such technical water supply, transmission pipe is required with a special specification, because of high contents of sulfide and chlorine in treated sewage, which would cause corrosion of pipes and mechanical facilities. If treated sewage is to be used, then the existing technical water distribution system and cooling facilities of the thermal plant should be renovated to accommodate the quality of treated sewage. From an economical point of view, treated sewage is not advantageous for technical water supply.

The plan to use treated sewage for technical water shall be re-considered from the view point of technical sustainability and water demand of the thermal plants in the further study.

3) River Sanitary Flow

There is much sewerage system in the world in which treated sewage is discharged to a river to maintain an appropriate river flow. In such case, sewage may have to be treated by an advanced treatment process to conserve the water quality in the river. If a large amount of water is extracted from the Ishim River, the Ishim could hardly keep the required sanitary flow. Treated sewage discharge to the Ishim River is one of the solutions to the reducing river discharge volume. However, the Kazakstan government does not allow the treated sewage to be discharged to a river, from the view point of possible water quality deterioration. At present, this plan can not be proposed.

Despite this, overflow water of Taldy Kol Reservoir is discharged to the Ishim River even at present, through an emergency pipe to the surrounding wet land. It is recommendable that some parts of treated sewage be discharged to the Ishim River in future.

4) Other Water Uses

Among other water uses, water for nursing trees in the city, sprinkling in streets, gardening, washing water, toilet water can be considered. In this case, distribution pipelines should be installed or a vehicle delivery system should be established.

In case of the pipe distribution, special types of pipe shall be installed the same as mentioned in 2) above. In the case of vehicle delivery system, even if 100 vehicles with a 5 m^3 water tank capacity delivering the water 10 times a day, only 2,500 m^3/day (0.9 MCM/ year) is consumed. Amount of water demand in this case is not considered as a substantial amount even in the future.

(3) Water Balance of Taldy Kol Reservoir

In order that the capacity of the Taldy Kol Reservoir would not be surpassed in future, the volume of effluent water to be discharged to the reservoir needs to be reduced in one of the following ways;

1) To discharge the effluent to the Ishim River and/or Nura River

2) To use the effluent for irrigation, which is most realistic re-use of treated wastewater

At present, discharge of effluent to the Ishim River and Nura River is not allowed due to the environmental regulation in Kazakhstan whilst agricultural land has not been ready yet to receive the treated wastewater.

Irrigation Development Plan

Irrigation use of treated sewage had been considered in the Soviet Union era, and irrigation land operated by using the water from Taldy Kol Reservoir was not more than 1,700 ha in area, although the scheme collapsed at the disintegration of Soviet Union. It is recorded that the productivity of crops in the agricultural land are 20,000 kg/ha of potato, 37,900 kg/ha of corn for silage of and 21,000 kg/ha of Forage Crop

As the unit water demand for the irrigation area is estimated at 4,000 m^3/ha /year by Ministry of Agriculture, water demand for 1,700 ha of irrigation area is roughly estimated 6.8 million m^3/year.

There is a large potential of agricultural development south of Taldy Kol Reservoir. The F/S of Water Supply and Sewerage for Astana indicated that 8,500 ha of land has the potential for irrigation using the treated wastewater. As the Short Term project by 2010, it is recommendable that about 1,700 ha of agriculture land, equal to the Soviet era extent, will be developed for re-use of the treated wastewater. As the Medium Phase by 2020, 8,500 ha of agriculture land is assumed for development. The proposed development plan of agriculture land and required minimum water demand is shown in the table below.

