CHAPTER E
WATER RESOURCES

SUPPORTING REPORT E: WATER RESOURCES

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E.1 Present Conditions of Water Resources

E.1.1 Surface Water

(1) Ishim River

1) Hydrology

The Ishim River originates in Niaz mountain in Karaganda Oblast and flows into Russian Federation after passing through Oblasts of Akmola and North Kazakhstan. Spring floods due to melting of ice and snow contribute about 80 to 85% of the annual water resources in the basin. The registered maximum flood discharge at Astana City was 1,200 m^3/sec in 1948.

The basin is characterized by small precipitation and strong unevenness in distribution of water flow throughout the year. In relatively warm months from April through October, evaporation exceeds precipitation and no substantial excess is expected from the river. The basin has experienced several times of multi-year continuation of dry period since regular observation started in 1932. Flow characteristics of the Ishim River are summarized below.

Flow Characteristics of the Ishim River

Flow parameter of Ishim River	Discharge measurement station		
	Astana City	Vyacheslavsky reservoir	Atbasar City
Distance from the mouth	2,241	2,300	1,871
Catchment area (km^2)	7,400	5,310	47,300
Discharge-mean rate (m^3/sec)	7.6	6.38	31.1
Discharge-Variation factor (Cv)	0.71	0.71	0.75
Discharge-Asymmetry factor (Cs)	1.36	1.36	0.98
Flow of 50% availability (m^3/sec)	6.45	5.41	26.4
Flow of 75% availability (m^3/sec)	3.67	3.06	12.3
Flow of 90% availability (m^3/sec)	1.24	1.02	2.5

Source: IKC report (Substantiation of Investment for the Project "Construction of the Pipeline from Irtysh-Karaganda Canal to Upstream of the Ishim River for Water Supply of Astana City")

2) Vyacheslavsky Reservoir

The Vyacheslavsky reservoir was constructed in the Ishim River 51 km upstream of Astana City for the purpose of stable water supply to Astana City and has been in operation since 1970. The hydraulic survey by design institute "Astana Gor Project" in the beginning of 2000 revealed that the effective storage capacity of the reservoir has been reduced to 389.9 million m^3 from the original design of 410.9 million m^3 due to siltation at Normal Water Level of 403.0m of the reservoir. The storage capacity and surface area of the reservoir is shown in Figure E.1.1.

Main features of the reservoir are summarized below.

Main Features of Vyacheslavsky Reservoir

Description	Features
a) Total storage capacity	389.9 million m^3 at normal water level 403.0 m
b) Effective storage volume	358.8 million m^3 at normal water level 403.0 m
c) Surface area	54.3 km^2 at normal water level 403.0 m
d) Dam crest	10 m wide, 1,154 m long
e) Spillway	1,420 m^3/sec in discharge capacity
f) Bottom outlet	1,000 mm dia. Outlet valve

The design discharge of the reservoir was 67.2 million m^3/year at 95 % dependability. Presently drinking water is conveyed to Astana City through a 55 km long pipeline, while technical water, sanitary flow and irrigation water to be used in Astana City and its proximity are released from the reservoir to the Ishim River. Besides, minimal amount of water is used for irrigation in the surrounding area of the reservoir.

Figure E.1.2 shows the reservoir operation records of Vyacheslavsky Reservoir from 1970 to 1999. As seen, no serious shortage of water has been encountered to date. Most of the floods took place in the month of April for the duration of one to three weeks. The volume of inflow to the reservoir greatly varied year by year. A large portion of inflow was directly released to Ishim River when the reservoir was full. The records of inflow and outflow volume due to spring floods in 1970 through 1999 are shown in Table E.1.1 and are summarized in the following table:

Volume of Inflow and Outflow of Floods in 1970 to 1999

Description	Volume (million m^3)
Inflow	38-540, average 197.5
Outflow	0-320, average 95.2

In recent years, the water level of the reservoir is low, as the replenishment from the spring floods was extraordinarily low in the years 1998 through 2000. The storage volume is 157.7 million m^3 as of November 23, 2000, which is the lowest, recorded of the reservoir.

Observing this situation with great concern, the Ishim Basin Water Association puts strict control on water discharge from the reservoir.

3) Dependability of Vyacheslavsky Reservoir

It is stipulated in the Construction Norms and Regulations CN and R 2.04.02-84 that availability of the minimal average monthly water discharge for water supply should be 95 %. Presently water supply of Astana City for drinking purpose fully depends on the water resources of Ishim River. The Vyacheslavsky reservoir was originally designed with an annual yield of 67.2 MCM.

The original design value of 67.2 MCM is based on a period of 9-dry years (observed from 1932 till 1940). According to estimations of the Institute of Energy, DI Gidroproekt and other organizations concerned, this event may happen once within 100-300 year periods.

The Design Institute "Kazgiprovodhoz" recommended in 1997 in the Report "Construction of the Pipeline from Irtysh-Karaganda Canal to upstream of the Ishym River for Water Supply of Astana City", to neglect such rare event of the long drought period so that the design yield of the reservoir should not be essentially decreased, and to apply a more realistic value, with a proposal of IKC-Ishim pipeline as a practical way to solve the problem of water shortage in the future. The design institute thus recommended applying a revised design value of 100 MCM, which was evaluated to have a 95% dependability.

In this connection the annual yield of the Vyacheslavsky reservoir has been reviewed based on the latest inflow records as input to the reservoir water in the 30-year period between 1970 and 1999.

Figure E.1.3 illustrates graphic analysis for computation of dependability of annual yield of the reservoir. The simplified mass curve of the reservoir for 1970 to 1999 reflects the annual pattern of inflow due to spring flood as the results of melting of snow/ice and additional inflow due to precipitation of rainfall within the reservoir area in summer and autumn seasons. The sloped straight line in the figure indicates constant draft from the reservoir including evaporation.

Dependability for a given draft from the reservoir is numerically computed by the percentage of number of years out of the total 30 years of data period, when the draft can be made available. The draft includes an annual loss of 40 MCM of water due to evaporation computed on the basis of annual evaporation of 735mm and surface area of 54.3 km^2 at normal high water level of 403 m of the reservoir.

The estimated dependability of annual yield of the reservoir is illustrated in Figure E.1.4. As seen, the annual volume of 89.2 MCM has been evaluated to have the dependability of 95% and is recommended to be applied as the revised design discharge.

4) Spring Floods in 1998 to 2000

Spring floods due to melting of snow/ice of the Ishim River basin are the major water resources of the Vyacheslavsky reservoir. The flood inflow from the spring floods in 1998 to 2000, however, was very little although precipitation of snowfall in these periods was not remarkably low.

The Study Team has been informed by the Regional Center of Hydrometeorology that the effective runoff of spring floods is largely affected by the precipitation of rainfalls before winter seasons. In this connection, flood volumes are analyzed against snowfall alone (Case 1) and snowfall plus rainfall in September and October (Case 2), as shown in Figures E.1.5 and E.1.6. The correlation factor between the flood volumes and precipitation was computed as 0.69 in Case 1 and 0.82 in Case 2. The results indicate that autumn precipitation play an important role in producing effective runoff from spring floods.

Meanwhile, Figure E.1.7 shows the monthly precipitation in 1997 to 1999 together with the mean values in the past 30 years. As seen the precipitation in September and October in the past three years was very little as compared with the mean values. The observed minimal volume of spring floods in 1998 to 2000 is thus explained as the results of little autumn precipitation in the previous years.

(2) Nura River

The Nura River originates from the central part of the Kazakh hilly lands on the territory of the Karaganda *Oblast* and flows into Tengiz Lake of Akmola *Oblast*. The river length is 978 km, out of which 407 km is in Akmola *Oblast* where it has no tributaries. The discharge at 50 % flow availability is 17.5 m3/sec (552 MCM/year) based on long period observation at Romanobka located at about 10 km upstream of the Nura-Ishim canal with a catchment area of 45,100 km2. About 80% of the discharge occur during spring thaw. The Nura River had been used for water supply to Astana City through the Nura-Ishim canal since 1974.

Astana City stopped water intake from the Nura River since 1992. Unfortunately the river has long been contaminated by industrial wastes from the upstream industrial enterprises. The carbide factory in Temirtau discharged large quantity of mercury into the river for 25 years. The discharge already ceased when the factory closed. The mercury and other pollution in the downstream of Nura River became known with the independence of Kazakhstan and human use of the Nura River virtually ceased.

The research carried out in 1997-1998 showed that the riverbed silt contains about 10 tons of mercury, while the floodplain topsoil contains 53 tons of mercury, and each of the local hotspot of Swamp Zhaur and old ash lagoon contains 50-100 tons of mercury. The mercury contamination is concentrated on the upper 25km of the river. Mercury content of 6 times the allowable limit was detected near the Nura Ishim Canal in 1998.

With the objectives to provide users in the Nura-Ishim basin with access to safe, reliable and affordable water supplies, the World Bank has committed to provide funding of the "Nura-Ishim River Basin Environmental Management Rehabilitation Project" which comprises the following four components:

Component 1: Water resources management plan

Component 2: Restoration of the Nura Valley

Component 3: Strengthening the monitoring network

Component 4: Strengthening the water pollution control system

The feasibility study for clean-up of the Nura River is scheduled to be completed in 2001 under the agreement of grant aid in 1999 and the actual clean-up work in the field will be started thereafter, while during the same time for two years a modern water management system for Nura-Ishim River basins is scheduled to be established. In Component 2 of the above, the World Bank put priority sites for clean up and disposal of mercury which includes the 25 km long riverbed immediate downstream from the Samarkand reservoir and floodplains.

