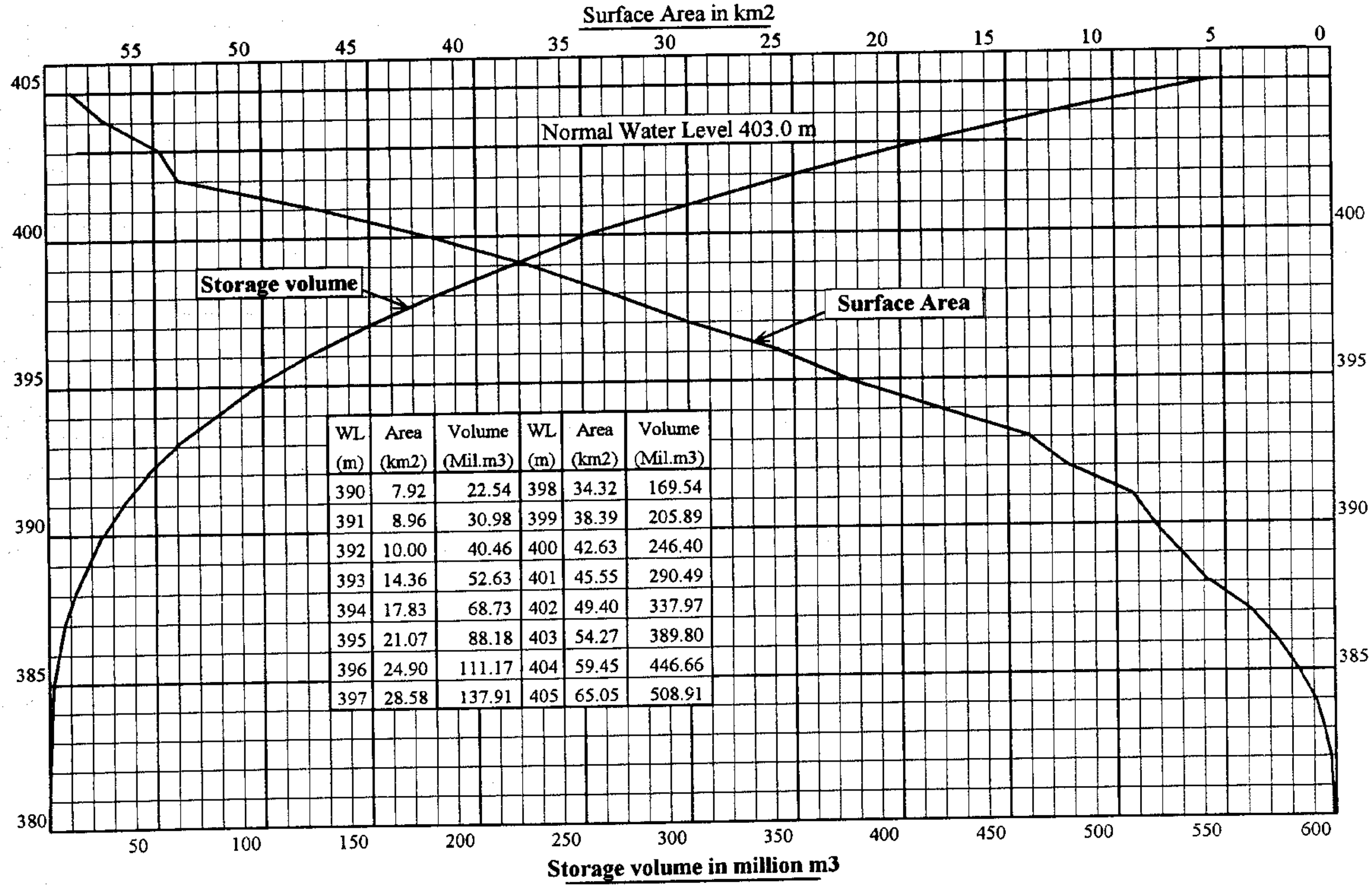
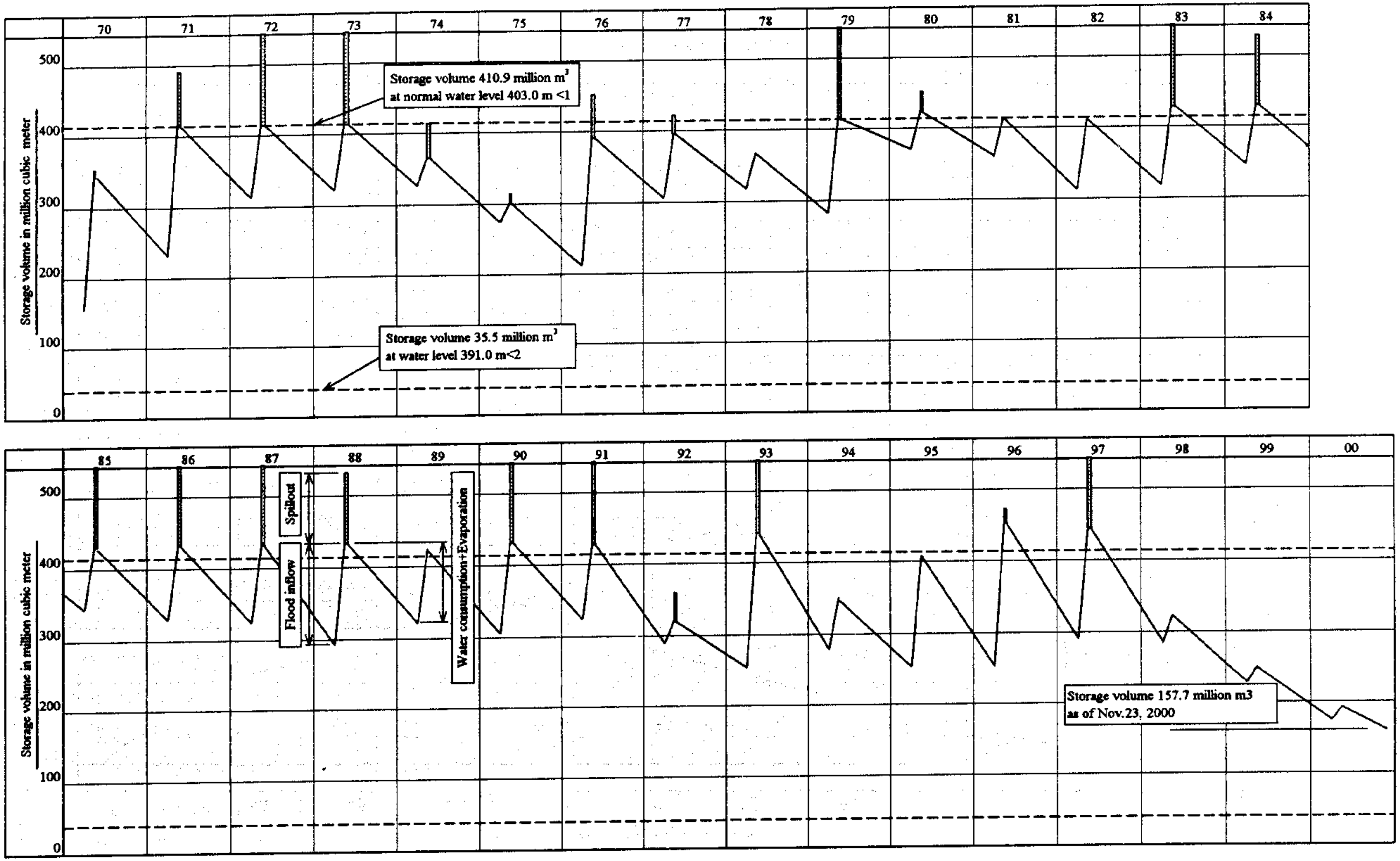
FIGURE

Figure E.1.1 Area Capacity Curve of Vyacheslavskoe Reservoir



WL (m)	Area (km2)	Volume (Mil.m3)	WL (m)	Area (km2)	Volume (Mil.m3)
390	7.92	22.54	398	34.32	169.54
391	8.96	30.98	399	38.39	205.89
392	10.00	40.46	400	42.63	246.40
393	14.36	52.63	401	45.55	290.49
394	17.83	68.73	402	49.40	337.97
395	21.07	88.18	403	54.27	389.80
396	24.90	111.17	404	59.45	446.66
397	28.58	137.91	405	65.05	508.91

Figure E.1.2 Record of Reservoir Operation of Vyacheslavsky Reservoir from 1970 to 1999



Note: <1: The storage volume at NWL 403.0 has been revised to 389.9 million m3 as the result of hydrographic survey in the beginning of 2000.
<2: The storage volume at WL 391.0 has been revised to 31.0 million m3 as the result of hydrographic survey in the beginning of 2000.

Figure E.1.3 Mass Curve of Flood Inflow of the Vyacheslavsky Reservoir in 1970 to 2000

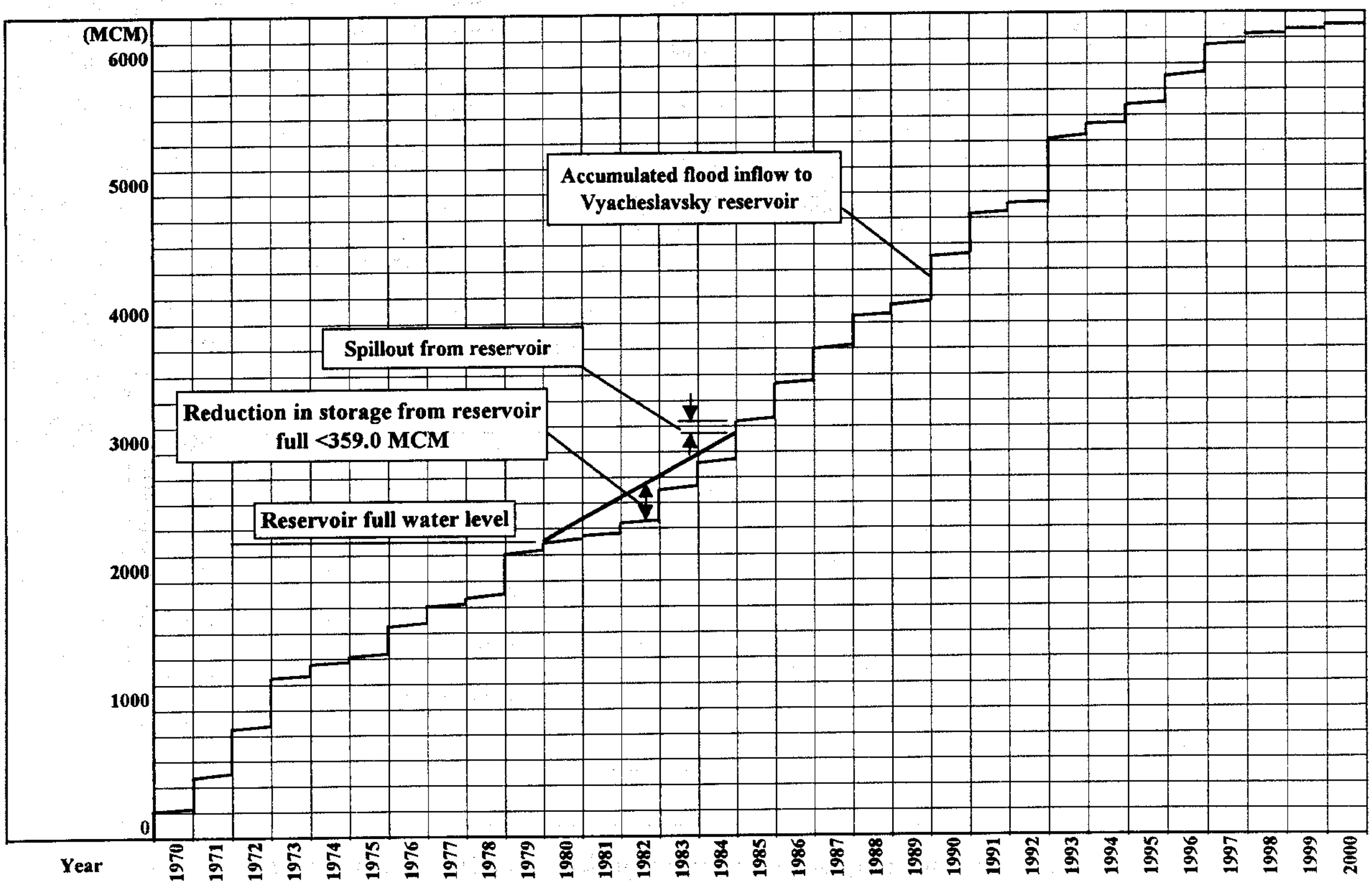
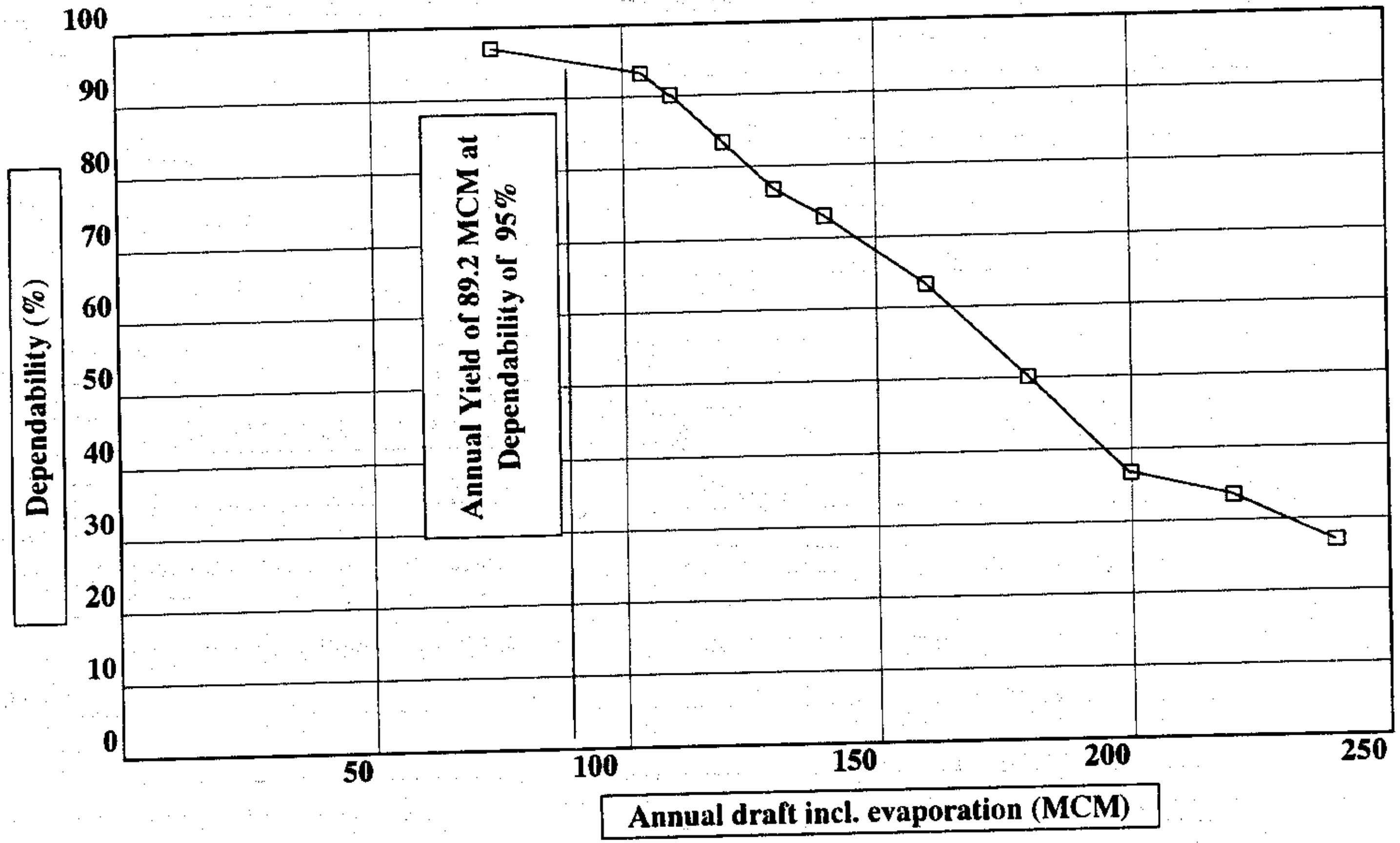


