3.5.2 Operation and Maintenance (O&M) Cost

The O&M cost of the project consists of annual O&M cost including electric consumption, chemical consumption, personnel expenses, repair costs and replacement cost.

The required annual maximum O&M cost of the after each construction works at each construction stage are estimated at 1994 price with the following break-down.

(Unit: US Dollar)

	Item	1st Stage	2nd Stage	3rd Stage
(1)	Electric Consumption Cost	354,605	129,508	179,436
(2)	Chemical Consumption Cost	420	101	242
(3)	Personnel Cost	0	0	37,800
(4)	Repair Cost	11,483	83,714	468,279
	Total Annual O&M Cost	366,508	213,323	685,756

The annual operation and maintenance costs (including the replacement cost) are further broken down as shown in Table III.3.8.

Furthermore, the pumps and other equipment of the intake facilities and other equipment of distribution facilities will be periodically replaced according to their life spans. Their life spans and replacement costs at 1994 price are estimated as follows.

(Unit : US Dollar)

No.	Item	Unit	Life Span	1 st Stage	2 nd Stage	3 rd Stage	Total
1	Intake Facilities			0	8,371,390	19,762,150	28,133,540
	(1) Intake Wells	Year	15	0	1,302,000	2,673,000	3,975,000
	(2) Pump House	Year	40	0	875,000	2,562,500	3,437,500
	(3) Intake Pumps	Year	15	0	326,000	1,022,780	1,348,780
	(4) Other equipment	Year	20	0	2,550,090	6,793,070	9,343,160
	(5) Collection Pipe	Year	40	0	3,318,300	6,710,800	10,029,100
2	Distribution Facilities			1,148,270	0	27,065,780	28,214,050
	(1) Reservoirs	Year	40	0	0	750,000	750,000
	(2) Other equipment	Year	20	761,630	0	1,033,900	1,795,530
	(3) Chlorination Eq	Year	15	386,640	0	343,680	730,320
	(4) Buildings	Year	40	0	0	1,208,200	1,208,200
	(5) Distribution Main	Year	40	0	0	23,730,000	23,730,000
	Total of Replacement Cost			1,148,270	8,371,390	46,827,930	56,347,590
	every 15 Years			386,640	1,628,000	4,039,460	6,054,100
	every 20 Years			761,630	2,550,090	7,826,970	11,138,690
	every 40 Years			0	4,193,300	34,961,500	39,154,800

Table III.3.1 (1/3) The Study of Transmission Main for Upper Water Source up to Zavsariin Reservoir

[Hazen-Williams Formula]

hl = I x L

I = 10.666 x (Ch^-1.85) x (D^-4.87) x (Q^1.85)

[Manning Formula]

hl = I x L

I = [(n x Q) / {0.312 x D^(8/3)}]^2

[CASE I, III : Q = 72,000 m3/day]

Point	Distance L (m)	Altitude above Sea Level H (m)	Water Flow Rate Q (m3/sec)	Pipe Diameter D (m)	Pipe Number (---)	Flow Velocity (m/sec)	Coefficient Related to the Pipe Condition Ch (---)	Roughness Coefficient n	By Hazen-Williams Formula: Hydraulic Gradient I (---)	By Hazen-Williams Formula: Friction Loss hl (m)	By Manning Formula: Hydraulic Gradient I (---)	By Manning Formula: Friction Loss hl (m)
Storage Reservoir (Upper Source)		1,425.2										
	17,704		0.8333	0.7	2	1.08	120	0.013	0.00171	30.2	0.00202	35.8
Highest Point		1,509.3										
	12,213		0.8333	0.6	2	1.47	120	0.013	0.00362	44.2	0.00460	56.1
Supply Reservoir (Zavsariin Reservoir)		1,429.8										
Total	29,917		0.8333							74.4		91.9

The total head of distribution Pump to be required (T-H) is as follows.

T-H = (1,509.3 - 1,425.2) + 30.2

= 114.3 ===> 120 m

[CASE II, IV : Q = 90,000 m3/day]

Point	Distance L (m)	Altitude above Sea Level H (m)	Water Flow Rate Q (m3/sec)	Pipe Diameter D (m)	Pipe Number (---)	Flow Velocity (m/sec)	Coefficient Related to the Pipe Condition Ch (---)	Roughness Coefficient n	By Hazen-Williams Formula: Hydraulic Gradient I (---)	By Hazen-Williams Formula: Friction Loss hl (m)	By Manning Formula: Hydraulic Gradient I (---)	By Manning Formula: Friction Loss hl (m)
Storage Reservoir (Upper Source)		1,425.2										
	17,704		1.0417	0.7	2	1.35	120	0.013	0.00258	45.7	0.00316	55.9
Highest Point		1,509.3										
	12,213		1.0417	0.6	2	1.84	120	0.013	0.00547	66.8	0.00718	87.7
Supply Reservoir (Zavsariin Reservoir)		1,429.8										
Total	29,917		1.0417							112.5		143.6

The total head of distribution Pump to be required (T-H) is as follows.

T-H = (1,429.8 + 87.7 + 45.7) - 1,425.2

= 138 ===> 140 m

Table III.3.1 (2/3)

[At Present : Q = 24,000 m3/day]

Point	Distance	Altitude above Sea Level	Water Flow Rate	Pipe Diameter	Pipe Number	Flow Velocity	Coefficient Related to the Pipe Condition	Roughness Coefficient	By Hazen-Williams Formula		By Manning Formula	
									Hydraulic Gradient	Friction Loss	Hydraulic Gradient	Friction Loss
	L (m)	H (m)	Q (m3/sec)	D (m)	(—)	(m/sec)	Ch (—)	n	I (—)	hl (m)	I (—)	hl (m)
Storage Reservoir (Upper Source)		1,425.2										
	17,704		0.2778	0.7	2	0.36	120	0.013	0.00022	4.0	0.00022	4.0
Highest Point		1,509.3										
	12,213		0.2778	0.6	2	0.49	120	0.013	0.00047	5.8	0.00051	6.2
Supply Reservoir (Zavsariin Reservoir)		1,429.8										
Total	29,917		0.2778							9.8		10.2

The total head of distribution Pump to be required (T-H) is as follows.

T-H = (1,509.3 - 1,425.2) + 4.0

= 88.1 ===> 90 m

Table III.3.1 (3/3)

The Profile of Transmission Main from Upper Pumping Station

Points		Distance		Altitude above Sea Level (m)			Pipeline		
		(m)	Each Distance	Ground	Top of Pipe	Center of Pipe	Diameter (m)	Line Number	Remarks
RS	0	0	0	1,425.20					Storage Reservoirs (Low Water Level)
PS	1	0	0						Upper Source Pumping Station
TK	16	1,600	1,600	1,425.84	1,423.62	1,423.27	0.70	2	
TK	18	1,766	166		1,437.76	1,437.41	0.70	2	
TK	25	2,654	888		1,398.70	1,398.35	0.70	2	
TK	38	3,809	1,155		1,453.27	1,452.92	0.70	2	
TK	40	4,051	242	1,488.00	1,445.50	1,445.15	0.70	2	
TK	56	5,566	1,515		1,459.00	1,458.65	0.70	2	
TK	75	7,608	2,042		1,422.40	1,422.05	0.70	2	
TK	86	8,708	1,100		1,396.80	1,396.45	0.70	2	
TK	110	11,108	2,400		1,446.32	1,445.97	0.70	2	
TK	114	11,508	400	1,453.50	1,451.53	1,451.18	0.70	2	
TK	128	12,908	1,400		1,418.50	1,418.15	0.70	2	
TK	131	13,223	315		1,412.12	1,411.77	0.70	2	
TK	159	16,092	2,869		1,459.62	1,459.27	0.70	2	
TK	176	17,704	1,612	1,509.27	1,507.28	1,506.98	0.60	2	Highest Point
TK	190	18,967	1,263		1,485.99	1,485.69	0.60	2	
TK	194	19,352	385		1,491.79	1,491.49	0.60	2	
TK	220	21,920	2,568		1,441.29	1,440.99	0.60	2	
TK	229	22,793	873	1,423.81	1,421.96	1,421.66	0.60	2	
TK	237	23,631	838		1,430.96	1,430.66	0.60	2	
TK	238	23,707	76		1,422.31	1,422.01	0.60	2	
TK	250	24,872	1,165		1,405.92	1,405.62	0.60	2	
TK	256	25,450	578		1,415.20	1,414.90	0.60	2	
TK	259	25,785	335		1,399.24	1,398.94	0.60	2	
TK	261	25,975	190		1,401.52	1,401.22	0.60	2	
TK	264	26,280	305		1,398.19	1,397.89	0.60	2	
TK	268	26,690	410	1,404.51	1,402.27	1,401.97	0.60	2	
TK	280	27,881	1,191		1,375.71	1,375.41	0.60	2	
TK	285	28,367	486		1,378.87	1,378.57	0.60	2	
TK	297	29,617	1,250	1,352.33	1,350.37	1,350.07	0.60	2	Diverging Point to Reservoir
TK		29,917	300	1,429.80			0.60	2	Zavsarin Reservoir High Water Level

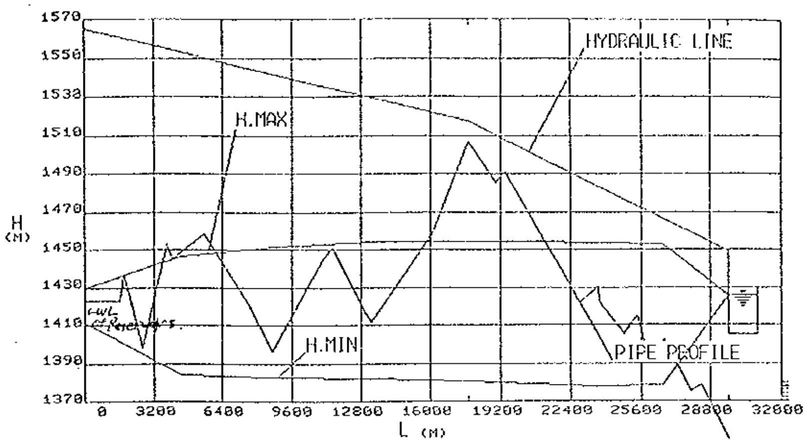
Table III.3.2 Water Hammer Analysis for Upper Pumping Station

Water hammer analysis for Upper Pumping station has been carried out in the graphic calculation method analyzed by a computer.
The applied data for this calculation are as shown in below Table.

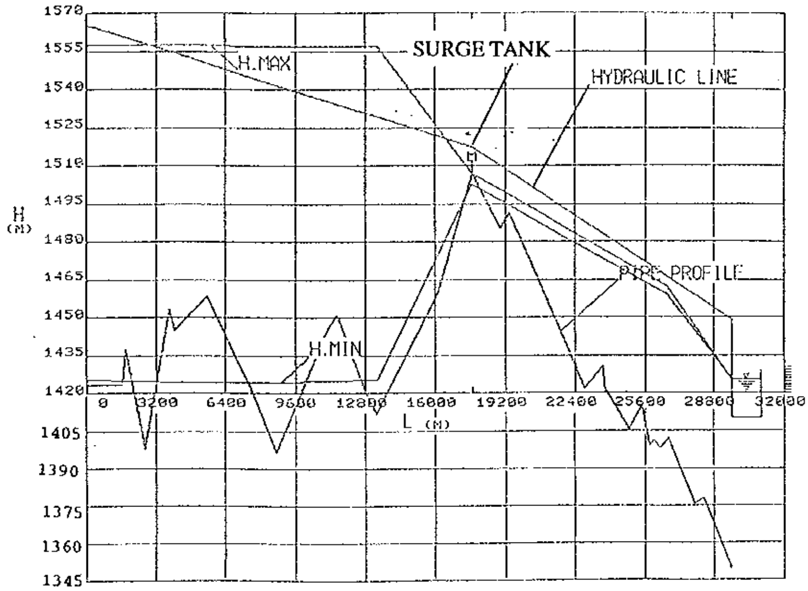
The results of analysis are shown in Fig Case A1 to A3. In accordance with these results, Case A1 and A2 show large negative pressure between the pipe profile and minimum pressure. Therefore these cases may cause harmful surge and Case A3 which have no large negative pressure are acceptable.
However these calculation are based on some assumptive data such as details of existing pump an distribution pipes. Accordingly detailed calculation with actual data will be carried out on the implementation stage.

No	Conditions	Unit	Case A1	Case A2	Case A3
1	Total Head	m	180	180	180
2	Static Head	m	0	0	0
3	Capacity per Pump	m^3/hr	1,000	1,000	1,000
4	Speed	round/min	1,480	1,480	1,480
5	Motor Output	kw	720	720	720
6	Pump Efficiency	%	79	79	79
7	Q'ty of Pumps	Sets	2	2	2
8	Moment of Inertia (GD^2)	kgm^2	75	75	75
9	Pipe Diameter	mm	D700 & D600	D700 & D600	D700 & D600
	D700 : between Pump Station and the highest point				
	D600 : between highest point and Zavsariin reservoir				
10	Material of Pipe		Steel	Steel	Steel
11	Thickness of Pipe				
	D700	mm	20	20	20
	D600	mm	18	18	18
12	Type of the Check Valve		Swing Type	Swing Type	Swing Type
13	Surge Vessel		No	No	Yes
14	One-way Surge Tank		No	Yes	Yes

Water Hammer Pressure Curve : Case A1



Water Hammer Pressure Curve : Case A2



Water Hammer Pressure Curve : Case A3

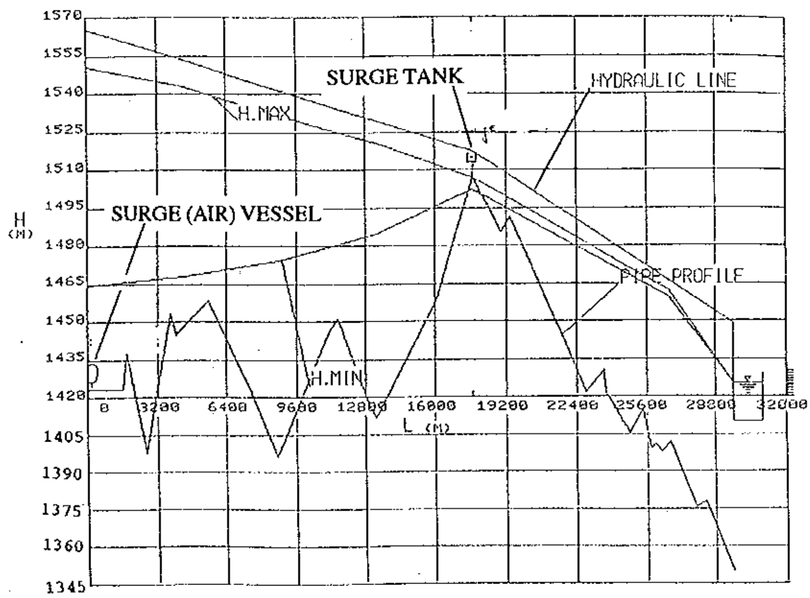


Table III.3.3 (1/2) Calculation of Hydraulic Gradient of Collection Pipeline for Central Water Source

[Hazen-Williams Formula]

h=I * L

I = 10.666*(Ch^-1.85)*(D^-4.87)*(Q^1.85)

[Where]

L1 : Distance Accumulated (m)
L2 : Distance of Between two point (m)
H1 : Altitude above Sea Level of Ground Level of Connection Point to Main Pipeline (m)
H2 : Installation Level of The Center of Main Pipeline
H3 : Altitude above Sea Level of Ground Level by Well (m)
H4 : Altitude above Sea Level of Dynamic Water Level by Well (m)
H5 : Altitude above Sea Level of Hydraulic Gradient Line
Q1 : Flow Rate Accumulated (m3/sec)
Q2 : Inflow (m3/sec)
D : Pipe Diameter (m)
Ch : Coefficient Related to the Pipe Condition Ch=130
I : Hydraulic Gradient (---)
V : Flow Velocity (m/sec)
hl-1: Friction Loss Accumulated (m)
hl-2: Friction Loss of Between two point (m)
T-H: Total Head of Well Pump (m)

Table III.3.3 (2/2) Calculation of Hydraulic Gradient of Collection Pipeline for Central Water Source

Central Water Source (New Intake Water Capacity Qc>=17300 m3/day * 1.2)

Connection		L (m)		H (m)					Q (m3/sec)		D	V	I	hl (m)		T-H'	T-H
Point	Well Number	L1	L2	H1	H2	H3	H4	H5	Q1	Q2	(m)	(m/sec)	(---)	hl-1	hl-2	(m)	(m)
114	No 114	7500		1,320.00	1,318.13	1,320.00	1,295.00	1,346.84		0.01736				46.885		55.84	55
			500						0.01736		0.15	0.98287	0.00746		3.731		
113	No 113	7000		1,318.00	1,316.10	1,318.00	1,293.00	1,343.10		0.01736				43.154		54.10	50
			500						0.03472		0.20	1.10573	0.00663		3.313		
112	No 112	6500		1,315.00	1,313.10	1,315.00	1,290.00	1,339.79		0.01736				39.841		53.79	50
			500						0.05208		0.20	1.65860	0.01403		7.015		
111	No 111	6000		1,314.00	1,312.08	1,314.00	1,289.00	1,332.78		0.01736				32.827		47.78	45
			500						0.06944		0.25	1.41534	0.00806		4.029		
110	No 110	5500		1,312.00	1,310.05	1,312.00	1,287.00	1,328.75		0.01736				28.798		45.75	45
			3400						0.08680		0.30	1.22859	0.00501		17.036		
109	No 109	2100		1,298.00	1,296.05	1,298.00	1,273.00	1,311.71		0.01736				11.762		42.71	45
			500						0.10416		0.30	1.47431	0.00702		3.510		
108	No 108	1600		1,297.00	1,295.05	1,297.00	1,272.00	1,308.20		0.01736				8.252		40.20	40
			500						0.12152		0.30	1.72003	0.00934		4.669		
107	No107	1100		1,296.00	1,294.00	1,296.00	1,271.00	1,303.53		0.01736				3.583		36.53	40
			500						0.13888		0.40	1.10573	0.00294		1.472		
106	No 106	600		1,295.00	1,293.00	1,295.00	1,270.00	1,302.06		0.01736				2.111		36.06	40
			500						0.15624		0.40	1.24395	0.00366		1.831		
100	No 101- 105	100		1,294.00	1,291.95	---	---	1,300.23		0.08680				0.280		---	---
			100						0.24304		0.50	1.23842	0.00280		0.280		
1a	Reservoir HWI	0		1,297.20	1,295.40			1,299.95		0							
Total			7500 m							0.24304 m3/sec (20,998.7 m3/day)					46.885 m		

Connection		L (m)		H (m)					Q (m3/sec)		D	V	I	hl (m)		T-H'	T-H
Point	Well Number	L1	L2	H1	H2	H3	H4	H5	Q1	Q2	(m)	(m/sec)	(---)	hl-1	hl-2	(m)	(m)
105	No 105	3000		1,299.50	1,297.63	1,299.50	1,274.50	1,325.87		0.01736				25.642		55.37	55
			500						0.01736		0.15	0.98287	0.00746		3.731		
104	No 104	2500		1,298.50	1,296.60	1,298.50	1,273.50	1,322.14		0.01736				21.911		52.64	55
			400						0.03472		0.20	1.10573	0.00663		2.650		
103	No 103	2100		1,297.50	1,295.60	1,297.50	1,272.50	1,319.49		0.01736				19.261		50.99	50
			800						0.05208		0.20	1.65860	0.01403		11.223		
102	No 102	1300		1,295.50	1,293.58	1,295.50	1,270.50	1,308.27		0.01736				8.037		41.77	40
			500						0.06944		0.25	1.41534	0.00806		4.029		
101	No 101	800		1,294.50	1,292.55	1,294.50	1,269.50	1,304.24		0.01736				4.008		38.74	40
			800						0.08680		0.30	1.22859	0.00501		4.008		
100	Connection to Main Pipe	0		1,294.00	1,292.20	----	----	1,300.23		0						----	----
Total			3000 m							0.0868 m3/sec					25.642 m		

Table III.3.4 (1/4) Calculation of Hydraulic Gradient of Collection Pipeline for Lower Part of Nalaih

[Hazen-Williams Formula]

h=I * L
I = 10.666*(Ch^-1.85)*(D^-4.87)*(Q^1.85)

[Where]
L1 : Distance Accumulated (m)
L2 : Distance of Between two point (m)
H1 : Altitude above Sea Level of Ground Level of Connection Point to Main Pipeline (m)
H2 : Installation Level of The Center of Main Pipeline
H3 : Altitude above Sea Level of Ground Level by Well (m)
H4 : Altitude above Sea Level of Dynamic Water Level by Well (m)
H5 : Altitude above Sea Level of Hydraulic Gradient Line
Q1 : Flow Rate Accumulated (m3/sec)
Q2 : Inflow (m3/sec)
D : Pipe Diameter (m)
Ch : Coefficient Related to the Pipe Condition Ch=130
I : Hydraulic Gradient (---)
V : Flow Velocity (m/sec)
hl-1: Friction Loss Accumulated (m)
hl-2: Friction Loss of Between two point (m)
T-H: Total Head of Well Pump (m)

Table III.3.4 (2/4) Calculation of Hydraulic Gradient of Collection Pipeline for Lower Part of Nalaih

	Connection	L (m)		H (m)					Q (m3/sec)		D	V	I	hl (m)		T-H'	T-H
Point	Well Number	L1	L2	H1	H2	H3	H4	H5	Q1	Q2	(m)	(m/sec)	(---)	hl-1	hl-2	(m)	(m)
41	No. 41	8000		1,340.00	1,338.10	1,340.00	1,325.00	1,399.39		0.01412				29.586		78.39	75
			300						0.01412		0.15	0.79943	0.00509		1.527		
40	No. 40	7700		1,340.00	1,338.10	1,340.00	1,325.00	1,397.86		0.01412				28.059		76.86	75
			300						0.02824		0.20	0.89936	0.00452		1.356		
39	No. 39	7400		1,340.00	1,338.10	1,340.00	1,325.00	1,396.50		0.01412				26.702		75.50	75
			150						0.04236		0.20	1.34904	0.00957		1.436		
38	No. 38	7250		1,340.00	1,338.10	1,340.00	1,325.00	1,395.07		0.01412				25.266		74.07	75
			150						0.05648		0.25	1.15118	0.00550		0.825		
37	No. 37	7100		1,340.00	1,338.10	1,340.00	1,325.00	1,394.24		0.01412				24.442		73.24	75
			150						0.07060		0.25	1.43898	0.00831		1.246		
36	No. 36	6950		1,340.00	1,338.10	1,340.00	1,325.00	1,393.00		0.01412				23.195		72.00	70
			150						0.08472		0.30	1.19915	0.00479		0.719		
35	No. 35	6800		1,340.00	1,338.10	1,340.00	1,325.00	1,392.28		0.01412				22.477		71.28	70
			300						0.09884		0.30	1.39901	0.00637		1.911		
34	No. 34	6500		1,340.00	1,338.10	1,340.00	1,325.00	1,390.37		0.01412				20.565		69.37	70
			300						0.11296		0.30	1.59887	0.00816		2.447		
33	No. 33	6200		1,340.00	1,338.00	1,340.00	1,325.00	1,387.92		0.01412				18.118		66.92	65
			150						0.12708		0.40	1.01178	0.00250		0.375		
32	No. 32	6050		1,340.00	1,338.00	1,340.00	1,325.00	1,387.54		0.01412				17.743		66.54	65
			150						0.14120		0.40	1.12420	0.00304		0.455		
31	No. 31	5900		1,340.00	1,338.00	1,340.00	1,325.00	1,387.09		0.01412				17.288		66.09	65
			150						0.15532		0.40	1.23662	0.00362		0.543		
30	No. 30	5750		1,340.00	1,338.00	1,340.00	1,325.00	1,386.54		0.01412				16.745		65.54	65
			150						0.16944		0.40	1.34904	0.00425		0.638		
29	No. 29	5600		1,340.00	1,338.00	1,340.00	1,325.00	1,385.91		0.01412				16.106		64.91	65
			150						0.18356		0.40	1.46146	0.00493		0.740		
28	No. 28	5450		1,340.00	1,338.00	1,340.00	1,325.00	1,385.17		0.01412				15.366		64.17	65
			150						0.19768		0.40	1.57389	0.00566		0.849		
27	No. 27	5300		1,340.00	1,338.00	1,340.00	1,325.00	1,384.32		0.01412				14.518		63.32	65
			150						0.21180		0.50	1.07924	0.00217		0.325		
26	No. 26	5150		1,340.00	1,338.00	1,340.00	1,325.00	1,383.99		0.01412				14.192		62.99	65
			150						0.22592		0.50	1.15118	0.00244		0.367		
25	No. 25	5000		1,340.00	1,338.00	1,340.00	1,325.00	1,383.63		0.01412				13.826		62.63	65
			150						0.24004		0.50	1.22313	0.00273		0.410		

Table III.3.4 (3/4) Calculation of Hydraulic Gradient of Collection Pipeline for Lower Part of Nalaih

Lower Part of Nalaih (Intake Water Capacity Q1>= 41,400m^3/day*1.2)

	Connection	L (m)		H (m)					Q (m3/sec)		D	V	I	hl (m)		T-H'	T-H
Point	Well Number	L1	L2	H1	H2	H3	H4	H5	Q1	Q2	(m)	(m/sec)	(---)	hl-1	hl-2	(m)	(m)
24	No. 24	4850		1,340.00	1,338.00	1,340.00	1,325.00	1,383.22		0.01412				13.416		62.22	65
			300						0.25416		0.50	1.29508	0.00304		0.912		
23	No. 23	4550		1,340.00	1,338.00	1,340.00	1,325.00	1,382.30		0.01412				12.504		61.30	60
			400						0.26828		0.50	1.36703	0.00336		1.343		
22	No. 22	4150		1,343.00	1,341.00	1,343.00	1,328.00	1,380.96		0.01412				11.161		56.96	60
			150						0.28240		0.50	1.43898	0.00369		0.554		
21	No. 21	4000		1,343.00	1,341.00	1,342.00	1,327.00	1,380.41		0.01412				10.607		57.41	60
			150						0.29652		0.50	1.51093	0.00404		0.606		
20	No. 20	3850		1,342.00	1,340.00	1,348.00	1,323.00	1,379.80		0.01412				10.001		60.80	60
			150						0.31064		0.50	1.58288	0.00440		0.661		
19	No. 19	3700		1,342.00	1,339.90	1,342.00	1,327.00	1,379.14		0.01412				9.340		56.14	55
			150						0.32476		0.60	1.14919	0.00197		0.295		
18	No. 18	3550		1,341.00	1,338.90	1,352.00	1,327.00	1,378.84		0.01412				9.045		55.84	55
			150						0.33888		0.60	1.19915	0.00213		0.319		
17	No. 17	3400		1,341.00	1,338.90	1,342.00	1,327.00	1,378.53		0.01412				8.726		55.53	55
			150						0.35300		0.60	1.24912	0.00230		0.344		
16	No. 16	3250		1,341.00	1,338.90	1,351.00	1,326.00	1,378.18		0.01412				8.381		56.18	55
			150						0.36712		0.60	1.29908	0.00247		0.370		
15	No. 15	3100		1,341.00	1,338.90	1,341.00	1,326.00	1,377.81		0.01412				8.011		55.81	55
			200						0.38124		0.60	1.34904	0.00265		0.529		
14	No. 14	2900		1,341.00	1,338.90	1,341.00	1,326.00	1,377.28		0.01412				7.481		55.28	55
			1600						0.39536		0.60	1.39901	0.00283		4.531		
4	No. 4	1300		1,357.00	1,354.90	1,340.00	1,325.00	1,372.75		0.01412				2.951		51.75	50
			300						0.40948		0.60	1.44897	0.00302		0.906		
3	No. 3	1000		1,350.00	1,347.90	1,339.00	1,324.00	1,371.84		0.01412				2.044		51.84	50
			300						0.42360		0.60	1.49894	0.00322		0.965		
2	No. 2	700		1,345.00	1,342.90	1,342.00	1,327.00	1,370.88		0.01412				1.079		47.88	50
			300						0.43772		0.70	1.13797	0.00161		0.484		
1	No. 1	400		1,340.00	1,337.90	1,341.00	1,326.00	1,370.39		0.01412				0.595		48.39	50
			100						0.45184		0.70	1.17468	0.00171		0.171		
0	No. 5 - No. 13	300		1,340.00	1,337.80	---	---	1,370.22		0.12708				0.424		---	---
			300						0.57892		0.80	1.15231	0.00141		0.424		
1a	Reservoir	0		1,371.10	1,365.40			1,369.80		0							
Total			8000 m						0.57892 m3/sec (50,018.7 m3/day)					29.586 m			