According to the World Bank, several mercury clean up programs have been reported from Eastern Europe, one Bank project is presently being implemented in Azerbaijan. The key lesson from such programs is that it is unrealistic to set any specific targets for post project mercury levels in the environment for the reason that the processes by which mercury moves in the environment are highly complex.

The Nura River eventually discharges into the Korgalzhinsky Lake System, an internationally recognized nature reserve. It is noted that the lake consumes huge amount of water due to evaporation from the water surface. In less wet years the lake suffers diminishing of the water area. Diversion of water of the Nura River to Ishim River through the Nura-Ishim canal for water intake in Astana City reduces the discharge to the downstream Lake System and will accelerate the negative impact on the nature reserve. The Irtysh-Karaganda Canal currently replenishes Nura River where they cross near Karaganda City to compensate for the volume consumed in Astana City and its proximity in less wet years.

(3) Irtysh-Karaganda Canal

1) Irtysh-Karaganda Canal

National State Enterprise of Irtysh-Karaganda Canal was established in 1970 to provide water to the Central Kazakhstan (Pavlodar, Karaganda, Akmola Oblasts) which was facing shortage of water. The enterprise has the Pavlodar branch in Shiderty Settlement and the Karaganda branch in Molodezhney Settlement. The head office is in Karaganda.

The Irtysh-Karaganda Canal started its operation in 1975 connecting industrial city of Karaganda with the Irtysh River, a large international river running through China, Kazakhstan and Russia. The total length is 458 km including 354 km of canals, 101 km of water reserves and 3 km of pumping stations. The static level of water lift is 418 m. It has 100 hydro-technical facilities including 22 pump stations with discharge capacity of 50 m^3/sec.

Due to the continuing decline in industrial and agricultural uses, the volume of water consumption from Irtysh-Karaganda Canal reduced from 885 MCM in 1989 to 252 MCM expected for 2000.

The IKC water shows indications of contamination by heavy metals particularly copper as verified in water quality tests in 1984 through 1996. A concentration of 6 PLP of copper was also detected in water quality tests in 2000.

2) Construction of Pipeline from Irtysh Karaganda Canal to Ishim River

It was assumed in the plan of Irtysh-Karaganda Canal that when necessary the Akmola Oblast will get 180 MCM/year from the canal by transferring water into the Nura River with its further delivery to the Ishim River. This method for compensating water deficit in Akmola region failed due to the industrial contamination of the Nura River. In the late 1980 new alternatives were considered to overcome the water shortage problem, particularly water transfer from IKC to the upstream of the Ishim River in order to supply water to Akmola region.

In view of the rapidly decreasing water of the Vyacheslavsky reservoir in the past three years, which is the sole water source of Astana City, the government decided to construct the pipeline to divert IKC water to the upstream of the Ishim River for replenishment.

A Resolution of the Prime Minister identified Astana City Mayor as a client in undertaking of the state procurement related to construction of the water pipeline. The first stage US$23.6 million water pipeline project is funded by the Government of RK and Astana City. The State Enterprise "Irtysh-Karaganda Canal" is commissioned to administer the construction supervision and management thereafter of the project. On November 29, 2000, the President of RK signed Minutes of Discussion on Development of Astana in 2001 for due financing and for inauguration of the water pipeline project in 2001. The project is scheduled to be put into operation by 1st July 2001.

The transfer capacity of the pipeline is 90 MCM/year. It is assumed in the design that about 70% of the transferred water will reach Vyacheslavsky reservoir and 30% will be lost while running down the Ishim River over the distance of about 100 km.

(4) Seletinsky Reservoir

The Selety River originates about 30 km to the north of Astana City and flows into the Seleti-Tengiz Lake located in the North Kazakhstan Oblast. The river length is 407 km including 302 km within the Akmola Oblast. The catchment area is 18,600 km^2. The river flow in its midstream is regulated by Seletinsky reservoir, which is located at about 130 km from the Astana City and has a catchment area of 12,300 km^2.

The reservoir is the water supplying source for the city of Stepnogorsk, an industrial city located about 140 km to the north of Astana City with a population of approximately 50,000. A total volume of 23.4 MCM was consumed in Stepnogorsk for domestic, industrial and agricultural use in 1998.

The annual inflow of the spring floods of the reservoir in 1968-1999 is given in Table E.1.2.

E.1.2 Groundwater

The following four aquifers are recognized in the vicinity of Astana City:

- Akmolinsky aquifer to the north of the city
- Tselinogradsky aquifer along the Ishim river
- Rodjdestvensky aquifer about 25 to 45 km away to the south of the city
- Nurinsky aquifer about 80 km to the southwest of the city

The total groundwater reserve of the above four aquifers is estimated to be 128,300 m^3/day (46.83 MCM) as shown below.

Ground Water Reserves in Vicinity of Astana City

(Thousand m^3/day)

Aquifer	Location	Estimated reserve
Akmolasky	North of Astana	50.1
Tselinogradsky	5 km south of Astana	6.8
Rozhdestvensky	25-45 km south of Astana	44.1
Nurinsky	80 km west of Astana	27.3
Total		128.3

Source: Annual Report of Ishim Basin Association on Water Use and Protection Regulation, 1998

The total groundwater consumption by users in Astana City and the surroundings area was reported to be 7,110 m^3/day in 1998 according to the Annual Report of Ishim Basin Association, as shown below. Most of the consumption is for industrial and agricultural uses.

Groundwater Consumption in Astana City and the Surroundings in 1998

(Unit: 1000m^3/day)

Aquifer	Communal household	Industry	Agriculture	Total
Akmolinsky	0.05	0.04	0.02	0.11
Tselinogradsky	-	-	-	-
Rozhdestvensky	-	-	0.33	0.33
Nurinsky	0.79	3.18	2.70	6.67
Total	0.84	3.22	3.05	7.11

In the studies in September 1999 to March 2000 which included restoration of existing wells and drilling of new ones, the Ministry of Natural Resources and

Environmental Protection worked out the possibility of ground water use for the needs of Astana City. The study confirmed the possibility of getting the operating reserves of 12,000 – 17,000 m^3/day at Koyandinsky and Sofievsky Occurrences of the Akmolinsky one. Prior confirmed reserves counted 31,100 m^3/day from these Occurrences.

Groundwater of the Nura River contains toxic chemical elements such as Mn, Pb, bromine, lithium, phenol, etc. with concentration exceeding PLP due to colliery waters and industrial wastes from Karaganda and Temirtau Cities (source: Azimut). The groundwater aquifer along the Nura River therefore is not considered as a water supply source for Astana City until large-scale engineering-ecological work of the Nura River is accomplished.

E.1.3 Water Quality

The following table shows criteria of surface water quality commonly used in Kazakhstan.

Criteria of Surface Water Quality

Class	Characteristics	Water pollution index (WPI)
I	Very pure	Less than 0.3
II	Pure	Between 0.3 and 1.0
III	Moderate pollution	Between 1.0 and 2.5
IV	Polluted	Between 2.5 and 4
V	Dirty	Between 4 and 6
VI	Very dirty	Between 6 and 10
VII	Extremely dirty	Greater than 10

The level of pollution is estimated by the Water Pollution Index (WPI) which is calculated by the averaged summed ratio of six parameters. These six parameters include BOD, DO and sulfate as common items and other three parameters depend on the features and objectives of use of water bodies. The formula for the calculation is given as follows:

$$WPI = \sum_{i=1}^{6} Ci / (MAC)I \times 1/6$$

where, Ci is the concentration of water pollution substance I, (MAC)I is the maximum allowable concentration of water pollution substance i.

The design institute "Kazgiprovodhoz" presented its results of evaluation of water quality of the Irtysh River, Irtysh-Karaganda Canal, Nura River and Ishim River, in the report "Construction of the Pipeline from Irtysh-Karaganda Canal to

Upstream of the Ishym River for Water Supply of Astana City" as summarized below.

Water Quality

Water	Location	Class	Contamination
IKC	Shiderty, Headwork	Class III	Moderate pollution
Nura River	Samarkand reservoir	Class IV-V	Polluted-dirty
	Romanobka village	Class III	Moderate pollution
Ishim River	U/S of Vyacheslavsky reservoir	Class II	Clean
	D/S of Astana City	Class III	Moderate pollution
Groundwater	South part of Akmola Oblast	Class III-IV	Moderate pollution
	North part of Akmola Oblast	Class II	Clean

IKC: Irtysh-Karaganda Canal
Source: KAZGIPROVODHOZ Report, 1997

Surface water sampling and testing was carried out by the Hydrometeorological Monitoring Center in Astana City (state enterprise "Kazgidromet") during the period from April to December 1999. The sampling was carried out at the Nura River, Nura-Ishim canal and Ishim River including Vyacheslavsky reservoir and other 4 locations, with the results as shown below.

Water Quality of Surface Water in 1999

Surface water	Place	Period	WPI (average)	Class
Nura River	Romanobka,	Apr - Dec	1.25 - 2.44 (2.1)	III
Nura-Ishim Canal	Entrance	Aug - Dec	1.63 - 2.03 (1.8)	III
Ishim River	Vyacheslavsky reservoir	Aug - Dec	0.55 - 1.02 (0.7)	II
	Turgenevka	Apr - Dec	1.00 - 2.16 (1.1)	III
	Telmana	Apr - Dec	0.73 - 1.35 (0.95)	III
	Astana City	Apr - Dec	0.69 - 1.63 (1.3)	III

Source: Kazgidromet

The water quality of the Ishim River is characterized as moderately polluted with the values of WPI from 0.95 to 1.3. Water in the Vyacheslavsky reservoir falls into the class II "pure" with WPI 0.55 to 1.02. The value of WPI of the Nura River ranging between 1.25 and 2.44 with an average value of 2.1 is classified into III, moderately polluted. The value also shows that the Nura River is more polluted than the Ishim River.

