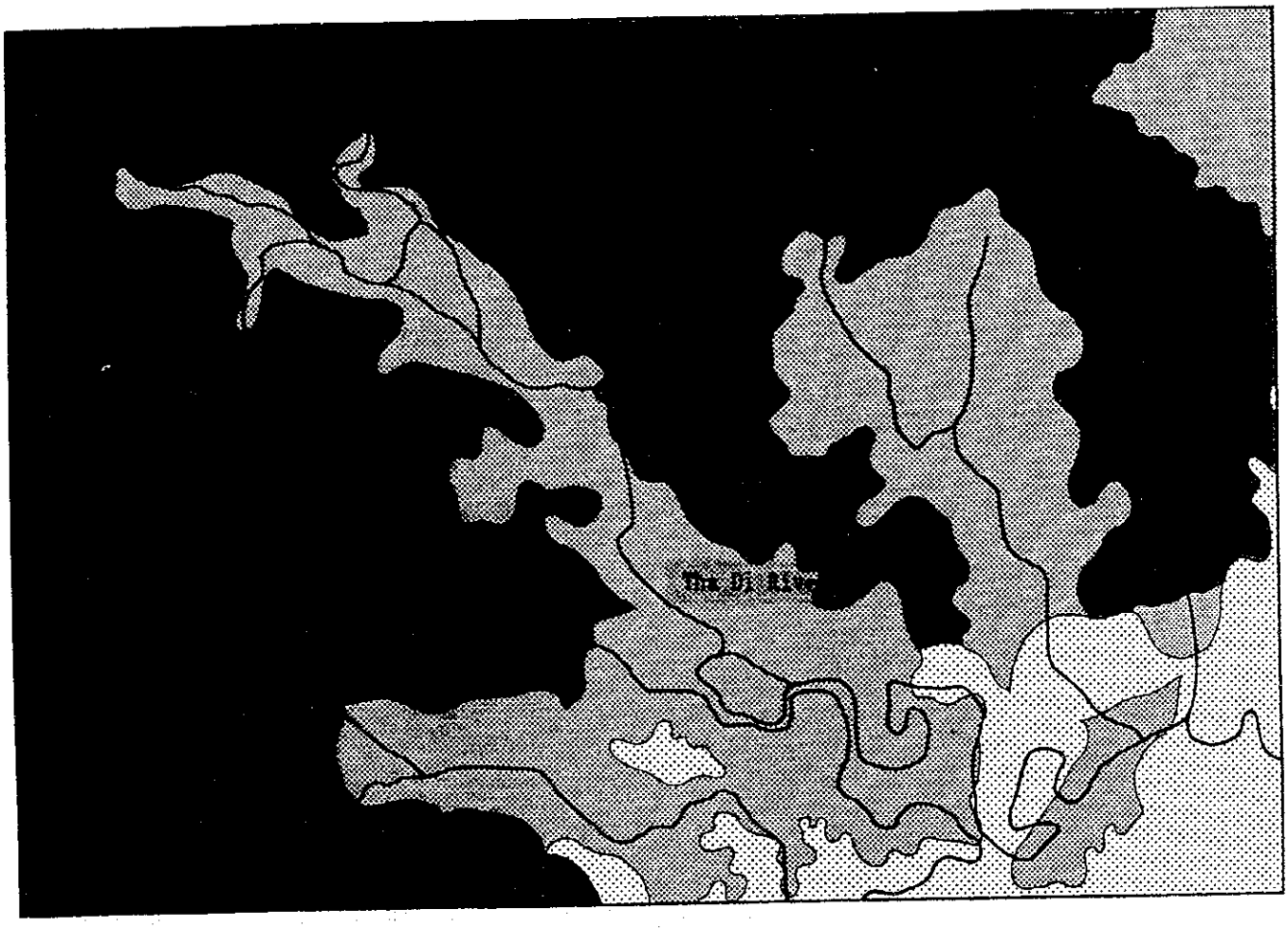

Figure F.2 Soil distribution map of Tha Di river basin (Lan Saka)

Explanation of the Legend

Type of Soil	
1.Alluvial Deposits	
2.Transported Material and Residuum from Sand Stone or other Equivalent Rocks	
3.Residuum and Transported Material from Granite	
4.Slope Complex	

Table F.8 Description of Kho Hong series derived from alluvial deposit

KHO HONG SERIES Field Symbol: Kh

Setting: Kho Hong series usually occur on undulating terrain at 20 to 100 meters above sea level. The most common physiography is erosion surface or strath terrace. Slope ranges from 3 to 8%. They may be formed directly from residuum and colluvium or formed from transported materials of sandstone or other equivalent coarse grain clastic rock. The soils are usually found under Tropical Monsoon Climate (Koppen 'Am') or Tropical Rain Forest Climate (Koppen 'Af'). The average annual air temperature is 26 to 28℃, average annual precipitation is 1,800 to 3,000 mm.

Drainage, Permeability and Runoff: Well drained with rapid runoff if occurs on sloping land. Permeability is estimated to be rapid.

Vegetation and Land Use: Almost exclusively used for rubber, coconut and fruit tree growing. Low secondary shrubs and grasses (Imperata Cylindrica) are also developed in many abandoned parts or in recently open forest areas.

Characteristic Profile Features: Kho Hong series is a coarse-loamy, siliceous, isohyperthermic, Typic Paleudults. They are very deep soils which characterized by a dark brown or very dark grayish brown sandy loam A horizon overlying a strong brown or yellowish brown or brownish yellow sandy loam argillic B horizon. However, at the greater depth of the solum (approximately below 80 cm from the soil surface) sandy clay loam texture may occur. Soil pH of the solum ranges from very strongly acid to strongly acid.

Range of Profile Features: The A horizon between 5 to 20 cm in thickness and has values of 3 or 4, chromas of 2 through 4 in hues 10YR or 7.5YR. The soil structure is weak fine to medium subangular blocky. The sill texture is sandy loam. Soil pH is 4.5 to 5.5.

The argillic B horizon has values of 5 or 6 chromas of 6 or 8 in hues 10YR or 7.5YR. The soil texture is sandy loam throughout the solum but sandy clay loam texture may occur at below 80 cm of the profile. The soil structure is weak fine to medium subangular blocky, Soil pH is 4.5 to 5.5.

Similar Soil Series:
Lang Suan series: in sandy family.
Tha sae series: in fine-loamy family, same in soil color and moisture regime.
Satuk series: in fine-loamy family, same in soil color but has an ustic moisture regime.

Principal Associated Soils: These include Tha Sae series, Sawi series and Nam Krachai series. Sawi series usually found ironstones at greater depth. Nam Krachai series occupy at lower position adjacent from Kho Hong series on higher position.