Figure E.1.4 Dependability of Annual Yield of Vyacheslavsky Reservoir



Draft (MCM)	Dependability (%)	Draft (MCM)	Dependability (%)
74.4	96.7	140	73.3
89.2	95.0	160	63.3
104	93.3	180	50.0
110	90.0	200	36.7
120	83.3	220	33.3
130	76.7	240	26.7

Figure E.1.5 Volume of Spring Flood - Annual Precipitation of Snow

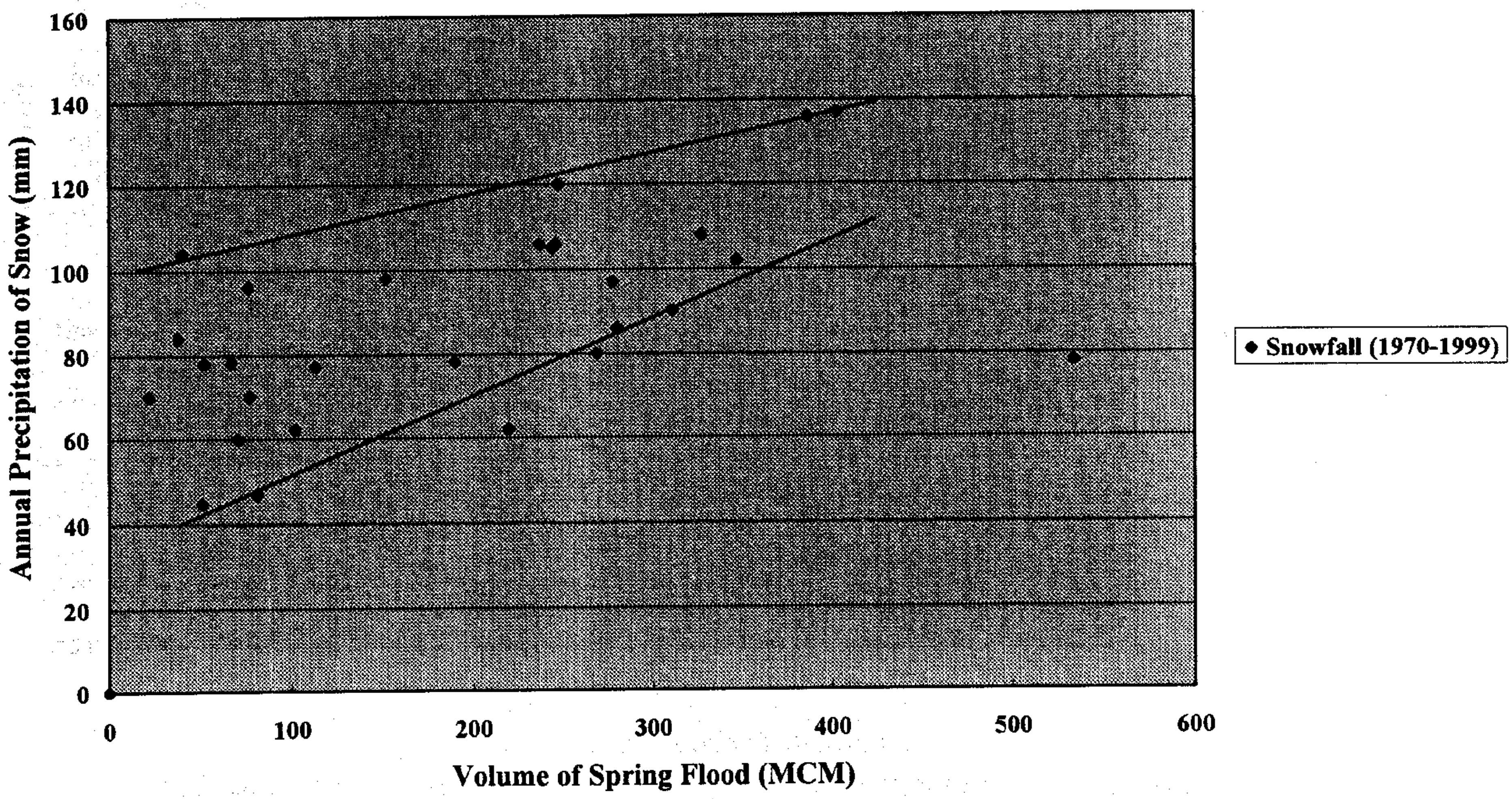


Figure E.1.6 Volume of Spring Flood - Precipitation of Snow Plus Rainfall (mid September & October)

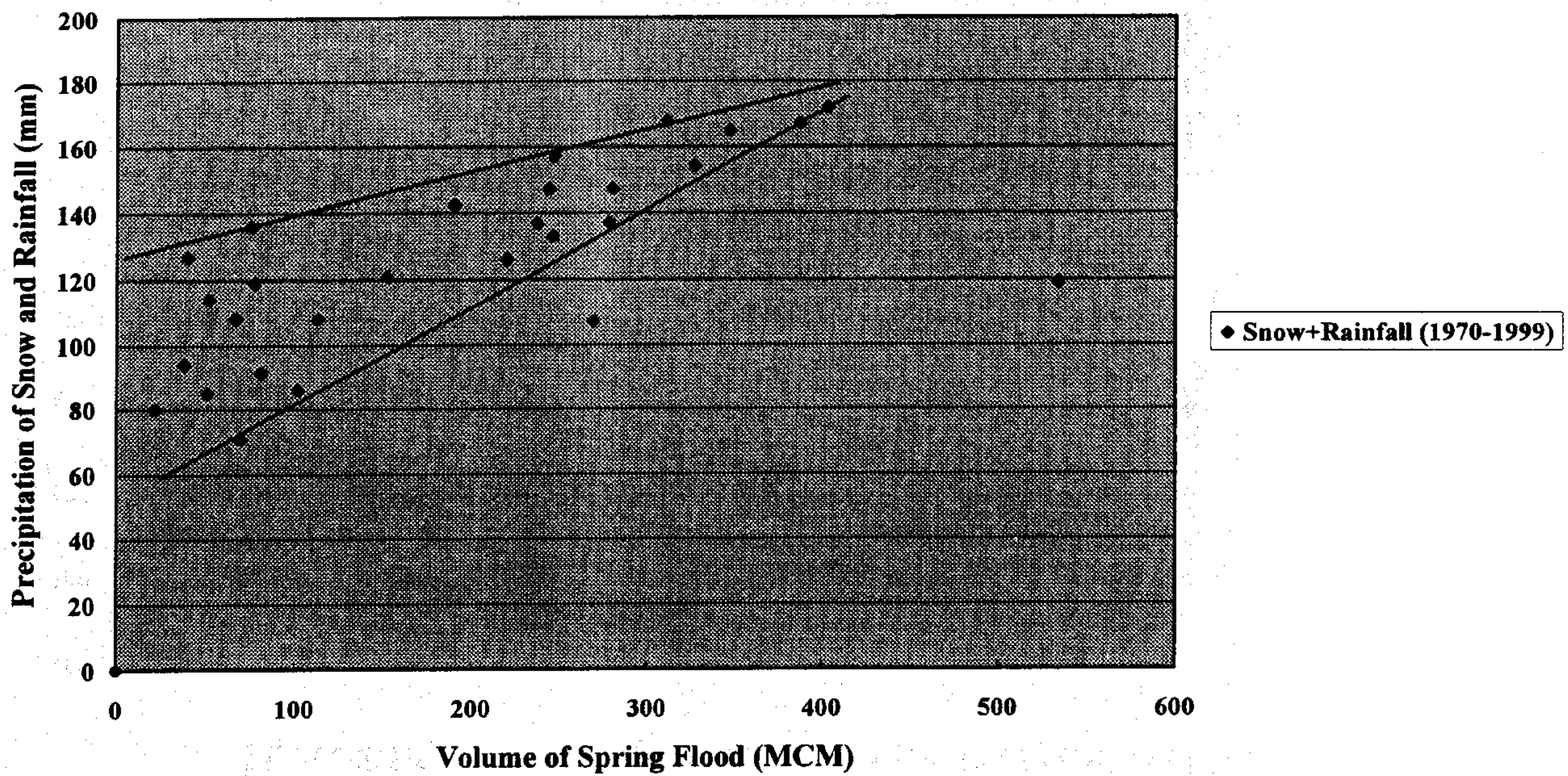
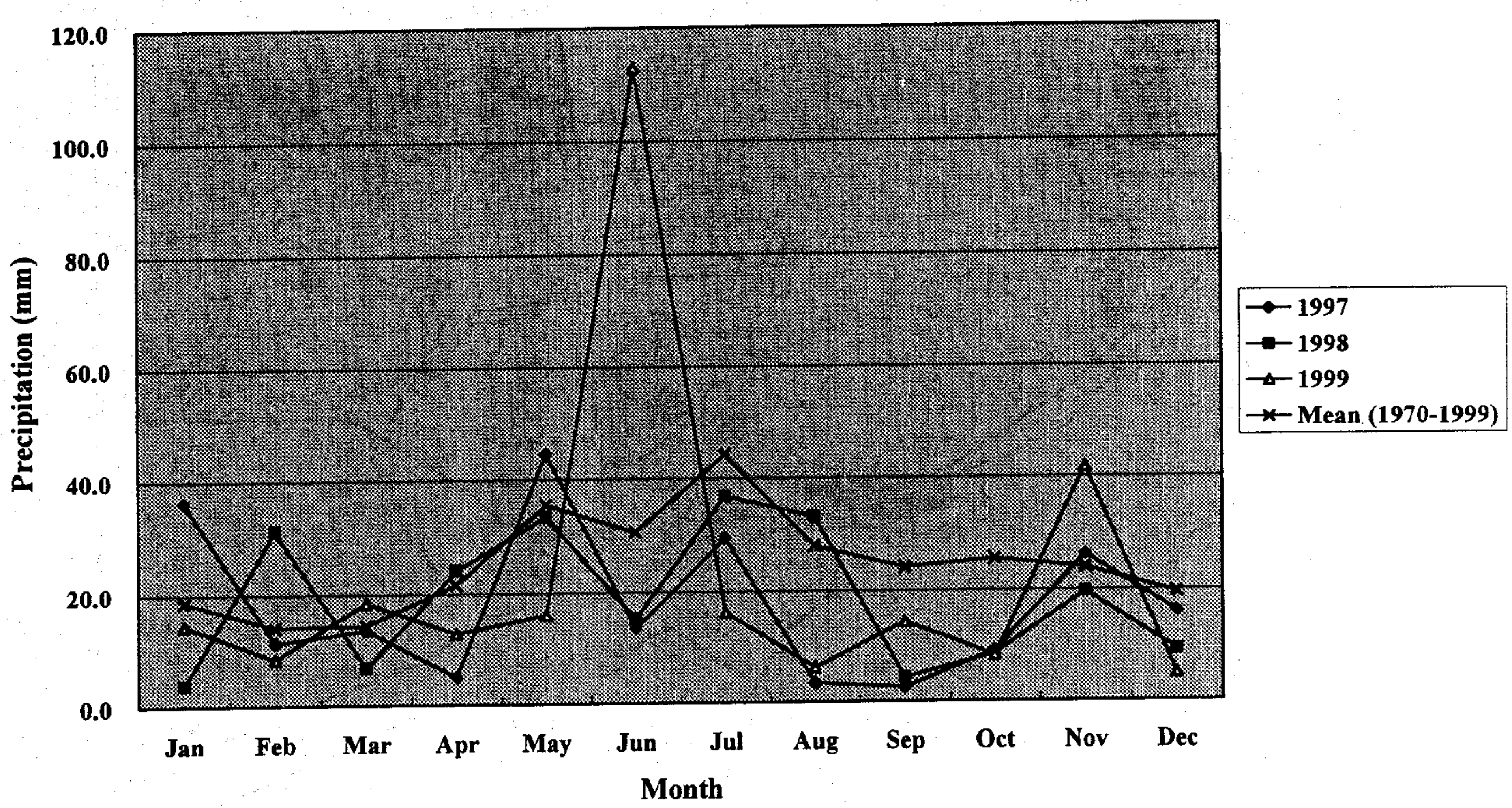