Tentative Development Plan for Agriculture Land for Re-use of Treated Wastewater

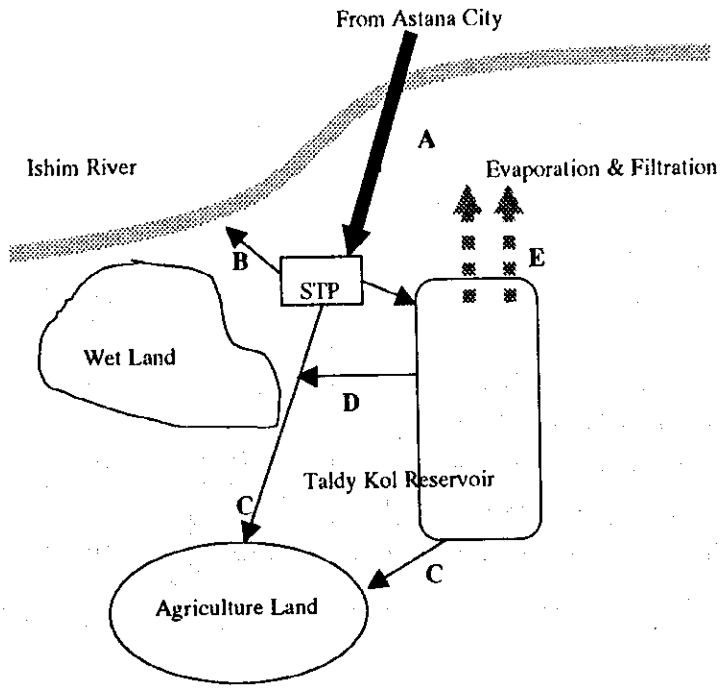
	Before 1995	2000	2010	2020	2030
Development Area for Irrigation (ha)	1,700	0	1,700	8,500	8,500
Irrigation Water Use (million m^3/year)	6.8	0	6.8	34.0	34.0

Even with agricultural development, lands would not be irrigated during the winter season. A large volume of seasonal storage would therefore be required to keep effluent in the winter. It is recommendable to keep Taldy Kol Reservoir as a seasonal storage pond to allow for an effective operation of the irrigation system.

Discharge to the Ishim River

Even if 8,500 ha of agriculture land is developed for the reuse of the treated wastewater, all the effluent could not be used up. For using up all of effluent of STP in 2030, 16,500 ha of agriculture land would be necessary. At present it is difficult to propose a development plan of this extent of agriculture land without a detail study for the development.

It would be a realistic option to discharge part of the treated wastewater to the Ishim River in winter season on the Long Term. Advanced treatment process would be required at STP to achieve suitable water quality in order to discharge to the Ishim River. In order to introduce proper changes in the environmnetal regulation and to select the suitable advanced treatment process, further study will be required. This option is also recommendable from viewpoint of water balance of the Ishim River.



Tentative Water Balance Diagram of Treated Sewage (Alternative 1)

(million m³/year)

		1999	2010	2020	2030
A	Sewage Generation Amount	36.5	40.9	62.5	79.1
B	Direct Discharge to Ishim River After Advanced Treatment	0	0	14.6	45.1
C	Irrigation Water Use	0	6.8	34.0	34.0
D	Discharge from Taldy Kol Reservoir to Wetland in Flood Season	6.9	6.9	6.9	0.0
E	Evaporation and Filtration (when Taldy Kol Reservoir is full)	29.6	27.2	7.0	0.0
F	Surface Area of Taldy Kol Reservoir (km^2)	21.3	19.6	5.1	0.0

There is an opinion that Taldy Kol Reservoir should be reclaimed completely before 2010. If this opinion is to be realized, about 8,500 ha of agriculture land for the reuse of treated wastewater and irrigation system with storage ponds shall have to be developed in due time as shown below.

Tentative Water Balance Diagram of Treated Sewage (Alternative 2)

(million m^3/year)

		1999	2010	2020	2030
A	Sewage Generation Amount	36.5	40.9	62.5	79.1
B	Direct Discharge to Ishim River After Advanced Treatment	0	0	14.6	45.1
C	Irrigation Water Use	0	34.0	34.0	34.0
D	Discharge from Taldy Kol Reservoir to Wetland in Flood Season	6.9	6.9	6.9	0.0
E	Evaporation and Filtration (when Taldy Kol Reservoir is full)	29.6	0.0	7.0	0.0
F	Surface Area of Taldy Kol Reservoir (km^2)	21.3	0.0	5.1	0.0

(4) Rehabilitation and Development of Sewage Treatment Plant

To meet the demand of sewerage service, the sewage treatment plant should be developed. Location, treatment level and treatment capacity and sludge treatment method should be considered. The points to be considered are as shown below.

Points to be considered on Development Plan of STP

	Points to be considered
Location	Impact on surrounding environment of STP Cost for relocation of STP
Sewage Treatment Level	Re-use of treated sewage Impact on discharged water bodies Cost of advanced treatment facility
Sludge Treatment	Impact on surrounding environment of STP Reuse of sludge and disposal of sludge

1) Location

At present there are two alternative locations of STP. One is the same location as the existing STP, and the other is a new location about 20 km south from Astana City. There are advantages and disadvantages in each option. One of the main advantages of the relocation option of the STP is to remove the source of offensive odor far from the city. The disadvantage of this new location is as shown below.

- In addition to the cost of constructing the plant from scratch, the cost of all infrastructures such as trunk sewers, power supply and access roads, etc. should also be incurred.