Table III.3.4 (4/4) Calculation of Hydraulic Gradient of Collection Pipeline for Lower Part of Nalaih

	Connection	L (m)		H (m)					Q (m3/sec)		D	V	I	hl (m)		T-H'	T-H
Point	Well Number	L1	L2	H1	H2	H3	H4	H5	Q1	Q2	(m)	(m/sec)	(---)	hl-1	hl-2	(m)	(m)
13	No. 13	2750		1,330.00	1,328.10	1,330.00	1,315.00	1,385.34		0.01412				15.115		74.34	75
			150						0.01412		0.15	0.79943	0.00509		0.764		
12	No. 12	2600		1,330.00	1,328.10	1,330.00	1,315.00	1,384.57		0.01412				14.351		73.57	75
			150						0.02824		0.20	0.89936	0.00452		0.678		
11	No. 11	2450		1,330.00	1,328.10	1,330.00	1,315.00	1,383.90		0.01412				13.673		72.90	70
			150						0.04236		0.20	1.34904	0.00957		1.436		
10	No. 10	2300		1,330.00	1,328.10	1,330.00	1,315.00	1,382.46		0.01412				12.237		71.46	70
			400						0.05648		0.25	1.15118	0.00550		2.199		
9	No. 9	1900		1,330.00	1,328.10	1,330.00	1,315.00	1,380.26		0.01412				10.038		69.26	70
			300						0.07060		0.25	1.43898	0.00831		2.493		
8	No. 8	1600		1,330.00	1,328.10	1,330.00	1,315.00	1,377.77		0.01412				7.545		66.77	65
			300						0.08472		0.30	1.19915	0.00479		1.437		
7	No. 7	1300		1,330.00	1,328.10	1,330.00	1,315.00	1,376.33		0.01412				6.108		65.33	65
			300						0.09884		0.30	1.39901	0.00637		1.911		
6	No. 6	1000		1,330.00	1,328.10	1,330.00	1,315.00	1,374.42		0.01412				4.196		63.42	65
			300						0.11296		0.30	1.59887	0.00816		2.447		
5	No. 5	700		1,330.00	1,328.00	1,330.00	1,315.00	1,371.97		0.01412				1.749		60.97	60
			700						0.12708		0.40	1.01178	0.00250		1.749		
0	Connection to Main Pipe	0		1,340.00	1,338.20	---	---	1,370.22		0						---	----
Total			2750 m							0.12708 m3/sec					15.115 m		

Table III.3.5 Calculation of the Distribution Main from Distribution Reservoirs to ULB City

1. Water Flow Rate

41,400 m3/day

2. Selection of the Pipe Diameter

1) Formula of Application

[Manning Formula]

$$Q = A * V = (1/n) * R^{2/3} * I^{1/2} * A$$
$$= (1/n) * (D/4)^{2/3} * I^{1/2} * (\pi D^2/4)$$
$$= (0.312/n) * I^{1/2} * D^{8/3}$$

Therefore,

$$D = [(n * Q) / (0.312 * I^{1/2})]^{3/8}$$
$$I = [(n * Q) / (0.312 * D^{8/3})]^2$$

[Where]

Q : Flow Rate (m^3/sec)
A : Area of the Pipe (mm)
V : Flow Velocity (m/sec)
n : Roughness Coefficient (---)
R : Hydraulic radius (m)
I : Hydraulic Gradient (---)
D : Pipe Diameter (m)
hl : Friction Loss (m)
H1-H2 : Difference of Elevation (m)
L : Length of Pipe (m)

2) Selection of Pipe Diameter

The pipe diameter is selected by below comparison table.

Q' (m3/day)	Q (m3/sec)	D (m)	n (---)	I-1 (---)	I-2 (---)	I-3 (---)	V (m/sec)	L (m)	H1 - H2 (m)	hl (m)
41,400	0.4792	0.50	0.013	0.0038	0.0038	0.0161	2.44	21,000	79	337.54
	0.4792	0.60	0.013	0.0038	0.0038	0.0061	1.70	21,000	79	127.65
	0.4792	0.70	0.013	0.0038	0.0038	0.0027	1.25	21,000	79	56.10
	0.4792	0.80	0.013	0.0038	0.0038	0.0013	0.95	21,000	79	27.52
	0.4792	0.90	0.013	0.0038	0.0038	0.0007	0.75	21,000	79	14.68
	0.4792	1.00	0.013	0.0038	0.0038	0.0004	0.61	21,000	79	8.37

I-1 : Average Grade of Ground
I-2 : Average Grade of Pipeline
I-3 : Average Hydraulic Gradient

As the results of above comparison study , the pipe diameter was selected with 800 mm.

Table III.3.6 (1/5) **Direct Construction Cost**

[Summary of Direct Construction Cost]
(As of September 1994 Price)

(Unit : US Dollar)

No	Facilities	Amount	Remarks
1	**Upper Water Source**	**1,148,270**	1 st Stage
	(Expansion of Existing Facilities)		
1)	Transmission Facilities	394,290	
2)	Others (for Zavsariin reservoir, etc.)	564,640	
3)	Telecommunication System	189,340	
2	**Central Water Source**	**8,371,390**	2 nd Stage
	(Expansion of Existing Facilities)		
1)	Intake Facilities	8,371,390	
3	**Lower Part of Nalaih**	**46,827,930**	3 rd Stage
1)	Intake Facilities	19,762,150	
2)	Distribution Facilities	27,065,780	
	Total	**56,347,590**	

Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0

Table III.3.6 (2/5) Detailed Direct Construction Cost
(As of September 1994 Price)

(Unit : US Dollar)

No	Item	Unit	Q' ty	Specification	Unit Cost	1 st Stage	2 nd Stage	3 rd Stage	Amount
1	**Upper Water Source**					1,148,270	0	0	1,148,270
	(Expansion of Existing Facilities)								
1)	Transmission Facilities					394,290	0	0	394,290
	(1) Check Valves	Nos	4	350 mm	30,860	123,440	0	0	123,440
	(2) Instrumentations	Set	1	Flow Meter, Level Meter		92,750	0	0	92,750
	(3) Surge Protection Facilities	Set	1	Surge Tank, Air Vessel, etc.		105,510	0	0	105,510
	(4) Transportation, Insurance	lot	1			13,340	0	0	13,340
	(5) Installation Works	lot	1			59,250	0	0	59,250
2)	Others (for Zavsariin reservoir, etc.)					564,640	0	0	564,640
	(1) Water Level Meters	Nos	4		24,000	96,000	0	0	96,000
	(2) Chlorination Equipment	Set	1	Container, Leakage detector, etc		386,640	0	0	386,640
	(3) Power distribution Panel	Set	1	including Instrumentation Panel		49,500	0	0	49,500
	(4) Transportation, Insurance	lot	1			9,000	0	0	9,000
	(5) Installation Works	lot	1			23,500	0	0	23,500
3)	Telecommunication System					189,340	0	0	189,340
	(1) Radio communication system	Set	3	150 MHz, 25w	19,580	58,740	0	0	58,740
	(2) Radio antenna	Set	3		15,130	45,390	0	0	45,390
	(3) Un-interrupted power supply	Set	3		7,700	23,100	0	0	23,100
	(4) Required cabling, etc.	Set	3		11,280	33,840	0	0	33,840
	(5) Transportation, Insurance	lot	1			4,770	0	0	4,770
	(6) Installation Works	lot	1			23,500	0	0	23,500

Table III.3.6 (3/5) Detailed Direct Construction Cost

No	Item	Unit	Q' ty	Specification	Unit Cost	1 st Stage	2 nd Stage	3 rd Stage	Amount
2	**Central Water Source**					0	8,371,390	0	8,371,390
	(Expansion of Existing Facilities)								
1)	Intake Facilities					0	8,371,390	0	8,371,390
	(1) Wells	Nos	14	30 m Deep	93,000	0	1,302,000	0	1,302,000
	(2) Pump Houses	Nos	14		62,500	0	875,000	0	875,000
	(3) Intake Pumps	Nos	14			0	1,823,970	0	1,823,970
	Submersible motor pumps	Nos	5	1500 m3/d x 40 m	17,670	0	88,350	0	88,350
	Submersible motor pumps	Nos	3	1500 m3/d x 45 m	20,560	0	61,680	0	61,680
	Submersible motor pumps	Nos	3	1500 m3/d x 50 m	20,560	0	61,680	0	61,680
	Submersible motor pumps	Nos	3	1500 m3/d x 55 m	23,900	0	71,700	0	71,700
	Pump Control Panels	Nos	14	Wall mounted type	16,500	0	231,000	0	231,000
	Motor Drive Valves	Nos	14	100 mm Gate Valve	6,790	0	95,060	0	95,060
	Flow measuring device	Nos	14	Orifice	4,200	0	58,800	0	58,800
	Steel Pipe	Set	14	including Bolts, Nuts, Packings	8,840	0	123,760	0	123,760
	Hoists, Heaters, Room Lights	Set	14		9,430	0	132,020	0	132,020
	Step Down Transformer	Set	14	Including Lighting Arrester, etc.	44,000	0	616,000	0	616,000
	Others	Set	14	Rising column Pipes, Valves etc.	7,380	0	103,320	0	103,320
	Spare Parts	Year	2	for Motors, Pumps, Transformer		0	180,600	0	180,600
	(4) Remote Control System	Set	1			0	708,000	0	708,000
	Telecontrol Unit	Set	14	Wall mounted type	12,540	0	175,560	0	175,560
	Remote Control Center	Set	1			0	125,400	0	125,400
	Un-interrupted power supply	Set	1			0	23,650	0	23,650
	Communication Cable	Set	1			0	79,800	0	79,800
	Power & Control Cable	Set	1			0	168,000	0	168,000
	Spare Parts	Year	2			0	135,590	0	135,590
	(5) Power Transmission Line	lot	1	35 kV, 35/10 kV		0	0	0	0
	(6) Power Distribution Line	lot	1	10 kV		0	90,000	0	90,000
	(7) Collection Pipe	m	1,400	DCIP 150 mm x 14 x @100 m	176	0	246,400	0	246,400
	(8) Collection Main Pipeline	m	10,500	DCIP 150 ~ 500 mm		0	3,071,900	0	3,071,900
		m	1,000	DCIP 150 mm	176	0	176,000	0	176,000
		m	2,200	DCIP 200 mm	218	0	479,600	0	479,600
		m	1,000	DCIP 250 mm	263	0	263,000	0	263,000
		m	5,200	DCIP 300 mm	318	0	1,653,600	0	1,653,600
		m	1,000	DCIP 400 mm	441	0	441,000	0	441,000
		m	100	DCIP 500 mm	587	0	58,700	0	58,700
	(9) Transportation, Insurance	lot	1	1)-(3), 1)-(4)		0	119,120	0	119,120
	(10) Installation Works	lot	1	1)-(3), 1)-(4)		0	135,000	0	135,000

Table III.3.6 (4/5) Detailed Direct Construction Cost

No	Item	Unit	Q'ty	Specification	Unit Cost	1 st Stage	2 nd Stage	3 rd Stage	Amount
3	Lower Part of Nalaih					0	0	46,827,930	46,827,930
1)	Intake Facilities					0	0	19,762,150	19,762,150
	(1) Wells	Nos	41			0	0	2,673,000	2,673,000
		Nos	38	20 m Deep	63,000	0	0	2,394,000	2,394,000
		Nos	3	30 m Deep	93,000	0	0	279,000	279,000
	(2) Pump Houses	Nos	41		62,500	0	0	2,562,500	2,562,500
	(3) Intake Pumps	Nos	41			0	0	5,534,710	5,534,710
	Submersible motor pumps	Nos	4	1220 m3/d x 50 m	17,530	0	0	70,120	70,120
	Submersible motor pumps	Nos	6	1220 m3/d x 55 m	20,140	0	0	120,840	120,840
	Submersible motor pumps	Nos	5	1220 m3/d x 60 m	20,140	0	0	100,700	100,700
	Submersible motor pumps	Nos	13	1220 m3/d x 65 m	28,120	0	0	365,560	365,560
	Submersible motor pumps	Nos	6	1220 m3/d x 70 m	28,120	0	0	168,720	168,720
	Submersible motor pumps	Nos	7	1220 m3/d x 75 m	28,120	0	0	196,840	196,840
	Rising column pipes	Nos	41	100 mm, including Volts, Nuts	3,650	0	0	149,650	149,650
	Pump Control Panels	Nos	41	Wall mounted type	16,500	0	0	676,500	676,500
	Motor Drive Valves	Nos	41	100 mm Gate Valve	6,790	0	0	278,390	278,390
	Flow measuring device	Nos	41	Orifice	4,200	0	0	172,200	172,200
	Steel Pipe	Set	41	including Bolts, Nuts, Packings	8,840	0	0	362,440	362,440
	Accessories for pump	Set	41	Low water level detector, etc.	2,040	0	0	83,640	83,640
	Hoists, Heaters, Room Lights	Set	41		9,430	0	0	386,630	386,630
	Step Down Transformer	Set	41	Including Lighting Arrester, etc.	44,000	0	0	1,804,000	1,804,000
	Others	Set	41	Valves etc.	1,690	0	0	69,290	69,290
	Spare Parts	Year	2	for Motors, Pumps, Transformer		0	0	529,190	529,190
	(4) Remote Control System	Set	1			0	0	1,676,460	1,676,460
	Telecontrol Unit	Set	41	Wall mounted type	12,540	0	0	514,140	514,140
	Remote Control Center	Set	1			0	0	125,400	125,400
	Un-interrupted power supply	Set	1			0	0	23,650	23,650
	Communication Cable	Set	1			0	0	319,200	319,200
	Power & Control Cable	Set	1			0	0	474,600	474,600
	Spare Parts	Year	2			0	0	219,470	219,470
	(5) Power Transmission Line	lot	1	35 kV, 35/10 kV		0	0	1,521,000	1,521,000
	(6) Power Distribution Line	lot	1	10 kV		0	0	360,000	360,000
	(7) Collection Pipe	m	4,100	DCIP 150 mm x 41 x @100 m	176	0	0	721,600	721,600
	(8) Collection Main Pipeline	m	10,750	DCIP 150 ~ 800 mm		0	0	5,650,200	5,650,200
		m	450	DCIP 150 mm	176	0	0	79,200	79,200
		m	750	DCIP 200 mm	218	0	0	163,500	163,500
		m	1,000	DCIP 250 mm	263	0	0	263,000	263,000
		m	1,650	DCIP 300 mm	318	0	0	524,700	524,700
		m	1,600	DCIP 400 mm	441	0	0	705,600	705,600
		m	1,600	DCIP 500 mm	587	0	0	939,200	939,200

Table III.3.6 (5/5) Detailed Direct Construction Cost

No	Item	Unit	Q'ty	Specification	Unit Cost	1 st Stage	2 nd Stage	3 rd Stage	Amount
		m	3,000	DCIP 600 mm	756	0	0	2,268,000	2,268,000
		m	400	DCIP 700 mm	920	0	0	368,000	368,000
		m	300	DCIP 800 mm	1,130	0	0	339,000	339,000
	(9) River Crossing	Site	3		75,000	0	0	225,000	225,000
2)	Distribution Facilities					0	0	26,473,980	26,473,980
	(1) Reservoirs	Nos	2	@6,900 m3		0	0	750,000	750,000
	(2) Other Equipment					0	0	442,100	442,100
	Valves	Nos	4	Hand Operated Butterfly Valve	44,400	0	0	177,600	177,600
	Flow Meters		2	Ultrasonic type	43,200	0	0	86,400	86,400
	Water Level Meters	Nos	2	Pressure measuring type	24,000	0	0	48,000	48,000
	Power distribution Panel	Set	1	including Instrumentation Panel		0	0	49,500	49,500
	Step Down Transformer	Set	2	Including Lighting Arrester, etc.	35,750	0	0	71,500	71,500
	Others	Set	1	Cabling and grounding materials		0	0	5,250	5,250
	Spare Parts	Year	2	Recording Paper, Fuse, etc.		0	0	3,850	3,850
	(3) Chlorination Equipment	Set	1	Container, Leakage detector, etc		0	0	343,680	343,680
	(4) Buildings	lot	1	Chlorination, Control, Admi		0	0	1,208,200	1,208,200
	(5) Distribution Main	m	21,000	DCIP 800 mm	1,130	0	0	23,730,000	23,730,000
3)	Transportation, Insurance	lot	1	1)-(3), 1)-(4), 2)-(2), 2)-(3)		0	0	354,800	354,800
4)	Installation Works	lot	1	1)-(3), 1)-(4), 2)-(2), 2)-(3)		0	0	237,000	237,000
	Total Construction Cost					1,148,270	8,371,390	46,827,930	56,347,590

Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0

Table III.3.7 Disbursement Schedule of Investment Cost
(As of September 1994 Price)

(Unit : US Dollar)

No	Work Item	1 st Stage		2 nd Stage		3 rd Stage			Amount
		1996 Design	1997 Construction	2000 Design	2001 Construction	2001 Design	2002 Construction	2003 Construction	
1	Direct Construction Cost	0	1,148,270	0	8,371,390	0	23,411,000	23,416,930	56,347,590
-1	Upper Water Source	0	1,148,270	0	0	0	0	0	1,148,270
	(Expansion of Existing Facilities)								
1)	Transmission Facilities	0	394,290	0	0	0	0	0	394,290
2)	Others(for Zavsariin reservoir,etc.)	0	564,640	0	0	0	0	0	564,640
3)	Telecommunication System	0	189,340	0	0	0	0	0	189,340
-2	Central Water Source	0	0	0	8,371,390	0	0	0	8,371,390
	(Expansion of Existing Facilities)								
1)	Intake Facilities	0	0	0	8,371,390	0	0	0	8,371,390
-3	New Water Source	0	0	0	0	0	23,411,000	23,416,930	46,827,930
1)	Intake Facilities	0	0	0	0	0	9,881,000	9,881,150	19,762,150
2)	Distribution Facilities	0	0	0	0	0	13,530,000	13,535,780	27,065,780
2	Land Acquisition Cost	0	0	0	0	0	0	0	0
3	Engineering Cost	325,000	167,900	391,000	416,800	850,000	755,950	755,950	3,662,600
4	Administration Cost [3% of 1]	17,448	17,000	125,142	126,000	468,000	468,420	468,420	1,690,430
5	Physical Contingency [10% of 1]	0	114,827	0	837,139	0	2,341,400	2,341,394	5,634,760
	Total	342,448	1,447,997	516,142	9,751,329	1,318,000	26,976,770	26,982,694	67,335,380

Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0

Table III.3.8 Annual Operation and Maintenance Cost for the project

(As of September 1994 Price) (Unit : US Dollar)

No	Item	Unit	Unit Cost	1 st Stage		2 nd Stage		3 rd Stage		Total
				Q'ty	Account	Q'ty	Account	Q'ty	Account	
1	Electric Consumption	US$/kw	0.044	8,059,200	354,605	2,943,360	129,508	4,078,080	179,436	663,548
2	Chemicals (Chlorine)	US$/kg	0.016	26,280	420	6,315	101	15,110	242	763
3	Personnel	US$/P/Y	1,800	0	0	0	0	21	37,800	37,800
4	Repairing (1 % of C-Cost)	lot		1	11,483	1	83,714	1	468,279	563,476
	Total Annual O & M Cost				366,508		213,323		685,756	1,265,587
5	Replacement		Life Span							
-1	Intake Facilities				0		8,371,390		19,762,150	28,133,540
	(1) Intake Wells	Year	15		0		1,302,000		2,673,000	3,975,000
	(2) Pump House	Year	40		0		875,000		2,562,500	3,437,500
	(3) Intake Pumps	Year	15		0		326,000		1,022,780	1,348,780
	(4) Other equipment	Year	20		0		2,550,090		6,793,070	9,343,160
	(5) Collection Pipe	Year	40		0		3,318,300		6,710,800	10,029,100
-2	Distribution Facilities				1,148,270		0		27,065,780	28,214,050
	(1) Reservoirs	Year	40		0		0		750,000	750,000
	(2) Other equipment	Year	20		761,630		0		1,033,900	1,795,530
	(3) Chlorination Equipmer	Year	15		386,640		0		343,680	730,320
	(4) Buildings	Year	40		0		0		1,208,200	1,208,200
	(5) Distribution Main	Year	40		0		0		23,730,000	23,730,000
	Total of Replacement Cost				1,148,270		8,371,390		46,827,930	56,347,590
	every 15 Years				386,640		1,628,000		4,039,460	6,054,100
	every 20 Years				761,630		2,550,090		7,826,970	11,138,690
	every 40 Years				0		4,193,300		34,961,500	39,154,800

Note

(1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0

(2)Electric consumption (kwh/Y) [Unit Cost : 17.6 Tg/kwh = 0.044 US$/kwh]

1) Intake Pumps

Central Water Source = 160 kwh x 24 hr/day x 365 day/Y x 0.8 = 1,121,280 kwh/Y

Lower Part of Nalaih = 590 kwh x 24 hr/day x 365 day/Y x 0.8 = 4,134,720 kwh/Y

2) Distribution Pumps

Upper Water Source = 1,150 kwh x 24 hr/day x 365 day/Y x 0.8 = 8,059,200 kwh/Y

Central Water Source = 260 kwh x 24 hr/day x 365 day/Y x 0.8 = 1,822,080 kwh/Y

Total = 1,121,280 + 4,078,080 + 8,059,200 + 1,822,080 = 15,080,640 (kwh/Y)

(3) Chemicals (Chlorine) (kg-Cl/Y) [Unit Cost : 6.4 Tg/kg-Cl = 0.016 US$/kg-Cl]

Upper Water Source = 72,000 m3/day x 365 day/Y x 1 g/m3 x (1/1000) = 26,280 kg-Cl/Y

Central Water Source = 17,300 m3/day x 365 day/Y x 1 g/m3 x (1/1000) = 6,315 kg-Cl/Y

Lower Part of Nalaih = 41,400 m3/day x 365 day/Y x 1 g/m3 x (1/1000) = 15,110 kg-Cl/Y

Total = 26,280 + 6,315 + 15,110 = 47,705 kg-Cl/Y

(4) Required Personnel

Lower Part of Nalaih : Total 21 (Chief: 1, Engineer: 2, Operator: 9, Maintenance worker: 5, Accountancy: 1, Labors: 3)

Table III.3.9(1) COMPARISON STUDY FOR FUTURE WATER SOURCE

No	Item	Unit	Case I				Case II				Case III				Case IV			
			1 st Stage	2 nd Stage	3 rd Stage	Sub-Total	1 st Stage	2 nd Stage	3 rd Stage	Sub-Total	1 st Stage	2 nd Stage	3 rd Stage	Sub-Total	1 st Stage	2 nd Stage	3 rd Stage	Sub-Total
1	Supply Capacity to be Developed																	
1)	Lower Part of Nalaih	m3/day	0	17,300	41,400	58,700	0	0	40,700	40,700	0	0	41,400	41,400	0	0	23,400	23,400
2)	Central	m3/day	0	0	0	0	0	0	0	0	0	17,300	0	17,300	0	17,300	0	17,300
3)	Industrial	m3/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4)	Meat Complex	m3/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5)	Upper	m3/day	48,000	0	0	48,000	48,000	18,000	0	66,000	48,000	0	0	48,000	48,000	0	18,000	66,000
	Total		48,000	17,300	41,400	106,700	48,000	18,000	40,700	106,700	48,000	17,300	41,400	106,700	48,000	17,300	41,400	106,700
2	Construction Cost																	
2.1	Direct Construction																	
1)	Lower Part of Nalaih	T-US$	0	35,994	20,557	56,551	0	0	46,828	46,828	0	0	46,828	46,828	0	0	37,344	37,344
2)	Central	T-US$	0	0	0	0	0	0	0	0	0	8,371	0	8,371	0	8,371	0	8,371
3)	Upper	T-US$	1,148	0	0	1,148	1,148	10,107	0	11,255	1,148	0	0	1,148	1,148	0	10,107	11,255
	Total of 2.1	T-US$	1,148	35,994	20,557	57,699	1,148	10,107	46,828	58,083	1,148	8,371	46,828	56,347	1,148	8,371	47,451	56,970
2.2	Land Acquisition	T-US$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.3	Engineering	T-US$	493	2,340	1,336	4,169	493	975	2,362	3,830	493	808	2,362	3,663	493	808	3,084	4,385
2.4	Administration	T-US$	34	1,080	617	1,731	34	303	1,405	1,742	34	251	1,405	1,690	34	251	1,424	1,709
2.5	Physical Contingen	T-US$	115	3,599	2,056	5,770	115	1,011	4,683	5,808	115	837	4,683	5,635	115	837	4,745	5,697
	Total of 2	T-US$	1,790	43,013	24,566	69,369	1,790	12,396	55,278	69,464	1,790	10,267	55,278	67,335	1,790	10,267	56,704	68,762
3	O&M (Electricity)																	
1)	Intake Pumps	T-US$/Y	0	77	179	256	0	68	170	237	0	49	179	228	0	49	151	200
2)	Distribution Pumps	T-US$/Y	355	0	0	355	355	136	0	490	355	80	0	435	355	80	136	570
	Total 2.2	T-US$/Y	355	77	179	611	355	204	170	728	355	130	179	663	355	130	287	771
4	Present Value of Total Cost (from 1995 up to 2020)	T-US$				54,741				53,289				51,529				52,825
5	Power Consumption																	
1)	Intake Pumps	kwh	0	250	580	830	0	220	550	770	0	160	590	750	0	160	490	650
2)	Distribution Pumps	kwh	1,150	0	0	1,150	1,150	440	0	1,590	1,150	260	0	1,410	1,150	260	440	1,850
	Total	kwh	1,150	250	580	1,980	1,150	660	550	2,360	1,150	420	590	2,160	1,150	420	930	2,500
	Unit Cost	US$/kw	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
	Day/Year	day	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365
	hr/Day	hour	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
	Working Ratio	---	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Table III.3.9(2)