Table F.9 Description of Ranong series derived from residuum and colluviated materials

RANONG SERIES Field Symbol: Rg

Setting: Ranong soils occur on recent erosional surfaces especially on foothill slopes, hill or hillock. They are derived from residuum and colluviated materials of sandstone and quartzite or other equivalent rocks. Slopes are commonly more than 5% up to 30%. The soils have formed under Tropical Rain Forest or Tropical Monsoon climate (Koppen 'Af' or 'Am'). Average annual air temperature and precipitation is 26 to 28°C and more than (800 mm) respectively.

Drainage, Permeability and Runoff: Well drained with a udic soil moisture regime. Surface runoff and permeability is estimated to be rapid. Ground water level falls below 2 meters throughout the year.

Vegetation and Land Use: Originally, occupied by Tropical Evergreen Forest but many areas have been cleared for rubber growing. If there is no landuse after land clearing, secondary scrub forest and native grasses are commonly developed.

Characteristic Profile Features: Ranong series is a loamy-skeletal, mixed, acid, isohyperthermic, Lithic Troporthents. They are shallow or very shallow soils and characterized by a dark brown or dark yellowish brown sandy loam A horizon overlying a strong brown grading to yellowish red very gravelly loam or very gravelly sandy clay loam. Most gravel are quartzite or sandstone fragments. This inturn overlies a layer of bedrock (quartzite and/or sandstone or quartzitic sandstone) which is generally found within 50 cm of the soil surface. Reaction ranges from strongly acid to very strongly acid and commonly decreases with depth.

Range of Profile Features: The A horizon ranges from 5 to 15 cm in thickness and has values and chromas of 3 through 4 in 10YR or 7.5YR hues. The structure is weak fine to medium subangular blocky. Soil pH ranges from 5.0 to 5.5.

The C horizon has moist values of 5 or 6, chromas of 6 or 8 in hue 7.5YR or/gradually grading to values of 4 or 5, chromas of 6 or 8 in hue 5YR. Rock fragments commonly composed of more than 50 of the soil matrix. The structure is generally undescribed. Soil pH is from 4.5-5.0.

The R horizon is commonly found within 50 cm of the soil surface.

Similar Soil Series:
Phato: has thin argillic horizon and R. horizon occurs below 50 cm of the surface.
Tha Yang: has an ustic moisture regime.

Principle Associated Soils:
These include Phato soils occurring on footslopes.

Table F.10 Description of Khlong Nok Krathung series derived from transported granitic rock

KHLONG NOK KRATHUNG SERIES Field Symbol: Knk

Setting: The Khlong Nok Krathung series are formed from transported material of granitic rocks. They occur on foothill slope, coalescing fans, or dispersing shadow (provenance) of granite ridges. Relief is gently undulating to undulating with slopes ranging from 2 to 5 percent. Elevation is approximately from 20 to 40 m above sea level. The climate is Tropical Monsoon (Koppen 'Am') or Tropical Rain Forest (Koppen 'Af'). Average annual precipitation is above 2,000 mm. Mean annual air temperature is from 20 to 28°C.

Drainage, Permeability and Runoff: The Khlong Nok Krathung series are well drained soils. Permeability is estimated to be rapid. Surface runoff is generally medium to rapid. Ground water level falls below 2 m throughout the year.

Vegetation and Land Use: Mainly used for rubber and fruit trees growing. Parts after clearance of climax forest reverted to low secondary shrubs and grasses.

Characteristic Profile Features: The Khlong Nok Krathung series is fine-loamy, mixed, isohyperthermic Typic Paleudults. They are very deep soils which characterized by a dark brown, very dark grayish brown or brown sandy loam A horizon overlying a brown light brown or very pale brown medium to coarse sandy loam or sandy clay loam argillic B horizon. Sand grains usually increase in size with depth. Reaction is strongly acid in surface soil and very strongly acid in subsoil.

Range of Profile Features: The A horizon is 10 to 15 cm in thickness and has 10YR or 7.5YR hues, values of 3 or 4 and chromas of 2 to 4. Loamy sand texture may occur. Structure is weak fine subangular blocky Field pH values range from 5.0 to 6.0.

The argillic B horizon has 10YR or 7.5YR hues, values of 5 to 7 and chromas of 3 or 4. Medium to coarse sandy clay loam may occur but should have clay more than 18 percent in average for the control section. Structure is weak fine to medium subangular blocky. Field pH values very from 4.5 to 5.5.

Similar Soil Series:
Thung Wa: is a coarse-loamy family and has cambic B horizon.
Huai Pong: is a clayey family.
Laharn: has grayer color in subsoil.

Principal Associated Soils: These include Thung Wa, Huai Pong and Laharn soils.

Table F.11 Deposited area of Chawang river basin (Ban Na San)

Level of Deposited Sediment / Area	Area (rai)	Percentage (%)
Total area of deposited sediments	9,825	100.0
I. < 25cm in depth.	5,680	57.8
II. 25-50cm in depth.	1,146	11.6
III. 50-150cm in depth.	725	7.4
IV. > 150cm in depth.	65	0.7
V. River Bed	2,209	22.5

Source: Department of Land Development, MOAC

Table F.12 Deposited area of Tha Di river basin (Lan Saka)

Level of Deposited Sediment / Area	Area (rai)	Percentage (%)
Total area of deposited sediments	2,765	100.0
I. < 25cm in depth.	422	15.3
II. 25-50cm in depth.	376	13.6
III. 50-150cm in depth.	34	1.2
IV. > 150cm in depth.	900	32.5
V. River Bed	1,033	37.4

Source: Department of Land Development, MOAC

Table F.13 Land use in Surat Thani and Nakhon Si Thammarat Province, 1988

Province / Type of Land Use	Surat Thani		Nakhon Si Thammarat	
	Area(Km2)	Percentage	Area(Km2)	Percentage
Total Land	12,891	100.0	9,943	100.0
Wood land	3,397	26.3	1,438	14.5
Farm hold land	4,754	36.9	5,256	52.8
Housing aria	86	0.7	137	1.4
Paddy land	762	5.9	1,839	18.5
Under field crop	109	0.8	52	0.5
Under fruit tree and tree crops	2,796	21.7	2,433	24.5
Under vegetable and flower	9	0.1	40	0.4
Idleland	887	6.8	579	5.7
Grassland	19	0.2	26	0.3
Others	86	0.7	149	1.5
Others	4,741	36.8	3,249	32.7

Source: 「Office of Agricultural Economic」 Ministry of Agricultural and Cooperative

Table F.14 Land use of Chawang river basin (Ban Na San)

Type of Land Use / Area	Area (Km2)	Percentage (%)
Total Land	119.0	100.0
Forest land	44.0	37.0
Tropical evergreen forest	33.4	28.1
Rubber, Dipterocarp forest	10.6	8.9
Agricultural land	72.1	60.5
Rubber and mixed orchards	66.5	55.8
Rambutan and town	5.6	4.7
Others(Village, mines, etc.)	2.9	2.5

Note: Area is calculated by digital planimeter (PLANIX, Japan)

Table F.15 Land use of Tha Di river basin (Lan Saka)