Figure E.1.7 Monthly Precipitation in 1997 to 1999



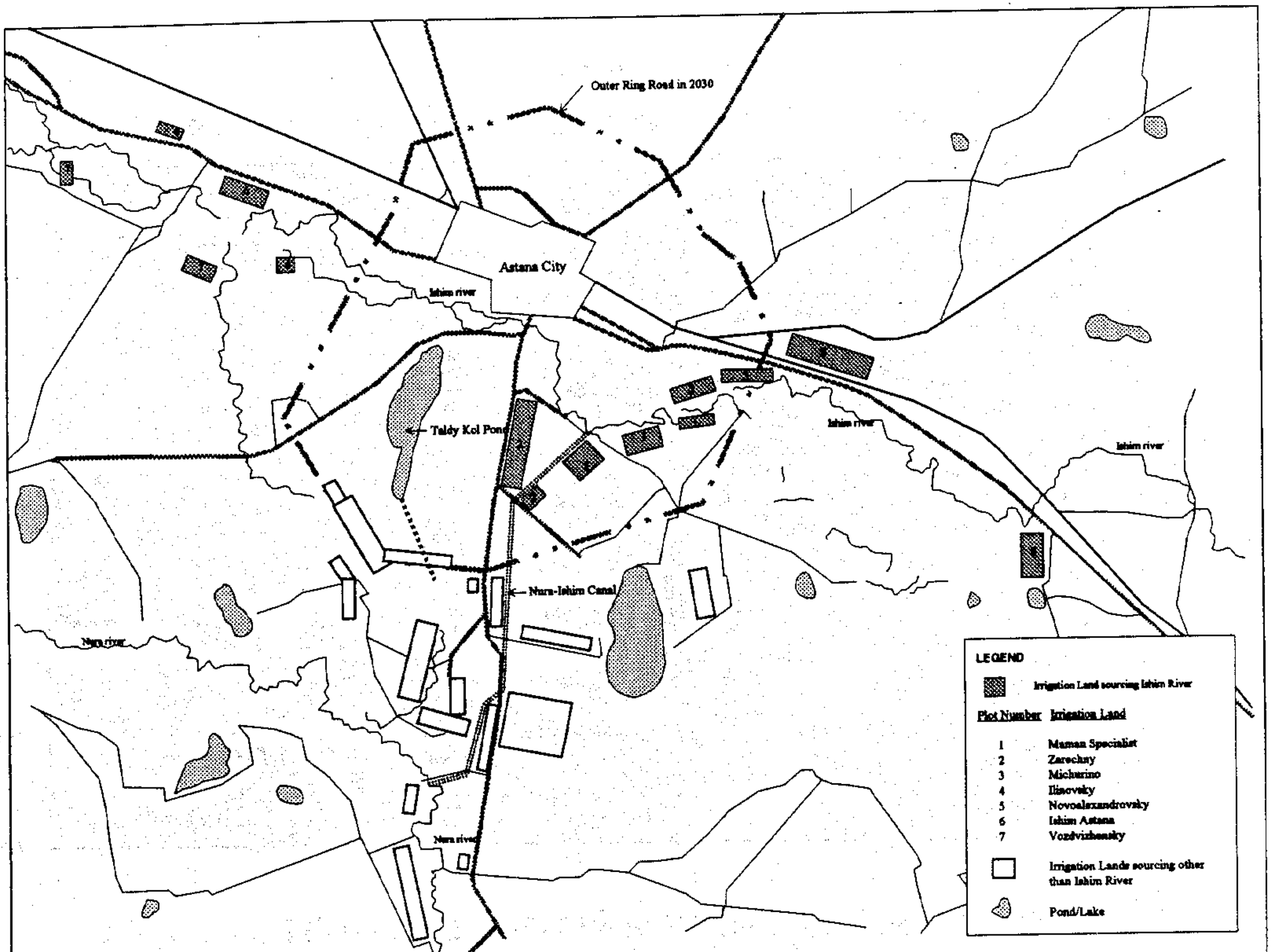
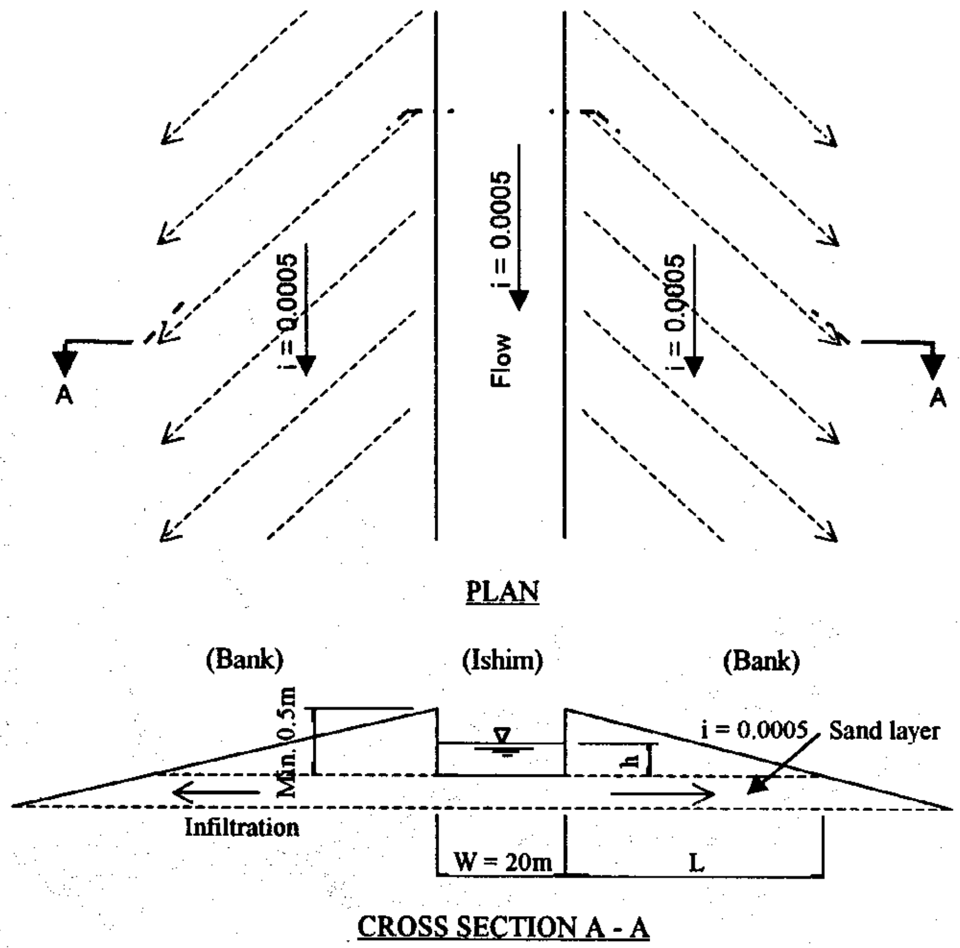


Figure E.1.8 Areas Developed for Irrigation in the Past



$Q = kiA$

where, k : coefficient of permeability = 1×10^{-4} m/sec (sand layer)

I : hydraulic gradient = h/L

A : cross sectional area of permeability layer = 300 km x 20 m

q (m^3/sec)	h	L	I = h/L	A (km2)	Q (MCM/year)
1.19	0.40	1,000	0.00040	6	7.6
1.37	0.43	1,000	0.00043	6	8.1
1.60	0.46	1,000	0.00046	6	8.7

Figure E.2.1 Hydro-Geology Model for Water Loss due to Infiltration in Ishim River

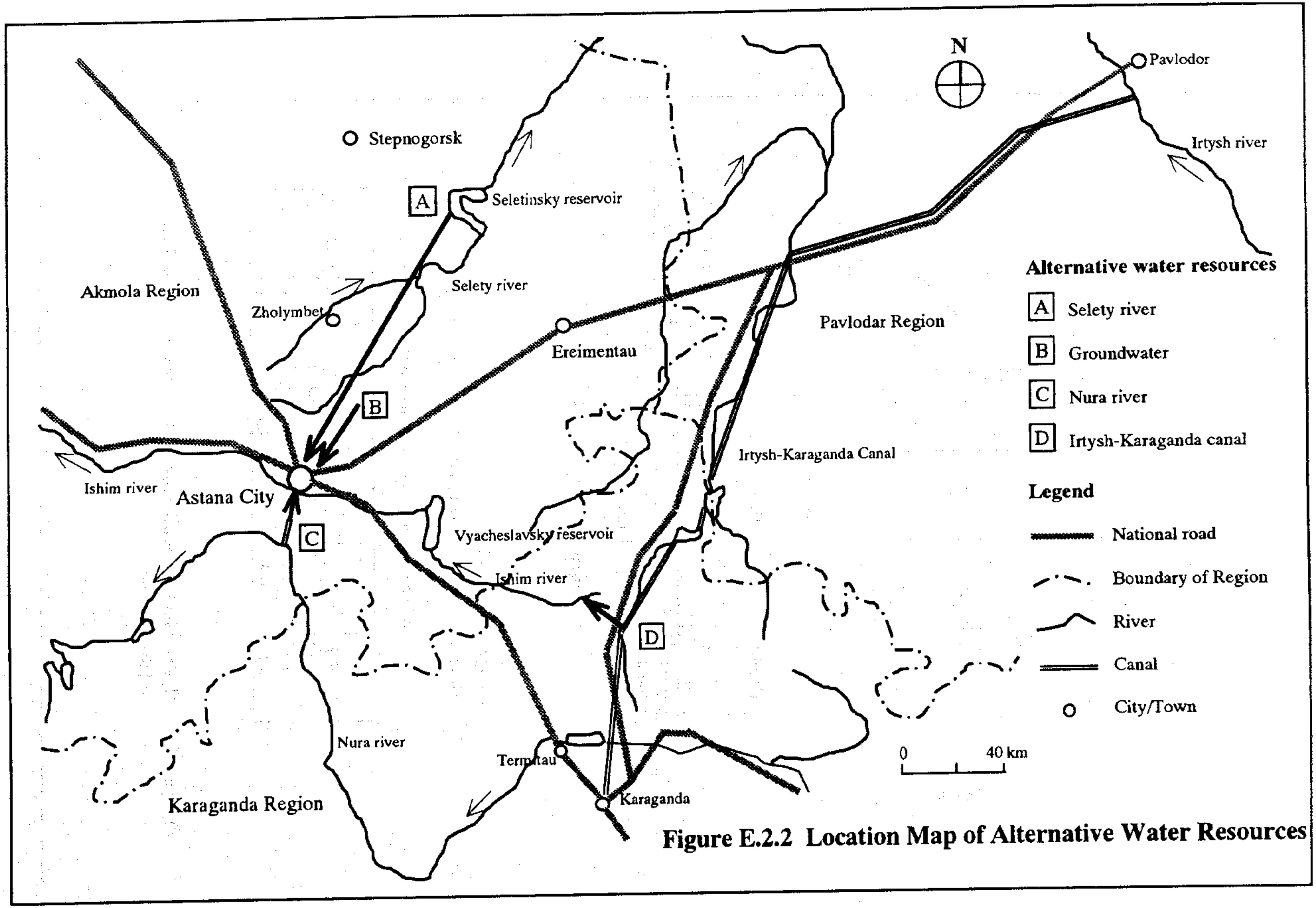
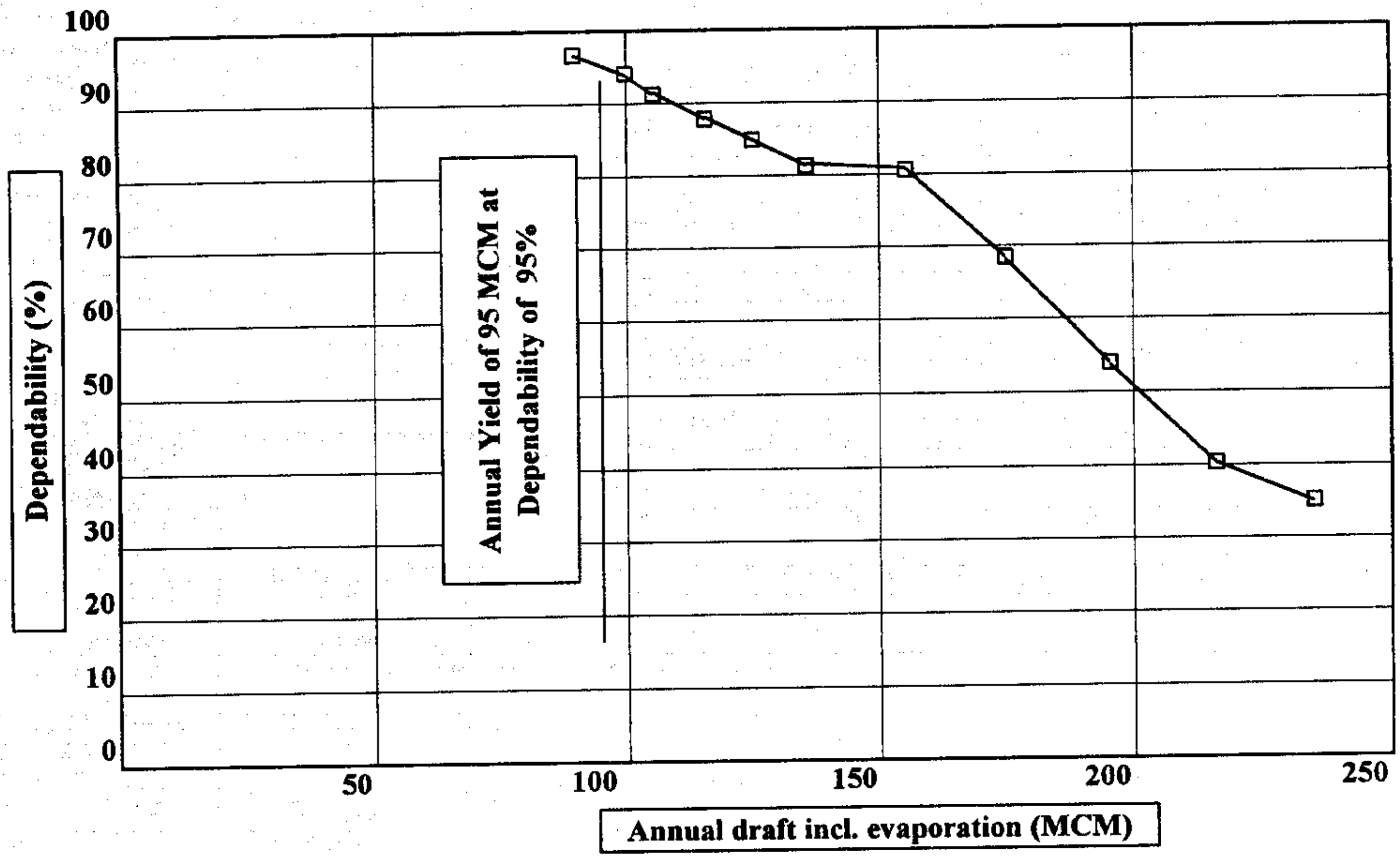