Case 1 Disbursement Schedule of Investment Cost
(As of September 1994 Price)

(Unit : US Dollar)

No	Work Item	1 st Stage		2 nd Stage		3 rd Stage			Amount
		1996	1997	2000	2001	2001	2002	2003	
		Design	Construction	Design	Construction	Design	Construction	Construction	
1	Direct Construction Cost	0	1,148,270	0	35,994,066	0	10,278,000	10,279,464	57,699,800
-1	Upper Water Source	0	1,148,270	0	0	0	0	0	1,148,270
	(Expansion of Existing Facilities)								
	1) Transmission Facilities	0	394,290	0	0	0	0	0	394,290
	2) Others (for Zavsariin reservoir, etc.)	0	564,640	0	0	0	0	0	564,640
	3) Telecommunication System	0	189,340	0	0	0	0	0	189,340
-2	Central Water Source	0	0	0	0	0	0	0	0
	(Expansion of Existing Facilities)								
	1) Intake Facilities	0	0	0	0	0	0	0	0
-3	Lower Part of Nalaih	0	0	0	35,994,066	0	10,278,000	10,279,464	56,551,530
	1) Intake Facilities	0	0	0	8,442,266	0	10,278,000	10,279,464	28,999,730
	2) Distribution Facilities	0	0	0	27,551,800	0	0	0	27,551,800
2	Land Acquisition Cost	0	0	0	0	0	0	0	0
3	Engineering Cost	325,000	167,900	1,123,000	1,216,600	450,000	443,120	443,120	4,168,740
4	Administration Cost [3% of 1]	17,448	17,000	539,900	539,900	205,000	205,860	205,860	1,730,968
5	Physical Contingency [10% of 1]	0	114,827	0	3,599,407	0	1,027,800	1,027,946	5,769,980
	Total	342,448	1,447,997	1,662,900	41,349,973	655,000	11,954,780	11,956,390	69,369,488

Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0

Case 2 Disbursement Schedule of Investment Cost
(As of September 1994 Price)

(Unit : US Dollar)

No	Work Item	1 st Stage		2 nd Stage		3 rd Stage			Amount
		1996	1997	2000	2001	2001	2002	2003	
		Design	Construction	Design	Construction	Design	Construction	Construction	
1	Direct Construction Cost	0	1,148,270	0	10,107,500	0	23,413,965	23,413,965	58,083,700
-1	Upper Water Source	0	1,148,270	0	10,107,500	0	0	0	11,255,770
	(Expansion of Existing Facilities)								
	1) Transmission Facilities	0	394,290	0	0	0	0	0	394,290
	2) Others (for Zavsariin reservoir, etc.)	0	564,640	0	0	0	0	0	564,640
	3) Telecommunication System	0	189,340	0	0	0	0	0	189,340
-2	Central Water Source	0	0	0	0	0	0	0	0
	(Expansion of Existing Facilities)								
	1) Intake Facilities	0	0	0	0	0	0	0	0
-3	Lower Part of Nalaih	0	0	0	0	0	23,413,965	23,413,965	46,827,930
	1) Intake Facilities	0	0	0	0	0	9,881,075	9,881,075	19,762,150
	2) Distribution Facilities	0	0	0	0	0	13,532,890	13,532,890	27,065,780
2	Land Acquisition Cost	0	0	0	0	0	0	0	0
3	Engineering Cost	325,000	167,900	487,500	487,500	850,000	755,950	755,950	3,829,800
4	Administration Cost [3% of 1]	17,448	17,000	151,600	151,625	468,280	468,280	468,280	1,742,513
5	Physical Contingency [10% of 1]	0	114,827	0	1,010,750	0	2,341,397	2,341,397	5,808,371
	Total	342,448	1,447,997	639,100	11,757,375	1,318,280	26,979,592	26,979,592	69,464,384

Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0

Case 3 Disbursement Schedule of Investment Cost
(As of September 1994 Price)

(Unit : US Dollar)

No	Work Item	1 st Stage		2 nd Stage		3 rd Stage			Amount
		1996	1997	2000	2001	2001	2002	2003	
		Design	Construction	Design	Construction	Design	Construction	Construction	
1	Direct Construction Cost	0	1,148,270	0	8,371,390	0	23,411,000	23,416,930	56,347,590
-1	Upper Water Source	0	1,148,270	0	0	0	0	0	1,148,270
	(Expansion of Existing Facilities)								
	1) Transmission Facilities	0	394,290	0	0	0	0	0	394,290
	2) Others (for Zavsariin reservoir, etc.)	0	564,640	0	0	0	0	0	564,640
	3) Telecommunication System	0	189,340	0	0	0	0	0	189,340
-2	Central Water Source	0	0	0	8,371,390	0	0	0	8,371,390
	(Expansion of Existing Facilities)								
	1) Intake Facilities	0	0	0	8,371,390	0	0	0	8,371,390
-3	Lower Part of Nalaih	0	0	0	0	0	23,411,000	23,416,930	46,827,930
	1) Intake Facilities	0	0	0	0	0	9,881,000	9,881,150	19,762,150
	2) Distribution Facilities	0	0	0	0	0	13,530,000	13,535,780	27,065,780
2	Land Acquisition Cost	0	0	0	0	0	0	0	0
3	Engineering Cost	325,000	167,900	391,000	416,800	850,000	755,950	755,950	3,662,600
4	Administration Cost [3% of 1]	17,448	17,000	125,142	126,000	468,000	468,420	468,420	1,690,430
5	Physical Contingency [10% of 1]	0	114,827	0	837,139	0	2,341,400	2,341,394	5,634,760
	Total	342,448	1,447,997	516,142	9,751,329	1,318,000	26,976,770	26,982,694	67,335,380

Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0

Case 4 Disbursement Schedule of Investment Cost
(As of September 1994 Price)

(Unit : US Dollar)

No	Work Item	1 st Stage		2 nd Stage		3 rd Stage			Amount
		1996	1997	2000	2001	2001	2002	2003	
		Design	Construction	Design	Construction	Design	Construction	Construction	
1	Direct Construction Cost	0	1,148,270	0	8,371,390	0	23,725,840	23,725,840	56,971,340
-1	Upper Water Source	0	1,148,270	0	0	0	5,053,750	5,053,750	11,255,770
	(Expansion of Existing Facilities)								
	1) Transmission Facilities	0	394,290	0	0	0	0	0	394,290
	2) Others (for Zavsariin reservoir, etc.)	0	564,640	0	0	0	0	0	564,640
	3) Telecommunication System	0	189,340	0	0	0	0	0	189,340
-2	Central Water Source	0	0	0	8,371,390	0	0	0	8,371,390
	(Expansion of Existing Facilities)								
	1) Intake Facilities	0	0	0	8,371,390	0	0	0	8,371,390
-3	Lower Part of Nalaih	0	0	0	0	0	18,672,090	18,672,090	37,344,180
	1) Intake Facilities	0	0	0	0	0	7,411,700	7,411,700	14,823,400
	2) Distribution Facilities	0	0	0	0	0	11,260,390	11,260,390	22,520,780
2	Land Acquisition Cost	0	0	0	0	0	0	0	0
3	Engineering Cost	325,000	167,900	391,000	416,800	1,025,000	1,025,000	1,034,315	4,385,015
4	Administration Cost [3% of 1]	17,448	17,000	125,570	125,570	474550	474,500	474,700	1,709,338
5	Physical Contingency [10% of 1]	0	114,827	0	837,139	0	2,372,584	2,372,584	5,697,134
	Total	342,448	1,447,997	516,570	9,750,899	1,499,500	27,598,124	27,607,439	68,762,977

Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0

Table III.3.9(3)
Total-COST ANALYSIS [Case I]

Construction Year : 1 st Stage--1997
: 2 nd Stage--2001
: 3 rd Stage--2002~3

[Unit : US$]

n	Year	[1] Investment Cost	[2]=[1] x 1.0% Repair Cost	[3] Electricity Cost	[4]=[1]+[2]+[3] Total Cost	[5]=[4]/[1+0.07]^n Discounted Cost	Additional Total Water Capacity (m3/day)
0	1,995	0	0	0	0	0	0
1	1,996	342,448	0	0	342,448	320,045	0
2	1,997	1,447,997	0	0	1,447,997	1,264,737	0
3	1,998	0	17,904	355,000	372,904	304,401	48,000
4	1,999	0	17,904	355,000	372,904	284,487	48,000
5	2,000	1,662,900	17,904	355,000	2,035,804	1,451,500	48,000
6	2,001	42,004,973	17,904	355,000	42,377,877	28,238,169	48,000
7	2,002	11,954,780	448,033	432,000	12,834,813	7,992,877	65,300
8	2,003	11,956,390	448,033	432,000	12,836,423	7,470,915	65,300
9	2,004	0	693,695	611,000	1,304,695	709,668	106,700
10	2,005	0	693,695	611,000	1,304,695	663,241	106,700
11	2,006	0	693,695	611,000	1,304,695	619,851	106,700
12	2,007	0	693,695	611,000	1,304,695	579,300	106,700
13	2,008	0	693,695	611,000	1,304,695	541,402	106,700
14	2,009	0	693,695	611,000	1,304,695	505,983	106,700
15	2,010	0	693,695	611,000	1,304,695	472,881	106,700
16	2,011	0	693,695	611,000	1,304,695	441,945	106,700
17	2,012	0	693,695	611,000	1,304,695	413,033	106,700
18	2,013	0	693,695	611,000	1,304,695	386,012	106,700
19	2,014	0	693,695	611,000	1,304,695	360,759	106,700
20	2,015	0	693,695	611,000	1,304,695	337,158	106,700
21	2,016	0	693,695	611,000	1,304,695	315,101	106,700
22	2,017	0	693,695	611,000	1,304,695	294,487	106,700
23	2,018	0	693,695	611,000	1,304,695	275,221	106,700
24	2,019	0	693,695	611,000	1,304,695	257,216	106,700
25	2,020	0	693,695	611,000	1,304,695	240,389	106,700
	TOTAL	69,369,488	12,760,497	12,671,000	94,800,985	54,740,779	

1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0
2) Cost : as of November 1994
3) Unit Power Rates : 0.044 US$/kwh (17.6 Tg/kwh)
4) Escalation Rate : 7 %/Year

Total-COST ANALYSIS [Case II]

Construction Year : 1 st Stage--1997
: 2 nd Stage--2001
: 3 rd Stage--2002~3

[Unit : US$]

n	Year	[1] Investment Cost	[2]=[1] x 1.0% Repair Cost	[3] Electricity Cost	[4]=[1]+[2]+[3] Total Cost	[5]=[4]/[1+0.07]^n Discounted Cost	Additional Total Water Capacity (m3/day)
0	1,995	0	0	0	0	0	0
1	1,996	342,448	0	0	342,448	320,045	0
2	1,997	1,447,997	0	0	1,447,997	1,264,737	0
3	1,998	0	17,904	355,000	372,904	304,401	48,000
4	1,999	0	17,904	355,000	372,904	284,487	48,000
5	2,000	639,100	17,904	355,000	1,012,004	721,545	48,000
6	2,001	13,075,655	17,904	355,000	13,448,559	8,961,343	48,000
7	2,002	26,979,592	141,869	559,000	27,680,461	17,238,000	66,000
8	2,003	26,979,592	141,869	559,000	27,680,461	16,110,280	66,000
9	2,004	0	694,644	728,000	1,422,644	773,824	106,700
10	2,005	0	694,644	728,000	1,422,644	723,200	106,700
11	2,006	0	694,644	728,000	1,422,644	675,888	106,700
12	2,007	0	694,644	728,000	1,422,644	631,671	106,700
13	2,008	0	694,644	728,000	1,422,644	590,347	106,700
14	2,009	0	694,644	728,000	1,422,644	551,726	106,700
15	2,010	0	694,644	728,000	1,422,644	515,632	106,700
16	2,011	0	694,644	728,000	1,422,644	481,899	106,700
17	2,012	0	694,644	728,000	1,422,644	450,373	106,700
18	2,013	0	694,644	728,000	1,422,644	420,909	106,700
19	2,014	0	694,644	728,000	1,422,644	393,373	106,700
20	2,015	0	694,644	728,000	1,422,644	367,638	106,700
21	2,016	0	694,644	728,000	1,422,644	343,587	106,700
22	2,017	0	694,644	728,000	1,422,644	321,109	106,700
23	2,018	0	694,644	728,000	1,422,644	300,102	106,700
24	2,019	0	694,644	728,000	1,422,644	280,469	106,700
25	2,020	0	694,644	728,000	1,422,644	262,121	106,700
	TOTAL	69,464,384	12,164,301	14,914,000	96,542,685	53,288,706	

1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0
2) Cost : as of November 1994
3) Unit Power Rates : 0.044 US$/kwh (17.6 Tg/kwh)
4) Escalation Rate : 7 %/Year

Total-COST ANALYSIS [Case III]

Construction Year : 1 st Stage--1997
: 2 nd Stage--2001
: 3 rd Stage--2002~3

[Unit : US$]

n	Year	[1] Investment Cost	[2]=[1] x 1.0% Repair Cost	[3] Electricity Cost	[4]=[1]+[2]+[3] Total Cost	[5]=[4]/[1+0.07]^n Discounted Cost	Additional Total Water Capacity (m3/day)
0	1,995	0	0	0	0	0	0
1	1,996	342,448	0	0	342,448	320,045	0
2	1,997	1,447,997	0	0	1,447,997	1,264,737	0
3	1,998	0	17,904	355,000	372,904	304,401	48,000
4	1,999	0	17,904	355,000	372,904	284,487	48,000
5	2,000	516,142	17,904	355,000	889,046	633,878	48,000
6	2,001	11,069,329	17,904	355,000	11,442,233	7,624,443	48,000
7	2,002	26,976,770	120,579	485,000	27,582,349	17,176,901	65,300
8	2,003	26,982,694	120,579	485,000	27,588,273	16,056,626	65,300
9	2,004	0	673,354	663,000	1,336,354	726,888	106,700
10	2,005	0	673,354	663,000	1,336,354	679,335	106,700
11	2,006	0	673,354	663,000	1,336,354	634,892	106,700
12	2,007	0	673,354	663,000	1,336,354	593,357	106,700
13	2,008	0	673,354	663,000	1,336,354	554,539	106,700
14	2,009	0	673,354	663,000	1,336,354	518,261	106,700
15	2,010	0	673,354	663,000	1,336,354	484,356	106,700
16	2,011	0	673,354	663,000	1,336,354	452,669	106,700
17	2,012	0	673,354	663,000	1,336,354	423,055	106,700
18	2,013	0	673,354	663,000	1,336,354	395,379	106,700
19	2,014	0	673,354	663,000	1,336,354	369,513	106,700
20	2,015	0	673,354	663,000	1,336,354	345,339	106,700
21	2,016	0	673,354	663,000	1,336,354	322,747	106,700
22	2,017	0	673,354	663,000	1,336,354	301,633	106,700
23	2,018	0	673,354	663,000	1,336,354	281,900	106,700
24	2,019	0	673,354	663,000	1,336,354	263,458	106,700
25	2,020	0	673,354	663,000	1,336,354	246,222	106,700
	TOTAL	67,335,380	11,759,791	13,661,000	92,756,171	51,259,060	

1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0
2) Cost : as of November 1994
3) Unit Power Rates : 0.044 US$/kwh (17.6 Tg/kwh)
4) Escalation Rate : 7 %/Year

Total-COST ANALYSIS [Case IV]

Construction Year : 1 st Stage--1997
: 2 nd Stage--2001
: 3 rd Stage--2002~3

[Unit : US$]

n	Year	[1] Investment Cost	[2]=[1] x 1.0% Repair Cost	[3] Electricity Cost	[4]=[1]+[2]+[3] Total Cost	[5]=[4]/[1+0.07]^n Discounted Cost	Additional Total Water Capacity (m3/day)
0	1,995	0	0	0	0	0	0
1	1,996	342,448	0	0	342,448	320,045	0
2	1,997	1,447,997	0	0	1,447,997	1,264,737	0
3	1,998	0	17,904	355,000	372,904	304,401	48,000
4	1,999	0	17,904	355,000	372,904	284,487	48,000
5	2,000	516,570	17,904	355,000	889,474	634,183	48,000
6	2,001	11,250,399	17,904	355,000	11,623,303	7,745,098	48,000
7	2,002	27,598,124	120,579	485,000	28,203,703	17,563,849	65,300
8	2,003	27,607,439	120,579	485,000	28,213,018	16,420,233	65,300
9	2,004	0	687,630	771,000	1,458,630	793,398	106,700
10	2,005	0	687,630	771,000	1,458,630	741,493	106,700
11	2,006	0	687,630	771,000	1,458,630	692,984	106,700
12	2,007	0	687,630	771,000	1,458,630	647,649	106,700
13	2,008	0	687,630	771,000	1,458,630	605,279	106,700
14	2,009	0	687,630	771,000	1,458,630	565,682	106,700
15	2,010	0	687,630	771,000	1,458,630	528,675	106,700
16	2,011	0	687,630	771,000	1,458,630	494,088	106,700
17	2,012	0	687,630	771,000	1,458,630	461,765	106,700
18	2,013	0	687,630	771,000	1,458,630	431,556	106,700
19	2,014	0	687,630	771,000	1,458,630	403,323	106,700
20	2,015	0	687,630	771,000	1,458,630	376,938	106,700
21	2,016	0	687,630	771,000	1,458,630	352,278	106,700
22	2,017	0	687,630	771,000	1,458,630	329,232	106,700
23	2,018	0	687,630	771,000	1,458,630	307,693	106,700
24	2,019	0	687,630	771,000	1,458,630	287,564	106,700
25	2,020	0	687,630	771,000	1,458,630	268,751	106,700
	TOTAL	68,762,977	12,002,482	15,497,000	96,262,459	52,825,382	

1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg 400.0
2) Cost : as of November 1994
3) Unit Power Rates : 0.044 US$/kwh (17.6 Tg/kwh)
4) Escalation Rate : 7 %/Year

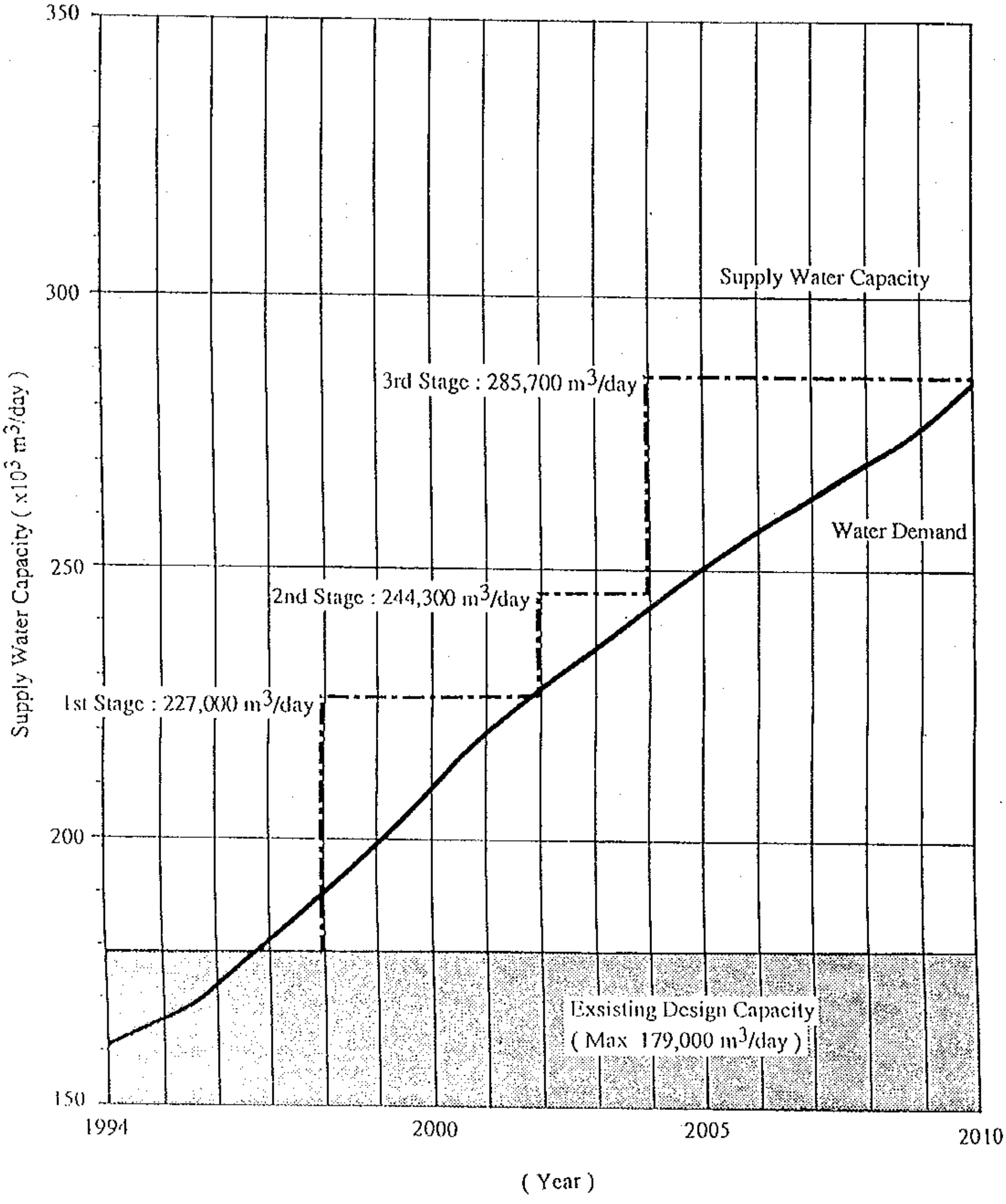
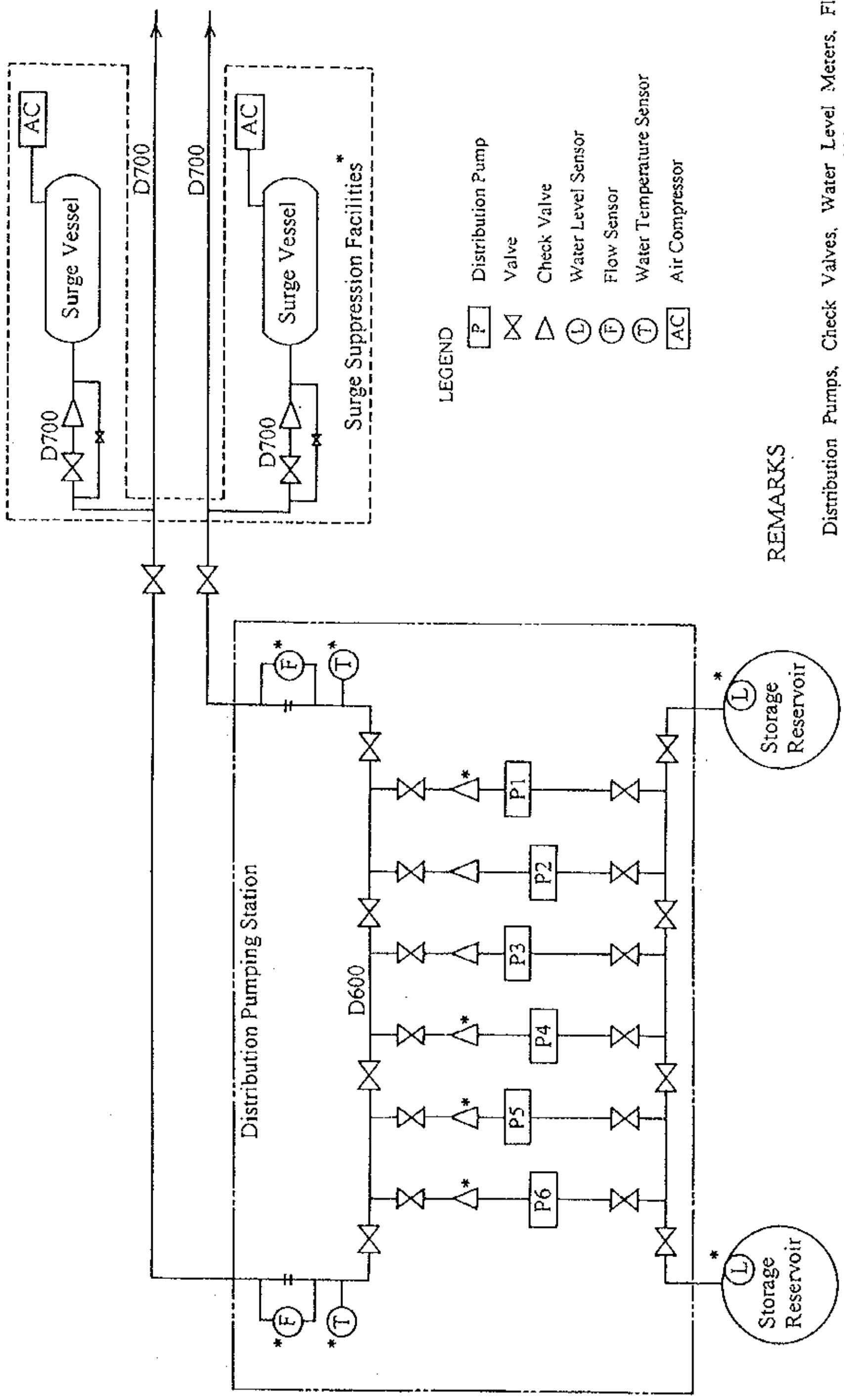


Fig.III.3.1	Future Water Demand and Supply Water Capacity
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings



REMARKS

Distribution Pumps, Check Valves, Water Level Meters, Flow Meters, Temperature Meters, and Surge Suppression Facilities marked * will be newly installed or rehabilitated.