Type of Land Use / Area	Area (Km2)	Percentage (%)
Total Land	70.0	100.0
Forest land	50.1	71.6
Tropical evergreen forest	12.1	17.3
Rubber affected tropical evergreen forest	38.0	54.3
Agricultural land	19.5	27.8
Rubber	9.2	13.1
Mixed orchards	7.9	11.3
Paddy field	1.3	1.8
Coconut	1.1	1.6
Others	0.4	0.6

Note: Area is calculated by digital planimeter (PLANIX, Japan)

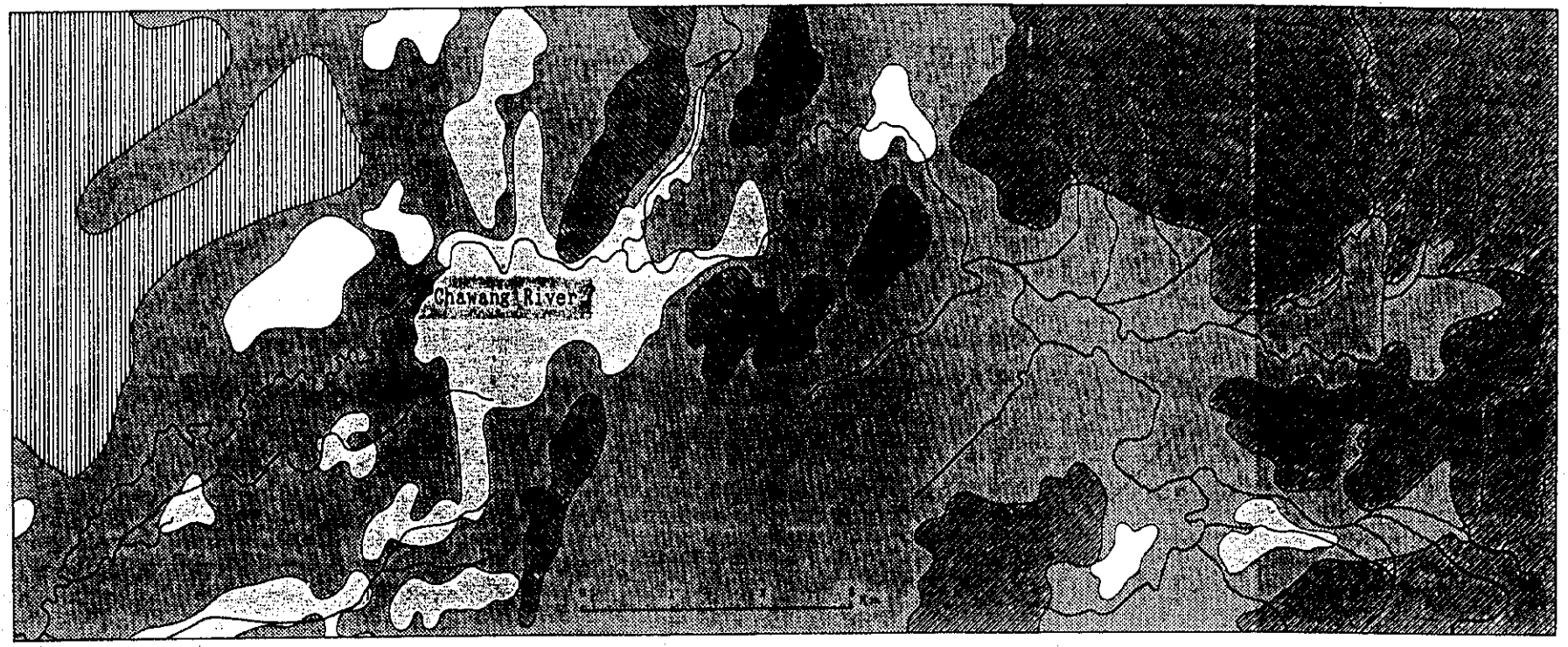

Figure F.3 Land use map of Chawang river basin (Ban Na San)

Explanation of the Legend

Type of Land Use	
1.Tropical Evergreen Forest	
2.Rubber, Dipterocarp Forest	
3.Rubber and Mixed Orchards	
4.Rambutan and Town	
5.Others	

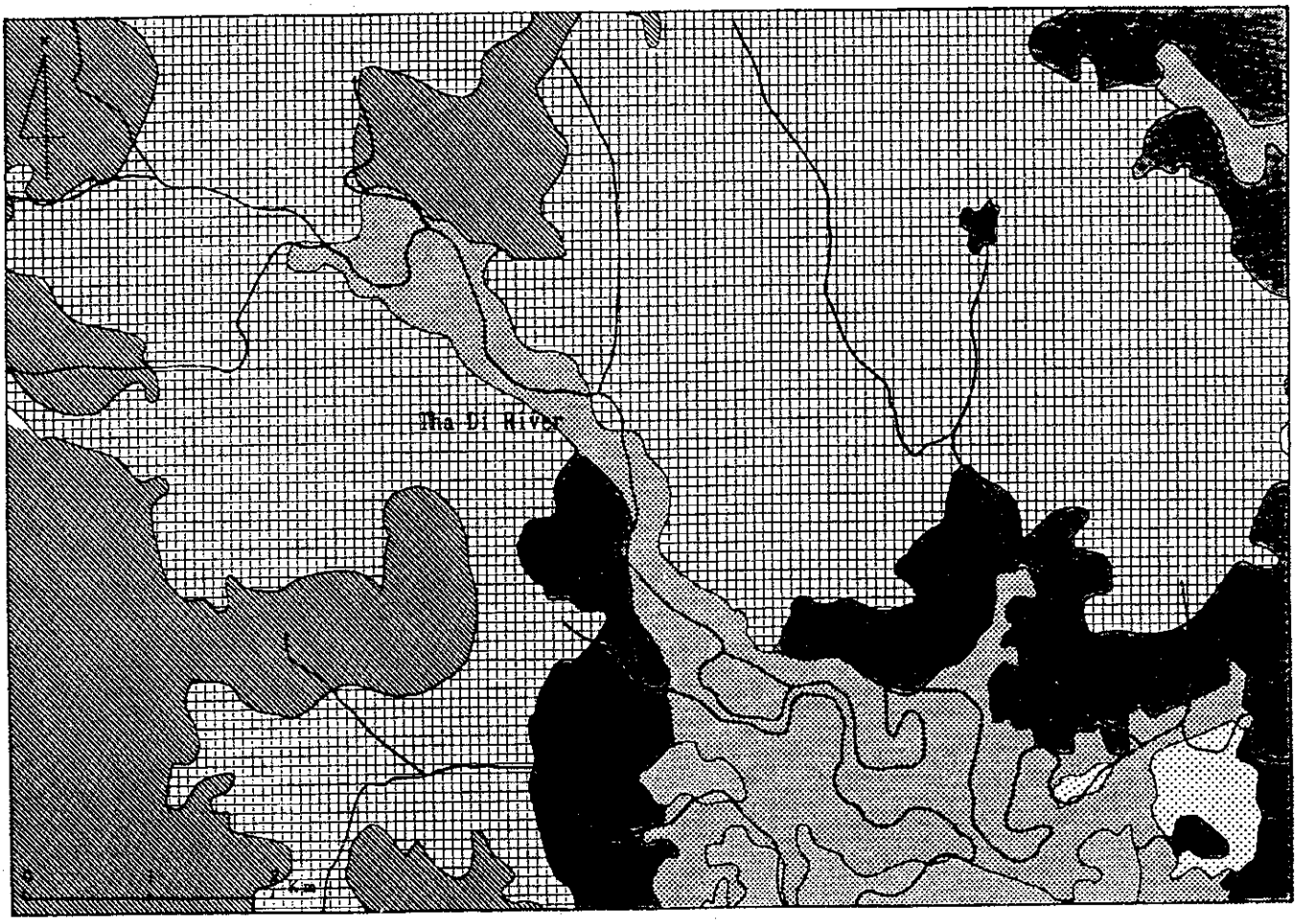

Figure F.4 Land use map of Tha Di river basin (Lan Saka)