Figure E.2.2 Location Map of Alternative Water Resources

Figure E.2.3 Dependability of Annual Yield of Selechinsky Reservoir



Draft (MCM)	Dependability (%)	Draft (MCM)	Dependability (%)
90	96.7	135	81.2
95	95.0	155	81.2
100	93.3	175	68.8
105	90.6	195	53.1
115	87.5	215	40.6
125	84.4	235	34.4

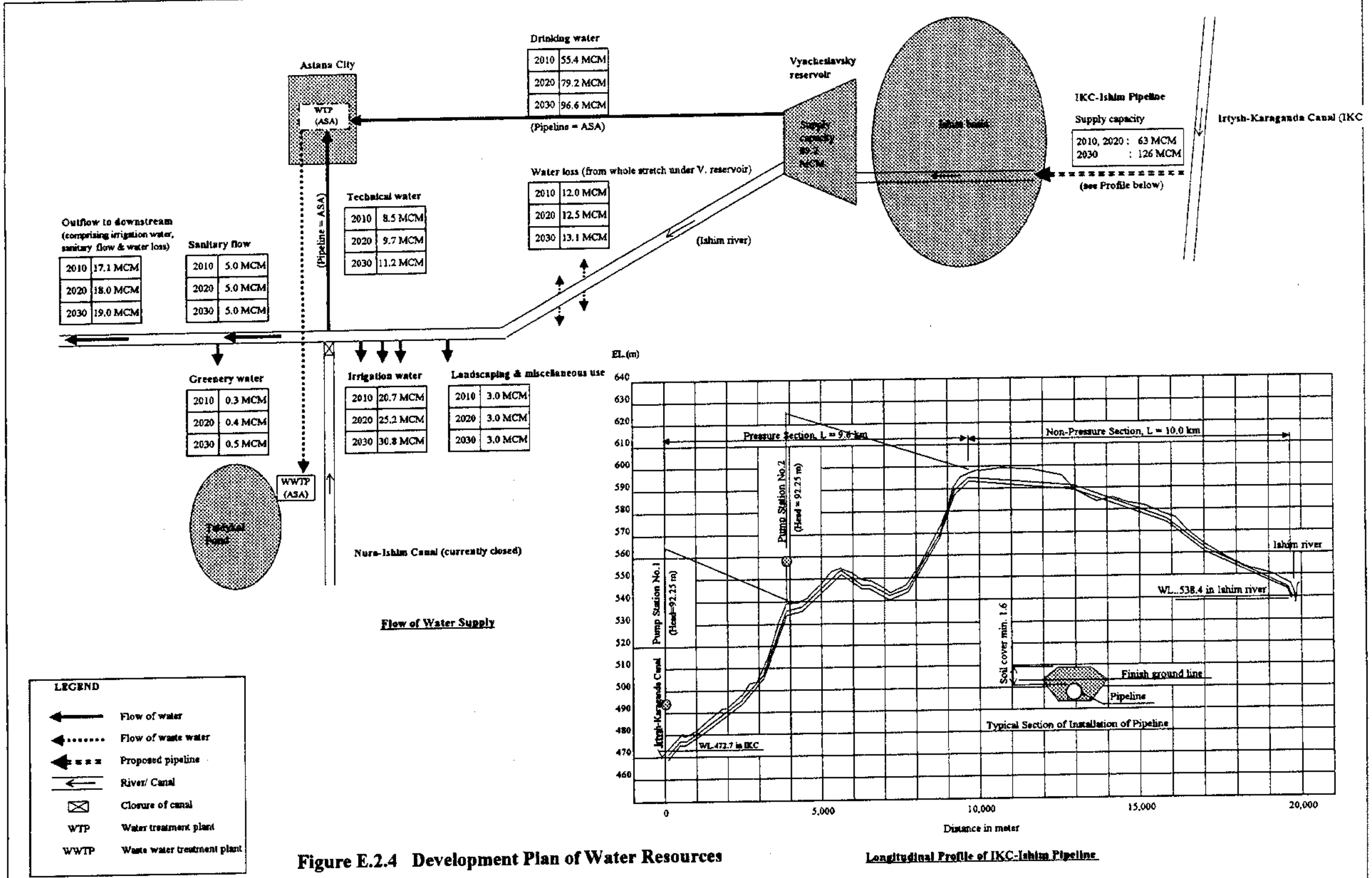


Figure E.2.4 Development Plan of Water Resources

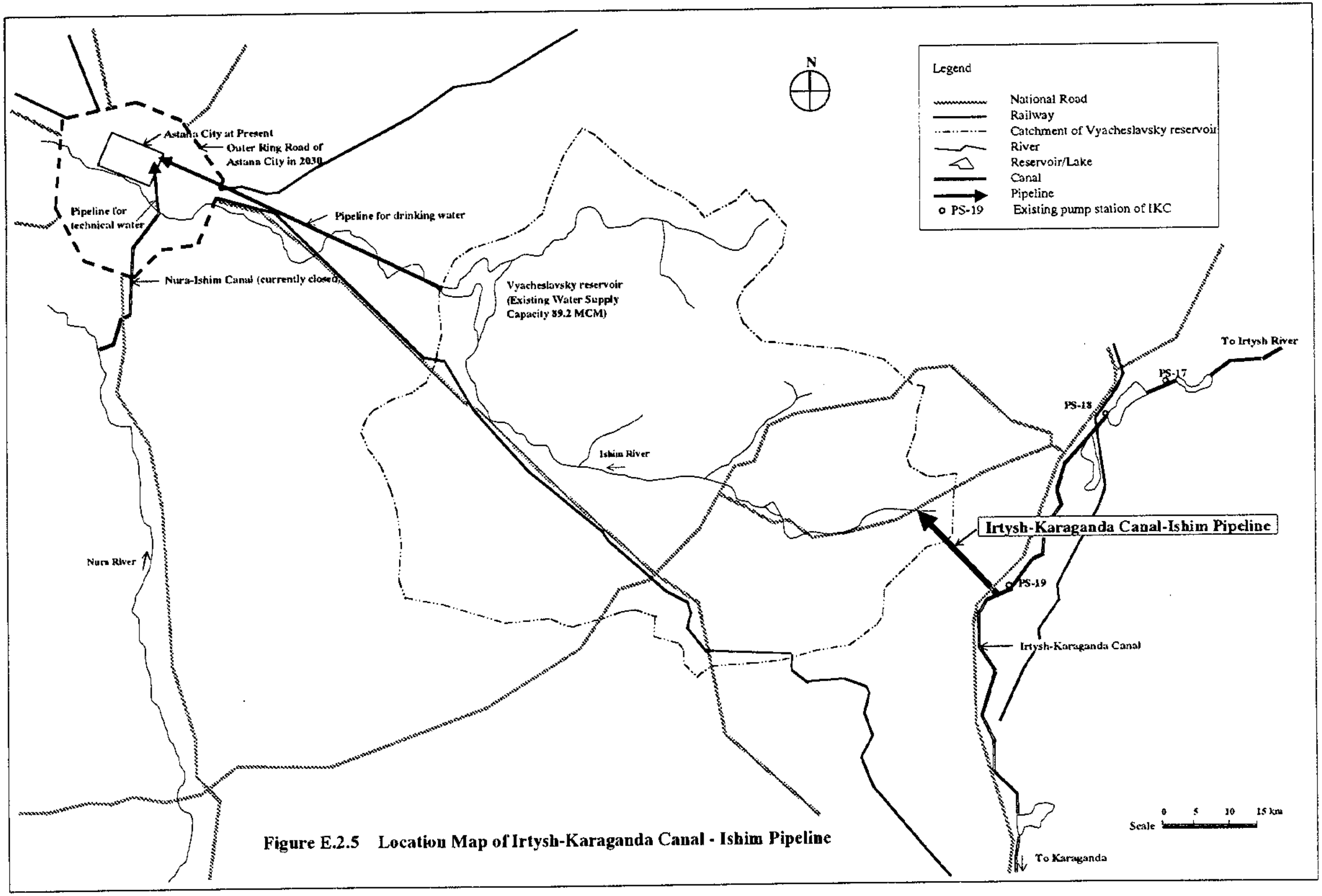


Figure E.2.5 Location Map of Irtysh-Karaganda Canal - Ishim Pipeline

ANNEX

Annex E.1 Water Balance of Vyacheslavsky Reservoir with Water Transfer from IKC

(1) Purpose of this Paper

This report presents the water balance of Vyacheslavsky reservoir with water transfer from the Irtysh-Karaganda Canal (IKC) to meet the water demands of 2010, 2020 and 2030 based on simulation of the reservoir operation of Vyacheslavsky reservoir.

(2) Water Demand

The water demand as discussed in the Master Plan is as the following.

Annual Water Demand in Target Years (MCM)

Item	1999	2010	2020	2030
Drinking	50.4	55.4	79.2	96.6
Technical water	6.5	8.5	9.7	11.2
Irrigation*1	2.7	20.7	25.2	30.8
Greenery	0.1	0.3	0.4	0.5
Sanitary flow	5.0	5.0	5.0	5.0
Landscaping and miscellaneous use	-	3.0	3.0	3.0
Water loss	-	12.0	12.5	13.1
Total	64.7	104.9	135.0	160.2

Note *1:Water requirement for limited period for forestation is not considered in this table.

The water demand for irrigation in the above table is given as 80% of the irrigation water requirement at 95% of water availability. In the simulation analysis, therefore, consumption of 100% of the irrigation water requirement is considered for up to 95% of the simulated period (in this calculation 28 years out of 30 years), while 80% of the requirement is considered for the rest of the period (2 years).

The following table indicates water requirement at Vyacheslavsky reservoir with irrigation water consumption at 100% and 80% of the requirement:

Annual Requirement for Intake and Release (MCM)

Item	2010	2020	2030
Required intake	55.4	79.2	96.6
Required release (*2)	(54.7) 49.5	(62.1) 55.8	(71.3) 63.6
Total (*2)	(110.1) 104.9	(141.3) 135.0	(167.9) 160.2

Note *1:Water requirement for limited period for forestation is not considered in this table.

*2:Figures in parentheses represent water requirement with consumption of 100% of irrigation requirement

(3) Water Balance Calculation

The first stage construction of the IKC-Ishim Pipeline Project is scheduled to be completed by July 2001, while the second stage construction is recommended to be completed by 2025, from the water balance point of view. It is presumed in the design of the IKC-Ishim Pipeline Project of Kazakhstan that 70% of the transferred volume through the pipeline is available at Vyacheslavsky reservoir. As a result, an annual volume of up to 63 MCM of IKC water is considered in the water balance calculation in 2010 and 2020, and up to 126 MCM in 2030, in addition to water supply from the Ishim basin.

A tentative operation rule is presumed in this water balance calculation that maintains minimum storage capacity equivalent to one-year reserve at the end of each year by water transfer from IKC.

The water balance calculation is made in Tables 1, 2 and 3. Notations representing each column of the tables are as follows:

1) Storage volume before annual spring flood
2) Inflow to the reservoir due to spring flood and precipitation in summer and autumn
3) Storage volume after spring flood
4) Water transfer from IKC, up to 63 MCM in 2010, 2020 and 126 MCM in 2030
5) Evaporation from reservoir, varies according to surface area of the reservoir
6) Total intake = Raw water demand for drinking water
7) Total release = Water demand other than drinking water, irrigation water is reduced to 80% of the requirement at 95% of water availability
8) Total = total consumption ((6) + (7)) + evaporation

(4) Assessment of Water Balance Result

As seen in Tables 1 and 3, the Vyacheslavsky reservoir is found to meet the water demand in 2010 and 2030 for the simulated period of 30 years without deficits, if the IKC project is implemented as proposed in the Master Plan.

On the other hand, water deficit will take place once in 30 years in 2020 (see the shaded part of Table 2). Considering the simulation period of 30 years, this result indicates the water availability of 96.7%. Compared with the minimum requirement of water availability of 95% according to SNiP 2.04.02-84, it can be concluded that the water balance is secured up to 2030. Figures 1 through 3 graphically presents water balance with water transfer from IKC in the reviewed horizon years of 2010, 2020 and 2030.