Fig. III.3.2 Improvement of Upper Water Pumping Station

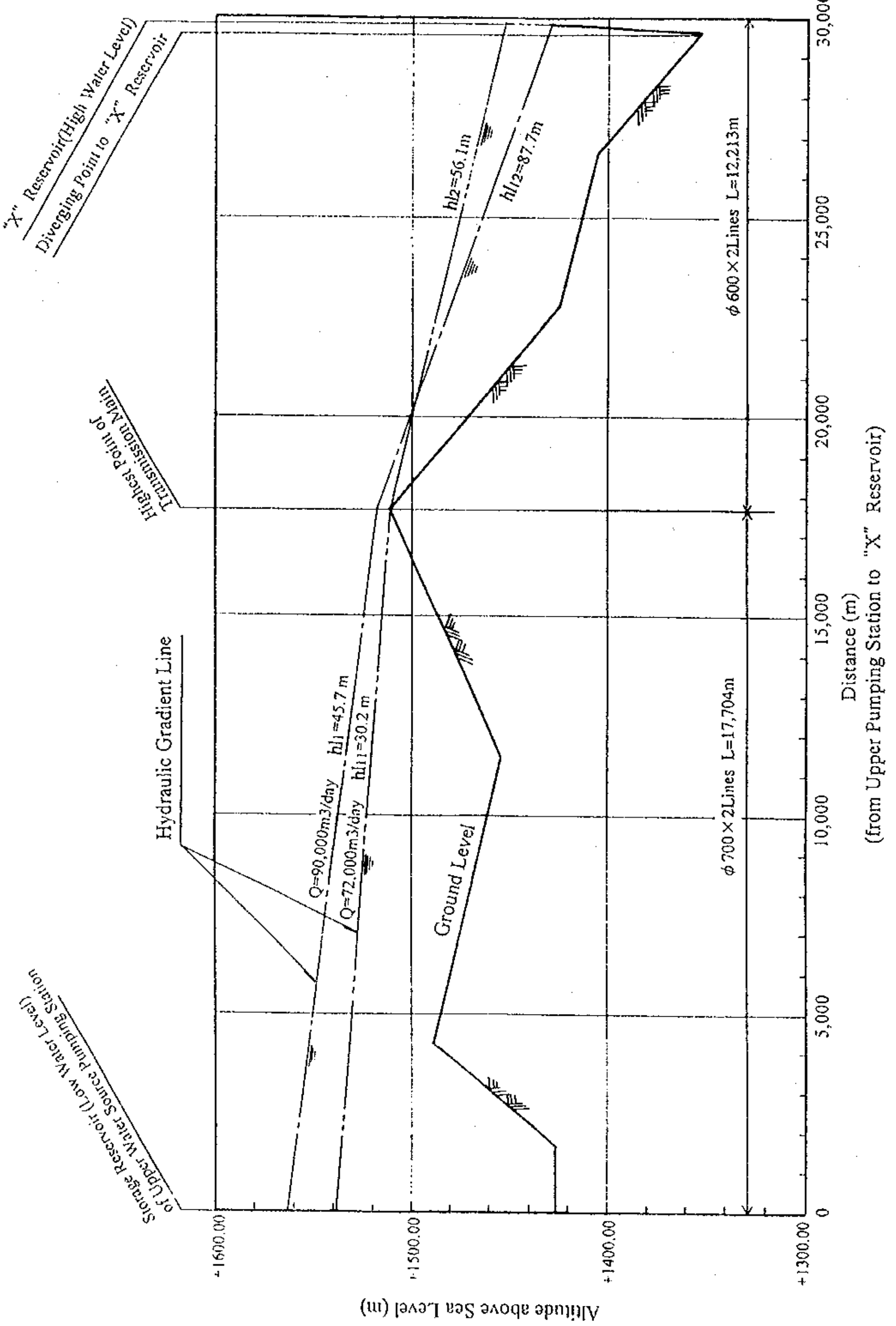


Fig. III.3.3	Longitudinal Profile of Existing Transmission Main for Upper Water Source
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

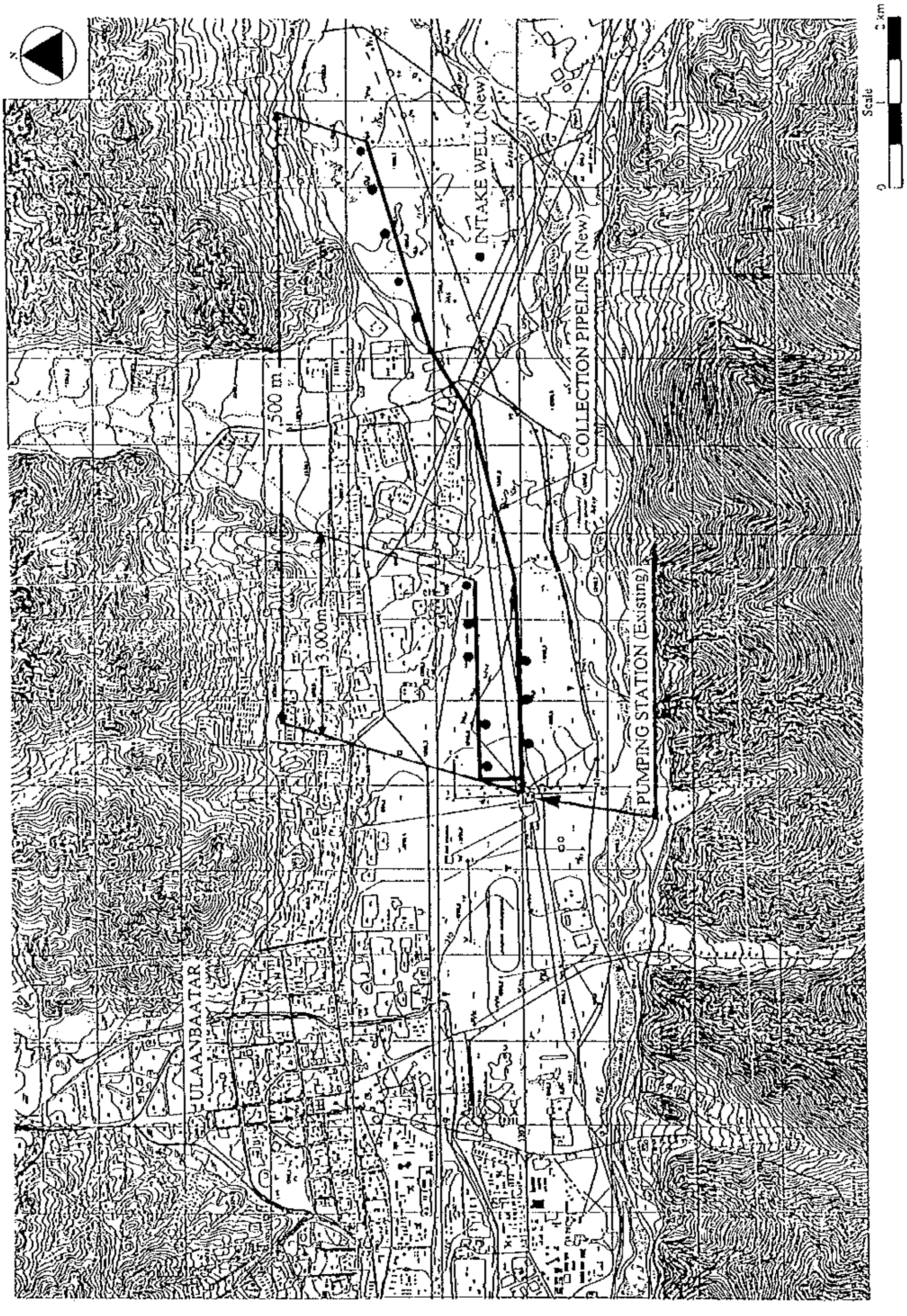


Fig. III.3.4 Location of Expansion of Central Water Source	
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

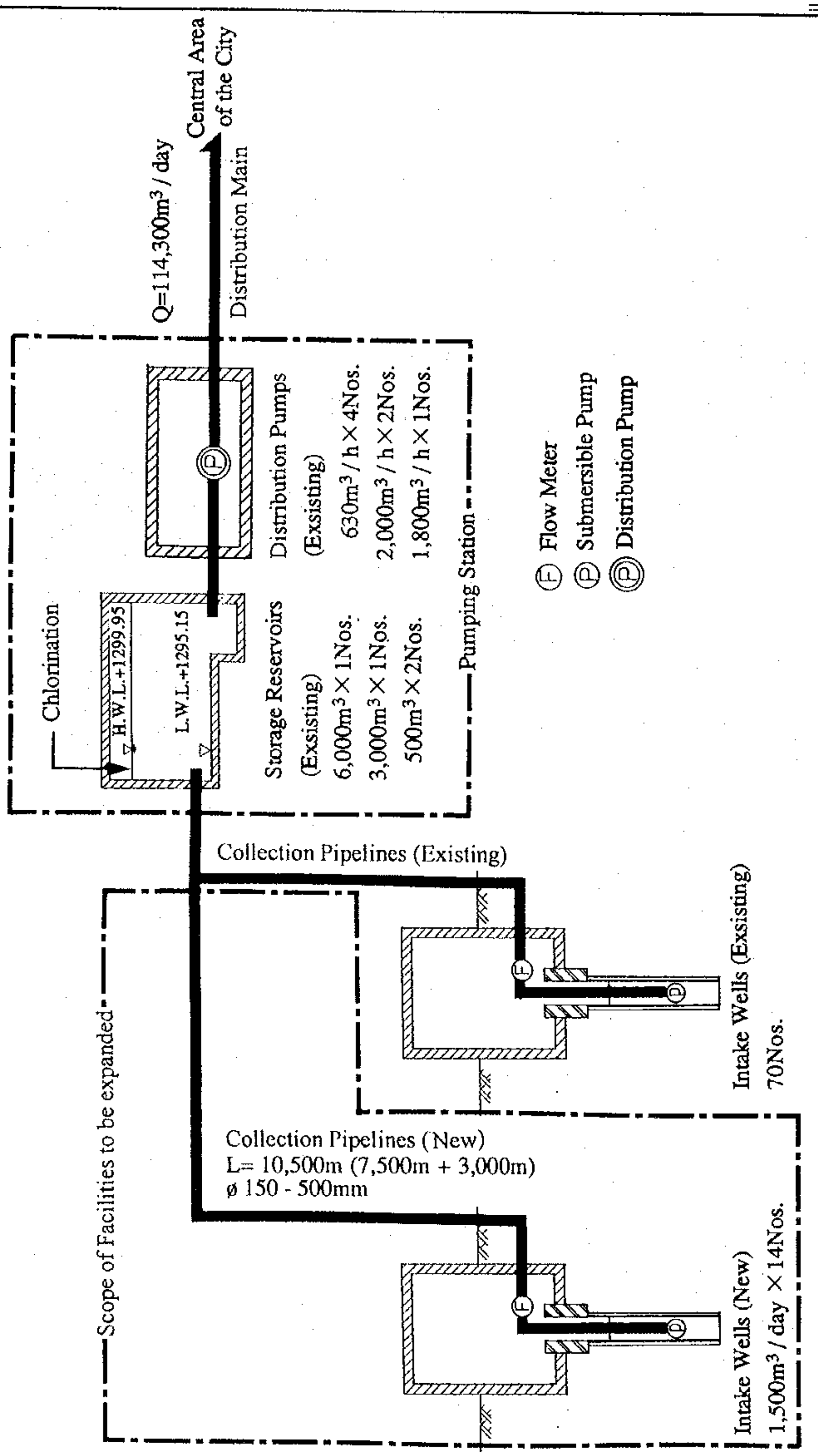


Fig. III.3.5 System Flow Diagram of Central Water Source

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

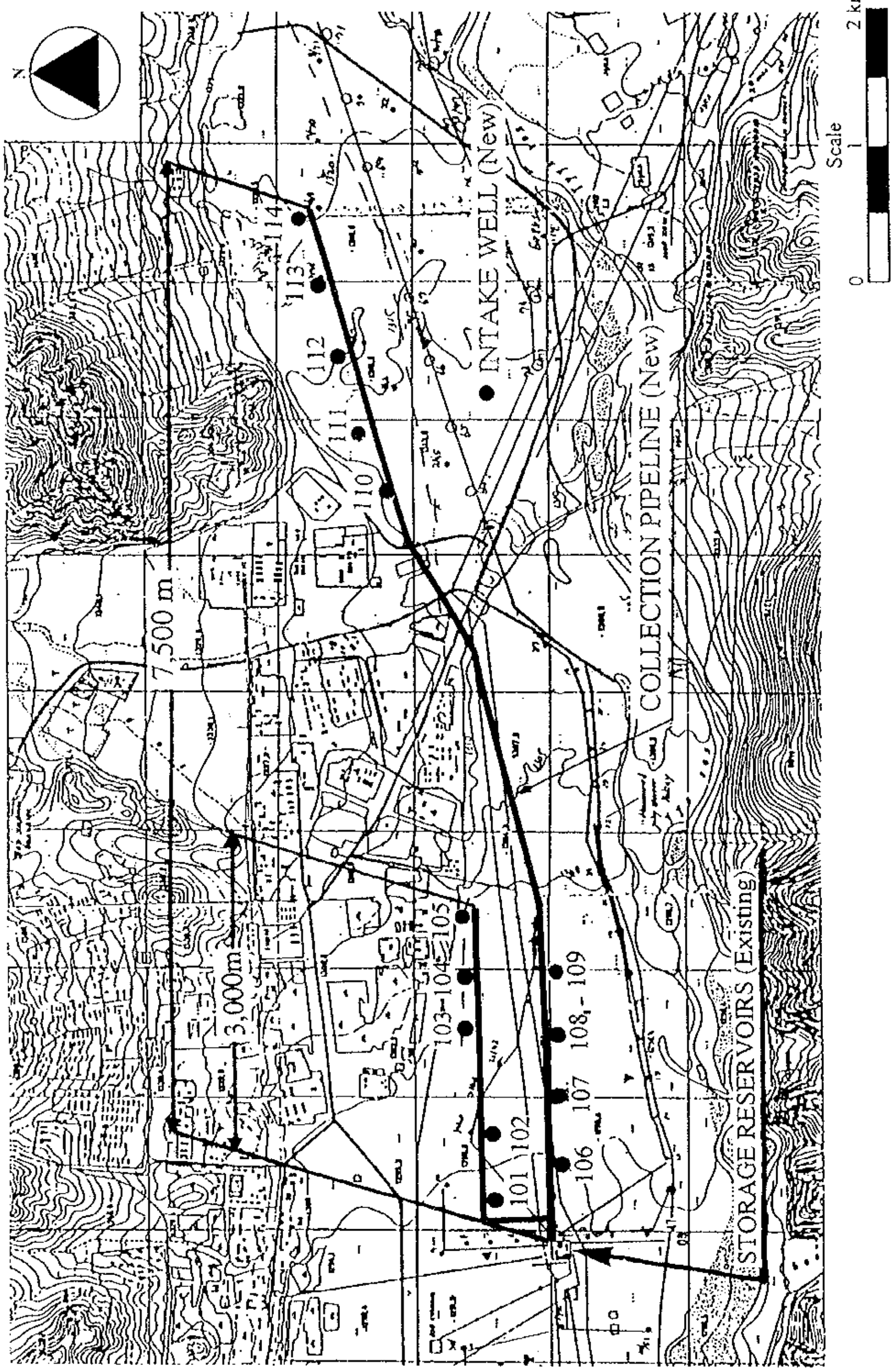
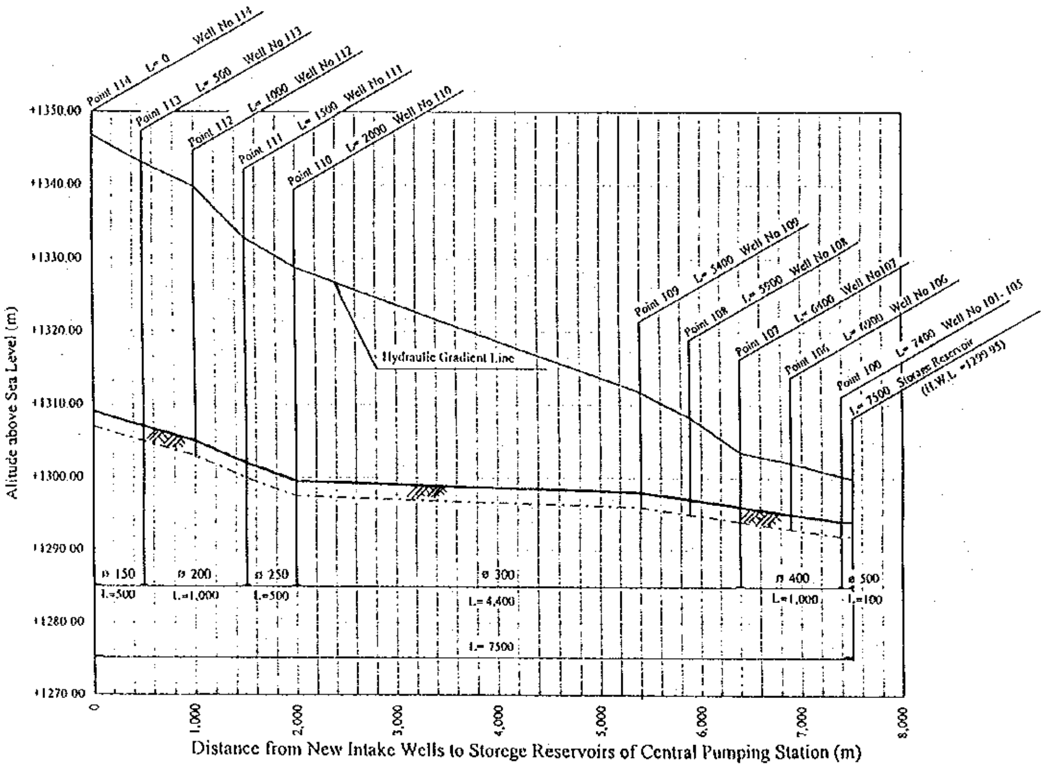


Fig. III.3.6 Location of Intake Facilities for Central Water Source

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings



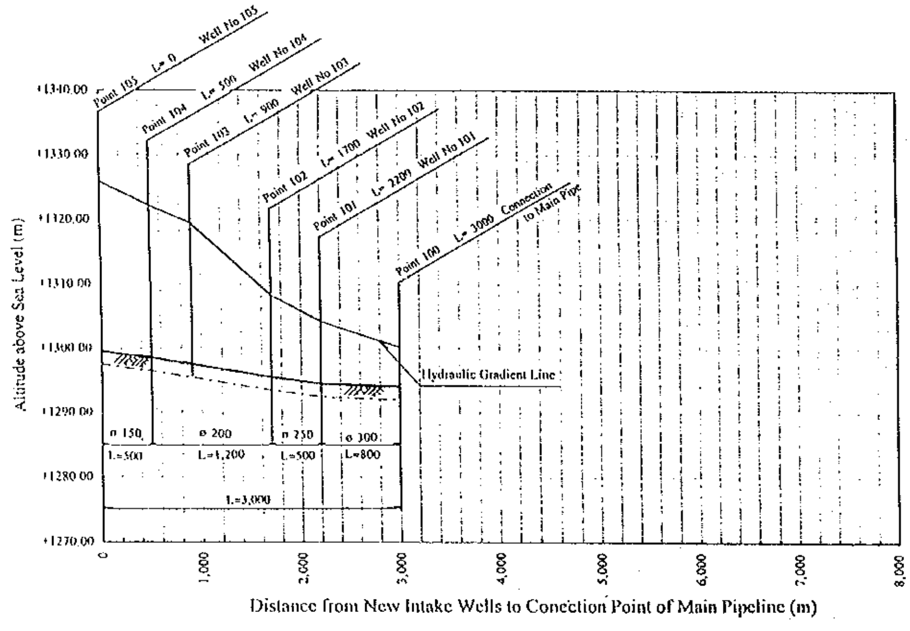


Fig. III.3.7 Longitudinal Profile of Collection Pipeline for Central Water Source

JICA | The Study on Water Supply System in Ulaanbaatar and Surroundings

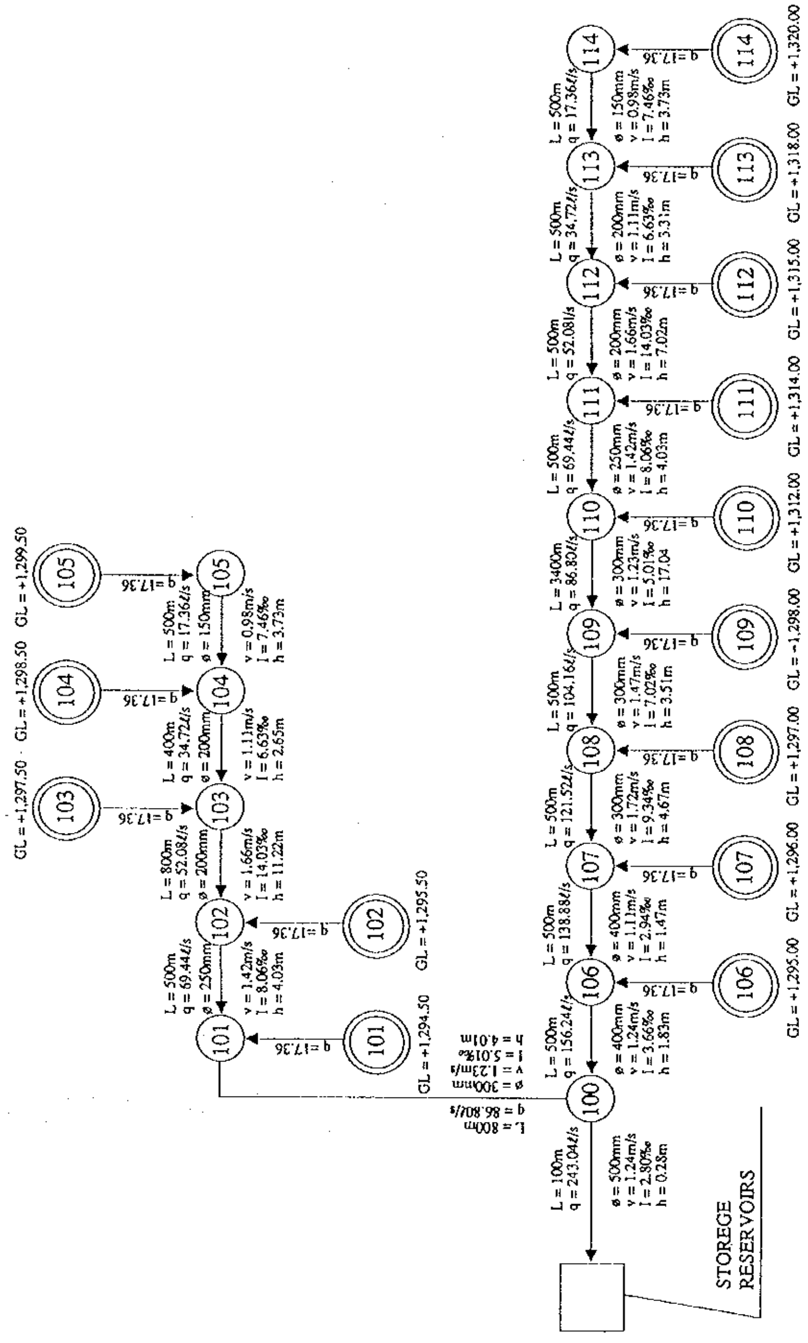
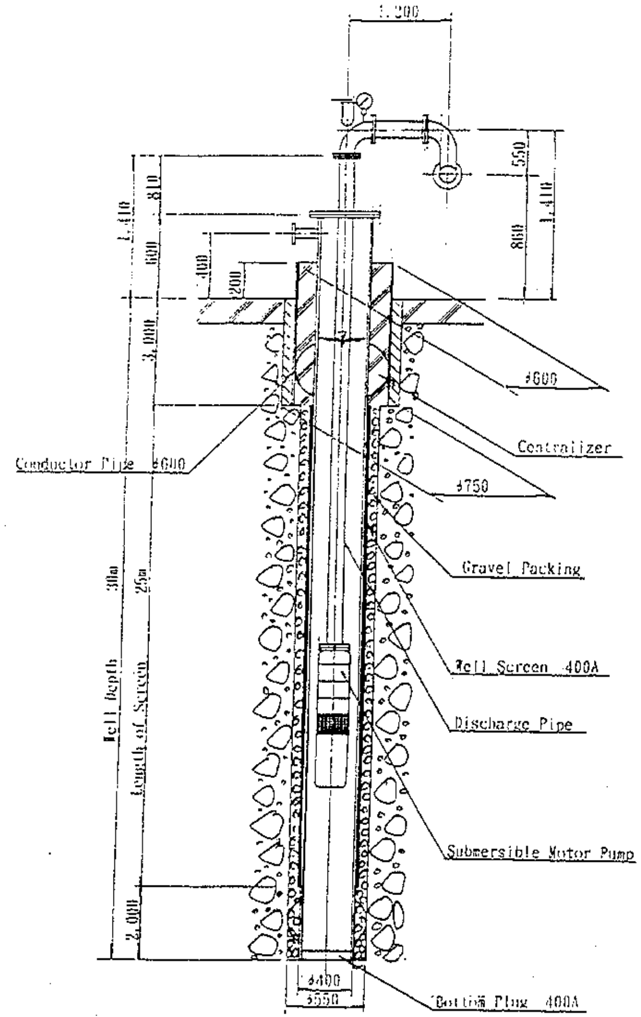


Fig. III.3.8 Hydraulic Chart of Collection Pipeline for Central Water Source



List of Wells and Intake Pumps
(Central Water Source)

Well No.	Ground Level	Well Depth	Discharge Capacity	Total Head	Motor Capacity
101	+1,294.50	30 m	17.36 l/sec	40 m	11 kW
102	+1,295.50	30 m	17.36 l/sec	40 m	11 kW
103	+1,297.50	30 m	17.36 l/sec	50 m	15 kW
104	+1,298.50	30 m	17.36 l/sec	55 m	18.5 kW
105	+1,299.50	30 m	17.36 l/sec	55 m	18.5 kW
106	+1,295.00	30 m	17.36 l/sec	40 m	11 kW
107	+1,296.00	30 m	17.36 l/sec	40 m	11 kW
108	+1,297.00	30 m	17.36 l/sec	40 m	11 kW
109	+1,298.00	30 m	17.36 l/sec	45 m	11 kW
110	+1,312.00	30 m	17.36 l/sec	45 m	11 kW
111	+1,314.00	30 m	17.36 l/sec	45 m	11 kW
112	+1,315.00	30 m	17.36 l/sec	50 m	15 kW
113	+1,318.00	30 m	17.36 l/sec	50 m	15 kW
114	+1,320.00	30 m	17.36 l/sec	55 m	18.5 kW
	Total Motor Capacity (14pumps) =				**189 kW**