Explanation of the Legend

Type of Land Use	
1.Tropical Evergreen Forest	
2.Rubber affected Tropical Evergreen Forest	
3.Rubber	
4.Mixed Orchards	
5.Paddy Field	
6.Coconut	
7.Others	

Table F.16 Deposited sediment of F/S area (Ban Na San)

Level of Deposited Sediment / Area	Area (rai)	Percentage (%)
Total area of deposited sediments	652.45	100.0
I. No Deposited Area.	48.31	7.4
II. < 25cm in depth.	65.31	10.0
III. 25-50cm in depth.	130.94	20.1
IV. 50-100cm in depth.	82.06	12.6
V. 100-150cm in depth.	28.63	4.4
VI. 150cm < in depth.	297.20	45.5

Note: Area is calculated by digital planimeter(PLANIX, Japan)

Table F.21 Deposited sediment of F/S area (Lan Saka)

Level of Deposited Sediment / Area	Area (rai)	Percentage (%)
Total area of deposited sediments	566.56	100.0
I. No Deposited Area.	125.78	22.2
II. < 25cm in depth.	60.31	10.6
III. 25-50cm in depth.	38.75	6.8
IV. 50-100cm in depth.	104.22	18.4
V. 100-150cm in depth.	14.53	2.6
VI. 150cm < in depth.	222.97	39.4

Note: Area is calculated by digital planimeter(PLANIX, Japan)

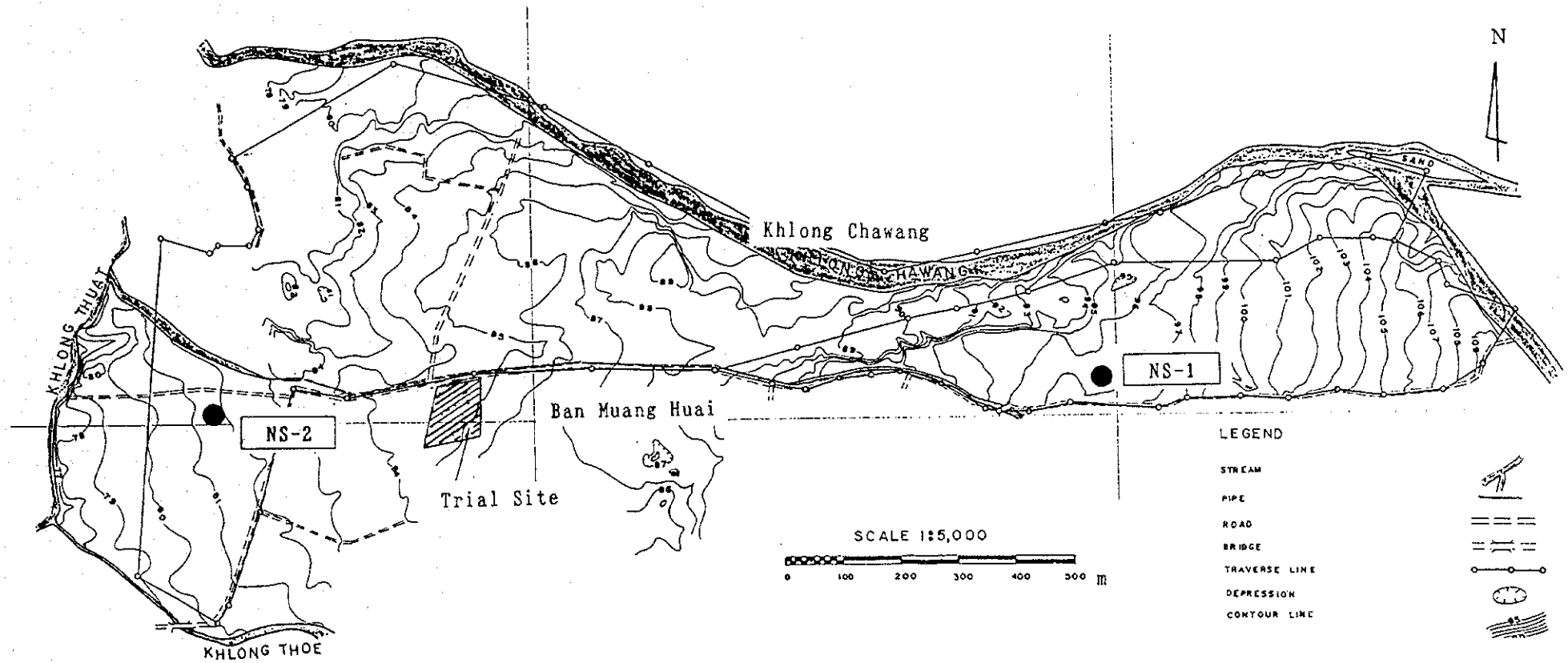

Figure F.5 Location map of detail soil survey in F/S area (Ban Na San)

Table F.17 Description of Pedon NS-1, deep deposited type (Ban Na San)

PEDON NO. NS-1

Series : New
Taxonomy : New
Location : Ban Muang Huai Thuad, Moo 4, Tambol Puumpoon Sup, Amphoe Ban Na San, Changwat Surat Thani Province
Latitude : E 99° 27' 17" Longitude N 8° 46' 31"
Physiography : Valley fills
Slope : 1%, with microrelief
Climate : Tropical monsoon climate Rain fall: 1637mm Air temp: 26.3℃ Humidity: 81.9%
Land use : Before 1988, being used for cultivation of paddy rice, but after disaster, cultivated to Rambutan orchard
Parent material : recent sediments from flash flood in 1988, mostly derived from Cretaceous granite

Soil profile description

Ow1: 0-40cm, Very pale brown (10YR7/3), coarse sand, structureless, loose, non sticky, non plastic, common gravels, mostly consisting of quartz and feldspar, many micas, neutral (pH7.0), compactness (0mm), abrupt, wavy boundary.