E.1.4 Water Consumption

Water use in Astana City is largely categorized into the drinking, technical and irrigation uses. The Ishim Basin Water Management Department under the Committee on Water Resources authorizes annual amount of water intake from the

Vyacheslavsky reservoir and along the Ishim River. The following table shows water intake by ASA (Astana Su Arancy) and irrigation users since 1991:

Annual Water Intake from Ishim River upstream of Astana City

(Million m3/year)

Intake Site	1991	1992	1993	1994	1995	1996	1997	1998	1999
A) Vyacheslavsky Reservoir									
1) ASA-Drinking	50.92	50.20	52.62	59.20	48.54	41.58	19.47	21.60	20.65
2) Irrigation	5.70	2.40	1.94	3.58	1.90	0.78	0.76	0.88	0.06
Sub-total (A)	56.62	52.60	54.56	62.78	50.44	42.36	20.23	22.48	20.71
B) Ishim River at Telman									
1) ASA-Technical	7.74	10.65	11.06	7.36	6.24	5.06	*35.84	*31.80	*16.86
2) Irrigation	13.59	12.68	6.63	9.86	7.85	5.24	3.70	3.61	2.61
Sub-total (B)	21.33	23.33	17.69	17.22	14.09	10.30	39.54	35.41	19.47
Total	77.95	75.93	72.25	80.00	64.53	52.66	59.77	57.89	40.18

(Source: Basin Ishim Association)

*: These volumes may contain water used for drinking water

(1) Drinking Water

ASA conveys the raw water for making drinking water for Astana City from Vyacheslavsky reservoir to Astana City through a 51 km long pipeline. The annual amount of water intake was about 40 to 60 MCM in 1991 - 1996. The amount of conveyed water through the pipeline was reduced to some 20 MCM in 1997 to 1999, while the balance of the drinking water was taken from the Ishim River at Telman during the same period.

(2) Technical Water

ASA takes technical water from the Ishim River at Telman and conveys it through a 10 km long pipeline to Astana City. The annual intake volume of the technical water has been reduced in principle from 10 MCM to 5 MCM in the past 10 years, due to decline of demands following closure of industries in Astana City.

(3) Irrigation Water

Irrigation water is taken from Vyacheslavsky reservoir directly and from the Ishim River. Consumption of irrigation water was 19.3 MCM in 1991, which comprised 13.6 MCM from the Ishim River and 5.7 MCM from the Vyacheslavsky reservoir. The irrigation water was reduced considerably to 2.7 MCM mostly from the Ishim River in 1999. This reduction reflects sharp decline in irrigated farmland due to social and economic changes in

Kazakhstan. Only limited lands are irrigated at present besides private small gardens in Astana City.

Tables E.1.3 shows the irrigation farms in the vicinity of Astana City sourcing the Ishim River for water supply as of 1993/1999, the location of which is shown in Figure E.1.8. As seen in the table, only 1,536 ha was irrigated out of 4,937 ha. in 1999 in this area.

E.2 Basic Concepts for Water Resources Development Plan

E.2.1 Projection of Water Demand up to 2030

Water demand projection up to 2030 is made covering Astana City. Water requirement for the riverine sections of the Ishim River about 300 km long between Vyacheslavsky reservoir and the confluence with the Kouloton River was also considered, as this area depends on Vyacheslavsky reservoir for water supply. Water demand projection is made for drinking water, technical water, irrigation water, greenery water, sanitary flow, landscaping and miscellaneous use and water loss. In addition, water discharge at control point downstream of Astana City is summarized in the item (7) of this Sub-section.

(1) Drinking Water & Technical Water

Drinking water in Astana City consists of domestic use at households and social use by employees of the public, industry, commercial and enterprises. Demand for drinking water is estimated in this Master Plan Study based on the population framework and per capita consumption up to 2030. Technical water is non-treated water used mainly at factories and power stations. Leakages and losses are considered both for drinking water and technical water. For detail explanation for the estimation of drinking and technical water for Astana City, refer to the Supporting Report A of Draft Final Report.

The following table shows a summary of the estimation:

Raw Water Demand for Drinking and Technical Water (MCM/Year)

Item	1999	2010	2020	2030
Drinking water	50.4	55.4	79.2	96.6
Technical water	6.5	8.5	9.7	11.2

In sections upstream and downstream of Astana City, people use groundwater for drinking purposes. Surface water is not utilized for water supply in these sections as there is no treatment plant. In case of no insufficient amount of groundwater being available due to dry year periods, however, it is essential to use surface water of the Ishim River.

The population in these areas is estimated by Akmola Regional Department of Economy as shown in Table E.2.1 and summarized below.

Number of Residents along Ishim River from Vyacheslavsky Reservoir to Confluence of Kouloton River

Area	Number of residents
Arshaly Region	4,506
Tselinogradsky Region	11,421
Astrakhansky Region	16,938
Total	32,865

Source: Akmola Regional Department of Economy

The annual water demand for this rural area is estimated to be 0.3 MCM based on the population of 32,865 and the consumption rate of 22 liter/capita/day under the unimproved condition. The estimated water demand is considered to be supplied using sanitary flow as explained in the Subsequent section (4) below.

(2) Irrigation Water

As shown in Table E.1.3, an irrigation area of about 5,000 ha in the vicinity of Astana City has been in place up to the present time, which depends on the Ishim River. This total includes 1,283 ha of plots of land for Dachas. However, actual irrigation subsided considerably, due to decline of the economy in Kazakhstan.

According to the Ministry of Agriculture, rehabilitation of the existing irrigation system in the project area is essential for development of agriculture. The following table shows rehabilitation plan of 5,412 ha of irrigation system fed from Vyacheslavsky reservoir:

Plan of Rehabilitation of Irrigation System

District	Area (ha)	Remarks
Arshalynsky	*2,095	Upstream of Astana
Tselinogradsky	2,667	Astana and its proximity
Astrazhansky	650	Downstream of Astana
Total	5,412	

Source: Ministry of Agriculture
Note: * Area includes 1,404 ha of "Kaisar" and 691 ha of "Novoaleksandrovsky

The above plan includes the area of 1,404 ha in the vicinity of the Vyacheslavsky reservoir, which is in the process of bidding for construction contract. With the completion of the rehabilitation plan, a total area of about 7,000 ha including the existing 1,283 ha of Dachas and 5,412 ha of planned rehabilitation is assumed to be irrigable. In the demand projection, the implementation of the above rehabilitation plans is presumed to be realized by 2010.

The Akmola *Oblast* published its indicative plan for a production target by year 2005 (see Supporting Report N of the Final Report). In the plan, the average annual growth rate is set at 2.7% for agriculture in general and 0.6 % and 0.7% for potatoes and vegetables, respectively.

It is assumed that irrigation in Astana City and its proximity will continue to be used mainly for cultivation of potatoes and vegetables in view of the projected high cost of transferring water from other sources during low water period in the Ishim basin. The annual growth in water demand for irrigation is assumed to be 2.0 % that is higher than the average in Akmola Oblast, taking into consideration the demandincrease for the agricultural products by population of Astana City, which is projected to increase at the rate of 3 % on the average up to 2030.

Irrigation water demand is calculated based on the unit water requirement of 4,000 m^3/ha. For unit water requirement in Dachas, the actual consumption of 2,300 m^3/ha in 1993/1999 is applied. Minimum of 80 % of the water requirement needs to be secured at 95 % of water availability (SNiP 2.06.03-85), and therefore the water demand for irrigation will be as follows:

Irrigation Water Demand (MCM/year)

1999	2010	2020	2030
2.7	22.4	27.3	33.3

(3) Greenery

It is envisaged in this Master Plan Study to achieve a unit greenery area of 12 m^2/person in 2030 as stipulated in SNiP 2.07.01.89. Unit rate of consumption is estimated to be 500 m^3/ha, which corresponds to the watering depth of 5 mm and 10 times per year (June to August). Annual water requirement is thus estimated at 0.5 MCM/year as of 2030. According to information from local expert, treated sewage is not allowed for watering of urban greenery. It is planned to take the greenery water from Ishim River.

Annual water requirement for forestation outside of the urban areas is estimated at 10.0 MCM/year for the target area of 20,000 ha as required by

SNiP (250 m^2/person) in 2030 and the same consumption rate as above. Ample volume of treated sewage from Taldy Kol Pond is planned to be used for this purpose, and therefore excluded from the water demand.

(4) Sanitary Flow

Sanitary flow is intended to keep sanitary condition of the river with minimum flow of water. Sanitary flow was considered for the whole stretch of the Ishim River up to the confluence of Kouloton River, 250 km downstream of Astana. In all, a volume of 5 MCM/year is counted for sanitary flow up to 2030 throughout the course of the Ishim River. This sanitary flow will also cover the assumed human consumption of 0.3 MCM in the downstream and upstream reaches of the river, as discussed in (1) above. The loss will be estimated separately in item (6) below.

(5) Landscaping and Miscellaneous Use

Astana is a city on the bank of the Ishim, and the body of water of the Ishim bears a special importance to the landscaping of the city. At present, the water of the Ishim is dammed up downstream of Astana, creating stagnant water surface in front of the existing city center. The landscaping effect of the Ishim shall be enhanced and maintained in future.

The present volume of the water in the pond is estimated to be about 2 MCM assuming the section for dam-up of the Ishim River to be 10 km in length, 150 m in width and 1 to 1.5 m in water depth. It is planned for the water in the pond is replaced once a year by replenishment.