Table 1 Water Balance Calculation of Vyacheslavsky Reservoir with Water Transfer from IKC (Year 2010)

Year	Before Flood (MCM)	Gross Inflow (MCM)	After Flood (MCM)	Water transfer from IKC<1 (MCM)	Evaporation from Reservoir (MCM)	Consumption		
						Total Intake (MCM)	Total Release (MCM)	Total outflow (MCM)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1970		215.00	390.00	0.00	35.00	55.40	54.70	145.10
1971	244.90	276.00	390.00	0.00	35.00	55.40	54.70	145.10
1972	244.90	397.00	390.00	0.00	35.00	55.40	54.70	145.10
1973	244.90	411.00	390.00	0.00	35.00	55.40	54.70	145.10
1974	244.90	86.00	330.90	0.00	35.00	55.40	54.70	145.10
1975	185.80	51.00	236.80	0.00	20.00	55.40	54.70	130.10
1976	106.70	258.00	364.70	0.00	35.00	55.40	54.70	145.10
1977	219.60	128.00	347.60	0.00	35.00	55.40	54.70	145.10
1978	202.50	66.00	268.50	0.00	20.00	55.40	54.70	130.10
1979	138.40	342.00	390.00	0.00	35.00	55.40	54.70	145.10
1980	244.90	94.00	338.90	0.00	35.00	55.40	54.70	145.10
1981	193.80	63.00	256.80	0.00	20.00	55.40	54.70	130.10
1982	126.70	88.00	214.70	20.20	20.00	55.40	54.70	130.10
1983	104.80	280.00	384.80	0.00	35.00	55.40	54.70	145.10
1984	239.70	203.00	390.00	0.00	35.00	55.40	54.70	145.10
1985	244.90	320.00	390.00	0.00	35.00	55.40	54.70	145.10
1986	244.90	299.00	390.00	0.00	35.00	55.40	54.70	145.10
1987	244.90	248.00	390.00	0.00	35.00	55.40	54.70	145.10
1988	244.90	256.00	390.00	0.00	35.00	55.40	54.70	145.10
1989	244.90	113.00	357.90	0.00	35.00	55.40	54.70	145.10
1990	212.80	353.00	390.00	0.00	35.00	55.40	54.70	145.10
1991	244.90	298.00	390.00	0.00	35.00	55.40	54.70	145.10
1992	244.90	77.00	321.90	0.00	35.00	55.40	54.70	145.10
1993	176.80	544.00	390.00	0.00	35.00	55.40	54.70	145.10
1994	244.90	82.00	326.90	0.00	35.00	55.40	54.70	145.10
1995	181.80	165.00	346.80	0.00	35.00	55.40	54.70	145.10
1996	201.70	226.00	390.00	0.00	35.00	55.40	54.70	145.10
1997	244.90	255.00	390.00	0.00	35.00	55.40	54.70	145.10
1998	244.90	48.00	292.90	0.00	20.00	55.40	54.70	130.10
1999	162.80	30.00	192.80	36.90	20.00	55.40	49.50	124.90
2000	104.80	28.00	132.80	63.00	15.00	55.40	49.50	119.90
2001	75.90							
Total				120.10				

Table 2 Water Balance Calculation of Vyacheslavsky Reservoir with Water Transfer from IKC (Year 2020)

Year	Before Flood (MCM)	Gross Inflow (MCM)	After Flood (MCM)	Water transfer from IKC<1 (MCM)	Evaporation from Reservoir (MCM)	Consumption		
						Total Intake (MCM)	Total Release (MCM)	Total outflow (MCM)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1970	153.00	215.00	355.00	0.00	35.00	79.20	62.10	176.30
1971	178.70	276.00	390.00	0.00	35.00	79.20	62.10	176.30
1972	213.70	397.00	390.00	0.00	35.00	79.20	62.10	176.30
1973	213.70	411.00	390.00	0.00	35.00	79.20	62.10	176.30
1974	213.70	86.00	299.70	16.60	35.00	79.20	62.10	176.30
1975	140.00	51.00	191.00	63.00	20.00	79.20	62.10	161.30
1976	92.70	258.00	350.70	0.00	35.00	79.20	62.10	176.30
1977	174.40	128.00	302.40	7.60	30.00	79.20	62.10	171.30
1978	138.70	66.00	204.70	63.00	20.00	79.20	62.10	161.30
1979	106.40	342.00	390.00	0.00	35.00	79.20	62.10	176.30
1980	213.70	94.00	307.70	8.60	35.00	79.20	62.10	176.30
1981	140.00	63.00	203.00	63.00	30.00	79.20	62.10	171.30
1982	94.70	88.00	182.70	63.00	35.00	79.20	62.10	176.30
1983	69.40	280.00	349.40	0.00	35.00	79.20	62.10	176.30
1984	173.10	203.00	376.10	0.00	35.00	79.20	62.10	176.30
1985	199.80	320.00	390.00	0.00	35.00	79.20	62.10	176.30
1986	213.70	299.00	390.00	0.00	35.00	79.20	62.10	176.30
1987	213.70	248.00	390.00	0.00	35.00	79.20	62.10	176.30
1988	213.70	256.00	390.00	0.00	35.00	79.20	62.10	176.30
1989	213.70	113.00	326.70	0.00	35.00	79.20	62.10	176.30
1990	150.40	353.00	390.00	0.00	35.00	79.20	62.10	176.30
1991	213.70	298.00	390.00	0.00	35.00	79.20	62.10	176.30
1992	213.70	77.00	290.70	25.60	35.00	79.20	62.10	176.30
1993	140.00	544.00	390.00	0.00	35.00	79.20	62.10	176.30
1994	213.70	82.00	295.70	20.60	35.00	79.20	62.10	176.30
1995	140.00	165.00	305.00	11.30	35.00	79.20	62.10	176.30
1996	140.00	226.00	366.00	0.00	35.00	79.20	62.10	176.30
1997	189.70	255.00	390.00	0.00	35.00	79.20	62.10	176.30
1998	213.70	48.00	261.70	43.30	30.00	79.20	62.10	171.30
1999	133.70	30.00	163.70	63.00	20.00	79.20	55.80	155.00
2000	71.70	28.00	99.70	63.00	10.00	79.20	42.50	131.70
2001	31.00							
Total				511.60				

Table 3 Water Balance Calculation of Vyacheslavsky Reservoir with Water Transfer from IKC (Year 2030)

Year	Before Flood (MCM)	Gross Inflow (MCM)	After Flood (MCM)	Water transfer from IKC<1 (MCM)	Evaporation from Reservoir (MCM)	Consumption		
						Total Intake (MCM)	Total Release (MCM)	Total outflow (MCM)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1970	153.00	215.00	368.00	0.00	35.00	96.60	71.30	202.90
1971	165.10	276.00	390.00	0.00	35.00	96.60	71.30	202.90
1972	187.10	397.00	390.00	0.00	35.00	96.60	71.30	202.90
1973	187.10	411.00	390.00	0.00	35.00	96.60	71.30	202.90
1974	187.10	86.00	273.10	89.80	35.00	96.60	71.30	202.90
1975	160.00	51.00	211.00	126.00	30.00	96.60	71.30	197.90
1976	139.10	258.00	397.10	0.00	35.00	96.60	71.30	202.90
1977	194.20	128.00	322.20	38.00	35.00	96.60	71.30	202.90
1978	157.30	66.00	223.30	126.00	30.00	96.60	71.30	197.90
1979	151.40	342.00	390.00	0.00	35.00	96.60	71.30	202.90
1980	187.10	94.00	281.10	81.80	35.00	96.60	71.30	202.90
1981	160.00	63.00	223.00	126.00	30.00	96.60	71.30	197.90
1982	151.10	88.00	239.10	121.10	35.00	96.60	71.30	202.90
1983	157.30	280.00	390.00	0.00	35.00	96.60	71.30	202.90
1984	187.10	203.00	390.10	0.00	35.00	96.60	71.30	202.90
1985	187.20	320.00	390.00	0.00	35.00	96.60	71.30	202.90
1986	187.10	299.00	390.00	0.00	35.00	96.60	71.30	202.90
1987	187.10	248.00	390.00	0.00	35.00	96.60	71.30	202.90
1988	187.10	256.00	390.00	0.00	35.00	96.60	71.30	202.90
1989	187.10	113.00	300.10	62.80	35.00	96.60	71.30	202.90
1990	160.00	353.00	390.00	0.00	35.00	96.60	71.30	202.90
1991	187.10	298.00	390.00	0.00	35.00	96.60	71.30	202.90
1992	187.10	77.00	264.10	98.80	35.00	96.60	71.30	202.90
1993	160.00	544.00	390.00	0.00	35.00	96.60	71.30	202.90
1994	187.10	82.00	269.10	93.80	35.00	96.60	71.30	202.90
1995	160.00	165.00	325.00	37.90	35.00	96.60	71.30	202.90
1996	160.00	226.00	386.00	0.00	35.00	96.60	71.30	202.90
1997	183.10	255.00	390.00	0.00	35.00	96.60	71.30	202.90
1998	187.10	48.00	235.10	120.10	30.00	96.60	71.30	197.90
1999	157.30	30.00	187.30	126.00	30.00	96.60	63.60	190.20
2000	123.10	28.00	151.10	126.00	25.00	96.60	63.60	185.20
2001	91.90							
Mean				1374.10				

Figure 1 Simulation on Water Balance of Vyacheslavsky Reservoir with Water Transfer from IKC (Year 2010)

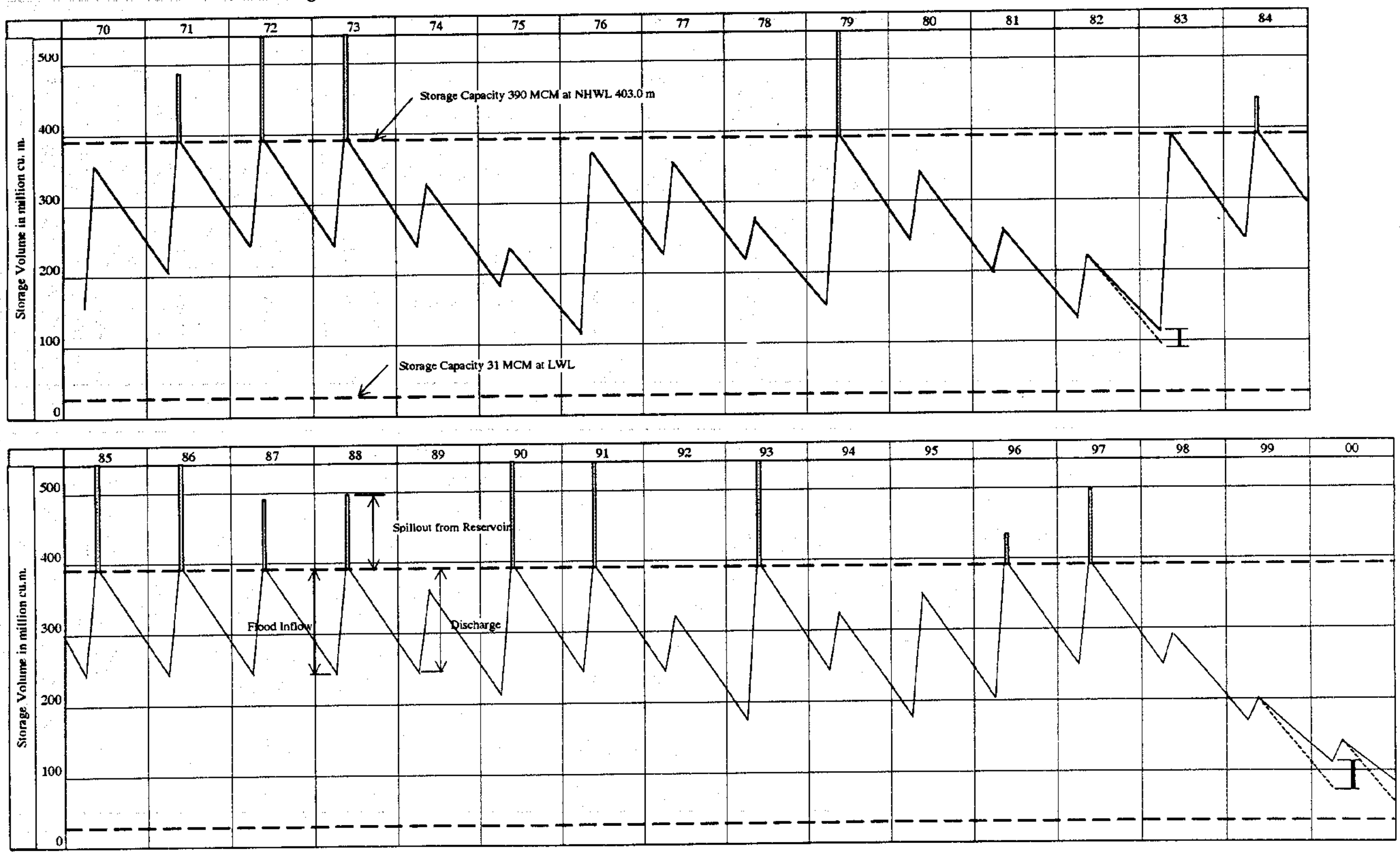


Figure 2 Simulation on Water Balance of Vyacheslavsky Reservoir with Water Transfer from IKC (Year 2020)