Ow2: 40-60cm, Brown (10YR5/3), loamy fine sand, few fine distinct mottles of strong brown (7.5YR5/6), weak subangular blocky structure breaking to single grain, very friable, non sticky, non plastic, thin layer (lens) of medium sand, many micas, strongly acid (pH5.5), compactness (9mm), abrupt , wavy boundary.

Ow3: 60-80cm, Pale brown (10YR6/3), medium sand, structureless (single grain), loose, non sticky, non plastic, many micas, medium acid (pH6.0), compactness (5mm), abrupt, wavy boundary.

Ow4: 80-100cm, Light yellowsh brown (10YR6/4), silt loam, common medium prominent mottles of reddish brown (5YR4/6), massive, slightly sticky, slightly plastic, many micas, strongly acid (pH5.5), compactness (11mm), abrupt, wavy boundary.

Ab : 100-110cm, Dark grayish brown (10YR4/1), loamy medium sand, few medium prominent mottles of reddish brown (5YR4/6), weak fine subangular blocky structure, friable, slightly sticky, non plastic, common micas, strongly acid (pH5.5), compactness (19mm).

Remarks: * Ow indicated new term 'Overwash'.
**Surface soils are relatively dry, but more moist with greater depth.

Table F.18 Description of Pedon NS-2, shallow deposited type (Ban Na San)

PEDON NO. NS-2

Series : Khlong Nok Kratung, aquic Variant, overwash phase
Taxonomy : Fine loamy, mixed, isohyperthic Aquic paleudult
Location : Ban Muang Huai Thuad, Moo 4, Tambol Puumpoon Sup, Amphoe Ban Na San, Changwat Surat Thani Province
Latitude : E 99° 26' 27" Longitude N 8° 46' 33"
Physiography : Valley fills
Slope : 1%
Climate : Tropical monsoon climate Rain fall: 1637mm Air temp: 26.3℃ Humidity: 81.9%
Drainage : Moderately well drained Permeability : rapid
Land use : Before 1988, being used for cultivation of paddy rice, but after disaster, cultivated to Durian orchard
Parent material : Transported material from , mostly derived from Cretaceous granite

Soil profile description

A11: 0-12cm, Brown (10YR5/3), loamy sand, structureless (single grain), loose, non sticky, non plastic, common fine root, many micas, medium acid (pH 6.0), compactness (15mm), clear, wavy boundary.

A12: 12-29cm, Dark grayish brown (10YR4/2), sandy loam, weak medium subangular blocky structure, friable, slighty sticky, non plastic, few small charcoals, few fine root, common micas, very strongly acid (pH5.0), compactness (20mm), clear, wavy boundary.

A3 : 29-41cm, Mixed dark grayish brown (10YR4/2) and (10YR3/2), many medium prominent mottles of yellwish red (5YR4/2), weak medium subangular blocky structure, firm, slighty sticky, non plastic, few fine roots, common manganese concretion, common micas, strongly acid (pH5.5), compactness (25mm), clear, wavy boundary.

B21t:41-65cm, Reddish brown (5YR4/3), medium sandy clay loam, common medium distinct mottles of dark brown (10YR5/2) and few fine faint mottles of reddish brown (5YR4/6), weak medium subangular blocky structure, firm, slightly sticky, slightly plastic, patchy thin clay coatings on ped faces , few manganese concretion, common micas, very strongly acid (pH5.0), compactness (25mm), clear, wavy boundary.

B23t:65-105cm, Reddish brown (5YR4/3), medium sandy clay loam, few medium distinct mottles of brown (10YR5/3), weak medium subangular blocky structure, firm, slightly sticky, slightly plastic, patchy thin clay coatings on ped faces, common micas, strongly acid (pH5.5), compactness (36mm), clear, wavy boundary.

Remarks: Soils are more moist with increasing depth.

Table F.19 Soil physical and chemical properties of F/S area (NS-1)

ANALYSIS RESULTS (Pedon NO. NS-1)
(OVEN DRY BASIS)

Horizon	Depth (cm)	Hydraulic Conductivity (cm/hr)	Particle size analysis (%)								Texture
			USDA Grading (mm)			Sand Fraction Grading (mm)					
			Sand 2-0.05	Silt 0.05-0.002	Clay 0.002>	Very Coarse 2.0-1.0	Coarse 1.0-0.5	Medium 0.5-0.25	Fine 0.25-0.1	Very Fine 0.1-0.05	
Ow1	0-40	Too rapid (Very high)	98.6	0.4	1.0	62.4	25.1	8.2	2.4	0.5	Sand
Ow2	40-60	Too rapid (Very high)	91.3	4.7	4.0	13.5	13.9	26.6	22.6	14.7	Sand
Ow3	60-80	Too rapid (Very high)	99.1	0.4	0.5	55.7	30.6	10.1	2.6	0.1	Sand
Ow4	80-100	15 (High)	79.3	11.1	9.6	3.8	3.5	7.8	16.7	47.5	Sandy Loam
Ab	100-110	20 (High)	85.2	8.8	6.0	16.3	27.2	23.3	13.6	4.8	Loamy Sand

Horizon	Moisture (%)	pH (1:1)		EC ds/m	T - C (%)	T - N (%)	C/N	Exchange Capacity and Cation (me/100g)					Base Saturation (%)	P_2O_5 (ppm)	K_2O (ppm)
		Water	KCl					Ca	Mg	K	Na	CEC			
Ow1	0.2	5.7	4.2	0.06	0.08	0.04	2	0.7	0.2	0.1	0.1	2.4	46	13.8	31.0
Ow2	0.7	5.1	3.8	0.08	0.18	0.02	9	0.8	0.1	0.2	0.1	5.6	21	20.1	58.0
Ow3	0.3	5.5	4.1	0.05	0.04	0	-	0.6	0.1	0.1	0.1	1.5	60	15.1	23.0
Ow4	1.4	4.8	3.8	0.12	0.45	0.04	11	0.9	0.1	0.3	0.2	4.8	31	27.2	56.0
Ab	0.6	4.3	3.7	0.12	0.48	0.05	10	0.5	0.1	0.1	0.1	3.1	26	21.4	48.0

Table F.20 Soil physical and chemical properties of F/S area (NS-2)

ANALYSIS RESULTS (Pedon NO. NS-2)

(OVEN DRY BASIS)

Horizon	Depth (cm)	Hydraulic Conductivity (cm/hr)	Particle size analysis (%)								Texture
			USDA Grading (mm)			Sand Fraction Grading (mm)					
			Sand 2-0.05	Silt 0.05-0.002	Clay 0.002>	Very Coarse 2.0-1.0	Coarse 1.0-0.5	Medium 0.5-0.25	Fine 0.25-0.1	Very Fine 0.1-0.05	
A11	0-12	34 (Very high)	89.3	3.6	7.1	28.3	25.4	18.0	12.7	4.9	Sand
A12	12-29	16 (High)	71.2	17.7	11.1	6.2	20.0	22.5	14.8	7.7	Sandy Loam
A3	29-41	10 (Moderately high)	71.9	14.1	14.0	4.8	25.6	24.1	11.4	6.0	Sandy Loam
B21t	41-65	3 (Moderate)	63.9	12.5	23.6	5.0	20.0	19.8	13.2	5.9	Sandy Clay Loam
B23t	65-105	5 (Moderate)	65.4	9.0	25.6	6.6	27.0	19.6	8.1	4.1	Sandy Clay Loam