Fig. III.3.9 Intake Well of Central Water Source

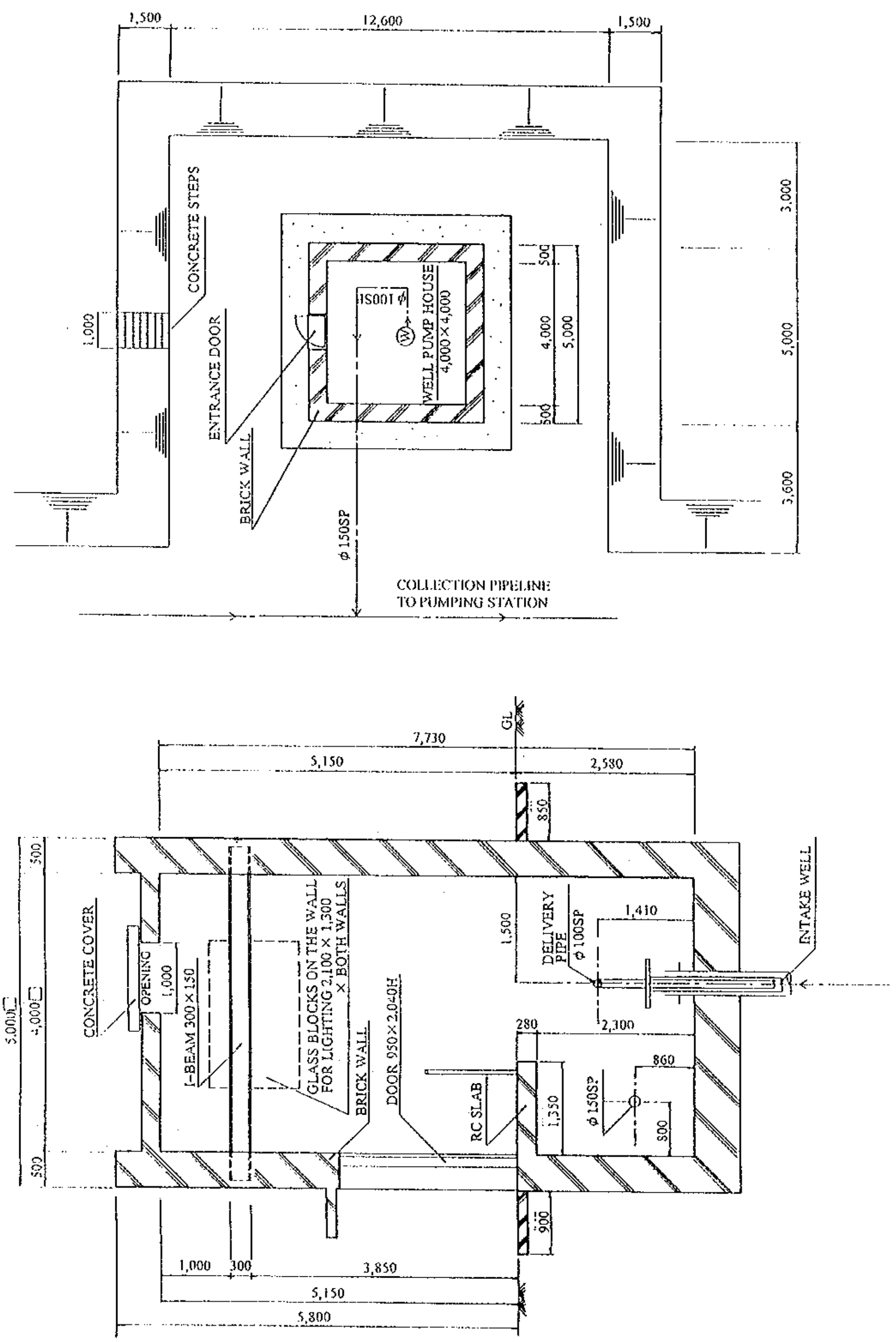
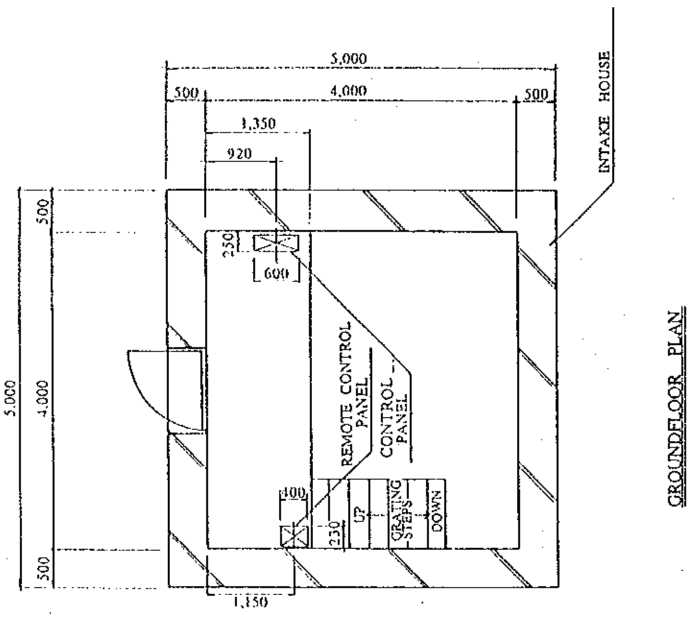
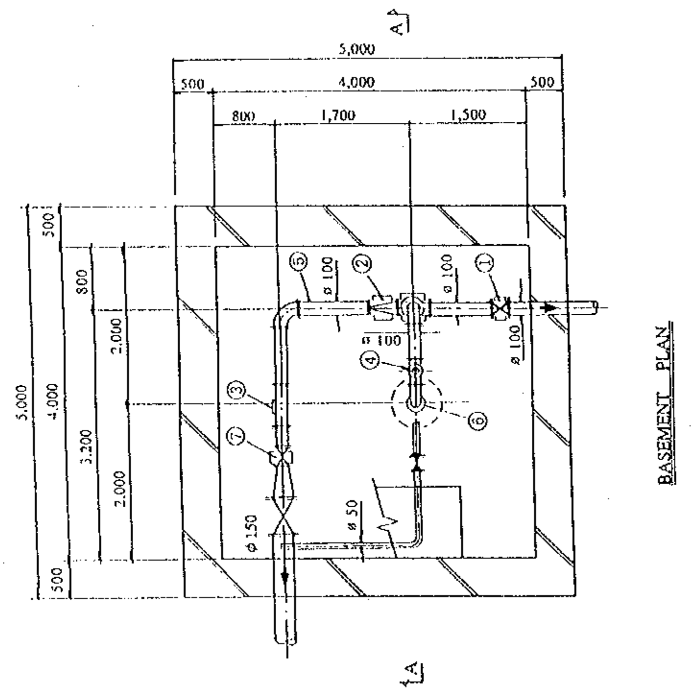


Fig. III.3.10 Typical Intake Pump House (1)
General Layout and Main Section

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings





No.	Name	Q'ty	Mesurement	Materials
1	Drain Valve	1	100 A	FC/BC
2	Check Valve	1	100 A	FC/BC
3	Flow Meter	1	100 A	
4	Air Vent Valve	1	10 A	
5	Pipe	1 set	100 A	Steel Pipe
6	Submersible Pump	1	100 A	
7	Motor Valve	1	100 A	FC/BC

Fig. III.3.11 Typical Intake Pump House (2)
Basement Plan and Ground Floor Plan

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

NEW WATER SOURCE
INTAKE PUMPS (SUBMERSIBLE MOTOR PUMPS)

Discharge Capacity	Total Head	Motor Capacity	Discharge Diameter	Pump Speed
(cu. m/d)	(m)	(kW)	(mm)	(rpm)
1220	50	15	100	2900
1220	55	15	100	2900
1220	60	15	100	2900
1220	65	18.5	100	2900
1220	70	18.5	100	2900
1220	75	18.5	100	2900

CENTRAL WATER SOURCE
INTAKE PUMPS (SUBMERSIBLE MOTOR PUMPS)

Discharge Capacity	Total Head	Motor Capacity	Discharge Diameter	Pump Speed
(cu. m/d)	(m)	(kW)	(mm)	(rpm)
1500	40	11	100	2900
1500	45	11	100	2900
1500	50	15	100	2900
1500	55	18.5	100	2900

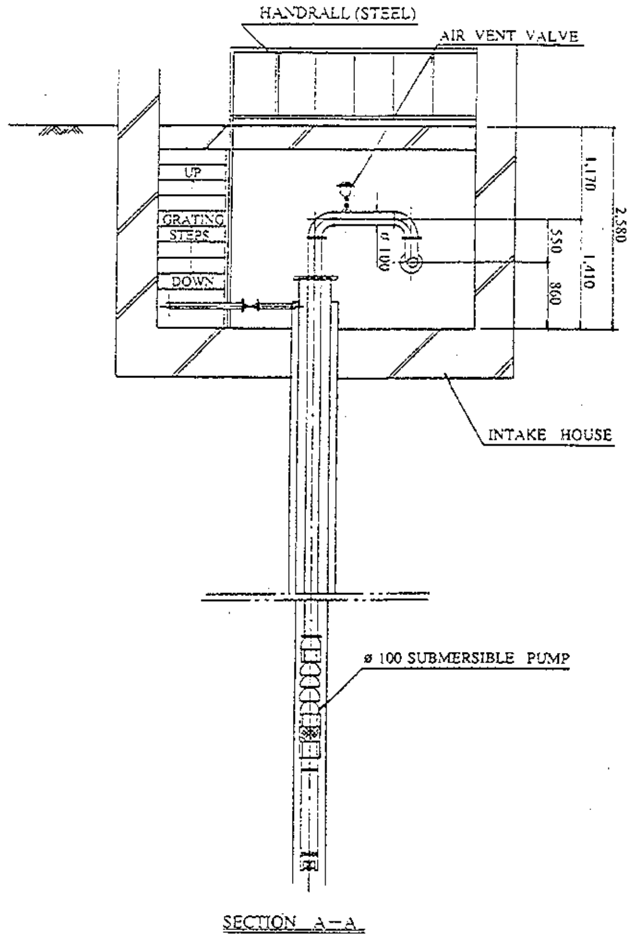
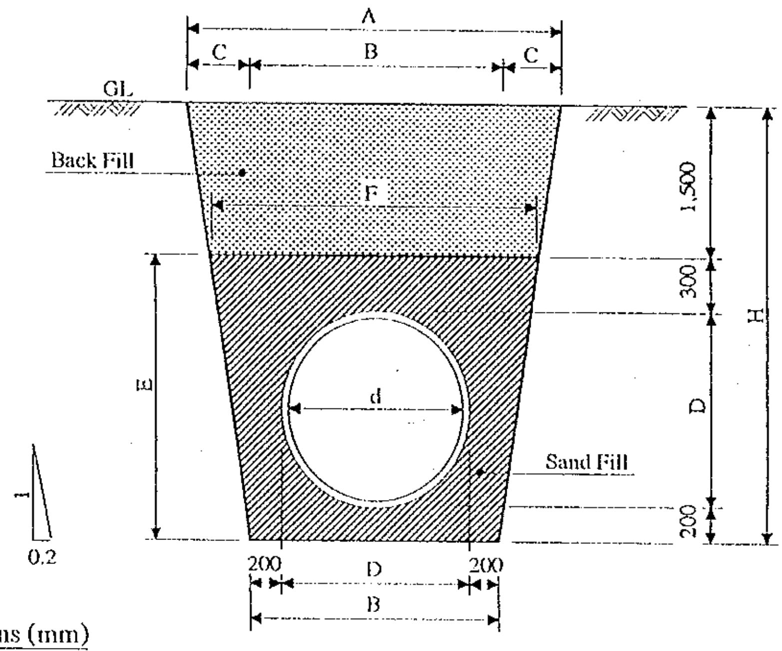


Fig. III.3.12 Typical Intake Pump House (3)
Details Well Section



Dimensions (mm)

d Nominal Diameter	D Outside Diameter	B Width of Bed	H Depth	C	A Width of Top	E Depth of Sand	F Width of Sand
150 mm	169	569	2,169	434	1,437	669	837
200 mm	220	620	2,220	444	1,508	720	908
250 mm	272	672	2,272	454	1,580	772	981
300 mm	323	723	2,323	465	1,653	823	1,052
350 mm	374	774	2,374	475	1,724	874	1,124
400 mm	426	826	2,426	485	1,796	926	1,196
450 mm	477	877	2,477	495	1,867	977	1,268
500 mm	528	928	2,528	506	1,940	1,028	1,339
600 mm	631	1,031	2,631	526	2,083	1,131	1,483
700 mm	733	1,133	2,733	547	2,227	1,233	1,626
800 mm	836	1,236	2,836	567	2,370	1,336	1,770
900 mm	939	1,339	2,939	588	2,515	1,439	1,915
1,000 mm	1,041	1,441	3,041	608	2,657	1,541	2,057

Quantities (m^3/m-pipe)

Nominal Diameter	Excavation	Sand Filling	Back Filling	Disposal of Soil			
150 mm	2.2	0.4	1.7	0.5			
200 mm	2.4	0.5	1.8	0.6			
250 mm	2.6	0.6	1.9	0.7			
300 mm	2.8	0.6	2.0	0.8			
350 mm	3.0	0.7	2.1	0.9			
400 mm	3.2	0.8	2.2	1.0			
450 mm	3.4	0.9	2.4	1.0			
500 mm	3.6	0.9	2.5	1.1			
600 mm	4.1	1.1	2.7	1.4			
700 mm	4.6	1.3	2.9	1.7			
800 mm	5.1	1.5	3.1	2.0			
900 mm	5.7	1.6	3.3	2.4			
1,000 mm	6.2	1.8	3.5	2.7			

Fig. III.3.13 Pipe Laying Work Standard for DCIP (Collection Pipeline)

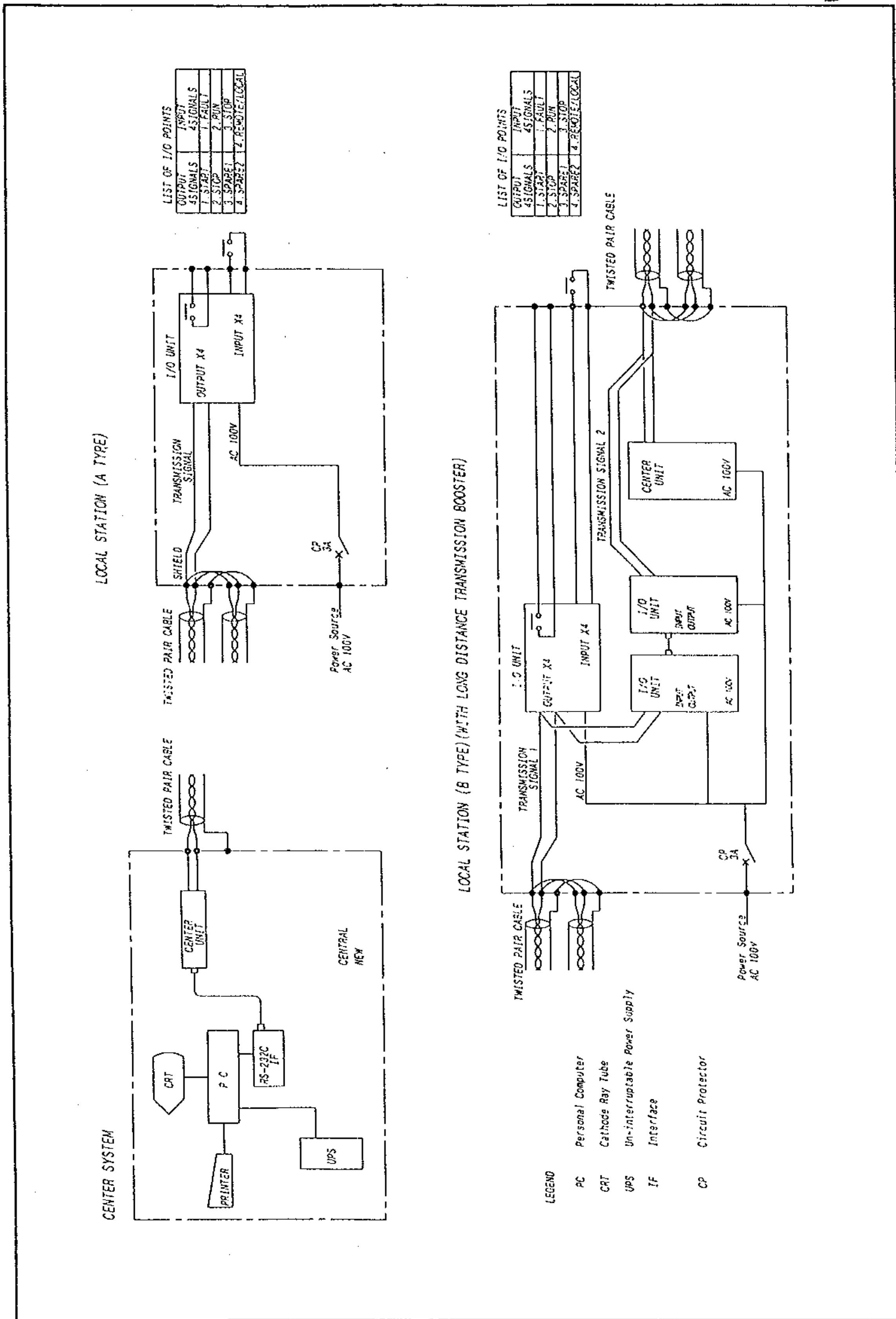


Fig. III.3.14 Flow Diagram of Remote Control System of intake pumps for the Expansion of Central Water Source

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

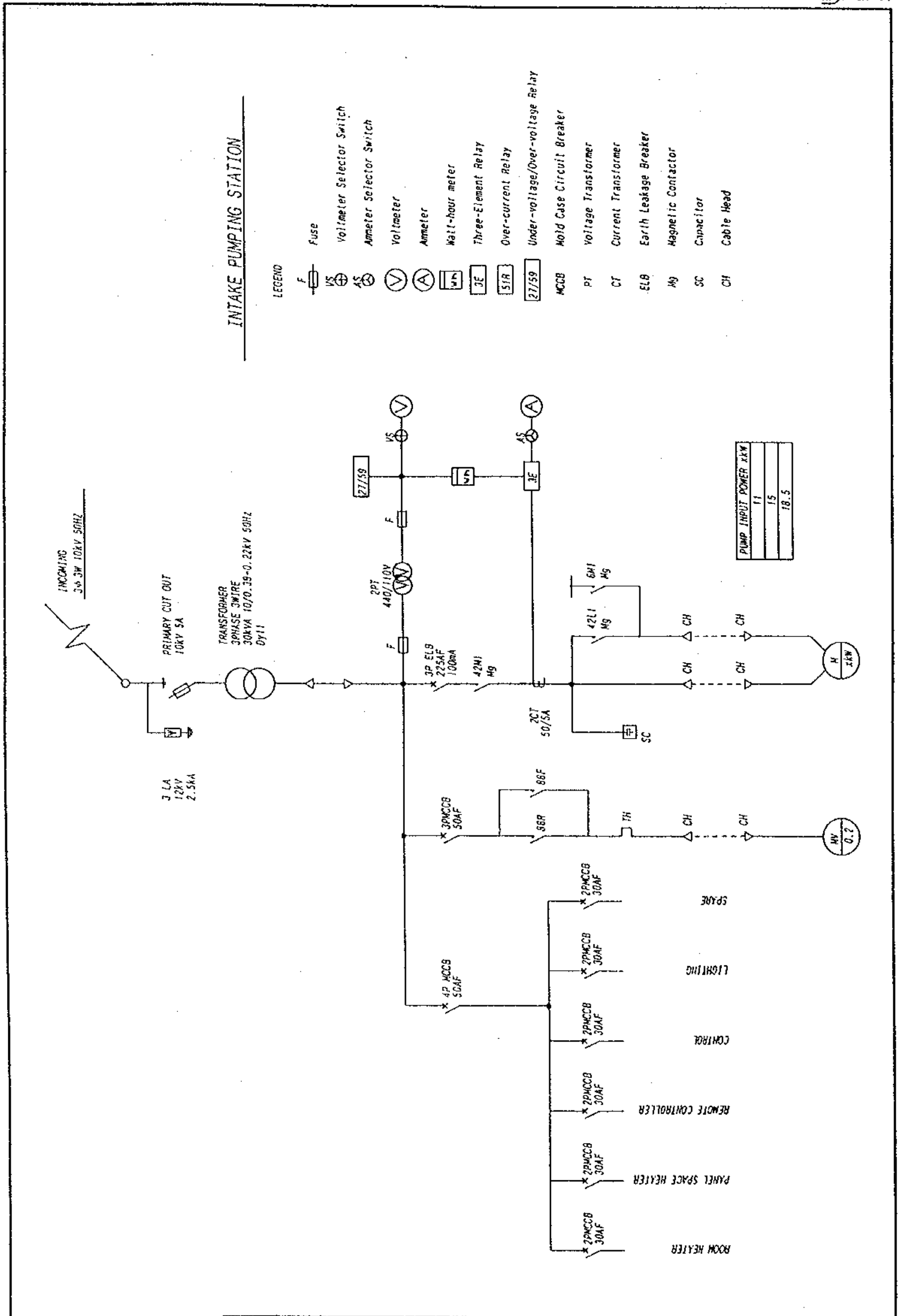


Fig. III.3.15 Single Power Line of Intake Facilities for the Expansion of Central Water Source