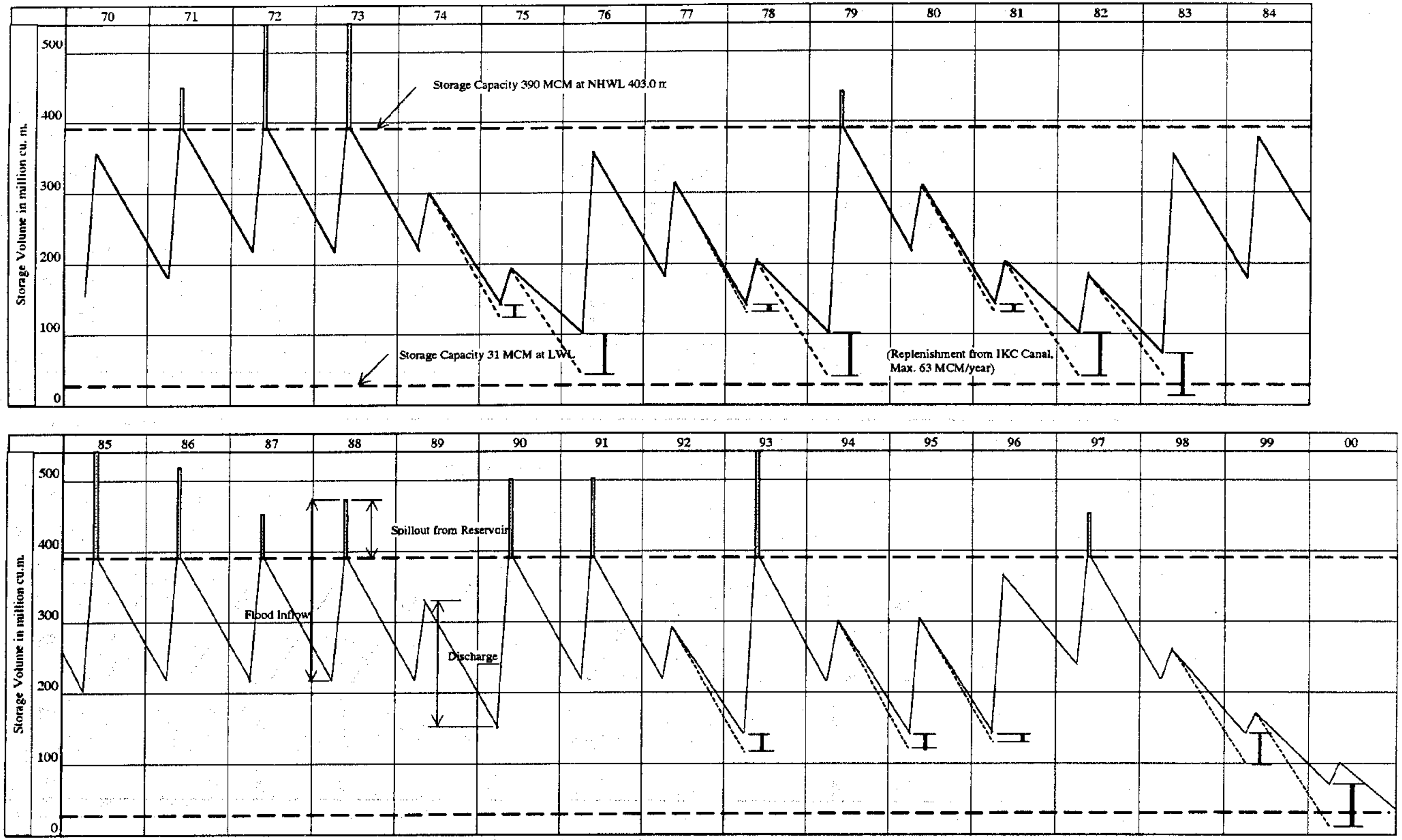
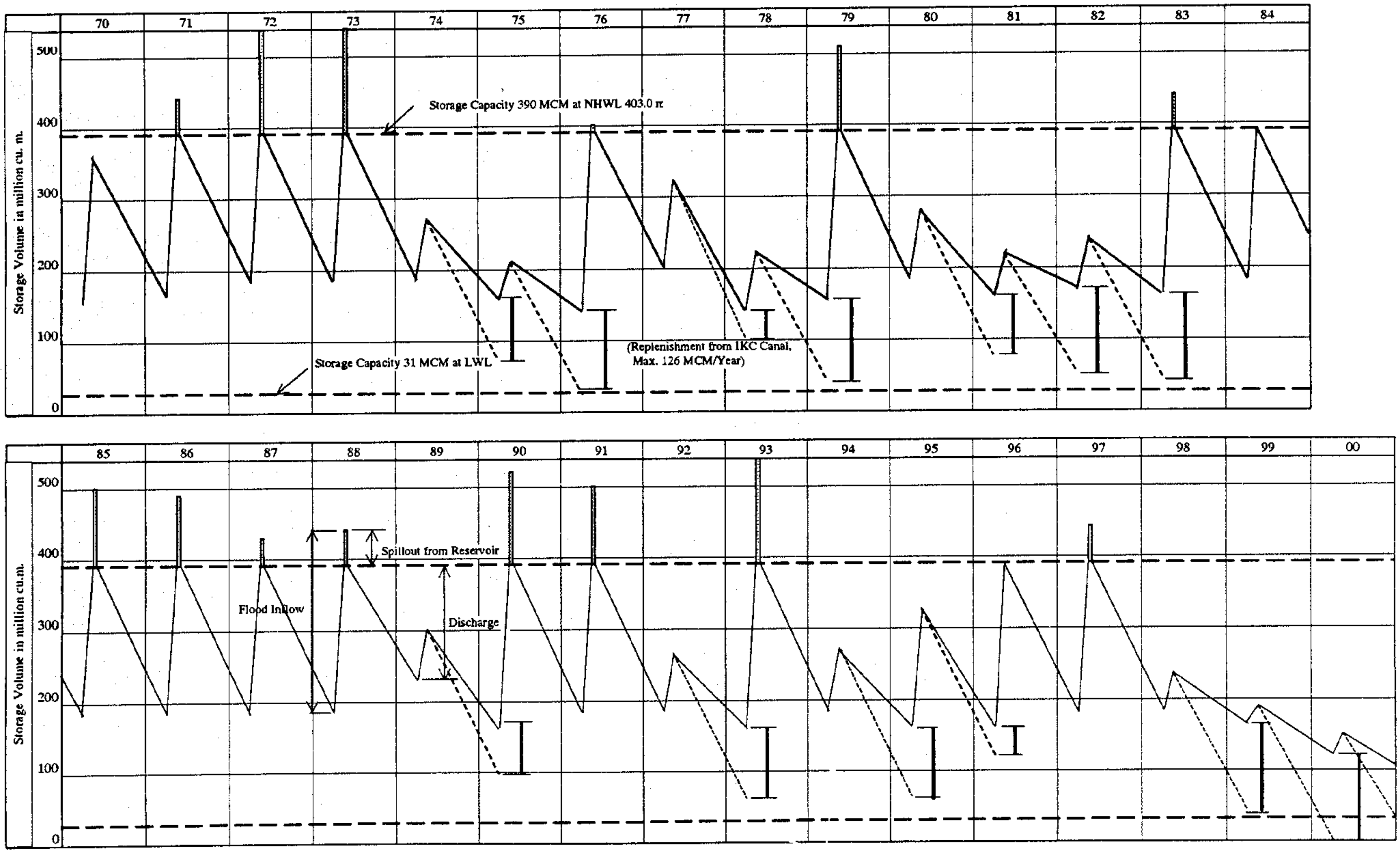


Figure 3 Simulation on Water Balance of Vyacheslavsky Reservoir with Water Transfer from IKC (Year 2030)



CHAPTER F
WATER SUPPLY

SUPPORTING REPORT F: WATER SUPPLY

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F.1 Present Conditions of Water Supply

Water supply in Astana City was started in 1937, and Gorvodokanal, a municipal enterprise for operation and maintenance of water supply and sewerage system in Astana City, was established in 1959. The enterprise was renamed in 2000 as ASA (Astana Su Arancy), which name will be used in this report hereafter. During the 63 years of operation, the service area has been expanded to some 55 km^2, covering the population of 321,600 in 2000. The water supply system consists of drinking water supply for domestic and commercial users and technical water supply, with non-treated river water, mainly for factories.

Location of the existing water supply facility is shown in Figure F.1.1 and F.1.2.

F.1.1 Water Sources

There are two major water sources, Vyacheslavsky Reservoir and the Ishim River, while one well also supplies water to the isolated system. Vyacheslavsky Reservoir shall be replenished with Irtysh-Karaganda Canal water and increase annual yield by on-going Irtysh-Karaganda Canal-Ishim Pipeline Scheme. Nura-Ishim Canal is closed at present due to water contamination by technical wastewater containing mercury. The World Bank, however, has started "Kazakhstan-Environment Management and Rehabilitation Project (including Mercury Clean Up of Nura River)".

Operation records of intake pump facilities at Vyacheslavsky Reservoir and Ishim River from March 15 to November 25, 2000 show the following operation. Actual flows in this period are shown in Figure F.1.3.

(Unit : m^3/day)

Location	Vyacheslavsky Res.	Ishim River	Total
Maximum	154,997	106,219	206,002
Average	115,332	45,746	150,058
Minimum	30,240	7,778	125,238

During 256 days of operation, intake flow from the river was larger than from the reservoir in 40 days, mostly from early in April to middle of May. This fact indicates that whenever water is available at the Ishim River, water was taken principally from the river.

Water quality of water sources is shown in Table F.1.1, which indicates maximum figures in 1999.

F.1.2 Raw Water Intake and Transmission Facilities

The total design capacity of two intake pumps at Vyacheslavsky Pump Station is 196,560 m^3/day, but actual intake volume is reported at around 150,000 m^3/day. Meanwhile, Ishim River Pump Station with an original design pump capacity of 110,400 m^3/day is considerably larger than the current average intake amount of 45,746 m^3/day. This surplus pump capacity is only used when river water is available during spring flood period, water quality in Vyacheslavsky Reservoir gets worse and/or pumps in Vyacheslavsky Pump Station are malfunctioning.

There are two transmission pipes to conduct water from Vyacheslavsky Reservoir to the Water Treatment Plant. Both pipes have a diameter of 1,000 mm and a length of 51 km and they were installed in 1967 and 1988, respectively. Since the capacity of the intake pump is larger than the practical transmission capacity of around 150,000 m^3/day, the intake flow by the pumps shall be regulated by delivery valves to prevent pipe breakage due to high pressure. A separate raw water transmission pipe was installed from Ishim River to the Water Treatment Plant with a diameter of 1,000 mm and 9 km long, and it works without problem. Details of major intake pump facilities are shown in Table F.1.2.

F.1.3 Water Treatment Plant

The existing water treatment plant is located 4 km east of the city center. This plant was constructed in two stages, the first stage in 1969 and the second in 1982. The plant has an original production capacity of 200,000 m^3/day and it mainly treats the raw water extracted and transmitted from Vyacheslavsky Reservoir. The technical water is extracted and transmitted from the Ishim River to the plant, and it is supplied without treatment.

Layout of the existing water treatment plant is shown in Figure F.1.4.

(1) Water Treatment Process

The water treatment plant utilizes a treatment process consisting of coagulation, sedimentation and filtration. Chlorine and alum (aluminum sulfate) as coagulants are dosed at inlet pipes to mixing tanks to facilitate impurity removal in raw water. After mixing of coagulants at the mixing tanks for a mixing period of 5 minutes, the water flows into twenty sedimentation tanks. Sedimentation tanks are fully covered and major impurity is settled as sludge in these tanks. The tanks have two compartments, one for flocculation with 16.5 minutes of retention and another for settling with 2.8 hours retention. The dose of coagulant is done from April to November, when water quality of raw water is relatively bad. Acryl amide polymer and activated carbon powder is also injected seasonally, only when turbidity, odor or color in raw water is high, especially in spring. Supernatant at sedimentation tanks goes through ten filters. Each filter has 107 m^2 of filter bed and filters are operated continuously for 12 to 24 hours after back washing. The filters are designed to treat water with the filtration speed of 187 m/day and no other washing than backwashing with clear water. Filtered water is disinfected by chlorine and stored in two clear water reservoirs. Sludge from sedimentation tanks and backwash wastewater is directly discharged to the nearest stream, Solyonaya Balka. In 1999, 3.8 million m^3 of water loss, including leakage from transmission pipelines was recorded, which accounts for 8.8% of intake water. Details of major facilities are shown in Table F.1.3.

Water from the Ishim River is stored in two reservoirs without treatment and is supplied as technical water. These four reservoirs (two for drinking water and two for technical water) are located between the plant and Distribution Pump Station.

Drinking water produced in recent years at this plant was approximately 146,000 m^3/day on the average, while technical water produced was approximately 32,000 m^3/day[1].

A major problem of this plant is that the original production capacity cannot be fully utilized now nor in the future due to severe deterioration of the mechanical and electrical equipment. There are also some problems coming from the system design, such as turbulence in sedimentation tanks and short filtration period due to improper washing of filter beds. Since the actual production has not been pushed to its limit and quality of raw water has been relatively good, potential problems have not come to surface up to now. As for the operation and maintenance, the plant is in a very difficult condition with regard to monitoring of the operating conditions, and repairing and replacement of equipment.

[1] Discrepancy exists in extracted and provided drinking and technical water amounts, reflecting the limited availability of flow measurement results.

(2) Distribution Pump Station

Distribution pump stations for both drinking and technical water are located in the same building. Drinking water and technical water are supplied by six pumps, and the detailed specification of these pumps is shown in Table F.1.4.

While observing pressures in distribution mains, operators manually control the number of pumps in operation. Early in 2000, flowmeters were installed to measure flows of the raw water inflow and the outflow for both drinking and technical water distributions to TETs 2. However, no flow measurement is conducted for the main distribution of drinking water.

No.7 Booster Pump Station was constructed in 1975 to serve the Industrial Estate, which was planned in north west of the City. Drinking water is stored in two reservoirs with capacity of 3,000 m^3/unit. Three units of centrifugal pumps with a capacity of 1,500 m^3/hr, including one unit as stand-by, are installed, and, only one pump is mainly operated currently.

Alyuviy Booster Pump Station was constructed in 1960 to supply water for Airport Area. Two units of circular service reservoirs with capacity of 500 m^3/unit were constructed. Two pumps, including one stand-by pump, were installed with a capacity of 200 m^3/hr. The pump will be operated, when the water pressure in the pipeline is lowered below 4 kg/cm^2. This Pump Station was seldom operated in recent years except at a time of an accident in treatment plant.

F.1.4 Distribution Network

Since ASA supplies drinking water and technical water, two separate distribution systems are facilitated in the city. Unaccounted-for-water was reported to be 8.9 million m^3 in 1999, and this volume was equal to 22.7% of distributed water from the water treatment plant.

Taking into consideration of sewage inflow data at the existing sewage treatment plant, the JICA Feasibility Study examined that the leakage from the distribution network was estimated at 26.2 % of the supplied volume from the water treatment plant, while the leakage and wastage at the consumer's facilities were estimated at 20.1 %. In total, 46.3 %, about a half of distributed drinking water is not used effectively.