Horizon	Moisture (%)	pH (1:1)		EC ds/m	T - C (%)	T - N (%)	C/N	Exchange Capacity and Cation (me/100g)					Base Saturation (%)	P_2O_5 (ppm)	K_2O (ppm)
		Water	KCl					Ca	Mg	K	Na	CEC			
A11	0.4	4.8	4.0	0.15	0.56	0.05	11	1.1	0.3	0.2	0.1	3.3	52	29.6	56.0
A12	0.7	4.4	3.7	0.12	0.62	0.05	12	0.5	0.1	0.1	0.2	5.6	16	11.4	36.0
A3	0.7	4.8	3.8	0.10	0.40	0.03	13	1.0	0.1	0.1	0.2	3.5	14	4.3	44.0
B21t	0.8	5.1	3.8	0.10	0.19	0.04	7	2.1	0.3	0.2	0.1	7.0	39	3.6	80.0
B23t	1.1	5.2	3.9	0.08	0.27	0.04	7	2.3	0.3	0.2	0.2	4.3	70	4.2	80.0

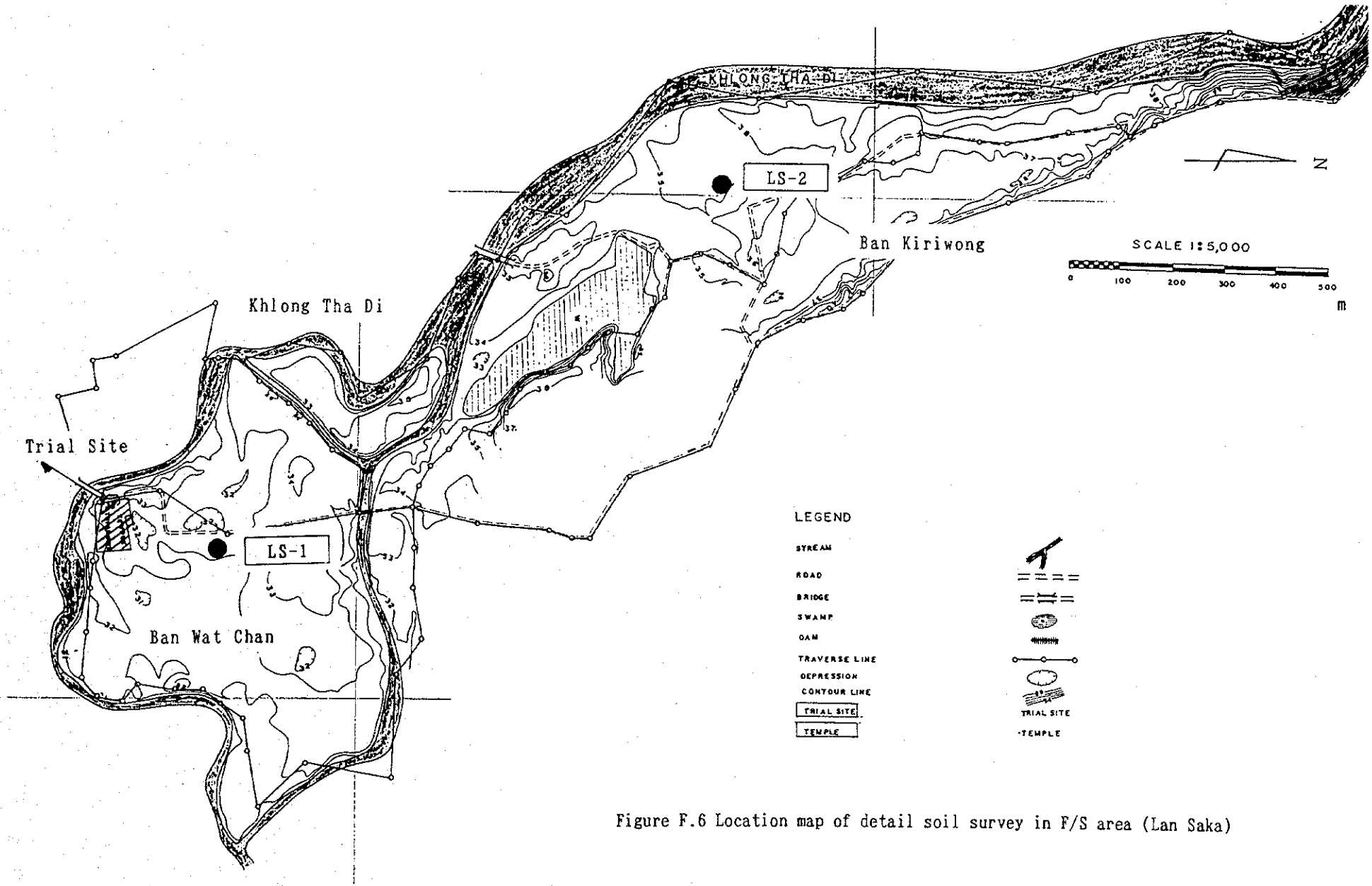

Figure F.6 Location map of detail soil survey in F/S area (Lan Saka)

Table F.22 Description of Pedon LS-1, deep deposited type (Lan Saka)

PEDON NO. LS-1

Series : New
Taxonomy : New
Location : Ban Wat Chan, Tambol Kumlone, Amphoe Lan Saka, Changwat Nakhon Si Thammarat Province
Latitude : E 99° 48' 24" Longitude N 8° 24' 4"
Physiography : Valley fills
Slope : 1%, with microrelief
Climate : Tropical monsoon climate Rain fall: 2382mm Air temp: 27.4℃ Humidity: 80.5%
Land use : Banen Land after flooding disaster in November 1988, parto were cultivated to Banana
Parent material : recent sediments from flash flood in 1988, mostly derived from Cretaceous granite and them association

Soil profile description

Ow1: 0-20cm, Brown (10YR5/3), fine sand, structureless (single grain), loose, non sticky, non plastic, few fine and medium roots, many micas, medium acid (pH6.0), compactness (7mm), clear, wavy boundary.

Ow2: 20-48cm, Mixed dark grayish brown (10YR4/2) and brown (10YR5/3), lens of loamy fine sand, weak structure breaking to single grain, soft, non sticky, non plastic, few fine roots, few buried woody materials, many micas, mildly aldaline (pH7.5), compactness (10mm), clear, wavy boundary.

Ow3: 48-77cm, Mixed brown (10YR4/3) and gray (10YR5/1) fine sand, common fine distinct mottles of strong brown (7.5YR5/6), weak structure breaking to single grain, loose, non sticky, non plastic, common fine and medium roots (possibly bamboo roots), many micas, strongly acid (pH5.5), compactness (7mm), abrupt, wavy boundary.