In addition, 1 MCM is allowed for miscellaneous water use for fountains and streams, firefighting, etc. Water demand for firefighting in the future is estimated based on the criteria of water demand for firefighting specified in SNiP 2.04.02 – 84 and expected number of fires as shown below.

Water Demand for Firefighting

	2000	2010	2020	2030
Population	321,600	490,000	690,000	800,000
Water flow (l/sec) <1		80	90	95
Number of fire <2	320<4	488	687	796
Water demand (MCM/year) <3		0.28	0.45	0.54

Note: <1: SNiP 2.04.02-84, Table 5
<2: Estimated as proportional to population based on 320 fires in 2000
<3: Water consumption for 2 hours to extinguish a fire is assumed.
<4: Number of major fires which required water intake from the city water supply system

As seen, a volume of 1 MCM/year for miscellaneous use will be sufficient to accommodate water demand for firefighting up to 2030. The water demand for firefighting is considered to be included in the miscellaneous use.

Therefore in total 3 MCM/year is counted for landscaping and miscellaneous use.

(6) Water Loss

Various types of water losses are conceived in this Master Plan. Loss and leakage through water supply system of ASA is already counted separately in the water demand of drinking water and technical water. Water loss due to evaporation and infiltration in the Ishim River is estimated hereunder for the entire 300 km length of the Ishim River between Vyacheslavsky reservoir and the confluence with Kouloton River.

1) Water Loss due to Evaporation

Water loss due to evaporation in the Ishim River is estimated assuming average river width of 20 m for the whole stretch between Vyacheslavsky reservoir and confluence with Kouloton River with the annual evaporation of 735 mm. The estimated total evaporation loss is 4.4 MCM/year.

2) Water Loss due to Infiltration

Water loss due to infiltration is estimated assuming a typical model of hydro-geology of the Ishim River as shown in Figure E.2.1. Assumptions are made in the hydraulic model that water loss due to infiltration is created through horizontal pervious layers that are extended toward the both banks of Ishim River.

The water loss due to infiltration is estimated per km of the Ishim River, based on the formula below.

$$q = kiA \ (m^3/sec)$$

Where, q is amount of water loss due to infiltration (m^3/sec), k is coefficient of permeability of the pervious layer, i is hydraulic gradient of the river, and A is cross sectional area for infiltration.

For coefficient of permeability, $k = 1 \times 10^{-4}$ m/sec is applied taking into consideration the pumping test results conducted on the left bank of the Ishim River as presented in Supporting Report D of the Final Report. In the analysis, it is assumed that the ground level of the river bank has a gradient of 0.0005 equal to average slope of the Ishim River.

Water loss due to infiltration is calculated to be 7.6 - 8.7 MCM/year as shown in Figure E.2.1.

Water loss due to evaporation and infiltration is summarized below.

Water Loss in Ishim River (MCM/year)

	2010	2020	2030
Evaporation	4.4	4.4	4.4
Infiltration	7.6	8.1	8.7
Total	12.0	12.5	13.1

(7) Summary of Water Demand

Water demand projection is summarized below.

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	125	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 following table summarizes the available discharge in the Ishim River downstream of Astana City as per the demand projection above: The discharge comprises the irrigation water use for areas downstream of Astana, the sanitary flow and the corresponding volume for the water loss.

Discharge downstream of Astana City (MCM/year)

	2010	2020	2030
Irrigation	2.1	2.6	3.1
Sanitary flow	5.0	5.0	5.0
Water loss	10.0	10.4	10.9
Total	17.1	18.0	19.0

E.2.2 Assessment of Alternative Water Resources

(1) Necessity of Additional Water Resources

The present water source provides 89.2 MCM of water at 95 % availability, as discussed in Subsection E.1.1(1),(c) above. With the projected increase in water demand, water deficit of 15.7 MCM/year would take place in 2010 unless some effective expansion of the water source is taken up. Development of additional water resources by 2010 is therefore essential, which will fill this deficit. In subsequent years, the deficit expands to 45.7 MCM/year in 2020 and further to 71.9 MCM/year in 2030, as shown below.

Water Balance without Additional Water Resources (MCM/year)

	2010	2020	2030
Water demand	104.9	135.0	160.2
Water supply frrom Vyacheslavsky reservoir	89.2	89.2	89.2
Deficit	15.7	45.8	71.0

(2) Assessment of Alternative Development Plans

The following alternative water resources are assessed from viewpoints of water quality, development cost and potential capacity for water supply (see Figure E.2.2 for location)

- Irtysh-Karaganda Canal (Irtysh river)
- Nura river
- Seletinsky reservoir (Selety river)
- Groundwater
- Treated sewage

As mentioned in Subsection E.1.1 (3), the Government of RK decided to implement the IKC-Ishim pipeline project for development of IKC water. It is planned to implement the project in two stages. The first stage of the construction is scheduled for completion by June 2001. The designed annual water supply capacity to Astana City is 126 MCM after second stage construction, which is estimated to cover the minimum water requirement of Astana City as of 2030 even in the severest dry condition of Ishim basin in these 30 years. Accordingly the on-going pipeline scheme of the government is adopted as the development plan of the IKC water and is considered hereunder in the alternative studies for development of water resources.

These water resources have more or less similar constraints against economical development, reflecting the scarcity of water in the project area, such as poor water quality and high cost for water transportation, as described below.

Irtysh-Karaganda Canal (IKC)-Ishim pipeline

The development plan of IKC-Ishim pipeline aims to transfer water of the IKC canal to the upstream of Ishim River through a 19.6 km long pipeline by pumping up a head of 122m. The transferred water further will run down the Ishim riverbed about 100 km to the intake structure at Vyacheslavsky reservoir. An annual amount of 63MCM and 126 MCM is planned to be available at Vyacheslavsky reservoir after construction of the first stage and second stage construction, respectively. The development cost including the O/M of the water pipeline project is estimated at Tenge 17.18 per m^3/year of raw water as shown in Table E.2.2.

Table E.2.3 shows the data of water quality of the IKC in the area of water diversion for 1984 – 1996. The Design Institute "Kazgiprovodhoz" analyzed in the report "Construction of the Pipeline from Irtysh-Karaganda Canal to upstream of the Ishim River for Water Supply of Astana City", that the water as a whole, corresponds to the permissible level of pollution (PLP), although, in some years the water contains heavy metals and categorized the water as class III "moderately contaminated water" in 1997.

Table E.2.4 shows the data of water quality including the IKC, which was conducted by Akmola Region Center of Hydrometeorology under the JICA Study Team in August-September 2000. The Region Center for Hydrometeorology analyzed the water quality as normal in terms of ingredient' contents but noticed that a high concentration of copper (0.006mg/l) was detected in August 2000.

The above test results show that no improvement has been made in the water quality of IKC in the last few years.

Nura river

The water quality of Nura river at Romanobka and Nura-Ishim canal as of August and September 2000 is shown in Table E.2.4. The data show that the concentration of the total mercury (Hg) is lower than but is close to the PLP.

Presently a Feasibility Study is being carried out to identify the suitable method for clean-up of the Nura River with the study period of one year. According to the information provided to the Study Team, the World Bank study team determined that the best technical solution to the problem would be to remove all sediments containing more than 10 mg/kg of mercury from the riverbed and its banks.

According to the World Bank, a volume of 200-300 tons of mercury is contained in the riverbed, topsoil, sediment, backwaters and oxbows along Nura River, and 95% of the total pollution is located in the first 25 km downstream from Samarkand reservoir.

The Feasibility Study Team of the World Bank will prepare a viable program for clean up of the mercury from Nura River in 2001 and will start clean up work thereafter.

As discussed in Subsection E.1.1 (2), it is required to replenish Nura River through Irtysh-Karaganda canal to compensate for the volume consumed in Astana City and its proximity for protection of natural reserve of Korgalzhinsky lake system. In this regard, the operation cost of Nura River as the alternative water resource should consider the water tariff of raw water in the Irtysh-Karaganda Canal. As seen in Table E.2.2, the development cost including O/M cost of Nura River is estimated at Tenge 10.16 per m^3 of raw water which is the lowest among the alternative plans because the water conveyance facility of Nura River is already existing.

Seletinsky reservoir (Selety river)

The Seletinsky reservoir in the middle reach of the Selety river has a catchment area of 12,300 km^2. The annual inflow due to spring floods to the reservoir in 1968-1999 is shown in Table E.1.2.

A simulation analysis of the reservoir operation using the inflow data has been conducted to clarify the dependable yield of the reservoir. The annual yield of the reservoir with a dependability of 95% is obtained at 95 MCM as shown on Figure E.2.3. The annual volume that can be supplied to Astana City is estimated to be about 60 MCM by subtracting 23.4 MCM for consumption in Stepnogorsk and assuming 5 MCM for future demand increasing in this area and 5 MCM for maintenance flow in the downstream.

For development of the Seletinsky reservoir for water supply to Astana City, a 140 km long pipeline and pumping up a static head of 130 m will be necessary. The development cost including O/M cost is estimated at Tenge 26.22 per m^3/year of raw water which is about 1.5 times higher than that of the IKC-Ishim pipeline scheme, as shown in Table E.2.2.

Although no data on the water quality is available, the local information suggests that no evident problem exists presumably because the sources of contamination are limited in the basin.

Groundwater

As discussed in Supporting Report D of the Final Report, the following five aquifers are recognized in the vicinity of Astana City:

- Akmolinsky aquifer to the north of the city
- Tselinogradsky aquifer along the Ishim River
- Rodjdestvensky aquifer about 25 to 45 km to the south of the city
- Nurinsky aquifer about 80 km to the south of the city
- Alluvial aquifer along the Ishim River downstream of the Vyacheslavsky reservoir to the City

The alluvial aquifer along the Ishim River downstream of the Vyacheslavsky reservoir to the city is discarded from the development plan since no reserve has been confirmed yet.