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

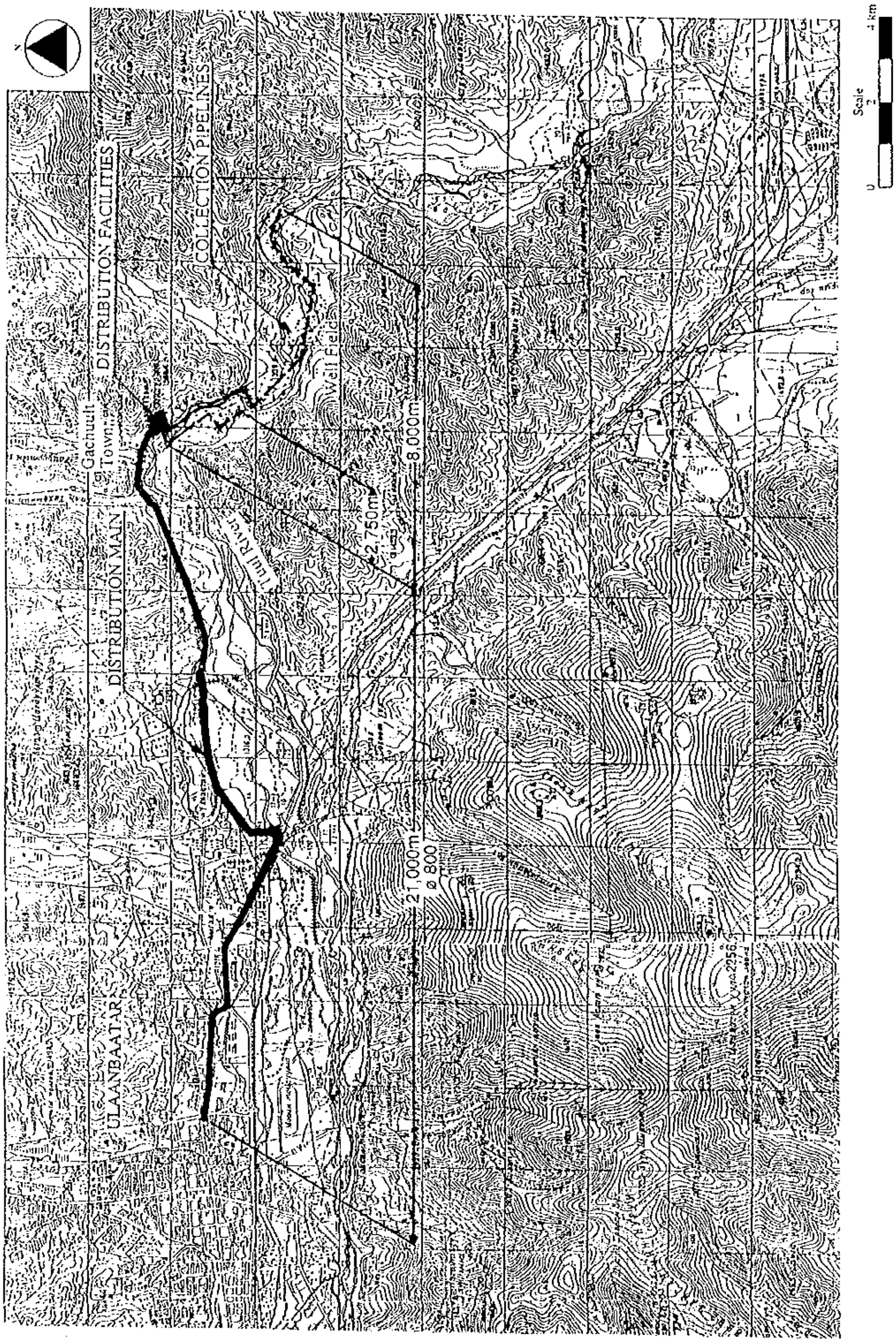


Fig. III.3.16 Location of Lower Part of Nalaih

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

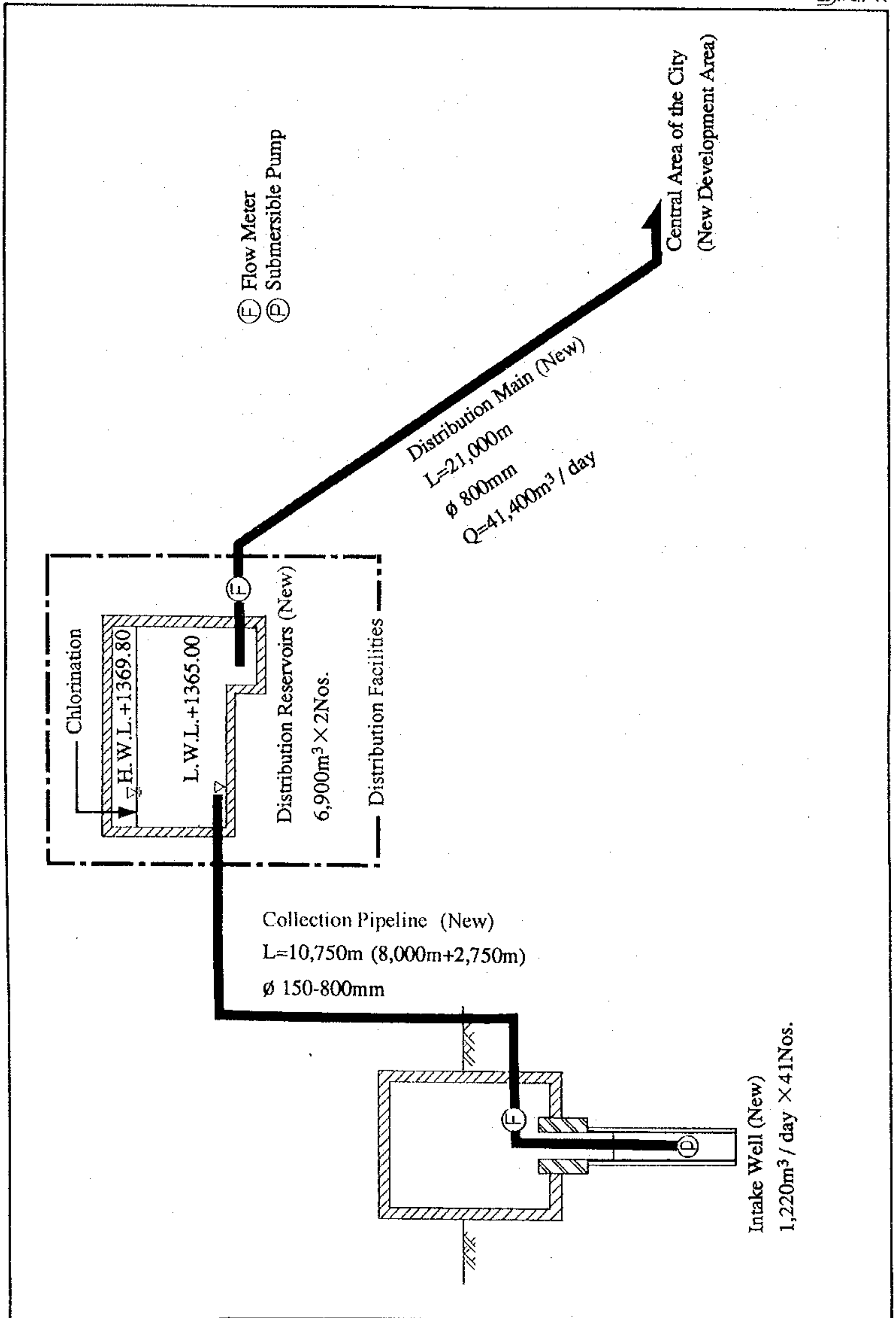


Fig. III.3.17 System Flow Diagram of Lower Part of Nalaih

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

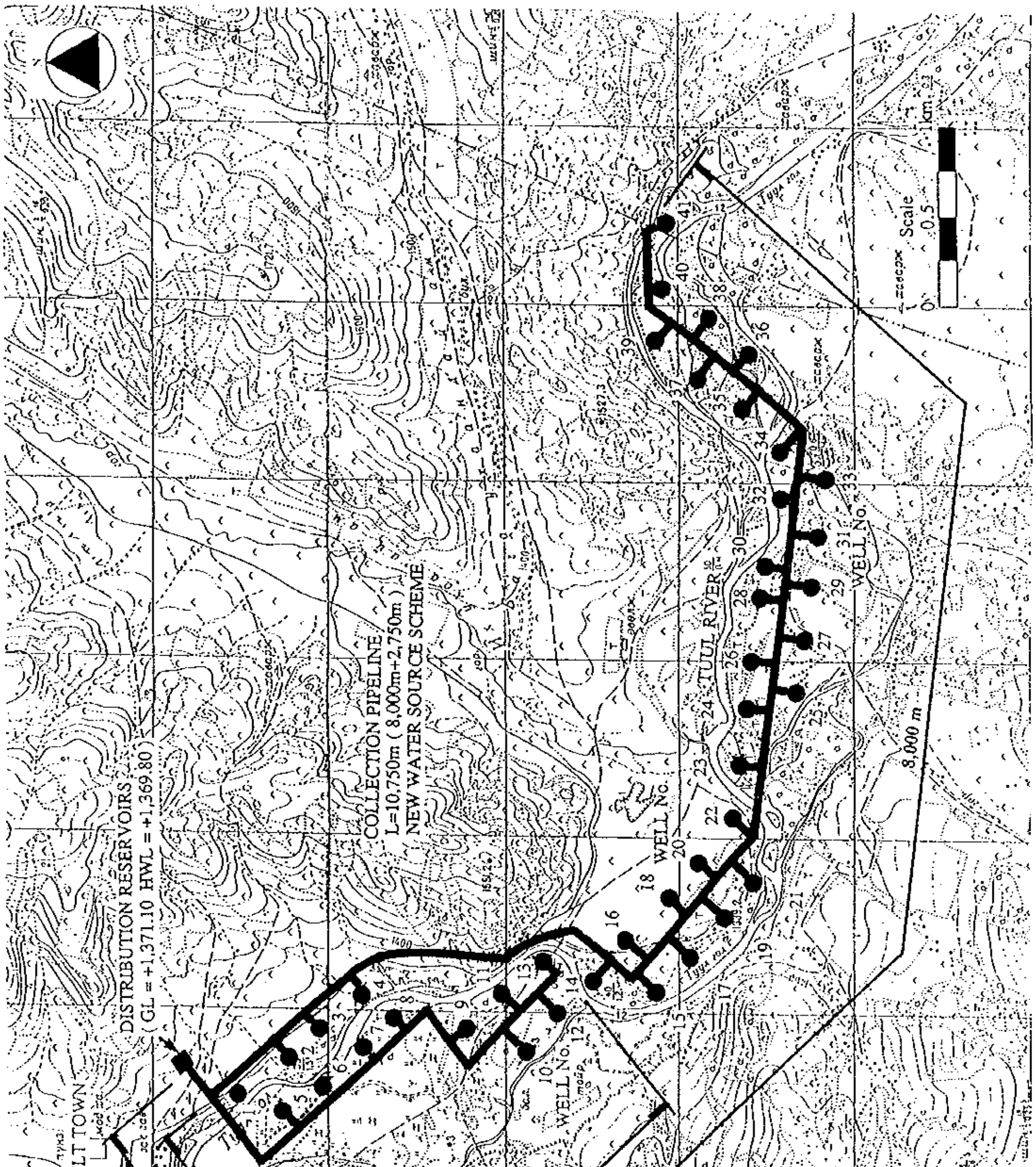
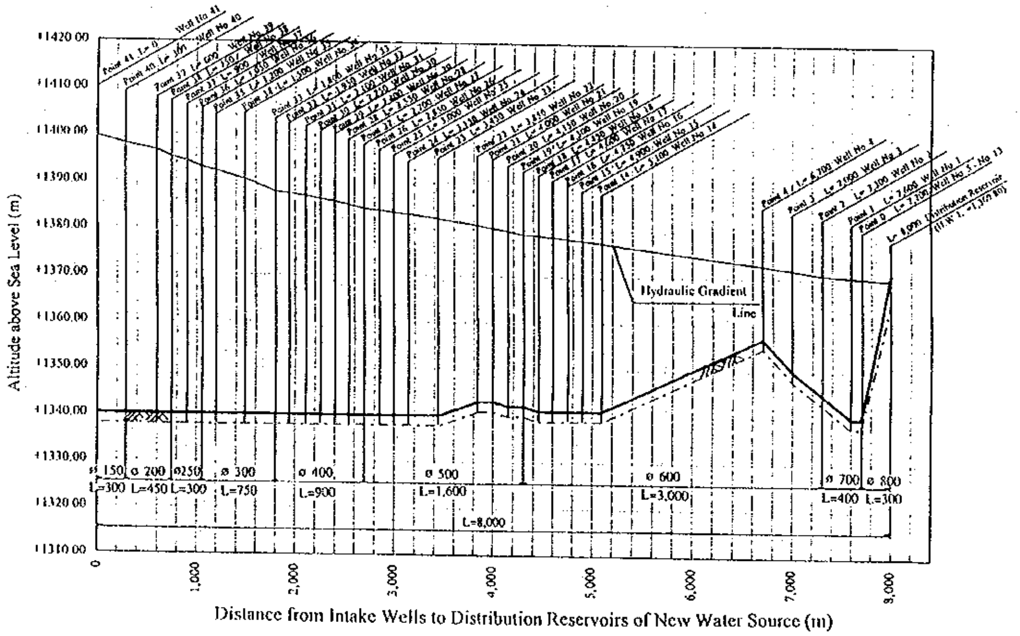


Fig. III.3.18	Location of the Intake Facilities for Lower Part of Nalaih
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings



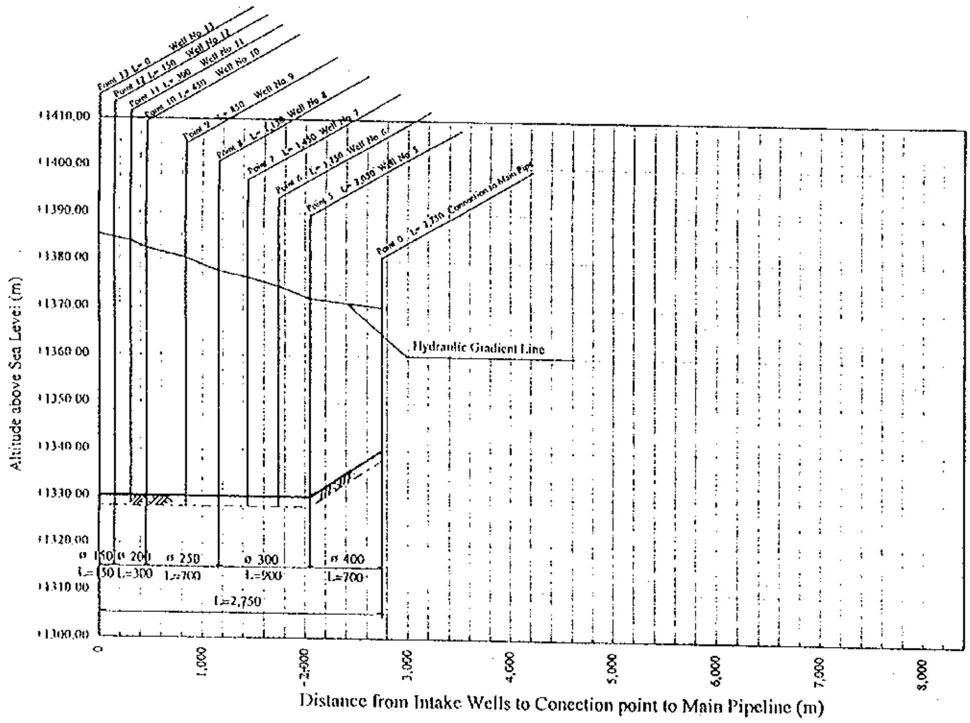


Fig. III.3.19 Longitudinal Profile of Collection Pipeline for Lower Part of Nalaih

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

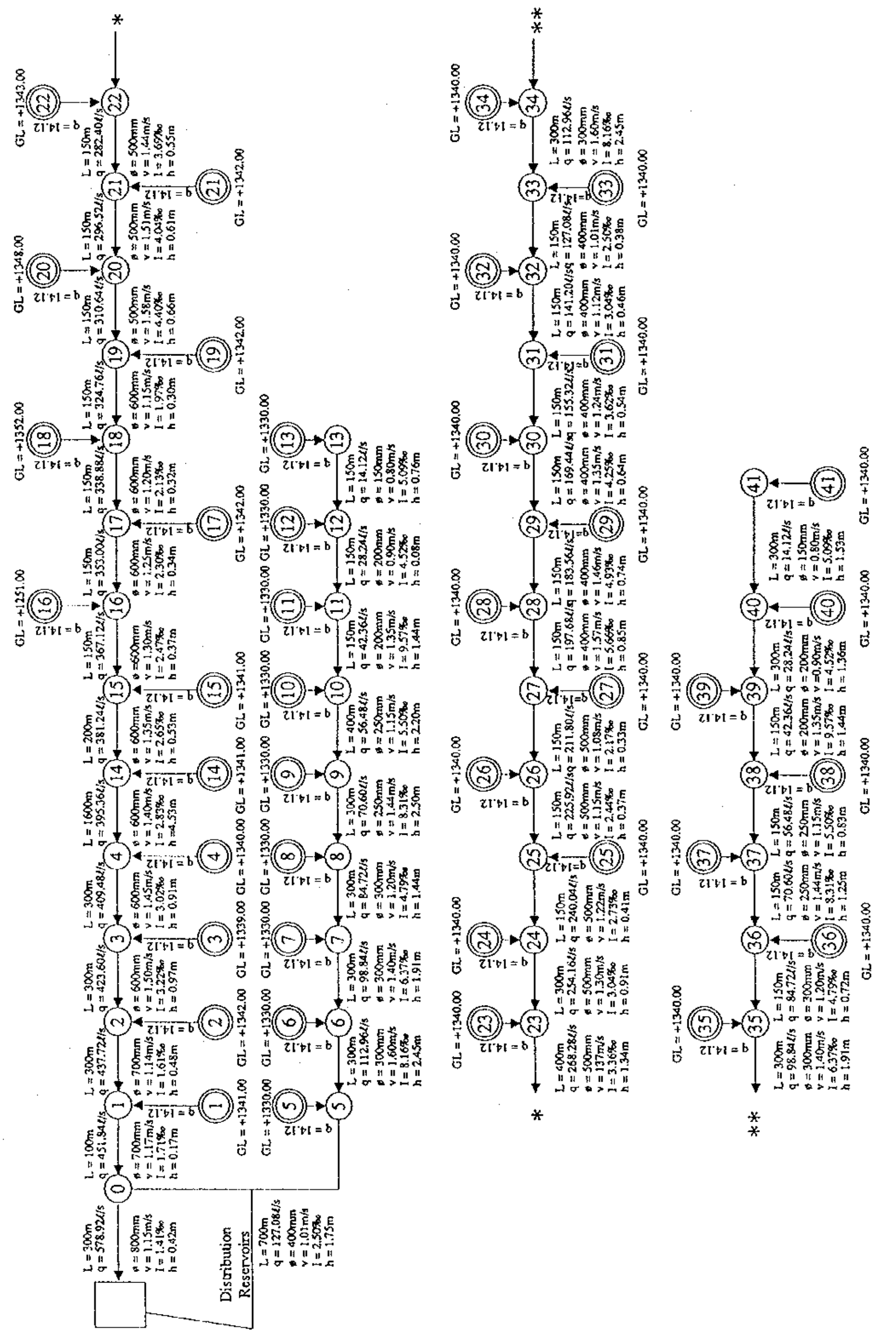
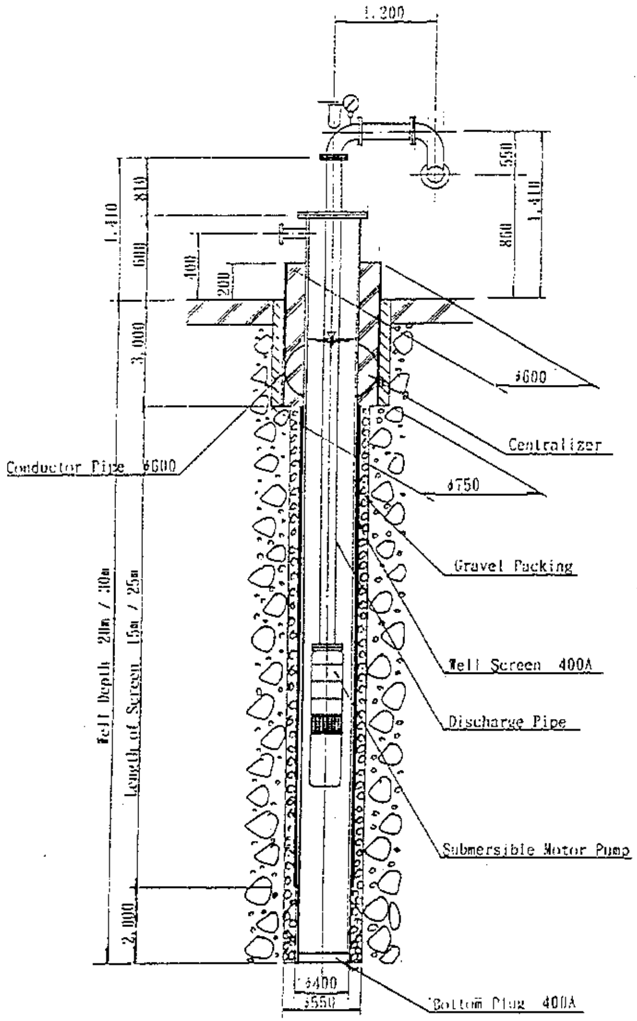


Fig. III.3.20 Hydraulic Chart of Collection Pipeline for Lower Part of Nalaih

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings



List of Wells and Intake Pumps
(New Water Source)

Well No.	Ground Level	Well Depth	Discharge Capacity	Total Head	Motor Capacity
1	+1,341m	20m	14.12 l / sec	50m	15Kw
2	+1,342m	20m	14.12 l / sec	50m	15Kw
3	+1,339m	20m	14.12 l / sec	50m	15Kw
4	+1,340m	20m	14.12 l / sec	50m	15Kw
5	+1,330m	20m	14.12 l / sec	60m	15Kw
6	+1,330m	20m	14.12 l / sec	65m	18.5KW
7	+1,330m	20m	14.12 l / sec	65m	18.5KW
8	+1,330m	20m	14.12 l / sec	65m	18.5KW
9	+1,330m	20m	14.12 l / sec	70m	18.5KW
10	+1,330m	20m	14.12 l / sec	70m	18.5KW
11	+1,330m	20m	14.12 l / sec	70m	18.5KW
12	+1,330m	20m	14.12 l / sec	75m	18.5KW
13	+1,330m	20m	14.12 l / sec	75m	18.5KW
14	+1,341m	20m	14.12 l / sec	55m	15KW
15	+1,341m	20m	14.12 l / sec	55m	15KW
16	+1,351m	30m	14.12 l / sec	55m	15KW
17	+1,342m	20m	14.12 l / sec	55m	15KW
18	+1,352m	30m	14.12 l / sec	55m	15KW
19	+1,342m	20m	14.12 l / sec	55m	15KW
20	+1,348m	30m	14.12 l / sec	60m	15KW
21	+1,342m	20m	14.12 l / sec	60m	15KW
22	+1,343m	20m	14.12 l / sec	60m	15KW
23	+1,340m	20m	14.12 l / sec	60m	15KW
24	+1,340m	20m	14.12 l / sec	65m	18.5KW
25	+1,340m	20m	14.12 l / sec	65m	18.5KW
26	+1,340m	20m	14.12 l / sec	65m	18.5KW
27	+1,340m	20m	14.12 l / sec	65m	18.5KW
28	+1,340m	20m	14.12 l / sec	65m	18.5KW
29	+1,340m	20m	14.12 l / sec	65m	18.5KW
30	+1,340m	20m	14.12 l / sec	65m	18.5KW
31	+1,340m	20m	14.12 l / sec	65m	18.5KW
32	+1,340m	20m	14.12 l / sec	65m	18.5KW
33	+1,340m	20m	14.12 l / sec	65m	18.5KW
34	+1,340m	20m	14.12 l / sec	70m	18.5KW
35	+1,340m	20m	14.12 l / sec	70m	18.5KW
36	+1,340m	20m	14.12 l / sec	70m	18.5KW
37	+1,340m	20m	14.12 l / sec	75m	18.5KW
38	+1,340m	20m	14.12 l / sec	75m	18.5KW
39	+1,340m	20m	14.12 l / sec	75m	18.5KW
40	+1,340m	20m	14.12 l / sec	75m	18.5KW
41	+1,340m	20m	14.12 l / sec	75m	18.5KW
	Total Motor Capacity (41pumps) =				706KW

Fig. III.3.21 Intake Well of Lower Part of Nalaih (including specification)

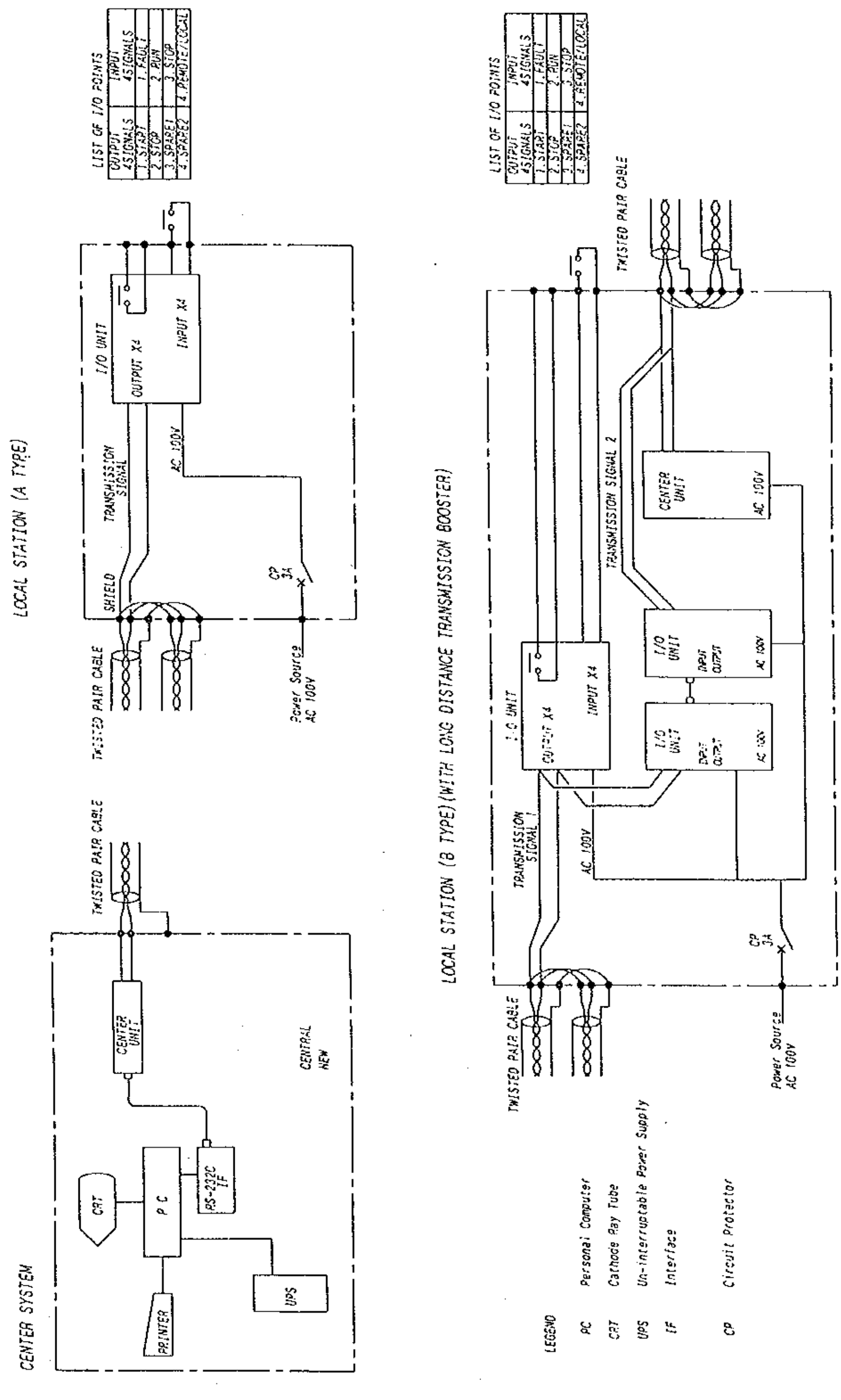


Fig. III.3.22 Flow Diagram of Remote Control System of Intake Pumps for Lower Part of Nalaih

JICA | The Study on Water Supply System in Ulaanbaatar and Surroundings

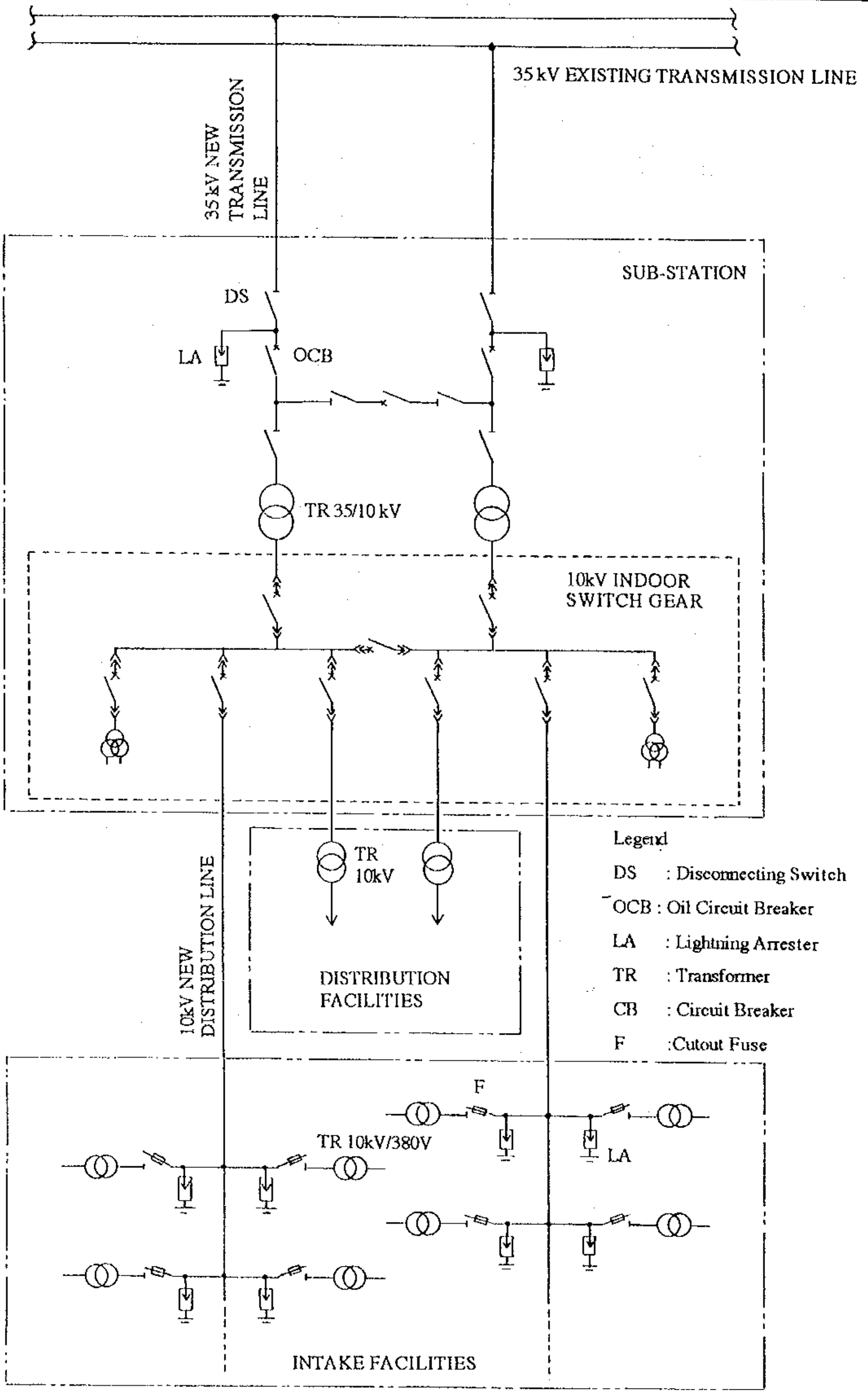


Fig. III.3.23 Single Power Line of Lower Part of Nalaih (1)