Ow4: 77-100cm, Dark gray (5Y4/1), fine sand, weak structure breaking to single grain, soft, non sticky, non plastic, few fine roots, many micas, neutral (pH7.0), compactness (9mm).

Remarks: * Ow indicated new term 'Overwash'.
**Soils are more moist with greater depth.

Table F.23 Description of Pedon LS-2, shallow deposited type (Lan Saka)

PEDON NO. LS-2

Series : New
Taxonomy : New
Location : Ban Kiriwong, Tambol Kumlone, Amphoe Lan Saka,
Changwat Nakhon Si Thammarat Province
Latitude : E 99° 48' 00" Longitude N 8° 24' 34"
Physiography : Valley fills
Slope : 1%, with micro relief
Climate : Tropical monsoon climate Rain fall: 2382mm Air temp: 27.4°C
Humidity: 80.5%
Land use : Fruit trees like Rambutan, Mangosteen, Betelnut and Banana
Parent material : Recent sediments from flash flood in 1988, mostly derived from Cretaceous granite and their association rock

Soil profile description

A1 : 0-5cm, Dark brown (10YR3/2), loamy fine sand, weak fine subangular blocky structure breaking to single grain, very friable, non sticky, non plastic, few fine roots, many micas, neutral (pH7.0), compactness (10mm), clear, smooth boundary.

C1 : 5-50cm, Brown (10YR5/3), fine sand loam, weak structure breaking to single grains, loose, non sticky, non plastic, few fine and medium roots, many micas, medium acid (pH6.0), compactness (8mm), clear, wavy boundary.

C2 : 50-80cm, Dark brown (10YR4/3), loamy fine sand, common fine distinct mottles of strong brown (7.5YR4/6) and few nedium faint mottles of brown (10YR5/2), weak structure breaking tp single grain, soft, non sticky, non plastic, friable, few medium roots, many micas, medium acid (pH6.0), compactness (6mm), abrupt, wavy boundary.

Ab1: 80-90cm, Dark gray (10YR4/1), loam, common fine prominent mottles of yellowish red (5YR4/6), weak medium subangular blocky structure, firm, slighty sticky, slighty plastic, common micas, medium acid (pH6.0), compactness (20mm), clear, smooth boundary.

Ab2: 90-110cm, Dark brown (10YR4/3), loam, common fine faint mottles of brown (10YR5/2), weak medium subangular blocky structure, friable, slighty sticky, slighty plastic, common micas, medium acid (pH6.0), compactness (12mm).

Remarks: Soils are more moist with great depth.

Table F.24 Soil physical and chemical properties of F/S area (LS-1)

ANALYSIS RESULTS (Pedon NO. LS-1)

(OVEN DRY BASIS)

Horizon	Depth (cm)	Hydraulic Conductivity (cm/hr)	Particle size analysis (%)								Texture
			USDA Grading (mm)			Sand Fraction Grading (mm)					
			Sand 2-0.05	Silt 0.05-0.002	Clay 0.002>	Very Coarse 2.0-1.0	Coarse 1.0-0.5	Medium 0.5-0.25	Fine 0.25-0.1	Very Fine 0.1-0.05	
Ow1	0-20	37 (Very high)	96.8	1.7	1.5	0	1.0	46.7	42.5	6.6	Sand
Ow2	20-48	19 (High)	92.6	4.9	2.5	0.4	0.8	21.7	60.6	9.1	Sand
Ow3	48-77	29 (Very high)	88.8	7.7	3.5	0.2	0.5	26.9	44.9	16.3	Sand
Ow4	77-100	24 (High)	94.3	5.2	0.5	0.2	0.2	21.6	56.3	16.0	Sand

Horizon	Moisture (%)	pH (1:1)		EC ds/m	T - C (%)	T - N (%)	C/N	Exchange Capacity and Cation (me/100g)					Base Saturation (%)	P_2O_5 (ppm)	K_2O (ppm)
		Water	KCl					Ca	Mg	K	Na	CEC			
Ow1	0.3	5.8	4.4	0.14	0.17	0.01	17	1.5	0.2	0.2	0.1	4.4	45	28.0	50.0
Ow2	0.6	5.6	4.5	0.17	0.31	0.02	16	1.7	0.2	0.2	0.1	2.9	76	36.6	95.0
Ow3	0.9	5.5	4.2	0.11	0.32	0.03	11	1.5	0.2	0.1	0.2	4.2	48	32.4	32.0
Ow4	0.5	4.5	4.0	0.35	0.12	0.02	6	0.8	0.1	0.1	0.1	2.8	39	31.2	44.0

Table F.25 Soil physical and chemical properties of F/S area (LS-2)

ANALYSIS RESULTS (Pedon NO. LS-2)
(OVEN DRY BASIS)

Horizon	Depth (cm)	Hydraulic Conductivity (cm/hr)	Particle size analysis (%)								Texture
			USDA Grading (mm)			Sand Fraction Grading (mm)					
			Sand 2-0.05	Silt 0.05-0.002	Clay 0.002>	Very Coarse 2.0-1.0	Coarse 1.0-0.5	Medium 0.5-0.25	Fine 0.25-0.1	Very Fine 0.1-0.05	
A1	0-5	13 (High)	69.2	24.7	6.1	0	0.1	2.9	48.2	18.0	Sandy Loam
C1	5-50	28 (Very high)	90.0	7.0	3.0	0.2	0.4	29.3	44.1	16.0	Sand
C2	50-80	30 (Very high)	82.8	12.7	4.5	0.2	0.7	44.1	26.4	11.4	Loamy Sand
Ab1	80-90	12 (Moderately high)	55.5	29.3	15.2	2.3	6.2	8.1	24.6	14.3	Sandy Loam
Ab2	90-110	15 (High)	56.6	27.2	16.2	3.4	7.6	13.7	19.9	12.0	Sandy Loam

Horizon	Moisture (%)	pH (1:1)		EC ds/m	T - C (%)	T - N (%)	C/N	Exchange Capacity and Cation (me/100g)					Base Saturation (%)	P_2O_5 (ppm)	K_2O (ppm)
		Water	KCl					Ca	Mg	K	Na	CEC			
A1	1.1	5.3	4.5	0.32	1.70	0.12	14	2.8	0.7	0.6	0.2	7.0	61	45.9	270.0
C1	0.6	5.5	4.2	0.08	0.21	0.03	7	0.8	0.1	0.3	0.1	3.3	39	29.6	92.0
C2	1.0	5.1	4.0	0.07	0.43	0.04	11	1.2	0.1	0.1	0.2	6.2	94	35.4	33.0
Ab1	1.1	5.6	4.2	0.10	0.83	0.07	12	2.1	0.3	0.4	0.2	6.3	48	78.6	130.0
Ab2	1.1	5.7	4.2	0.10	0.56	0.05	11	1.8	0.3	0.4	0.2	5.7	47	52.2	158.0