(1) Drinking Water

For residents in Astana City, water supplied by ASA is the only water source for their living. The drinking water distribution network consists of pipes with diameters of 1,000 mm to 50 mm with the total length of 489.3 km. These pipes are mainly cast iron pipes and steel pipes, while asbestos pipes and polyethylene pipes are used in limited quantities. The distribution system is a pressured distribution system without using elevated reservoirs or tanks. The pressure of the system is required to be enough to supply water up to five-story apartments without booster pumps, while buildings with more than five stories have booster pump stations operated by ASA.

The network supplies to about 90,000 connections and 340 public faucets of domestic users and 1,800 commercial, industrial users or public utilities.

(2) Technical Water

Technical water is mainly supplied to factories. The technical water distribution network mainly extends to the industrial area located in the northern part of the city. It consists of three main pipes, a 800 mm pipeline for TETs (Heat and Electric Power Generating Station) No.1, a 1,000 mm for TETs No.2 and a 1,000 mm for other enterprises. These pipes belong to each individual enterprise.

At present, twelve factories use technical water, and TETs 1 & 2 are the major consumers among them.

F.1.5 Water Use

Flowmeters had not been used for measuring water flows in the pipelines until recently. The following is based on the estimation by ASA in 1999, based on the operation hours of pumps etc, which may contain 10 to 20% of error.

(1) Drinking Water

According to ASA's reports, drinking water is grouped into three categories; domestic use, public use and others. The domestic use consists of water consumption at living places, such as apartments, houses and public faucets. The public use refers to the water consumption at governmental offices, schools, hospitals etc, and others include water consumption at working places such as enterprises, hotels, restaurants, shops etc. Water consumption by these three categories in 1998, 1999 and 2000 (plan) is as follows.

Water Consumption by Category

Year	Annual (MCM)			Daily (m3/day) equivalent to annual			Per capita (lpcd)		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
Domestic use	13.670	17.080	21,304	37,500	46800	58,400	135	155	181
Public use	2.271	1.762	2,076	6,200	4,800	5,700	22	16	18
Others uses	9.701	8.070	8,124	26,600	22,100	22,300	96	73	69
Total	25.642	26.912	31,504	70,300	73,700	86,300	253	244	286

Domestic Water Use

Domestic consumption is divided into twelve users (categories) by housing type, service level of water and heat supply, water facilities (bath and shower) etc. These categories can be summarized into the following three groups, and water consumption per capita per day for each group is as follows.

Type (Lpcd)	Range (Lpcd)	Ave. (Lpcd)	Population 1998	Population 1999	Water Consumption (m^3/day) 1998	Water Consumption (m^3/day) 1999
High	250	250	156,400 (52%)	172,000 (57%)	39,100 (75%)	43,000 (83%)
Middle	85-230	151	48,100 (16%)	48,100 (16%)	7,254 (14%)	7,254 (14%)
Low	22-30	22	72,330 (24%)	80,700 (27%)	1,613 (3%)	1,808 (3%)
Total		173	276,900	300,800	47,967	52,062

Source: Data from ASA. (The above population was estimated by ASA.)

Feasibility Study Team has reviewed drinking water consumption by measuring actual flows, and the results reveal that more water was consumed in 1999.

The summary of the result is as follows.

Drinking Water (Unit: 1,000 m^3/Year)

Category	1999
Domestic use	54,920 (183 Lpcd)
Public use	4,814 (16 Lpcd)
Others uses	14,790 (49 Lpcd)
Sub-Total	19,604 (65 Lpcd)
Total (m^3/day)	75,524 (248 Lpcd)

Domestic Water Consumption (Unit: m^3/day)

Type	ASA (Lpcd)	Actual (Lpcd)	Population	Water Consumption (m^3/day)
High	250	270	172,000 (57%)	46,440 (85%)
Middle	85-230	130	52,200 (17%)	6,795 (12%)
Low	22-30	22	76,600 (26%)	1,685 (3%)
Total		183	300,800	54,920

Availability of watermeters at connection differentiates the consumption. There are about 9,400 flats with individual watermeters while some part of the remainder are equipped with bulk watermeters, total number of which is approximately one hundred, wherein a watermeter measures the total water consumption for the community in an entire apartment building. Actual water consumption was analyzed to collate the effects of individual watermetering on consumption, using the data on water measurements for 102 flats and 41 communities with bulk meters.

Comparison of per capita water consumption of these two groups of users, one with a bulk watermeter and the other with individual watermeter are shown in the following table.

Comparison of Per Capita Water Consumption

Lpcd	Bulk Watermeter	Individual Watermeter
Minimum	116.7	51.7
Average	283.1	132.5
Maximum	428.2	750.0
Median	293.9	130.6

Comparison of these two samples is shown in Figure F.1.5.

People living in flats with individual watermeters consumed only 130 Lpcd, while, those in apartments with bulk watermeters consumed as much as 294 Lpcd. This signifies that a significant gap exists between the two groups of consumers with substantial latent wastage of water in apartments with bulk watermeters. A large part of this gap is presumably caused by lack of bulk watermeter and consumers' inattentiveness to water use. To raise the consumers' attentiveness on water use shall be a key step in rationalizing the water use in the future in Astana City.

Public/Industry/Commercial Water Use

Among public, industrial and commercial water uses, two heat and electric power generating stations (TETs 1&2) are the largest consumers.

Consumer	Water Consumption (m^3/day)	Employment (1999)	Per employee Consumption (l)
Public	4,814	36,100	133
Industry/Commercial	14,790	111,200	133
TETs-1&2	22,260	-	-
Total	26,864	147,300	-

ASA is promoting to install watermeters to public, industrial and commercial water uses, and approximately 1,800 watermeters are installed for these users. According to ASA's record, "Akmola-Astyk (bakery)", "JSC-Narkes (food processing factory)", "International Airport - Astana" etc are the large consumers.

Drinking water was used for make-up water of hot water circulation pipeline in TETs 2. Technical water however was started to be use for this purpose in 1999, due to the lower cost.

(2) Technical Water

At present, there are twelve consumers for technical water, but TETs-1 and 2 are the major consumers. They consumed 96.8% of total technical water supply of 5.57 million m^3 in 1999, while the remaining factories used only 0.19 million m^3 in the same year.

Maximum water consumption of 28,972 m^3/day was recorded in February, while a minimum of 4,630 m^3/day in July. This was caused by the seasonal fluctuation of water consumption at TETs 1 and 2, which are mainly operated in winter.

It was also reported that the consumption of technical water was 9.3 million m^3 in 1990 and 15 million m^3 in 1995. The rapid decrease of technical water consumption after 1995 shows the decline of local industries.

F.1.6 Problems of the Existing Water Supply System

(1) Water Source

The flood inflow from the spring floods in 1998 to 2000 was very little, and the current storage of Vyacheslavsky Reservoir is reducing for last three years. The present situation is critical, and an additional water source is required for future increase of water consumption.

(2) Intake Pump Station

Due to the less availability of pumps in the NIS countries, the performances of the existing pumps are not properly matched to the operations for both intake pump stations at Vyacheslavsky Reservoir and Ishim River. The existing civil structure of intake pump station at the reservoir is still operational but improvement work will be extremely difficult since most facilities are located in the underground.

(3) Raw Water Transmission Pipeline

The existing two lines of transmission pipes, especially old one, have already started to deteriorate and they don't have enough durability against the full pump capacity. The flow rate and pressure have to be regulated by valve control to prevent pipe breakage from high pressure.

(4) Water Treatment Plant

There are some critical design problems to secure appropriate quality of treated water, coming from the system design, such as turbulence in sedimentation tanks, short filtration period due to improper washing of filter beds, etc. There are also structural problems, such as concrete cover over flocculation tanks and the sedimentation basin, which is disturbing the visual investigation on water treatment status and future improvement works. Other major problem of this plant is superannuating of mechanical and electrical equipment and this causes the original production capacity cannot be fully utilized now. As for the operation and maintenance, the plant is in a very difficult condition with regard to monitoring of the operating conditions, and repairing and replacement of equipment.

(5) Distribution Pump Station

Flowmeters had not been used for measuring water flows in the pipelines until recently, and delivered water is not fully measure at present. Flow records of ASA are based on the estimation, related to the operation hours of pumps etc, which may contain 10 to 20% of error.

(6) Distribution Network

According to JICA Feasibility Study, the leakage from the distribution network was estimated at 26.2 % of the supplied volume from the water treatment plant. One fifth of distribution pipes were installed forty years ago, and there are reports of 390 bursts in1998. However, no major replacement work has been conducted.

(7) Water Usage

The leakage and wastage at the consumer's facility was estimated 20.1 % in JICA Feasibility Study. Only limited data on actual water consumption was available, but it was reported that the facility was in generally poor condition and the leakage and wastage was considerably large.

F.1.7 Planned and Scheduled Improvements

(1) Third Pipeline from Vyacheslavsky Reservoir to Water Treatment Plant

Although bidding for the third pipeline from the reservoir to the plant was carried out, the bid by a French contractor was canceled after reviewing the proposed terms and conditions. Kazakhstan Government has decided to implement this pipeline installation by local funding.

(2) Water Treatment Plant

Replacement of filter sand and repair of electrical equipment are planned and some part of the budget will be allocated from Akimat in 2001.

(3) Distribution

Flowmeters and Watermeter

Installation of flowmeters at major water supply facilities as well as the installation of watermeters at major consumers is on going.

(4) European Bank for Reconstruction and Development

As part of the TACIS interstate project Widening the Environmental Action Program to the NIS and Mongolia, EBRD undertook a pre-investment feasibility assessment for funding in water supply and environmental infrastructure in Astana. The overall objective of the project is the introduction of sustainable, safe and efficient water and wastewater services in Astana. More specifically its purposes are to:

- improve the quality and efficiency of the City's water and wastewater services through financial and operational performance improvements and priority rehabilitation investments.
- increase autonomy and corporatisation, and improved financial viability for Astana Su Arancy (ASA) through institutional strengthening and private sector involvement.

The results of the financial modeling show that the following measures will be required to service a loan of 14m US$.

- Tariff re-structuring and increases to nearly the maximum affordable level.
- Improvements to of revenue collection to give an overall realization of around 88% by the year 2004.
- Progress towards decrease of leakage, and reduction of metered household consumption by 30% of present normative consumption with full application of measured tariffs by the year 2010.
- Either a direct Akimat subsidy of 50m Tg. (0.35m US$) per year to support repayments or relief for ASA from all taxes except the Social Tax for a period of 5-7 years.

It is recommended that discussions with the Akimat be continued to determine whether these conditions are likely to be realizable.

This project is dormant now, for a clear and explicit commitment for managerial improvement of ASA, which is a prerequisite of financing by EBRD and which has not been approved by *Akimat*.

F.2 Basic Concepts for Water Supply Development Plan

F.2.1 Principles for Water Supply System Development

Observing the existing and current operation of water supply system, the following principles will be considered for establishing water supply system development in Astana City.

a. Reliable water supply system shall be established for new capital city of Astana.

b. Valuable water resources shall be used effectively, therefore loss and wastage of water supply system shall be minimized.

c. Water supply system shall be efficient to fit for ASA as self-supported organization.

F.2.2 Framework for Water Supply System Development

In this Sub-section, the framework for water supply system development in Astana City is discussed and established.

(1) Population

As for the future population in the city, the result of the population forecast Case 3 described in Chapter 2.2 is applied.

The present urban areas, most of which extend on the right bank of Ishim River, accommodate the present population of Astana. By 2030, improvement and upgrading of the existing urban areas will have been implemented and the total population in those areas is estimated to be about 400,000. The remaining 400,000 in 2030 will be accommodated in new urban areas mainly on the left bank of Ishim River.

Population Projection for Astana up to 2030

Planning Region	2000	2010	2020	2030
Central	176,000	191,000	213,000	220,000
Northern	16,000	9,000	9,000	9,000
Southeastern	92,000	217,000	283,000	283,000
Southern	16,000	42,000	98,000	188,000
Northwestern	31,000	31,000	87,000	100,000
Total	331,000	490,000	690,000	800,000

(2) Employment

As stipulated in the Sub-section 2.2, Astana will be a government, business and industrial city. Astana as the capital city will require highly cultural, medical and educational facilities. Workforce involved in such public services will continue to account for a large portion of the total employment in this city.

In the long run, Astana will expand its light industry including food processing, agricultural machine fabrication as well as agricultural product transportation and commercial activities. Other services include hotels and restaurants, financial activities, real estates etc.

In order to utilize this for water demand projection, number of employees is divided into three categories, (1) Public (2) Industry, and (3) Commercial.

Employment Projection for Astana up to 2030

Year	2000	2010	2020	2030
Public	36,100	61,900	94,300	108,600
Industry	15,900	28,000	37,000	44,000
Commercial	95,300	164,900	247,800	287,500
Total	147,300	254,800	379,100	440,100

F.2.3 Water Demand Projection

Taking the above Sub-section into consideration, the water demand projection is discussed and estimated for drinking water and technical water respectively in this Sub-section. Drinking water is consumed by domestic, industrial, commercial and public users, while technical water is mainly used by industrial users.

Summarizing the following detailed calculations, the drinking water demand both at homes (domestic) and at working places, supplied with the treated water will be as follows.

Drinking water demand both at homes (domestic) and at working places - Summary

Housing Type	2010			2020			2030		
	Population	Lpcd	Demand (m^3/day)	Population	Lpcd	Demand (m^3/day)	Population	Lpcd	Demand (m^3/day)
Domestic	490,000	130	63,900	690,000	150	103,500	800,000	170	136,000
Working Place	-	-	20,130	-	-	29,100	-	-	31,700
Leakage	-	-	28,800	-	-	41,200	-	-	50,300
Total	490,000	230	112,840	690,000	252	173,800	800,000	273	218,000

Note; The drinking water consumed at working place does not include the water consumed for industrial use.