JICA | The Study on Water Supply System in Ulaanbaatar and Surroundings

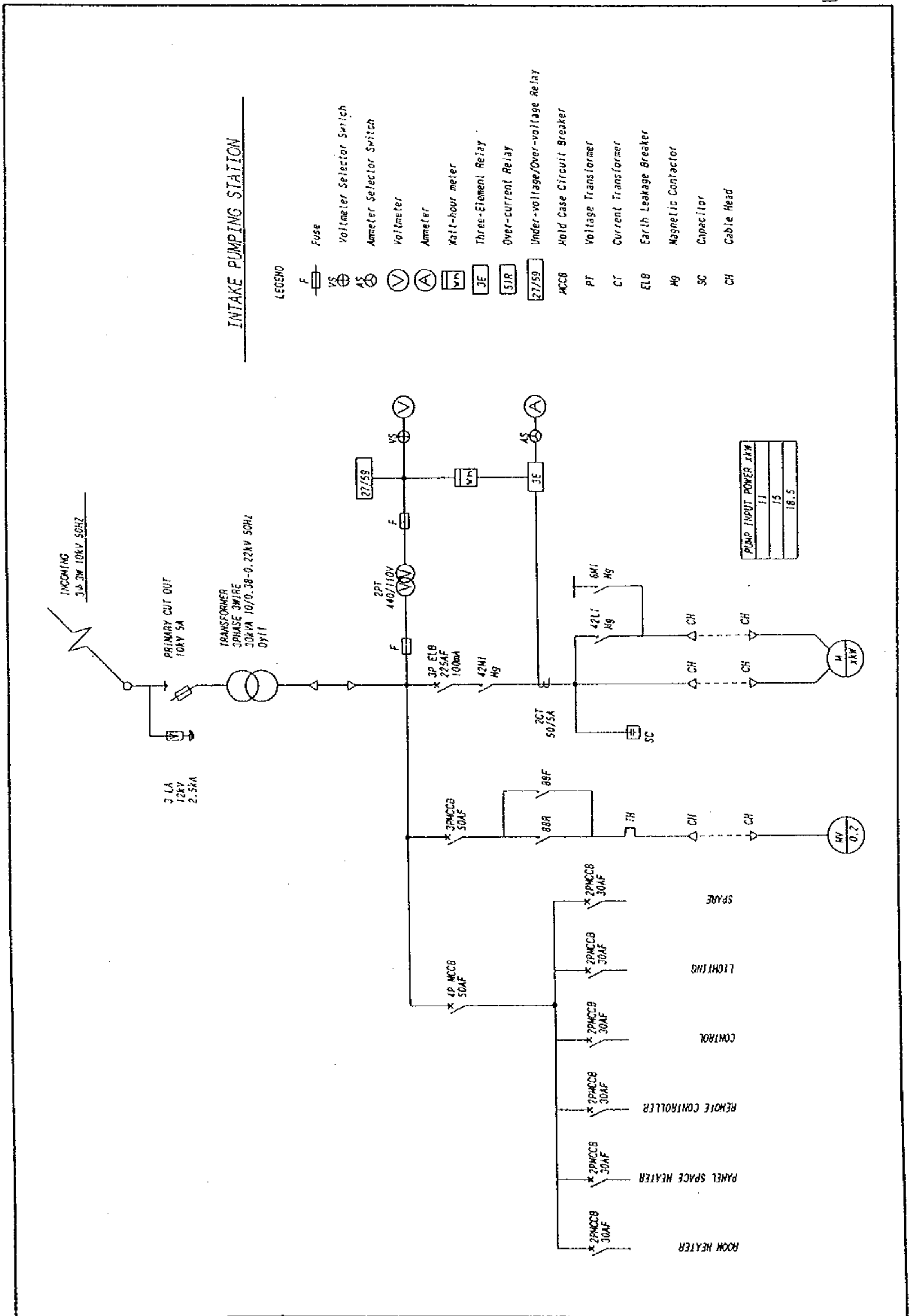


Fig. III.3.24 Single Power Line of Lower Part of Nalaih (2)

JICA | The Study on Water Supply System in Ulaanbaatar and Surroundings

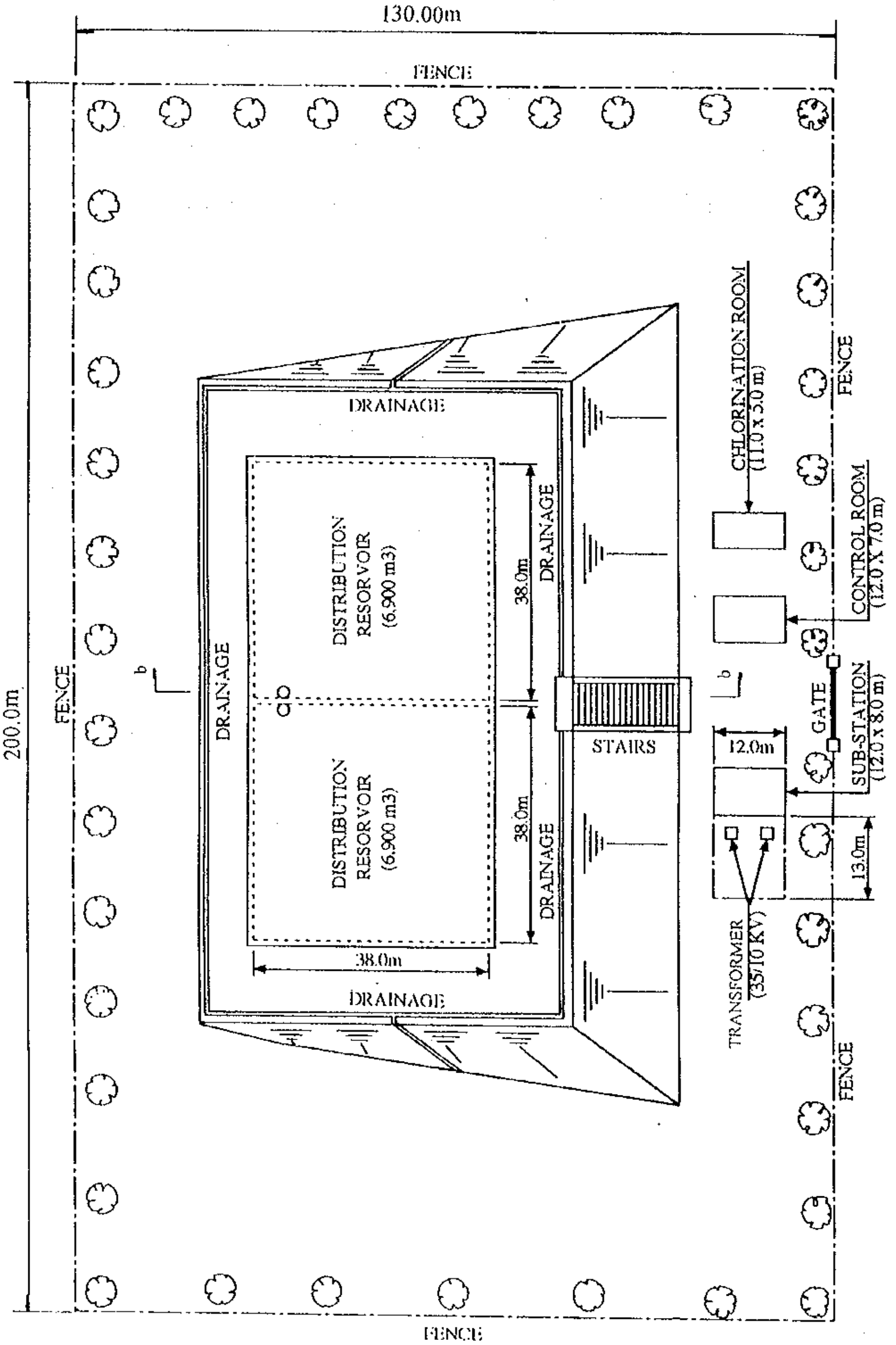


Fig. III.3.25	Layout of Distribution Facilities for Lower Part of Nalaih
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

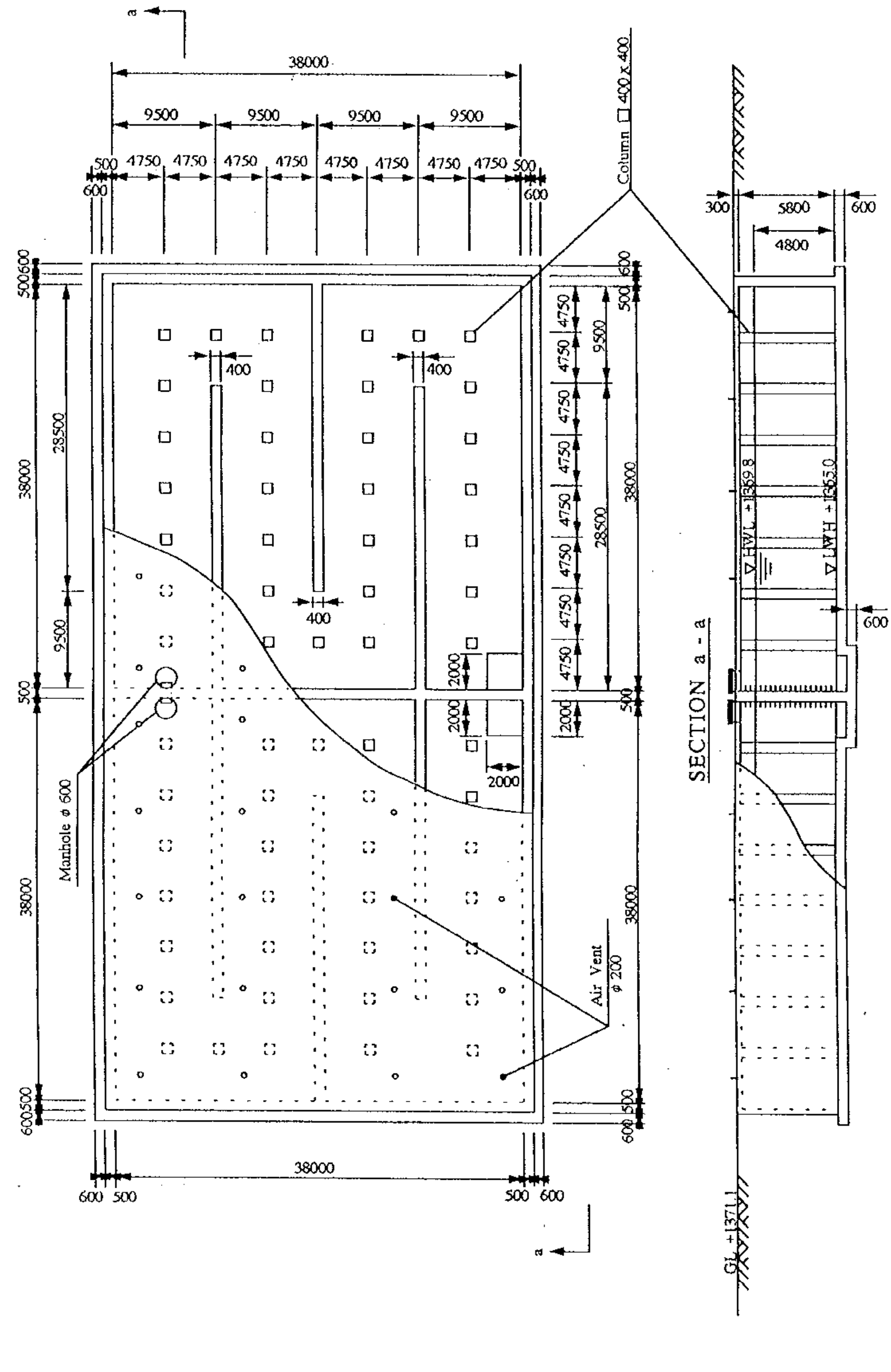


Fig. III.3.26 Distribution Reservoirs of Lower Part of Nalaih (1)

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

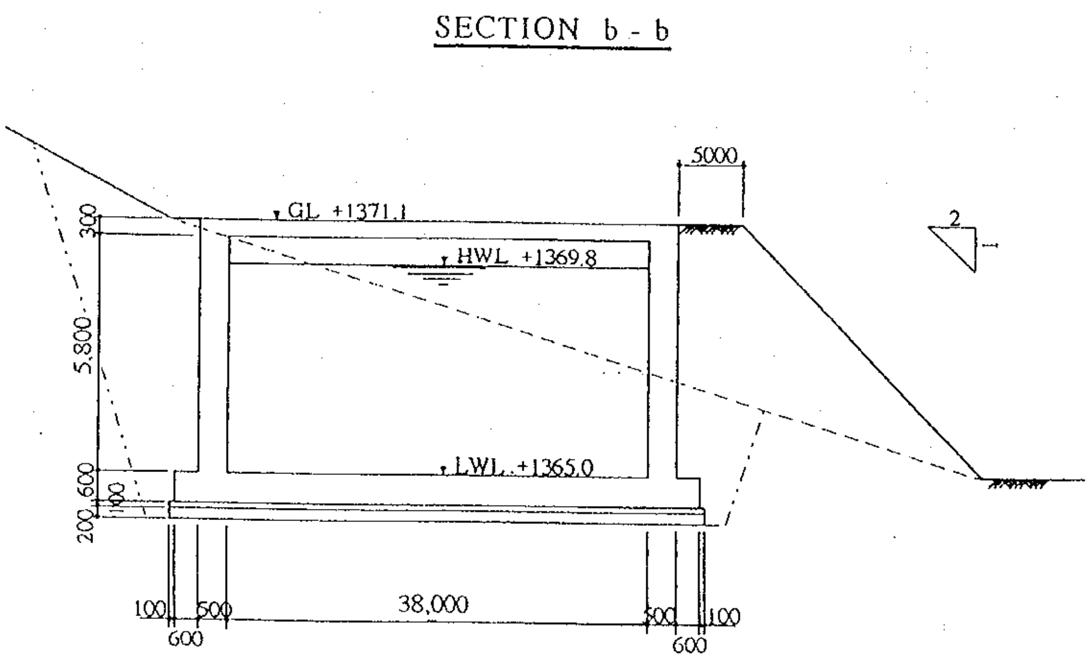


Fig. III.3.27 Distribution Reservoirs of Lower Part of Nalaih (2)

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

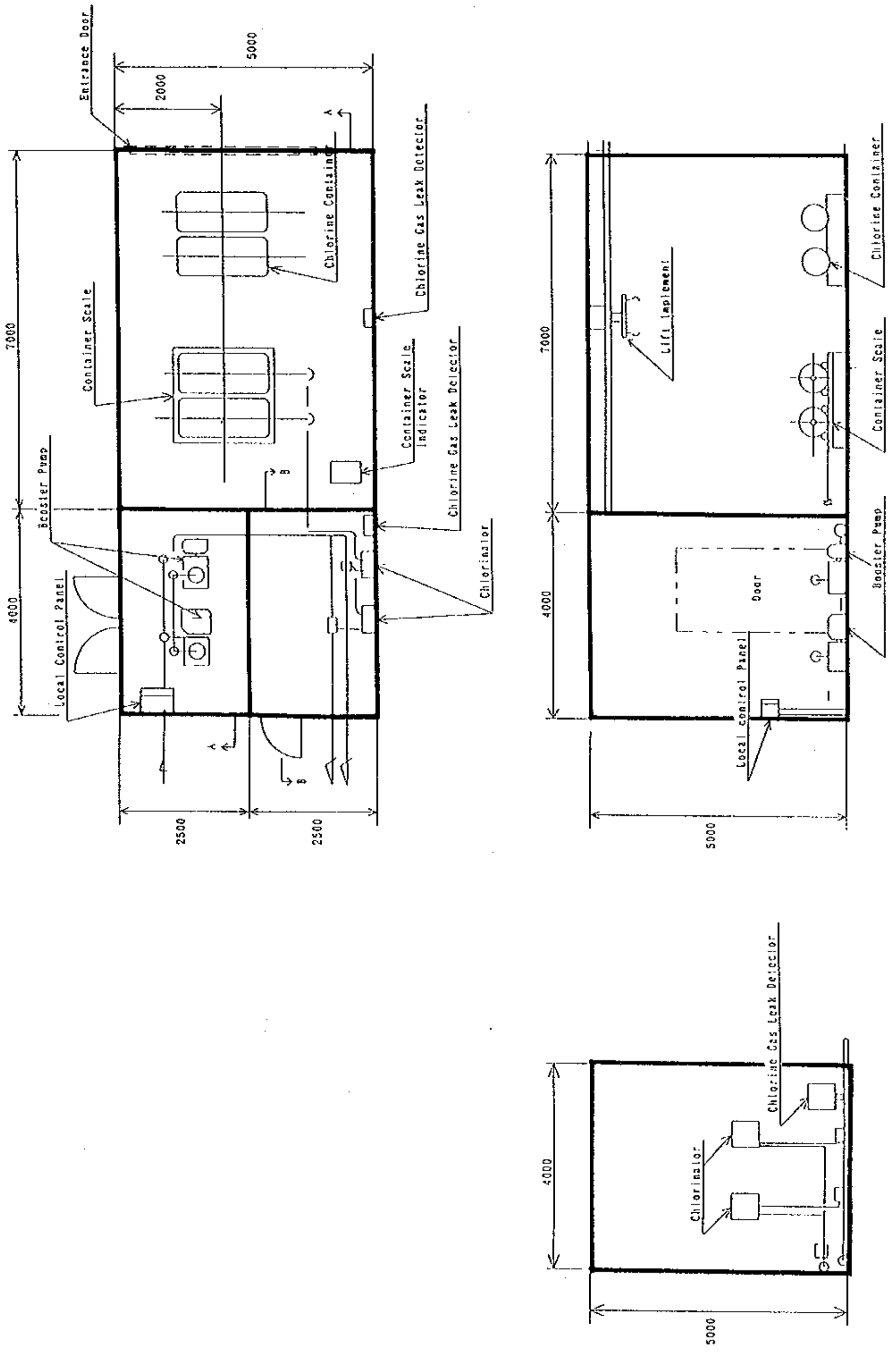


Fig. III.3.28 Layout of Chlorination Equipment for Lower Part of Nalaih

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

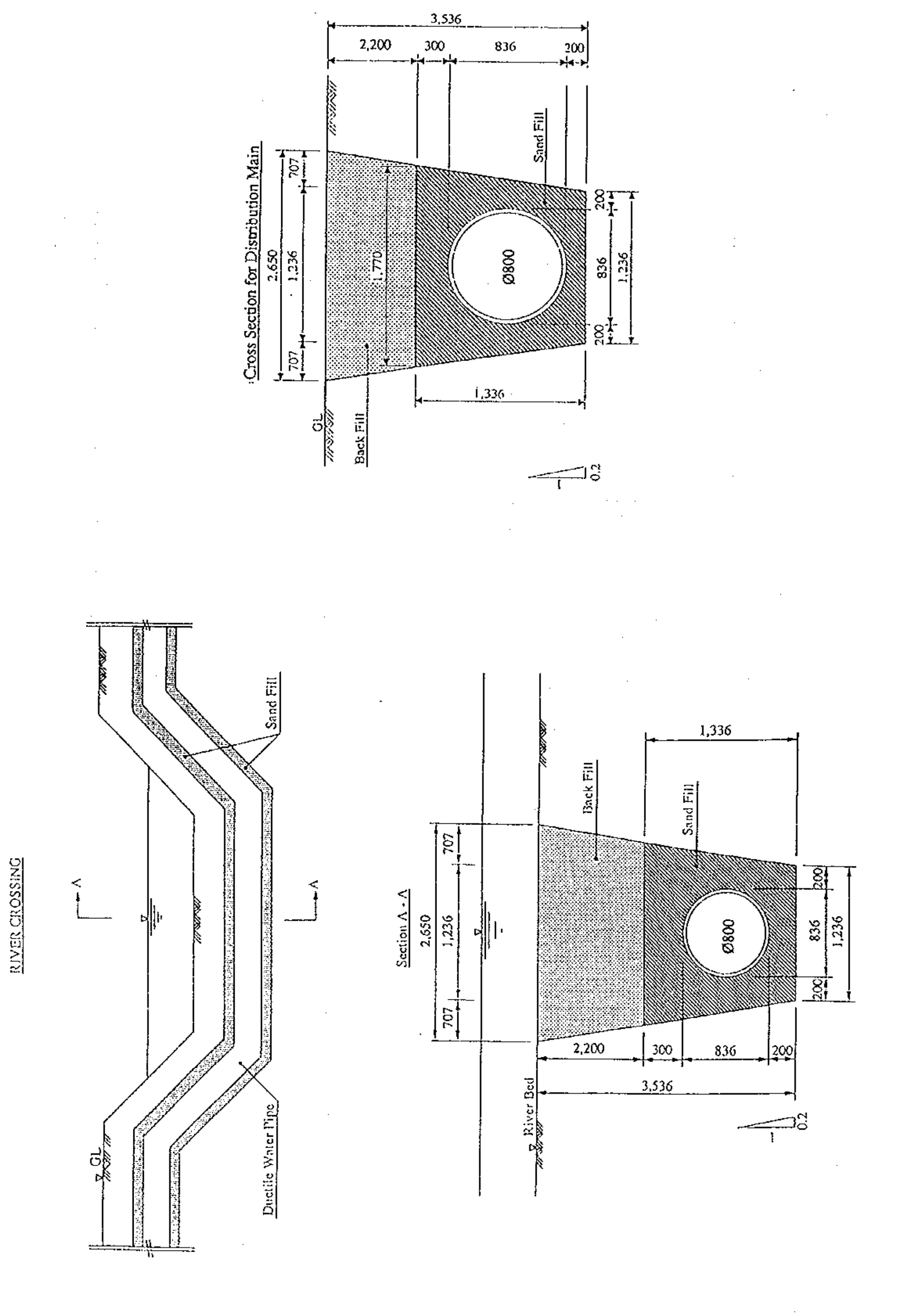


Fig. III.3.29 Pipe Laying Work Standard of Distribution Main (1)	
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

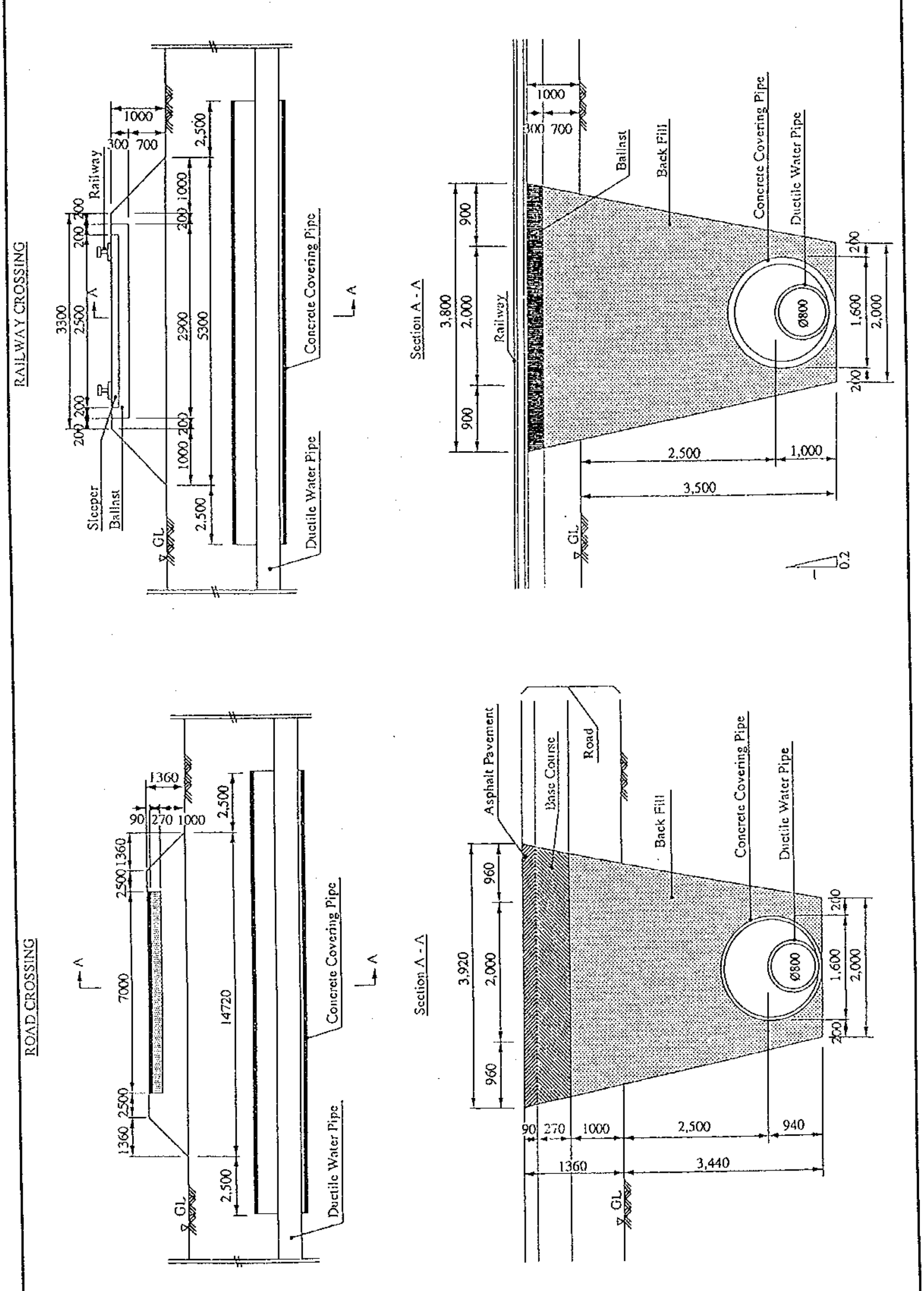
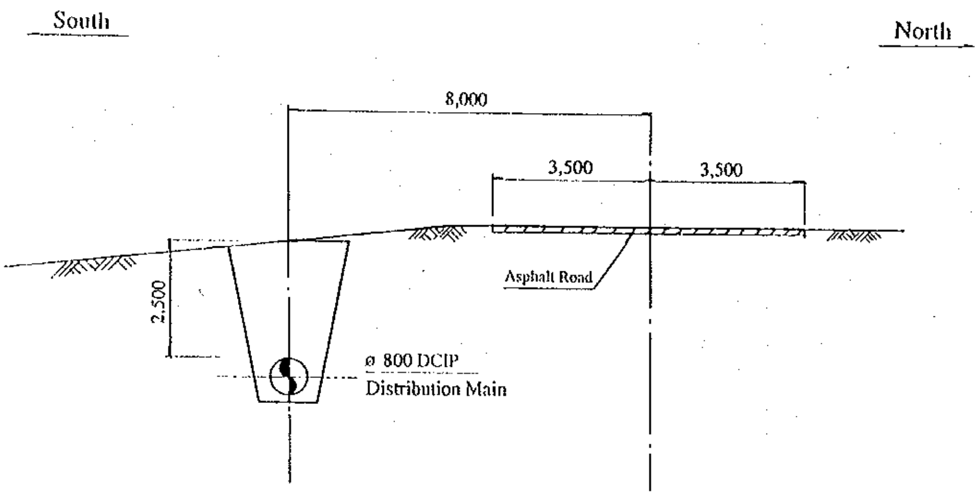
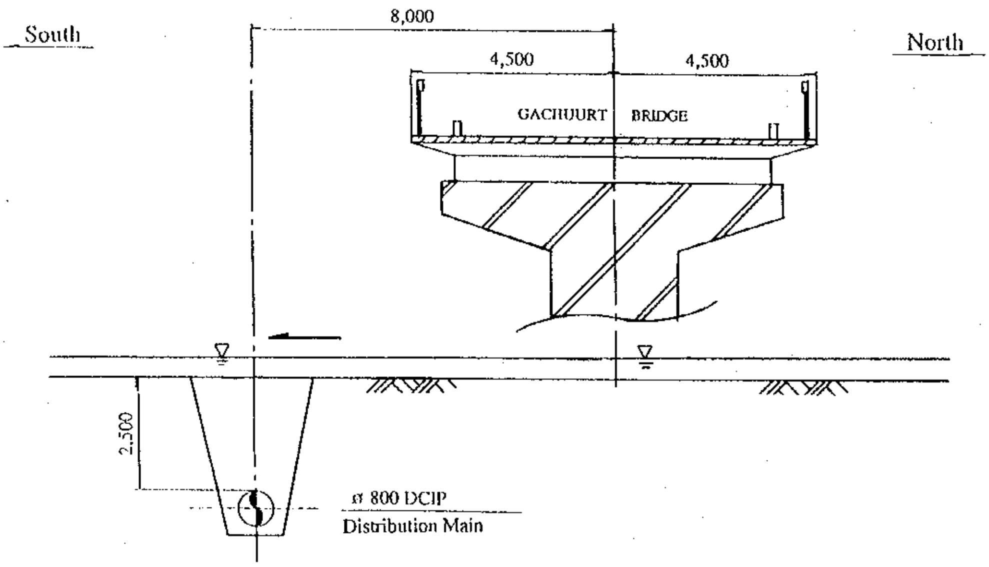