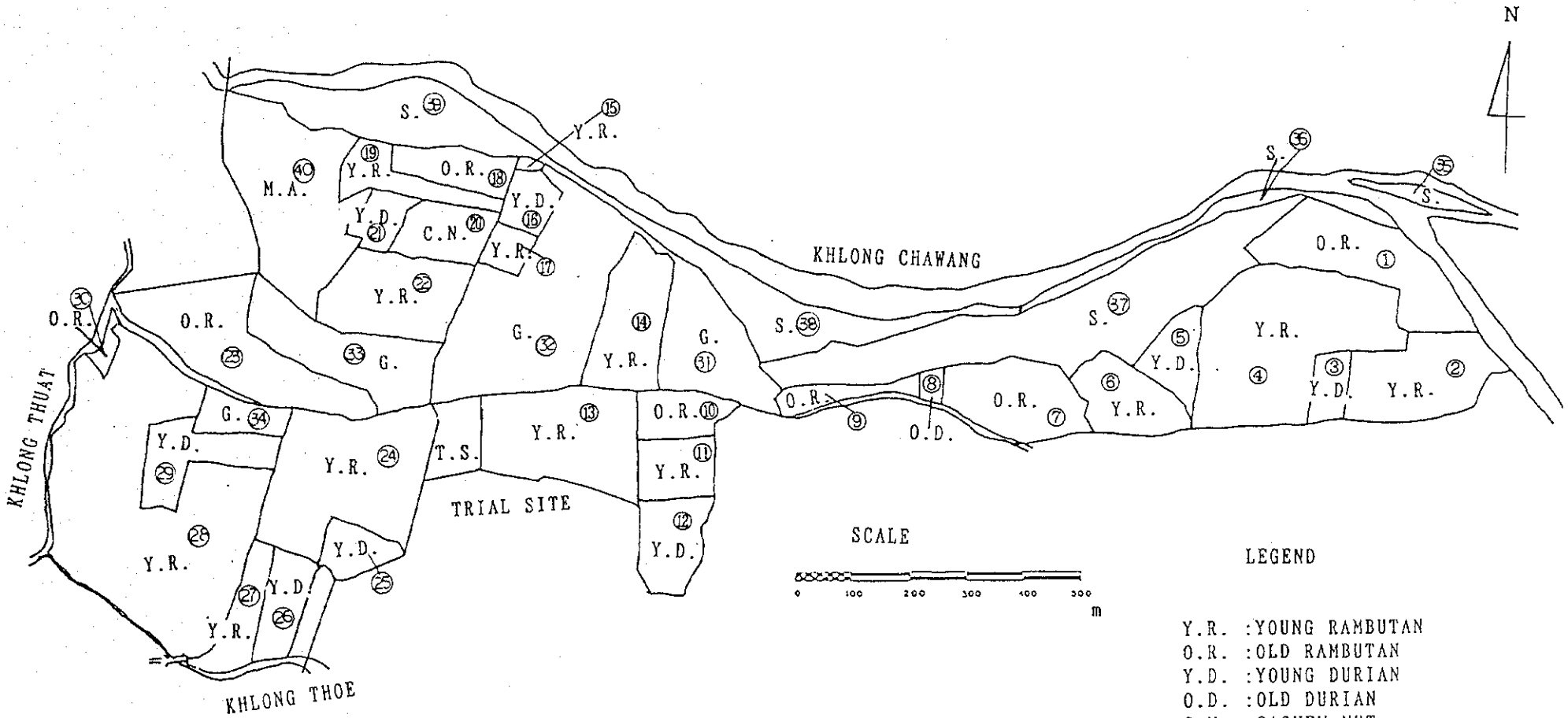

Figure F.7 Land use map of F/S area (Ban Na San)

Table F.26 Charactristics of land use in F/S area (Ban Na San)

Plot NO.	Crop	Depth of Deposit(cm)	Area(rai)	percentage(%)
1	Old Rambutan	25-50	23.30	3.5
2	Young Rambutan	No Deposit, 25-50	22.08	3.4
3	Young Durian	No Deposit	4.83	0.7
4	Young Rambutan	25-50	43.10	6.5
5	Young Durian	25-100	7.45	1.1
6	Young Rambutan	25-100	12.30	1.9
7	Old Rambutan	No Deposit	16.00	2.4
8	Old Durian	No Deposit	1.05	0.2
9	Old Rambutan	No Deposit	3.88	0.6
10	Old Rambutan	100-150	4.23	0.6
11	Young Rambutan	100-150	9.53	1.4
12	Young Durian	50-100	9.45	1.4
13	Young Rambutan	100-150, 150<	24.48	3.7
14	Young Rambutan	150<	18.05	2.7
15	Young Rambutan	150<	0.55	0.1
16	Young Durian	25-50, 150<	4.90	0.7
17	Young Rambutan	25-50, 150<	3.45	0.5
18	Old Rambutan	25-50	8.35	1.3
19	Young Rambutan	25>, 25-50	8.03	1.2
20	Cashew Nut	25-50	8.50	1.3
21	Young Durian	25>	4.73	0.7

Table F.26 Continued

Plot NO.	Crop	Depth of Deposit(cm)	Area(rai)	percentage(%)
22	Young Rambutan	150<	20.05	3.0
23	Old Rambutan	25>, 50-100	27.70	4.2
24	Young Rambutan	150<	31.73	4.8
25	Young Durian	150<	4.50	0.7
26	Young Durian	25-100	7.68	1.2
27	Young Rambutan	25-100	7.73	1.2
28	Young Rambutan	25>, 25-100	60.08	9.1
29	Young Durian	25>, 50-100	11.53	1.8
30	Old Rambutan	No Deposit	2.23	0.3
31	Grass	150<	22.05	3.4
32	Grass	150<	46.03	7.1
33	Grass	150<	20.53	3.1
34	Grass	50-100	6.35	1.0
35	Sand	150<	3.48	0.5
36	Sand	150<	9.10	1.4
37	Sand	150<	56.03	8.6
38	Sand	150<	21.43	3.3
39	Sand	150<	20.05	3.0
40	Marshy Area	150<	35.93	5.5
41	Trial Site	150<	5.60	0.9
	Total		658.05	100.0

Note: Area is calculated by digital planimeter(PLANIX, Japan)

Table F.27 Characteristics of land use in F/S area (Lan Saka)

Class	Area(rai)	percentage(%)
I. Flood Affected Area	322.62	56.0
Upper Stream Area	(74.50)	(12.9)
Down Stream Area	(248.12)	(43.1)
(Not growing fruit tree)		
II. Flooded Area, Not Damage (Still growing fruit tree)	47.08	8.2
III. Swamp (Can't grow anything)	27.03	4.7
IV. Low and/or Wet Land (Grass land, mixed fruit tree)	87.03	15.1
V. Highland (Mixed fruit tree)	92.28	16.0
Total	576.04	100.0

Note: Area is calculated by digital planimeter(PLANIX, Japan)