The present situation of the groundwater aquifers is discussed in Supporting Report D of the Final Report. The Tselinogradsky aquifer has not been used since 1973. Part of the recharge area has been covered with buildings. According to the data collected by the Akmola Hydrogeological Expedition from 1988 to 1990, phenol, oil products, mercury, sterol, and naphthalene contaminated the groundwater near Nura River. The mercury contents in the alluvial sediments on the section of Rodjdestvenska-Mayly village range from 3.2 to 10.8 PLP with an average of 7 PLP according to the hydrogeological research which was conducted in 1997-1998 by JSC "Azimut".

In view of the present situation, only the Akmolinsky aquifer is considered as a prospective water resource. The groundwater source of the Akmolinsky aquifer is classified as shown in the following table:

Groundwater Resources of the Akmolinsky Aquifer

(unit:1,000m^3/day)

Aquifer	Exploited	Confirmed	Potential		Total
	A	B	C1	C2	
A-1: Zholymbet	-	-	1.8	9.0	10.8
A-2: Sofievsky	-	1.7	14.4	-	16.1
A-3: Koyandinsky	-	15.0	-	-	15.0
A-4: Northeastern	4.1	2.5	1.6	-	8.2
Total	4.1	19.2	17.8	9.0	50.1

The Ministry of Natural Resources and Environment worked out a study regarding the possibility of getting water use for the needs of the Astana City.

The study indicates possibility of getting the operating reserves of 12,000 - 17,000 m^3/day at Koyandinsky and Sofievsky sub-aquifers, which is less than the formerly confirmed reserves of 31,100 m^3/day from these sub-aquifers. It is noted that the reliable yield potential of the Zholymbet sub-aquifer is only 1,800 m^3/day although it is located 60km to the north of Astana City.

Taking into consideration the above, the Koyandinsky and Sofievsky sub-aquifers are considered as prospective alternative water resources with the daily yield of 14,500 m^3/day.

The development plan of the groundwater will involve 50 deep wells and a pipeline network connecting the deep wells and the treatment plant in Astana City. The development cost including O/M cost of the groundwater is estimated at Tenge 44.52 per m^3/year of raw water as shown in Table E.2.2.

The above study results indicate that the available volume of groundwater is limited (about 10% of the present raw water demand of Astana City) while the development cost is relatively high as compared with other alternatives of water resource development. However, it is necessary to consider the Akmolinsky aquifer as a future option of water supply as much as possible in view of the limited volume of fresh water in the project area. Meanwhile, SNiP 2.04.02–84 dictates that groundwater which meets sanitary - hygienic requirement should be used as drinking water to the maximum. In this regard it is essential to further work out confirmation of groundwater reserve together with monitoring of the water quality of Akmolinsky aquifer.

Treated sewage

About 50 to 80 MCM/year of treated sewage is projected to be available in 2010 through 2030. In view of the limited water resources in the project area, it is recommended to use the treated sewage as much as possible.

Re-use of the treated sewage water as the technical water, however, is discarded in this Master Plan Study for the reason that there is an apprehension of pipe corrosion due to existence of sulfur in the treated water, while oil products and high concentration of SS will work to reduce efficiency of heat exchange of the cooling water.

Re-use of the treated sewage for irrigation was practiced during the period from 1985 to 1995 near Taldy Kol Pond of Astana City according to the Ministry of Agriculture. The irrigation, however, has since been closed down due to lack of money. According to a preliminary study by JICA

Feasibility Study Team for Water Supply and Sewage, there is a large potential of irrigation development utilizing the treated sewage in the vicinity of Astana City. The preliminary study is supported by the following technical data provided by the Ministry of Agriculture:

- A large area of land owned by agricultural enterprises can be potentially developed (maximum 40,000 ha) in the vicinity of Taldy Kol Pond and on the left bank of Nura River.
- A crop rotation system "Alva" consisting of several fodder crops will minimize the risk management on salinisation of the farm soil because of the characteristic of the treated sewage.
- A feasibility study showed that production can be greatly improved with irrigation. (However, a full feasibility study is necessary to confirm this proposal)

Re-use of treated sewage needs, however, a full feasibility study. It is further noted that re-use of treated sewage is allowed for cultivation of fodder crops but is not allowed for cultivation of crops for human consumption in Kazakhstan.

Besides, it is proposed in this Master Plan Study to use treated sewage for forestation.

The above alternative water resources are compared in the aspects of potential capacity for water supply, development cost and water quality, as summarized below.

1) Potential Capacity for Water Supply

The potential capacity for water supply of the development plan is 63 MCM (first stage development), 60 MCM and 5.3 MCM for IKC-Ishim pipeline, Seletinsky reservoir and groundwater, respectively. In addition, that of IKC-Ishim pipeline can be increased to 126 MCM by the construction of the 2nd stage.

2) Development Cost

The development cost including O/M cost of the alternative water resources is summarized below.

O/M Cost of Raw Water (Tenge/m^3/year)

IKC-Ishim pipeline	Nura River	Seletinsky reservoir	Groundwater
17.18	10.16	26.22	44.52

The development cost should be minimized in view of the living standard of the local people. In this regard, the Seletinsky reservoir and the groundwater of the Akmolinsky aquifer are not recommended.

3) Water Quality

Since the economic feasibility and technical viability of clean-up of the mercury in the Nura River are not clarified yet, the Nura River can not be considered at present as a sound alternative water resource for the future use.

The water quality of the IKC canal is contaminated with heavy metals, particularly copper. The water contamination is judged to be reducible within the allowable limit through dilution effect or removal/control of the waste disposal at the source of contamination, depending on the rate of replenishment of IKC water.

The Seletinsky reservoir and the groundwater in the Akmolinsky aquifer are judged not to involve serious water quality problems.

(3) Selection of Alternative Water Resources

Table E.2.5 shows a summary of assessment of the development plans of alternative water resources. In comparison from aspects of potential for water supply, development cost and water quality, the development of the IKC-Ishim pipeline is selected as the preferred alternative plan.

It is recommended to consider the groundwater as a future option for source of drinking water of Astana City as much as possible considering the limited availability of fresh water in the project area. It is essential to continue elaboration on groundwater reserve and monitoring of water quality of Akmolinsky aquifer.

There is a potential for development of irrigation using treated sewage in the project area although in-depth study needs to be done. Treated sewage is also recommended for forestation, which is less sensitive for water quality.

With regard to the water quality issue, it is recommended to take stage wise countermeasures. First when the amount of transferred water is not sizable, the dilution by mixing with the available water from the Ishim shall take effects to maintain the water quality. In later stage, dilution effects dissipate and more substantial measure needs to be enacted. This issue shall be discussed later in Sub-section E.2.3.

E.2.3 Proposed Development Plan for Alternative Water Resources up to 2030

(1) Stage-wise Development of IKC-Ishim Pipeline Project

The water deficit in Astana City and its vicinity expands over a time period of 30 years as calculated in the previous section. In view of the necessity for a large scale facility to transfer the IKC water to the Ishim basin due to need of additional water resources, it is recommended to implement the IKC pipeline project in two stages; to develop one half (90 MCM/year) of the water transfer capacity of the project in the first stage, and to develop the remaining one half (90 MCM/year) of the capacity in the second stage.

Principal features of the proposed IKC-Ishim pipeline are shown in Table E.2.6.

(2) Development Plan of IKC-Ishim Pipeline Project for Target Years

1) Development Plan Up to 2010

Taking into consideration the water demand of Astana City and its vicinity, it is necessary to complete the first stage construction by 2003.

The pipeline is designed to transfer an annual amount of 90 MCM to the upstream of the Ishim River. It is assumed that 30% of the transferred amount will be lost due to evaporation at small ponds/lakes and human consumption while the haulage over a distance of 100 km of the Ishim River and a net volume of 63 MCM is designed to be available at Vyacheslavsky reservoir. After the first stage development, an annual volume of 152.2 MCM including the design yield of 89.2 MCM of the Vyacheslavsky reservoir will be available at 95% dependability in Astana City and its vicinity.

The pipeline is 19.6 km in total length with the intake provided at about 6 km upstream of the pumping station No.19 of the IKC and the discharging outlet in the upstream of the Ishim River near Priishimsky village. Two-step elevation of water is designed on the total height of 122 m by two pumping stations.

The water pipeline consists of three sections; (i) a 9.6 km long pressure section of 1.4 m dia. steel pipe, (ii) a 3.2 km box culvert section, and (iii) a 6.8 km long non-pressure section of 1.2 m dia. RC pipe. The whole length of the pipeline is designed to be embedded under ground with a soil cover of minimum 1.6 m in order to enable water transfer even in winter season (see Figures E.2.4 and 2.5).

In addition, one unit of the water pump with a discharge capacity of 7 m^3/sec is designed to be provided at each of the pump stations No.17, 18 and 19 of the existing IKC in order to facilitate synchronized pump operation at these pumping stations for water transfer to the Ishim River. The following table shows major structures to be constructed/installed in the first stage development:

Major Facilities of First Stage Development

Structure	Nos.	Discharge capcity/Dimension
1) Steel pipe	1 lane	3.5 m^3/sec, 1.4 m dia. x 9.6 km long
2) RC pipe with box culvert	1 lane	3.5 m^3/sec, 1.2 m dia. x 10.0 km long
3) Pump stations with substations	2 stations	
4) Water pump at P/S of pipeline.	2 sets	3.5 m^3/sec, 61.0 m in static head
5) Water pumps at IKC P/S Nos.17, 18, 19	3 units	7.0 m^3/sec

2) Development Plan up to 2020

The total water supply capacity of 152.2 MCM from the Ishim basin and the first stage development of IKC water will meet the water demand up to 2020, as calculated in Subsection E.2.2 (1). No additional development of the IKC-Ishim pipeline project is required in this period.