Fig. III.3.30 Pipe Laying Work Standard of Distribution Main (2)





Typical Cross Section of Pipe Installation

Fig. III.3.31 Pipe Laying Work Standard of Distribution Main (3)

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

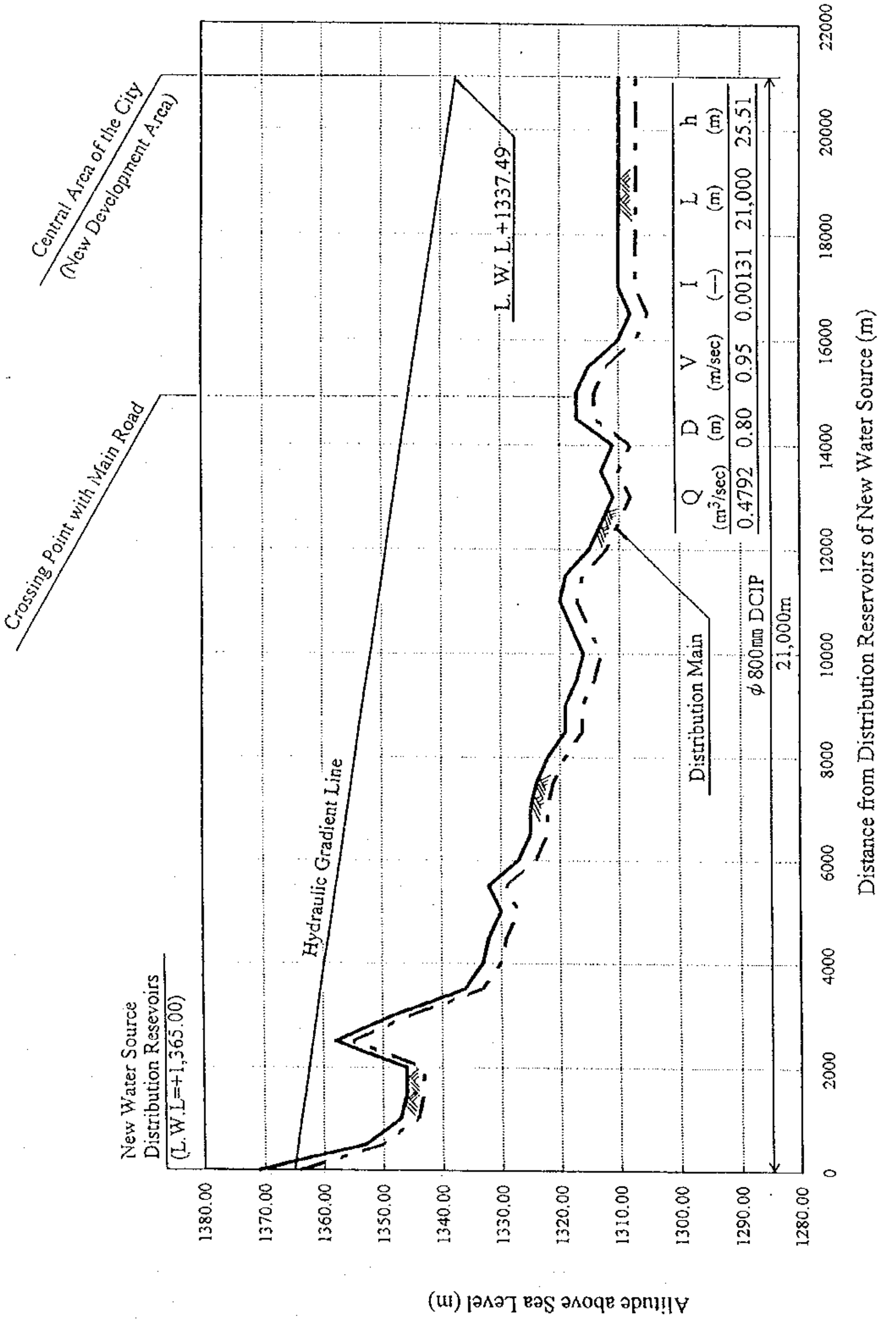
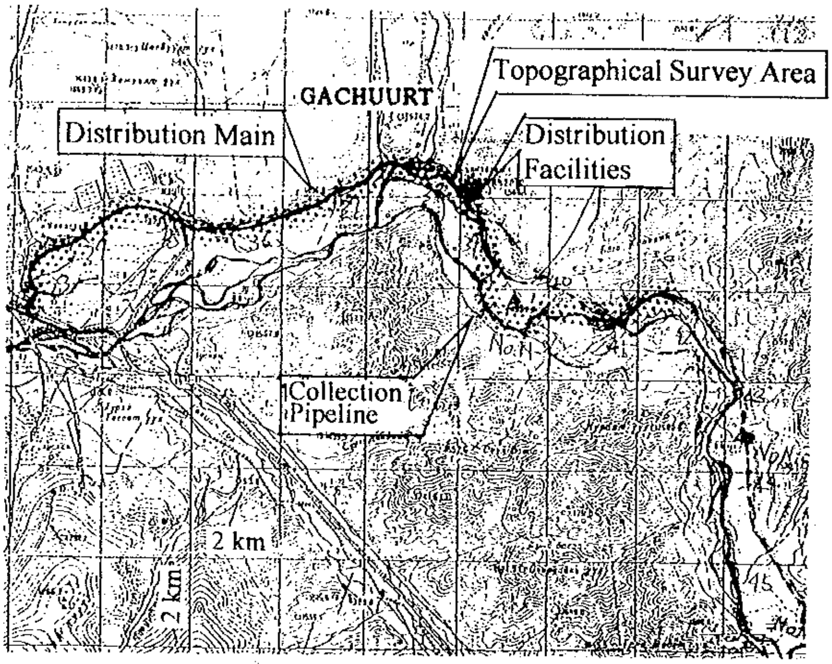
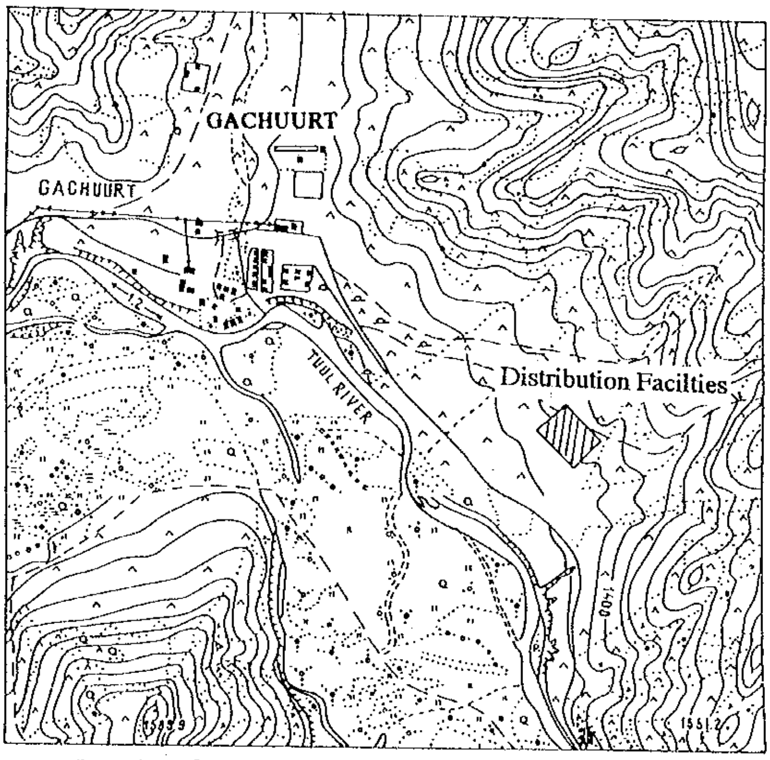


Fig. III.3.32	Longitudinal Profile of Distribution Main for Lower Part of Nalaih
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings



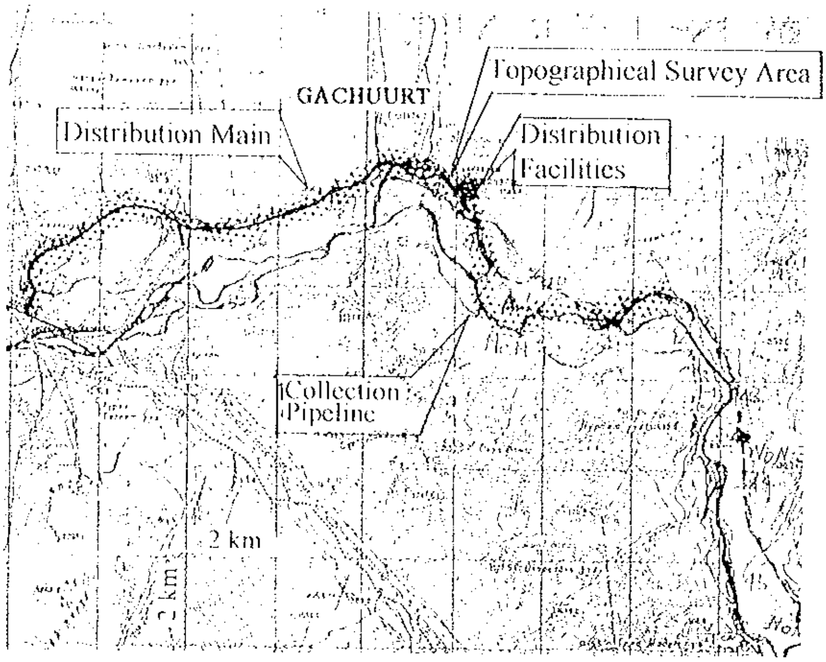
Location of Topographical Survey Area for Pipeline



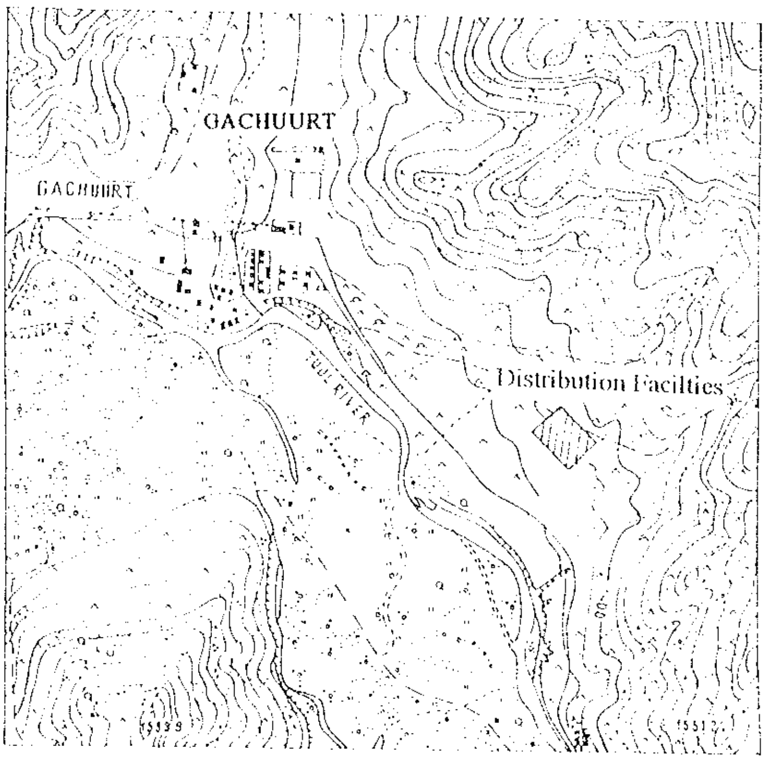
Location of Topographical Survey for Distribution Facilities
(Scale 1 : 25,000)

Fig. III.3.33 Location of Topographical Survey

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings



Location of Topographical Survey Area for Pipeline



Location of Topographical Survey for Distribution Facilities
(Scale 1 : 25,000)

Fig. III.3.33 Location of Topographical Survey

EFFLUENT QUALITY FROM INDUSTRIES

APPENDIX

Effluent Quality from Industries

(1) Discharge water (effluent) from factories in the industrial area flows into sewerage system controlled by USAG. Before discharging to the sewer pipeline, some of the industrial waste water is treated to some extent to secure the Sewage Treatment Facilities of USAG, the treated water of which flows into Tuul River. There are two main treatment plants for industrial waste water; one for meat factory and the other for leather factory.

(2) In order to survey the influence of effluent from Industries to Tuul River, water quality analysis was conducted by the Study Team. Sampling locations are shown in Fig. IV.1.1. The results of water quality analysis are shown in Table IV.1.1.

(3) As shown in Table IV.1.1, the quality of treated water from the treatment plant for the leather factories clears the standard to sewerage system except Cu. However, the treatment plant for the leather factories is old enough and looks superannuated. Also the production ratio of the leather factories in this year will be less than 50% due to the lack of raw materials. The details of water quality of this treatment plant are shown in Appendix IV.4.1.

Table IV.1.1 Water Quality of Effluent from Industries

	Location	E-1			E-2			E-3		
Item	Unit	MAX	MIN	Ave.	MAX	MIN	Ave.	MAX	MIN	Ave.
Water temparture	℃	22	16	19	20	13	15.8	18	13	15.5
pH		11.7	8.8	10.1	8.2	7.3	7.7	7.8	7	7.4
Conductivity	micro s/cm	4700	210	2003	690	400	603	590	380	488
Turbidity	NTU	220	0.1	77.8	49	0.1	21.5	18	0.1	7.1
DO	mg/l	9.9	6	8.9	11.8	7.4	10.5	11.8	7.8	10.5
Alkali	mg/lCaCO3	168	46	113	198	36	128	2720	30	774
SO4--	mg/l	75	5	61	75	14	55	49	2	32
Cl-	mg/l	860	45	255	220	31	90	160	31.5	69
Ca++	mg/l	4.25	1.65	3.11	3.2	1.15	1.84	2.57	1.35	1.94
Mg++	mg/l	24.3	4.62	12.19	18.24	1.21	8.51	12.52	7.66	10.48
TDS	mg/l	1564	314	682	1484	232	631	1148.5	125.8	434.3
NO2-	mg/l	0.259	0.069	0.128	0.33	0.114	0.26	0.33	0.144	0.241
NO3-	mg/l	35.5	0.8	15.7	16	2.4	8.1	8.5	2.3	4.5
NH4+	mg/l	2.76	2.21	2.62	2.75	2.17	2.63	3.28	1.13	2.26
PO4	mg/l	2.74	0.56	1.19	2.75	0.63	2.22	2.75	0.38	1.74
Cr	mg/l	1.58	0	0.65	0.42	0.08	0.26	0.38	0.03	0.22
Mn	mg/l	3.6	0	1.5	2.3	0	1.2	0.6	0	0.2
Fe	mg/l	0.96	0.15	0.53	0.7	0.3	0.56	0.25	0.04	0.13
CN	mg/l	0.043	0	0.013	0.028	0	0.011	0.001	0	0.001
F	mg/l	2.2	0	0.8	1.82	0.02	0.67	1.57	0	0.54
Cu	mg/l	2.15	0.07	0.84	0.57	0.03	0.37	0.08	0	0.02
Zn	mg/l	0.62	0	0.27	0.42	0	0.18	0.39	0.01	0.09
COD	mg/l	334	10	94	99	24	49	35	18	27
Pb	mg/l	0.28	0.026	0.17	0.19	0.076	0.16	0.2	0.009	0.092
Cd	mg/l	0.1	0.004	0.031	0.1	0.004	0.029	0.005	0	0.002
Phenol	mg/l	0.006	0.003	0.004	0.006	0	0.002	0.007	0	0.002
Hg	mg/l	0.0042	0	0.002	0.0017	0	0.001	0	0	0
As	mg/l	0.1	0.07	0.08	0.12	0.06	0.09	0.09	0.01	0.06

E-1:Treated water from the treatment plant for the leather factory

E-2:Inflow to the Sewage treatment plant

E-3:Treated water from the Sewage treatment plant

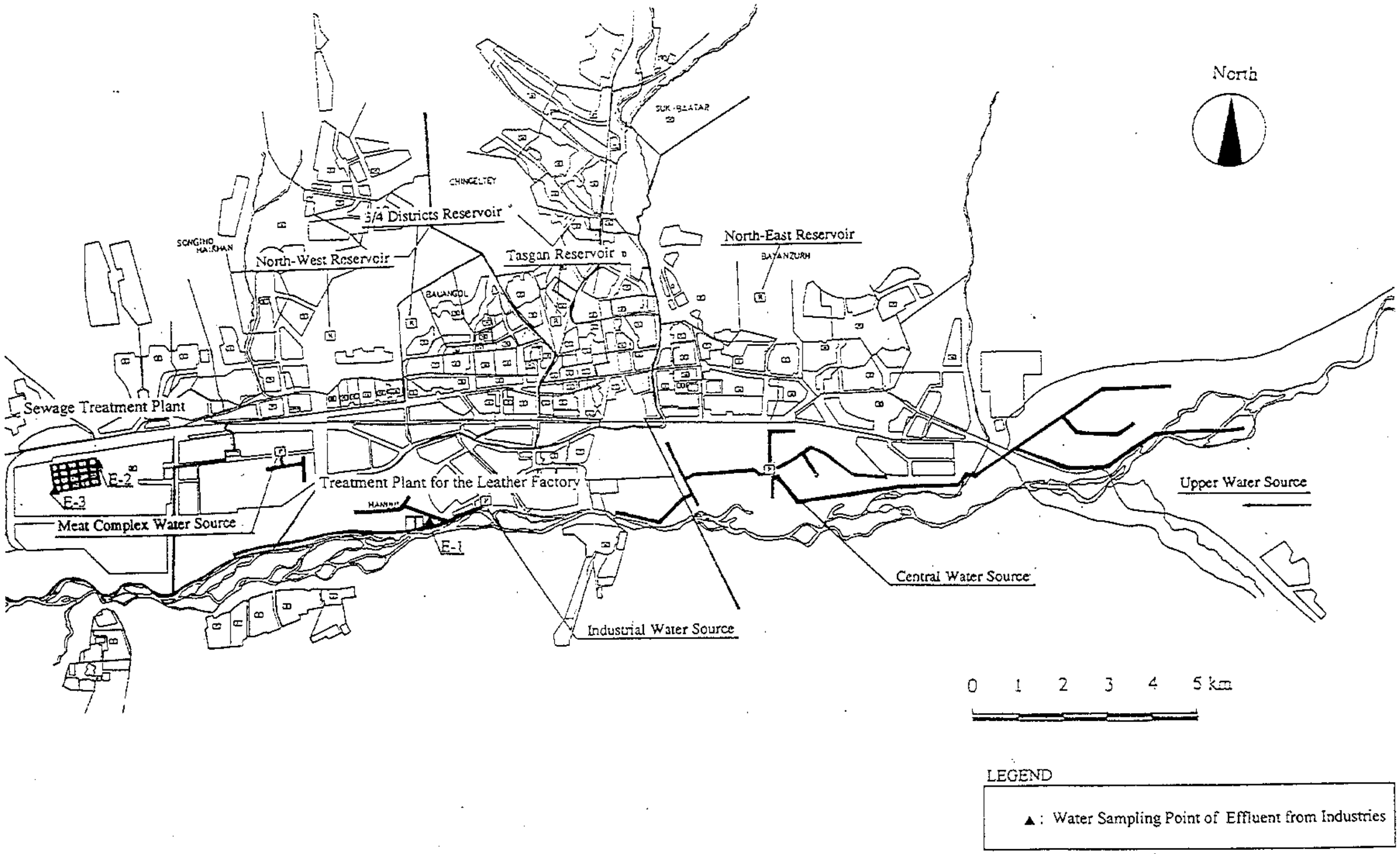


Fig. IV.1.1 Sampling Point of Wastewater from Industries

JICA | The Study on Water Supply System in Ulaanbaatar and Surroundings

Appendix I.2.1

Location of Electrical Sounding

Location of Electrical Sounding

ST.NO.	LAT. (N)	LONG. (E)	AREA CODE	ST.NO.	LAT. (N)	LONG. (E)	AREA CODE
1*	47 51.71	107 05.99	B	36	47 52.734	107 37.724	F
2*	47 49.62	107 09.31	B	37	47 51.499	107 35.685	F
3	47 48.530	107 08.900	B	38	47 50.881	107 34.072	F
4*	47 48.89	107 12.50	B	39	47 50.165	107 32.589	F
5	47 53.393	107 04.879	B	40	47 49.397	107 28.956	F
6*	47 53.90	107 05.94	G	41	47 48.837	107 27.778	F
7*	47 53.95	107 03.69	G	42	47 47.970	107 26.961	F
8*	47 54.95	107 06.65	G	43	47 59.713	107 27.239	L
9*	47 55.39	107 08.40	G	44	47 59.232	107 26.443	L
10	47 56.603	107 09.905	C	45	47 58.940	107 25.116	L
11	47 57.993	107 08.475	C	46	47 58.896	107 23.841	L
12*	47 54.84	107 04.80	C	47*	47 58.91	107 27.67	L
13	47 54.334	106 56.248	G	48	47 58.143	107 27.924	L
14A	47 53.880	106 55.442	G	49	47 57.711	106 42.395	C
15	47 53.482	106 56.783	G	50A	47 59.060	106 42.841	C
16	47 53.588	106 58.734	G	51A	47 59.867	106 43.323	C
17	47 53.663	106 59.687	G	52A	47 59.543	106 42.033	C
18*	47 56.00	107 02.00	C	53	47 57.012	106 43.086	C
19	47 57.321	107 02.319	C	54	47 56.029	106 43.650	C
20	47 58.750	107 02.899	C	55A	47 55.433	106 44.484	C
21	47 59.299	107 05.315	C	56A	47 58.624	106 40.269	C
22A	47 58.190	107 01.683	C	57A	47 57.744	106 40.566	C
23	47 59.664	107 01.893	C	58	47 56.624	106 40.896	C
24	47 52.839	106 47.759	H	59	47 55.012	106 41.604	C
25	47 53.223	106 48.922	H	60A	47 56.582	106 39.122	C
26	47 52.798	106 46.954	I	61A	47 54.885	106 39.736	C
27	47 52.813	106 44.789	I	62	47 44.767	106 31.586	D
28	47 53.228	106 45.084	I	63	47 45.347	106 34.743	J
29	47 55.243	106 50.340	C	64	47 46.387	106 36.561	J
30*	47 47.28	107 19.20	A	65	47 47.448	106 37.998	J
31	47 47.131	107 21.125	A	66	47 48.525	106 38.478	J
32	47 48.262	107 19.170	A	67	47 49.161	106 39.356	J
33*	47 49.19	107 19.61	A	68	47 49.994	106 41.474	J
34	47 49.017	107 25.662	F	69	47 41.494	106 16.881	E
35	47 49.403	107 23.194	A	70	47 38.697	106 08.979	E

* ; by topographic map   A ; re-measurement

to be continued

ST.NO.	LAT. (N)	LONG. (E)	AREA CODE	ST.NO.	LAT. (N)	LONG. (E)	AREA CODE
71	47 40.909	106 14.535	E	111	47 59.400	107 07.571	C
72	47 42.602	106 19.045	D	112	47 56.947	107 08.776	C
73	47 42.717	106 22.427	D	113	47 53.446	107 35.397	F
74	47 41.228	106 24.765	D	114	47 54.213	107 36.119	F
75	47 44.156	106 28.189	D	115	47 53.422	107 36.541	F
76	47 48.487	106 34.942	J	116	47 53.456	107 34.702	F
77	47 47.633	106 35.753	J	117	47 52.394	107 34.449	F
78	47 46.798	106 34.289	J	118	47 51.797	107 33.143	F
79	47 46.227	106 32.484	D	119	47 51.316	107 32.060	F
80	47 45.815	106 29.911	D	120	47 49.260	107 18.384	A
81	47 46.601	106 28.854	D	121	47 50.275	107 15.901	A
82	47 47.210	106 30.907	D	122	47 51.610	107 14.916	A
83	47 43.556	106 09.854	E	123	47 48.964	107 16.449	A
84	47 44.240	106 12.677	E	124	47 46.904	106 11.405	B
85	47 45.372	106 16.571	E	125	47 58.738	107 30.089	L
86	47 43.880	106 17.473	E	126	47 58.569	107 31.717	L
87	47 44.729	106 20.298	D	127	47 57.364	107 34.942	L
88	47 43.811	106 21.860	D	128	47 58.403	107 34.443	L
89	47 44.884	106 24.384	D	129	47 58.147	107 33.592	L
90	47 44.317	106 35.901	K	130	47 59.166	107 36.217	L
91	47 43.171	106 37.215	K	131	47 50.092	107 07.579	B
92	47 42.101	106 38.321	K	132	48 01.552	106 55.236	C
93	47 41.317	106 39.409	K	133	48 00.183	107 02.527	C
94	47 39.556	106 39.552	K	134	47 53.282	107 01.618	G
95	47 37.954	106 39.309	K	135	47 57.229	107 06.791	C
96	47 39.842	106 42.973	K	136	47 58.659	107 10.626	C
97	47 38.573	106 44.527	K				
98	47 40.963	106 41.442	K				
99	47 58.822	106 45.195	C				
100	47 57.912	106 45.384	C				
101	47 56.713	106 45.921	C				
102	47 55.763	106 46.028	C				
103	48 00.460	106 49.402	C				
104	47 58.964	106 49.432	C				
105	47 59.437	106 48.338	C				
106	47 57.263	106 49.181	C				
107*	48 00.32	106 58.30	C				
108A	48 00.556	106 55.872	C				
109	47 58.770	106 55.449	C				
110	47 57.304	106 55.894	C				

* ; by topographic map   A ; re-measurement