In comparison to the standard established in RK in SNiP the above estimation reasonably falls within the minimum and maximum bounds. This water demand has been discussed thoroughly between the Study Team and the relevant authorities including Construction Committee, and was accepted duly by the

Kazakhstan side. The following table summarizes the overall comparison between the estimation herein and those stipulated in SNiP.

Comparison of Water Consumption Projection and SNiP

Year		2010		2020		2030	
Unit		Lpcd	m^3/day	Lpcd	m^3/day	Lpcd	m^3/day
JICA M/P		230	112,840	252	173,820	272	217,970
SNiP	Min	200	98,135	225	155,574	237	189,624
	Max	301	147,495	342	235,858	357	285,712

Detail of this comparison is explained in the following Sub-sections and summary is shown in Table F.2.1. Projected water demand is similar to the levels of water supply service in some European countries. (Refer to Table F.2.2)

Detail projection is explained in the following Sub-sections and summarized in Table F.2.3.

(1) Domestic Use

Domestic use is usually estimated by using the data of population and per capita water consumption.

ASA has standard per capita water consumption, which has 12 types. The summary of these categories and the estimated population in 1999 is as follows;

ASA's Estimation of Per Capita Water Consumption

Type		Lpcd	Population (1999)
High	Houses/Flats (1 type)	250	172,000
Middle	Houses/Flats/Dormitories (9 types)	85-230	48,100
Low	Houses/Flats without Sewerage (2 types)	22-30	80,700

Taking the result of watermetering examined in Sub-section F.1.5 into consideration, it is judged that the actual water consumption is far less than the ASA's estimation of 250 Lpcd and the future water consumption can be reduced substantially from this estimation, if proper countermeasures are enforced to motivate users towards water conservation by installing individual watermeters.

Therefore, installation of watermeters at each household connection shall be a pre-requirement for the future water demand projection. By launching this individual metering scheme throughout the water supply service area, the per capita drinking water consumption for domestic use shall be decreased to 130 Lpcd in 2010. Thenceforward average increase of 20 Lpcd for every decade is applied in accordance with the projected income increase depicted in Section 2.2. The drinking water consumption at homes is thereby projected at 150 Lpcd in 2020 and 170 Lpcd in 2030 as shown below.

Type of Housing and Population/Water Consumption

Housing Type	2010			2020			2030		
	Population	Lpcd	Demand (m^3/day)	Population	Lpcd	Demand (m^3/day)	Population	Lpcd	Demand (m^3/day)
High	322,500	159	51,278	575,700	165	94,990	691,700	180	124,510
Middle - 1	42,100	137	5,768	49,700	130	6,460	49,700	160	7,960
Middle - 2	47,800	103	4,923						
Low	77,600	25	1,940	64,600	40	2,050	58,600	60	3,530
Domestic	490,000	130	63,900	690,000	150	103,500	800,000	170	136,000

Majority of the population who lives in high housing type is projected to have per capita water supply of 155 Lpcd in 2010, 165 Lpcd in2020 and 180 Lpcd in 2030.

(2) Public/Industrial/Commercial Use

Public, industrial and commercial water consumption of drinking water is estimated with consideration of the numbers of the employees, as shown in Sub-Section 4.3.

At present some meters are installed to measure the public, industrial and commercial water consumption, and where the measurement is not taken water tariff is charged at a fixed rate. The users therefore are not motivated to reducing water consumption.

Providing that watermeters are installed to all connections, water consumption for each category is estimated as 70 percent of the present water consumption and water will be saved further, owing to stronger motivation for water conservation.

Public/Commercial Consumption (Working Place) up to 2030

Year	1999	2010	2020	2030
No. of Employee (persons)				
Public workers	36,100	61,900	94,300	108,600
Commercial workers	95,300	164,900	247,800	287,500
Total	131,400	226,800	342,100	396,100
Per Employee (lpcd)	133	90	85	80
Total Demand (m^3/day)	17,476	20400	29,100	31,700

Note; This is the drinking water consumed at working place, in addition to the water consumed at homes.

Industrial water consumption of drinking water is estimated in consideration of the number employed and the development plans of TETs 1 and 2.

Industrial Consumption up to 2030

Year	1999	2010	2020	2030
No. of Industry workers	15,900	28,000	37,000	44,000
Per Employee (lpcd)	133	90	85	80
Demand by Employee(m^3/day)	2,115	2,520	3,150	3,520
TETs-1&2 (m^3/day)	22,260	28,590	29,250	29,880
Total (m^3/day)	24,375	31,110	32,400	33,400

(3) Technical Water

With respect to the technical water demand supplied with non-treated water, Astana will expand its light industry including food processing and agricultural machine fabrication, as discussed in Section 3.4. These industries do not require large quantity of non-treated technical water. Therefore the same water consumption rate per employee as at present will be applied up to 2030, as shown in the table below. Technical water for TETs-1 and 2 is also estimated in consideration of their development plans.

Technical Water Consumption up to 2030

Year	1999	2010	2020	2030
No. of Employee				
Industry	15,900	28,000	37,000	44,000
Per Employee (l)	27	27	27	27
Demand (m^3/day)	440	760	1,000	1,200
TETs – 1&2 (m^3/day)	15,560	21,440	24,300	28,000
Total (m^3/day)	16,000	22,200	25,300	29,200

(4) Leakage and Loss

In general all water supply systems have leakage and losses. Leakage occurs in (1) raw water transmission pipeline, (2) distribution network, and at (3) building/ houses. Losses also occur in the water treatment plant when de-slugging of sedimentation tanks and backwashing of filters.

Since flow measurement of the existing water supply system in Astana is not accurate, the following data in 1998 and 1999 seem to be somewhat different from the actual figures. Especially, leakage from drinking water distribution network was estimated at 26.1 % by JICA Feasibility Study.

Reduction of leakage and losses can be thought of as equivalent to exploitation of a new and additional water source. In view of the wide range of leakage detections, 20 % of the leakage in the distribution network and 5 % of the loss in water treatment process are considered as a proper target for the improvement of water loss reduction for dinking water supply in Astana. For technical water supply, a flat rate of 5% is applied.

Ratio of Leakage and Loss

Year	1999	2010	2020	2030
Drinking Water				
- Leakage	26 %	20 %	20 %	20 %
- Loss	10 %	5 %	5 %	5 %
Technical Water				
- Leakage	(15 %)	5 %	5 %	5 %

(5) Raw Water Demand

In conclusion, the daily average water demands for the drinking water and technical water, as well as the daily average raw water demand for Astana are summarized in the following table.

Raw Water Demand (Daily Average)

Year	2010	2020	2030
Drinking Water (m^3/day)			
- Water Demand	115,200	165,000	201,100
- Loss and Leakage	36,500	52,100	63,500
- Raw Water Demand	151,700	217,100	264,600
Technical Water (m^3/day)			
- Water Demand	22,200	25,300	29,200
- Leakage	1,200	1,300	1,500
- Raw Water Demand	23,400	26,600	30,700
Raw Water Demand - Total	175,100	243,700	295,300

F.2.4 Assessment of Long Term Development Needs

Owing to the projected population growth and economic development, water demand for drinking water and technical water will rapidly increase. Water demand in the future as compared with that of 1999 is 1.1 times that of in 2010, 1.57 times in 2020 and 1.92 times in 2030. To cope with this rapid increase, the following requirements have to be fulfilled.

(1) Water Source

In general, Vyacheslavsky Reservoir has better water quality than the mainstream of the Ishim River and the reservoir can supply 89.2 million m^3 annually. Therefore the reservoir will be utilized as a major water source for the drinking water of the future. The reservoir, however, will have a shortage in the future and annual yield of the reservoir shall be replenished with Irtysh-Karaganda Canal water.

The total raw water demand is 175,100 m^3/day in 2010, 243,700 m^3/day in 2020 and 295,300m^3/day in 2030, respectively.

(2) Water Supply Facility

Raw Water Intake Facility

The existing pump stations at Vyacheslavsky Reservoir and the Ishim River shall be augmented to meet the required capacity of the future. The existing pump facilities can be utilized, but some part of the facilities are already damaged and renovation of the system, especially the controls and instrumentation, shall be implemented.

Water Treatment Plant

Water treatment plants shall be provided with total production capacity of more than 301,700 m^3/day by 2030.

The existing water treatment plant had the original design production capacity of 200,000 m^3/day. The plant, however, has impaired the capability in terms of quantity and quality due to the limitation of the original design and aging of the facility in the 33 years of operation. Therefore, reconstruction of the whole treatment plant is considered to be required in three stages of constructions, as well as construction of an additional treatment plant.

Water Distribution Facility

The distribution pump station at the water treatment plant shall have the distribution capacity of 422,400 m^3/day for drinking water and 64,100 m^3/day for technical water in the year 2030.

The water supply service area will be extended to new development areas, and distribution pipes shall be installed at the time of the development. At the same time, some of the existing pipes shall be replaced with the larger pipes or additional pipes shall be provided. The supply pressure shall be maintained at 21 m head for 5-story apartments and 5 m for public faucets.

The distribution pump station at the water treatment plant has to be augmented to cope with the demand. The existing pump facility is considerably superannuated and renovation of control and instrumentation systems is also required for proper and reliable operation.

(3) Non-Revenue Water Reduction Program

Without non-revenue water reduction program, water demand will increase rapidly in pace with the progress of new development. The existing water source would run into short supply and a new water source development would be necessary requiring a large investment.

Non-revenue water reduction program will be one of the major activities to be conducted, besides the new construction of water supply facility. This program consists of two aspects; one is a reduction of physical losses which requires monitoring of leakage, etc. while the other is minimizing wastage of water use by consumers' inattentiveness and an introduction of an improved tariff system.

F.2.5 Basic Concept for Long Term Development Project

Detailed development plan will be explained in the next sub-section, and the followings are basic concept for the development plan.

(1) Water Sources

Vyacheslavsky Reservoir has good water quality and it will be used as a main water source of Astana City. The Irtysh-Karaganda Canal-Ishim Pipeline Scheme is under construction and it will increase annual yield of the reservoir by replenishment from Irtysh-Karaganda Canal.

(2) Water Supply Facility

Vyacheslavsky Reservoir and Ishim River will provide different characteristics of availability and quality of water. Raw water intake facilities, intake pump stations and raw water transmission pipelines shall have proper capacities to fully utilize these two water sources.

The existing water treatment plant, due to defects of design, aging of facilities and difficulty of operations shall be reconstructed in stages. New plant will incorporate some facilitates for some automatic operation and a remote monitoring system to meet the future requirement of reliable and efficient operation.

Distribution pump station shall be improved not only by increasing distribution capacity, but also by providing an automated operation system for accurate control for water distribution, introduction of variable speed control for pumps, pressure monitoring of distribution mains etc.

The performance of existing distribution network will be improved by replacement of the distribution mains and valves in the networks. New distribution pipelines will be provided to supply to new development areas.

(3) Non-Revenue Water Reduction Program

Flowmeters in major water supply facilities will be installed to monitor actual water flow. Leakage detectors shall be provided for the monitoring of physical losses in the distribution network.

Watermeters for all connections including all flats shall be provided in this program to measure actual consumption and collect tariff according to the consumption. To accelerate effective tariff collection, a computerized billing system shall be introduced. Using these systems, water consumption shall be reduced by minimizing wastage of water use by consumers' attentiveness.

(4) Facility Design Basis

In this Sub-section, design basis for water supply facility is examined and established.

Daily Average Water Demand

As a result of the above examinations, daily average water demands for the drinking water and the technical water is established.

Daily Maximum Water Demand for Drinking Water

ASA's operation records showed the annual variation of drinking water consumption in 1999. In February the largest water demand occurred which recorded 116 % of the average daily water demand.

Daily Maximum Water Demand of Drinking Water in 1999

Month	February (Max)	July (Min)	Average
Domestic	52,269	42,823	46,667
Others	30,684	18,351	24,827
Drinking Water - Total	82,953	61,173	71,494
Ratio to Average	116 %	86 %	100 %

Therefore, 120 % of daily average is considered as daily maximum water demand for the drinking water.

Daily Maximum Water Demand for Technical Water

Major consumers of the technical water are Thermal Plant No.1 and No.2. Their consumption increase in winter and the largest consumption of 1999 occurred in January with 186 % of average consumption.

Therefore, 190 % of daily average is considered as daily maximum water demand for the technical water.

Hourly Maximum Water Demand

Through the examination of the available data, hourly maximum water demands are set 140 % of daily average for the drinking water and 110 % for the technical water, respectively.

The following table summarizes daily average, daily maximum and hourly maximum water demands.

Daily and Hourly Maximum Water Demand

Year	Ratio	2010	2020	2030
Drinking Water (m^3/day)				
- Daily Average without Leakage and Loss	-	115,200	165,000	201,100
- Daily Average with Leakage and Loss (Raw Water)	-	151,700	217,100	264,600
- Daily Average with Leakage	1.00	144,000	206,200	251,400
- Daily Maximum with Leakage (Treatment Plant)	1.20	172,800	247,200	301,700
- Hourly Maximum with Leakage (Distribution System)	1.40	241,900	364,100	422,400
Technical Water (m^3/day)				
- Daily Average without Leakage	-	22,200	25,300	29,200
- Daily Average with Leakage	1.00	23,400	26,600	30,700
- Daily Maximum	1.90	44,500	50,500	58,300
- Hourly Maximum	1.10	49,000	55,600	64,100

Capacity of Water Supply Facility

These major development plants for water supply facilities are summarized in the following table.

Design Parameters of Facility

Facility	Drinking Water	Technical Water
Intake Pump	Daily Maximum with Leakage and Treatment Loss	Daily Maximum with Leakage
Raw Water Transmission Pipe	Daily Maximum with Leakage and Treatment Loss	Daily Maximum with Leakage
Water Treatment Plant	Daily Maximum with Leakage and Treatment Loss	Daily Maximum
Distribution Pump	Hourly Maximum with Leakage	Hourly Maximum with Leakage
Distribution Network	Hourly Maximum with Leakage	Hourly Maximum with Leakage