3) Development Plan up to 2030

Taking into consideration the projected water demand in this period, it is considered necessary to complete the second stage development of the IKC-Ishim pipeline project by 2025. After the second stage development, an annual volume of 215.2 MCM will be available at 95% dependability in Astana City and its vicinity. The structural facilities that are required for the second stage development are (i) additional lane of water pipeline including a steel pipe for the pressure section and RC pipe of the non-pressure section, and (ii) water pump units with the discharge capacity of 3.5 m^3/sec. The relevant RC structures of two pump stations and box culver for water pipeline are included in the first stage construction. The following table shows list of major structures to be constructed/installed in the second stage development:

Major Facilities of Second Stage Development

Structure	Nos.	Discharge capcity/Dimension
1) Steel pipe	1 lane	3.5 m3/sec, 1.4 m dia. x 9.6 km long
2) RC pipe with box culvert	1 lane	3.5 m3/sec, 1.2 m dia. x 10.0 km long
3) Water pumps at P/S of pipeline	2 sets	3.5 m3/sec, 61.0 m in static head

(3) Dependability of Water Supply in Target Years

A water balance study of the Vyacheslavsky reservoir with water transfer from Irtysh-Karaganda Canal (IKC) was conducted for target years of 2010, 2020 and 2030 as shown in Annex E.1.

The study is based on simulation analysis on reservoir operation of the Vyacheslavsky reservoir taking into account additional water from IKC up to 63 MCM/year in 2010 and 2020, and 126 MCM/year in 2030. A tentative reservoir operation rule is presumed that maintains minimum storage capacity equivalent to one-year water consumption at the end of each year by replenishment from IKC.

The water balance study revealed that water demand is fully met for the simulated period of 30 years in 2010 and 2030 but water deficit will take place once in 30 years, with the dependability as summarized below.

Dependability of Water Supply in Horizon Years

	2010	2020	2030
Number of years of water deficit	0	1	0
Dependability (%)	100	96.8	100

The above results show that the proposed development plan of water resources gives a dependability of water supply exceeding the minimum requirement of 95 % and thus can be justified.

(4) Water Resources Allocation

The simulation analysis mentioned above also depicted the operational aspect of the pipeline project in conjunction with the Ishim river basin. As the water from IKC requires to be lifted for the static head of more than 100 m and subject to water loss detailed in (1) above, operation of the pipelines should be minimal.

The results of the simulation revealed water resources allocation under such principle to meet the water demand in 2010, 2020 and 2030, is as summarized below. Replenishment by IKC is calculated to be 3.7 % in 2010 of the total, 12.2 % in 2020 and 27.7 % in 2030, respectively.

Water Resources Allocation

	2010	2020	2030
Ishim basin	101.0	118.5	115.9
IKC	3.9	16.5	44.3
Total	104.9	135.0	160.2
Note: IKC (%)	3.7	12.2	27.7

(5) Water Quality Control

It is proposed to adopt stage wise countermeasures for practical solution of water quality of IKC, which indicates high content of copper in the water. During the course of development of water resources of IKC, the following actions will be required:

1) First Phase

In the period up to 2020, replenishment from IKC will remain relatively low on the average as calculated in Subsection (4) above. The IKC water will be substantially diluted to the level of Vyacheslavsky reservoir. In this phase, it is essential to establish a monitoring scheme for water quality of the Vyacheslavsky reservoir and in IKC. Since replenishment from IKC tends to increase at the end of dry year period, particular care should be taken on these occasions.

2) Second Phase

In the period after 2020, replenishment from the IKC will increase up to 27.7 % on the average in 2030. Monitoring needs to be intensified, as the water quality is expected to worsen in due course. Dilution effect will substantially dissipate with the increase of replenished volume, and more substantial countermeasures will need to be enacted.

For this purpose, it is essential to control water quality at the source of contamination. The watershed of the Irtysh river, which is the source of IKC, involves several industrial sites. In cases where water contamination of copper in IKC is connected to a large number by industries, an extensive watershed management will have to be considered.

The World Bank has carried out studies on issues of local conditions of watershed of the Irtysh River, in the projects "Action Program for

Improvement of Water Quality in the Irtysh River basin" and "The Reduction in Industrial Waste in Ust-Kamenogorsk to Underground Water Contamination". Besides, "The Northern Environment Management and Rehabilitation Project", with the specific components including priority to toxic waste clean up and pollution control in the Irtysh River basin, is being prepared by the World Bank. These studies and programmed actions will give essential information regarding control of the water quality of the Irtysh River in the future.

(6) Implementation Schedule and Development Cost

1) Implementation Schedule

Taking into consideration the future increase in water demand, it is estimated that the additional water supply from IKC will become necessary in 2004, so that the first stage construction of the IKC-Ishim pipeline will be required to be completed by 2003. However, in view of the water storage in Vyacheslavsky reservoir, the first stage construction is scheduled to be completed by July 2001.

The additional water supply from IKC will be required to be increased in 2026, so that it will be necessary to complete the second stage construction of the IKC-Ishim pipeline by the end of 2025. Assuming that the construction will take two years, it is necessary to start construction in the beginning of 2024.

The implementation schedule of the pipeline project is shown below.

Implementation Schedule of IKC-Ishim Pipeline Project

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
IKC-Ishim pipeline																															
1) 1 st stage construction	━	━																													
2) 2 nd stage construction																									━	━					

TABLE

Table E.1.1 Record of Flood Operation of Vyacheslavsky Reservoir from 1970 to 1999

Year	Initial Storage (MCM)	Prior Spillout		Storage before flooding (MCM)	Flood Inflow		Flood Spillout		Total			Daily Maximum Inflow		
		Period	Volume (MCM)		Period	Volume (MCM)	Period	Volume (MCM)	Inflow (MCM)	Spillout (MCM)	Reservoir Storage (MCM)	Date	Daily Inflow (MCM)	Per Second (m^3/s)
1970	153	-	-	153	-	-	-	-	202	11	344	-	-	-
1971	229	-	-	229	-	-	-	-	262	80	411	-	-	-
1972	308	-	-	308	-	-	-	-	387	284	411	-	-	-
1973	317	28/3-6/4	38	279	8/4-15/4	294	8/4-15/4	206	403	308	412	8/4	58	671
1974	323	-	-	323	10/4-14/4	34	16/4-18/4	25	76	56	343	10/4	10	116
1975	272	-	-	272	-	-	-	-	40	12	300	-	-	-
1976	206	-	-	206	11/4-21/4	204	16/4-22/4	64	247	64	389	19/4	34	393
1977	303	-	-	303	9/4-14/4	112	9/4-10/4	8	113	22	394	10/4	30	347
1978	314	-	-	314	1/4-8/4	31	-	-	51	-	365	-	-	-
1979	278	1/4-10/4	5	273	16/4-30/4	322	10/4-30/4	187	327	192	413	21/4	76	880
1980	368	-	-	368	2/4-19/4	59	13/4-21/4	30	81	30	419	-	-	-
1981	358	-	-	358	1/4-9/4	38	-	-	52	-	410	-	-	-
1982	330	-	-	330	6/4-16/4	47	-	-	77	-	407	-	-	-
1983	315	20/3-31/3	49	266	30/3-20/4	251	6/4-21/4	109	269	158	426	4/4	39	451
1984	344	-	-	344	4/4-25/4	134	8/4-26/4	108	190	108	426	-	-	-
1985	340	19/3-28/3	47	293	5/4-23/4	300	8/4-24/4	176	311	223	428	8/4	42	486
1986	325	24/3-6/4	57	268	12/4-23/4	257	16/4-24/4	120	280	177	428	15/4	49	567
1987	320	9/3-18/4	82	238	18/4-30/4	176	26/4-20/5	46	237	128	429	21/4	33	382
1988	292	11/3-1/4	30	262	10/4-25/4	164	15/4-3/5	73	244	103	433	14/4	42	486
1989	317	-	-	317	1/4-21/4	66	-	-	102	-	419	-	-	-
1990	302	19/3-29/3	41	261	9/4-20/4	253	10/4-28/4	179	347	221	428	13/4	34	393
1991	319	6/3-9/4	37	282	12/4-22/4	216	17/4-23/4	84	278	172	425	18/4	31	359
1992	290	17/3-4/4	38	252	-	-	-		67	40	317	19/4	6	69
1993	253	-	-	253	13/4-19/4	357	15/4-20/4	212	534	350	437	17/4	84	972
1994	275	-	-	275	17/4-16/5	-	-	-	70	-	345	-	-	-
1995	252	-	-	252	28/3-11/4	-	-	-	152	-	404	17/3	17	197
1996	250	-	-	250	15/4-22/4	194	18/4-19/4	13.8	220	18	452	18/4	50	579
1997	289	-	-	289	6/4-11/4	130	10/4-12/4	28	246	94	441	9/4	27	312
1998	286	-	-	286	-	-	-	-	38	6	318	-	-	-
1999	225	-	-	225	-	-	-	-	-	-	247	-	-	-
2000	171	-	-	171										

Source: Astana-Su

Table E.1.2 Inflow to the Seletinsky Reservoir due to Spring Flood

Year	Spring flood		Water level (m)		Storage(MCM)		Inflow	Discharge
	Start	End	Start	End	Start	End	(MCM)	(MCM)
1968	21-Mar	4-May	220.4	221.1	202.0	232.0	53.0	23.0
1969	3-Apr	10-May	218.8	221.0	159.0	229.0	186.0	115.0
1970	21-Mar	13-May	219.0	221.4	163.0	243.0	231.0	151.0
1971	30-Mar	1-Jun	219.6	221.3	182.0	240.0	220.0	158.0
1972	9-Apr	21-May	219.2	221.2	168.0	238.0	315.0	245.0
1973	1-Apr	23-May	219.9	220.6	186.0	228.0	216.0	174.0
1974	30-Mar	25-May	220.0	221.2	191.0	234.0	210.0	167.0
1975	26-Mar	14-May	219.9	221.3	188.0	240.0	113.0	61.0
1976	12-Apr	21-May	219.2	221.1	167.0	231.0	114.0	50.0
1977	6-Apr	15-May	218.8	221.1	162.0	234.0	135.0	63.0
1978	29-Mar	3-May	219.3	220.0	170.0	189.0	19.0	-
1979	13-Apr	2-Jun	217.9	221.2	138.0	239.0	262.0	161.0
1980	28-Mar	7-May	220.0	221.1	189.0	235.0	75.0	29.0
1981	28-Mar	23-Apr	219.8	220.8	185.0	223.0	45.0	7.0
1982	6-Apr	28-Apr	218.7	220.9	155.0	225.2	75.0	4.8
1983	28-Mar	12-May	219.0	221.0	161.8	230.4	388.9	320.3
1984	1-Apr	26-May	219.2	221.1	167.6	232.4	136.4	71.6
1985	29-Mar	26-May	219.0	221.1	162.8	232.0	470.9	401.7
1986	1-Apr	26-May	219.2	221.2	167.3	239.2	314.9	242.7
1987	10-Apr	25-May	219.4	221.1	172.7	233.2	320.0	259.5
1988	7-Apr	5-Jun	219.5	221.2	177.0	236.0	257.0	198.0
1989	28-Mar	22-May	219.3	221.1	171.4	234.0	81.8	19.2
1990	28-Mar	22-May	219.0	221.2	163.0	237.6	319.0	244.4
1991	4-Apr	20-May	219.6	221.1	178.6	233.6	212.0	157.0
1992	31-Mar	15-May	219.1	221.1	165.4	233.6	77.0	8.8
1993	25-Mar	26-May	219.5	221.1	177.3	235.2	363.0	305.1
1994	11-Apr	13-May	219.8	221.1	185.4	233.2	110.0	62.6
1995	28-Mar	2-May	219.2	221.0	168.4	231.6	150.1	86.9
1996	15-Apr	11-May	218.8	221.0	158.6	230.4	346.5	274.7
1997	27-Mar	2-May	220.0	221.2	188.9	236.0	299.6	252.5
1998	10-Apr	29-May	219.1	220.0	164.4	188.7	24.3	-
1999							8.4	-

Source: Astana Su

Table E.1.3 Irrigation Area in Astana City and Vicinity in 1993/1999

(Unit: ha)

Name of Farms	Region	Irrigation Area		
		1993	1999	
		Irrigated	design	actual
Zarechny	Tselinogradsky	865	804	253
Ilinovsky	Tselinogradsky	176	176	-
Tselinograd Agricultural Institut (Maman=specialist)	Tselinogradsky	558	558	-
Novoaleksandrovsky	Arshalynsky	691	691	-
Kuigenzhar (Michurino)	Tselinogradsky	687	670	-
Vozdvizhensky (Aktyk)	Tselinogradsky	302	302	-
Plot of land incl. Dachas	Tselinogradsky	1,283	1,283	1,283
Ishim-Astana (Kirov farm)	Tselinogradsky	469	453	-
Total		5,031	4,937	1,536

Source : Ministry of Agriculture

Table E.2.1 Number of Population along Ishim River between Vyacheslavsky Reservoir and Confluence of Kouloton River

Region	Settlement	Number of Residents
Arshalynsky	Volgodonovka	941
	Vyacheslavska	1,078
	Novoalexandrovka	2,487
	Sub-total	**4,506**
Tselinogradsky	Bortak	295
	Vozdvizhenka	1,094
	Semionovka	935
	Sadovoye	453
	Maximovka	1,380
	Novoishimska	1,951
	Novostroika	589
	Priozernoye	1,163
	Pokrovka	438
	Razdolnoye	334
	Lugovoye	953
	Talapker	501
	Topkeris	741
	Hadjimukan	287
	Zeleniy Gai	307
	Sub-total	**11,421**
Astrakhansky	Algabas	264
	Astrakhanka	6,566
	Lazovoye	413
	Lugovoye	89
	Karatubek	64
	Kamyshenka	944
	Novocherkasskoye	1,471
	Ornek	184
	Tavolzhanka	422
	Petrovka	1,190
	Priishimka	302
	Pervomaika	1,385
	Kamenka	1,023
	Undruz (Kypshak)	561
	Shilikty	281
	Zhanabirlik	135
	Zhambul	419
	Zelenoye	1,225
	Sub-total	**16,938**
	Total	**32,865**

Source: Akmola Regional Department of Economy

Table E.2.2 O/M Cost for Alternative Water Resources

	Unit	IKC-Ishim Pipeline	Seletinsky reservoir	Groundwater	Nura river
					to be compensated
(1) Development capacity	MCM	63	60	5.475	from IKC
(2) Power Consumption	Thousand kWH	64,775	82,870	5,740	17,410
(3) Project Cost					Existing
- Direct Cost	Thousand Tenge	3,926,000	18,447,000	3,312,000	
- Administration & Engineering	Thousand Tenge	588,900	2,767,050	496,800	
- Physical Contingency	Thousand Tenge	451,490	2,121,405	380,880	
Total	Thousand Tenge	4,966,390	23,335,455	4,189,680	
(4) Annual O/M Cost					
- Depreciation cost	Thousand Tenge	255,950	1,241,840	220,790	
- Power cost	Thousand Tenge	259,100	331,480	22,960	
Total O/M cost	Thousand Tenge	515,050	1,573,320	243,750	
O/M cost per 1 m^3 of water	Tenge	8.18	26.22	44.52	1.16
Cost of 1 m^3 of raw water	Tenge	9.00	0.00	0.00	9.00
Total O/M Cost	Tenge	17.18	26.22	44.52	10.16

Source: Estimate by JICA Strudy Team

Table E.2.3 Chemical Composition and Contamination of Water at Irtysh-Karaganda Canal Point PS-18 (1984-1996)

Indicators & ingredients	Unit	Irrigation (FAO)	ndustry Fishery	Irtysh-Karaganda Canalat Point PS-18												
				16-Oct 1984	25-Jun 1985	7-Jul 1986	14-Aug 1987	19-May 1988	22-Aug 1989	17-Aug 1990	10-Jul 1991	18-Jun 1992	4-Aug 1993	2-Aug 1994	3-Jul 1995	9-Jul 1996
1 Colour	degree	-	15-30	-	-	-	10	13	13	29	23	16	19	16	10	10
2 Odour		-	1	-	-	-	-	-	0	0	0	0	0	1	1	1
3 Transparency	cm	-	70	28	7	12	23	29	13	26.5	2	11	24	25	25	30
4 SS	mg/l	2000	0.25	1	46	-	2.5	-	10	-	29	0	4	-	-	-
5 PH		6-8	6.5-8.5	7.8	8.4	8.25	8.15	7.1	8.42	8.09	8.18	-	-	-	7.7	7.8
6 BOD	mg/l	150	3-9	3.45	6.7	2	3.2	3	10	12.4	7.1	9.2	9.95	7.9	1.45	1.67
7 Oxidizability	mg/l	-	-	4.64	8.64	2.56	4	4.48	4.96	6.08	3.84	5.9	4.96	4.8	3.3	6.4
8 COD		3,000	15-30	40	12.4	3.2	4.8	5	26.7	36.4	21.5	28	28.7	22	21	25
9 Hardness	mg equiv./l	-	7-10	4	2.8	3	3	3.4	4	4.2	3.5	5	6.4	5	3.9	5.3
10 Dry residues	mg/l	2,500	1,000	481	482	329	364	480	305	445	397	359	399	447	450	625
11 Ferrum	mg/l	5	0.05	0.072	0.009	0	0.01	0.06	0.08	0.11	0.32	0.15	0.02	0.07	0.03	0.01
12 Chloride	mg/l	250	300	105	46	60	56	61	75	49	80	69	69	87	98	148.3
13 Sulphite	mg/l	500	100	182	73	96	112	180	28	192	105	86.4	86.4	81.6	72	86
14 Ammonia	mg/l	-	0.05	0	0.32	0.23	0.13	0	0.45	0.13	0.1	0	0.089	0.16	0.03	0.05
15 Nitrites	mg/l	0.08	0.08	0	0	0.06	0.13	0.02	0	0.008	0	0.02	0.002	0.02	0.004	0.004
16 Nitrates	mg/l	40	40	0	0	0.06	0	0	0.05	0.39	0	0	0.12	0.04	0	0
17 Ferrum	mg/l	1	1.5	0.52	0.42	-	0.29	0.42	0.39	0.31	0.57	0.44	0.43	0.48	0.44	0.6
18 Oil Products	mg/l	-	0.3	0.03	0.01	0.01	0.001	0.003	0	-	0.1	0	0	-	-	-
19 Phenol	mg/l	40	0.001	0.0072	0	0	0.0015	0	0	0.014	0	0.02	0.001	0.004	-	-
20 Cyanide	mg/l	-	0.05	0	-	0	-	-	-	-	-	-	-	-	-	-
21 Cu	mg/l	0.2	0.001	0.024	0	0.016	0.02	0.03	0.03	0.01	0.2	0.12	0.002	0.07	-	-
22 Pb	mg/l	5	0.1	0	0	0	-	0	0	-	0	0	0	0	-	-
23 Cr+3		0.1	0.1	0	-	0	0	0	0.006	0	0.02	0	0.0006	-	-	-
24 Cr+6	mg/l	0.05	0.1	-	0	0	0	0	0	0	0.003	0	0	0.003	-	-
25 Se	mg/l	0.02	0.001	-	0	0.0028	0	0	0	0	0.01	0	0	-	-	-
26 As	mg/l	0.1	0.01	0	0	0	0	0	-	0	0	0	0	0	-	-
27 Mn	mg/l	0.2	0.01	0	0	0	-	0	0.033	0	0.26	0	0	0.005	0	0
28 Sr	mg/l	7	10	-	-	2.75	2.1	-	-	-	-	-	-	-	-	-
29 Phosphate	mg/l	-	-	0.022	-	0.19	0.09	0	0.12	0.17	0.013	0	0.08	0.05	-	-
30 Mo	mg/l	0.5	0.0012	-	-	0	0	0	0	-	0	-	-	-	-	-
31	mg/l	-	0.5	0.057	0.012	0.048	0.04	0.042	-	0.06	0	0.01	0.004	0.03	0.03	0.03
32 Bi	mg/l	0.5	0.1	0	0	0	-	-	0.03	0.014	0	0	0.016	0	-	-
33 V	mg/l	0.1	0.001	0	0	0	-	-	0.025	0.18	0	0	0	0	-	-
34 Be	mg/l	0.1	0.0002	-	-	-	-	0.024	-	0	-	0	0	0	-	-

Source: Report on "Construction of the Pipeline from Irtysh-Karaganda Canal to Upstream of the Ishym River for Water Supply of the Astana City", ,1997 by Design Institute "Kazgiprovodnoz"

Table E.2.4 Chemical Composition and Contamination of Water of Ishim River, Irtysh-Karaganda Canal, Nura River in 2000

Indicators and Ingredients	Unit	MAC	Chemical compositiion and contamination													
			Ishim River Vyacheslavsky Reservoir		Ishim River Astana City Telimana		Irtysh-Karaganda Canal km from P/S No.		Nura River Romanovka		Nura River ura-Ishim Cana		Taldykol Reservoir North point		Taldykol Reservoir East point	
			31-Aug	14-Sep	31-Aug	14-Sep	31-Aug	14-Sep	31-Aug	14-Sep	31-Aug	14-Sep	31-Aug	14-Sep	31-Aug	14-Sep
1 pH		6-9	8.5	8.6	8.2	8.45	8.65	8.6	8.9	8.8	8.8	8.8	9.3	8.9	9.3	8.8
2 Chemical Oxygen Demand (COD)	mg/l	15	14.7	31.7	44	82.5	33	57.1	47.7	57.1	14.9	50.8	25.7	74.3	36.7	74.3
3 Biological Oxygen Demand (BOD_5	mg/l	3	1.68	0.55	0.74	2.82	0.88	2.43	6.49	1.1	5.38	5.68	6.48	7	3.2	4
4 Suspendid Solid (SS)	mg/l	2000	3	4.5	9	11	9	10	11.0	10.0	12	7.8	15.2	11.2	14.6	10.8
5 Disolved Oxygen (DO)	%		89	87	70	84	89	48	96	84	88	78	98	75	99	85
6 Turbidity			1.9	2.6	1.1	1.9	2.2	6.9	2.2	12	5.2	8.6	3.9	5.2	4.3	5.9
7 Chloride	mg/l	250	147	147	217	204	79	80.5	330	329	336	327	260	269	264	267
8 Nitrite Nitrogen (NO_2)	mg/l	0.08	0.015	0.008	0.002	0.002	0.002	0.004	0.009	0.01	0.004	0.006	0.05	0.1	0.032	0.105
9 Nitrate Nitrogen (NO_3)	mg/l	40	0.04	0.02	0	0	0.03	0	0	0.06	0.06	0.06	4	4.8	4.05	5.01
10 Total Nitrogen (T-N)	mg/l		0.14	0.04	0.01	0.01	0.03	0.03	0.11	0.12	0.09	0.1	5.45	7.27	5.28	7.32
11 Ammonia Nitrogen (NH_3)	mg/l	0.5	0.08	0.01	0.01	0.01	0	0.03	0.10	0.05	0.03	0.03	1.4	2.37	1.2	2.2
12 Phosphoric Acid (PO_4)	mg/l		0.058	0.034	0.036	0.05	0.014	0.098	0.23	0.272	0.46	0.242	9600	9300	9150	9310
13 Total Phosphorus (T-P)	mg/l		0.018	0.022	0.029	0.02	0.013	0.078	0.072	0.063	0	0.089	4850	4400	4650	4400
14 Iron (Fe)	mg/l	0.1	0.12	0.08	0.06	0.05	0.24	0.18	0.40	0.65	0.54	0.69	0.21	0.27	0.51	0.36
15 Copper (Cu)	mg/l	2	1	1	3	1	6	2	5	2	2	1	16	6	16	3
16 Zinc (Zn)	mg/l	5	9	4	3	3	6	6	5	8	3	4	25	15	17	15
17 Cyanide	mg/l	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 Fluoride (F)	mg/l	0.75	0.41	1	0.59	0.79	0.43	0.93	0.90	1.40	1.24	1.32	1.03	1.48	1.06	1.11
19 Oil & Grease	mg/l	0.05	0.05	0.04	0.09	0.05	0.05	0.05	0.16	0.07	0.06	0.05	0.05	0.38	0.04	0.09
20 Chromium (Cr)	mg/l		4	0	6	4	6	4	24	24	18	17	8	5	10	13
21 Hexavalent Chromium (Cr_6)	mg/l	0.05	0.004	0	0.006	0.004	0.006	0	0.02	0.021	0.014	0.014	0.008	0.003	0.01	0.009
22 Total Mercury (Hg)	mg/l	0.0005	0.0001	0.0003	0.0007	0.0006	9E-05	8E-05	0.0004	0.0004	0.0002	0.0004	0.0001	6E-05	8E-05	5E-05

Source: Report on surface water, sewage and atmosphere quality surveys in Astana City by Center of Hydrometeorological Monitoring of Astana City, 2000

Table E.2.5 Assessment of Alternative Water Resources

Water Resources	Development Scheme		Quality of Water	Development Scale	Development cost including O/M cost<1	Constraint in Development
Irtysh river	Existing: New facility: (pipeline)	Irtysh-Karaganda canal: 458km long, 418 m in static level of water lift 19.6 km long (1 lane), 122 m in static level of water lift, 3.5 - 7.0 m3/sec in discharge capacity	Class III-IV (Moderately contaminated to contaminated)	Annual discharge capacity of IKC: 838 MCM (in 1989) Capacity of pipeline: 63 - 126 MCM/year	Tenge 17.18 per 1 m3 (including cost of raw water in IKC)	Concentration of heavy metal (copper) should be controlled by dilution/ removal
Nura river	Existing:	Nura-Ishim canal: 25 km long Pipeline to treatment plant: 9km long, static level of water lift 20 m	Contaminated by mercury	Consumed volume should be compensated from IKC	Tenge 10.16 per 1 m3	Clean-up of mercury should be completed.
Selety river	Existing: New facility: (pipeline)	Seletinsky reservoir supply water to Stepnogorsk for dometsic, industrial and agricultural use. 140 km in direct length, 130 m in static water lift	Clean (local information)	60 MCM/year	Tenge 26.22 per 1 m3	High operation cost
Groundwater (Akmolinsky)	New facility: (deep wells, pipeline)	100 m deep wells: 50 nos. Pipeline: 60 km in direct length, 30m in static level of water lift	Class II (Potable)	12,000-17,000 m3/day from Akmolinsky aquifer	Tenge 44.52 per 1 m3	High operation cost & Limited supply capacity
Treated sewage	Existing:	Taldy Kol pond	Available for irrigation use (fodder crops)	About 50 - 70 MCM/year is available		Need detail feasibility study

<1 Estimate by JICA Study Team

Table E.2.6 Principal Features of IKC-Ishim Pipeline

Structures	Principal Features
I. First stage development	
1 Pipeline	
(1) Steel pipe for pressure section	1 lane - Dia.1,400 mm x 9,600 m long, discharge capacity 3,5 m^3/sec
(2) Concrete pipe for non-pressure section	1 lane - Dia 1,200 mm x 10,000 m long, discharge capacity 3.5 m^3/sec
2 Pump stations	
(1) Reinforeced concrete pump station of pipeline	2 stations, each having a space to accommodate 6 units of water pumps
(2) Water pumps at IKC-Ishim pipeline	3 units of 3.5 m^3/sec in total discharge capacity and 61.0 m in static head
	(92.5 m in dynamic head) at two pumping stations of pipeline, respectively
(3) Water pumps at IKC canal	1 unit of 7.0 m^3/sec in discharge capacity and approx. 20 m in static head
	at existing pumping stations PS-17, 18 and 19 of IKC canal
II. Second stage development	
1 Pipeline	
(1) Steel pipe for pressure section	1 lane - Dia.1,400 mm x 9,600 m long, discharge capacity 3,5 m^3/sec
(2) Concrete pipe for non-pressure section	1 lane - Dia 1,200 mm x 10,000 m long, discharge capacity 3.5 m^3/sec
2 Water pumps	
(1) Water pumps at IKC-Ishim pipeline	3 units of 3.5 m^3/sec in total discharge capacity and 6.01 m in static head of
	(92.5 m in dynamic head) at two pumping stations of pipeline, respectively