- Operation and maintenance works of STP become difficult, because of the long distance of the STP from the city.

According to the future land use plan in the Master Plan, new residential areas will be developed at about 1 km away from Taldy Kol Reservoir and at about 3 km away from the STP. Offensive odor generated from STP can be managed by adopting of a suitable sludge treatment method. Existing STP site is therefore recommendable for the future use also.

2) Required Treatment Level

For the purpose of irrigation use of treated wastewater, the minimum required treatment level is the same as the present level, which is the secondary treatment process (conventional activated sludge process)

As mentioned above, some part of effluent of STP shall be discharged directly to the wet land of Ishim River. The surface water quality norms defined in SpanPin 4630 is targeted for water bodies to be used either for water supply or for recreational purposes. According to the Kazakstan law, any effluent which exceeds the standard will not be allowed to discharge to the water bodies.

Water Quality Standard in SanPin 4630-88

Water Quality Items	Unit	Permissible Level
BOD_5	mg/L	3
COD	mg/L	15
Nitrate	mg/L	45
Fecal Coliforms	MPN/100 ml	100
Total Coloforms	MPN/100 ml	100,000

Advanced treatment process is required when conventional STP (secondary treatment process) cannot achieve a sufficiently high quality required for the effluent.

A rapid sand filter process is recommendable for advanced treatment process to the STP, because of operation reliability and easy maintenance of rapid sand filter. However, even if rapid sand filter is adopted, it is difficult to achieve the level of the water quality standard. When making a plan for the introduction of advanced treatment process, the level of the standard shall be discussed from view points of actual environmental conditions and water usage condition of Ishim River.

3) Sludge Treatment

The sludge treatment system in the existing STP consists of sludge thickening tanks, sludge digestion tanks and sludge drying beds. A sludge thickening tank and a digestion tank should be prepared for suitable sludge volume reduction and pathogenic removal. For drying sludge, there are three options, namely 1) effective use of existing sludge drying bed in existing STP site, 2) relocation of the new sludge drying bed far from the city and 3) mechanical de-watering in the existing STP site. The evaluation of the three alternatives is given below.

- Considering initial costs and operation costs reduction, sludge drying bed is the most reasonable method. However, a sludge drying bed requires a large space. Moreover, in the cold and long winter, a sludge drying bed cannot dry the sludge in winter when the sludge is frozen. Sludge storage area is therefore required. Even so, there is enough space for sludge drying bed for the demand until 2020 in the existing STP site.
- Relocation of the sludge drying bed far from the city also requires a large area. The land acquisition for the site is difficult.
- Considering the required area for sludge drying bed and offensive odor protection, mechanical de-watering is evaluated as the most suitable after 2030. Before 2030 when residential area will expand near the site, mechanical de-watering facilities shall be introduced to STP.

Rehabilitation and expansion of sludge treatment process comprising the sludge thickening tanks, the sludge digestion tanks and the sludge drying bed are therefore required to meet the increasing demand until 2020. After 2020, mechanical de-watering facilities shall be introduced.

Dried sludge is useful for agricultural use. However, the sludge reuse in the irrigated area is not popular in Kazakhstan. Large part of dried sludge may have to be disposed of at the solid waste disposal site. After introduction of a pilot plant of incinerator for solid waste as described in Supporting Report (K), the incinerator plant for the sludge could be considered.

G.3 Sewerage Development Plan

G.3.1 Medium Term Development Needs

(1) Sewage Treatment Plant

The existing sewage treatment plant is considered to be operating properly at present, and has a large enough capacity to treat the volume of sewage that would be generated in 2010. In order to assure proper operation in the future, however, large-scale rehabilitation works of STP are required. The rehabilitation works includes sludge treatment process.

(2) Sewage Collection System

Although the design capacity of the existing sewage collection system is considered to have enough capacity for the present demand, some rehabilitation and/or expansion works need to be carried out for the present and future operation, as discussed below.

Rehabilitation

Old and decrepit sewer pipes and sewage pumping stations sometimes cause blockage of sewage flow. For proper operation of the sewage collection system, rehabilitation of old sewer pipes and sewage pumping station is required.

Expansion

About 4,300 ha of new residential area will be developed by 2010 both on the left bank of the Ishim River and eastern part of the right bank. Installation of sewage collection system shall become necessary in the new development area in time for the commencement of construction of housing units in the area.

G.3.2 Long Term Development Needs

(1) Sewage Treatment Plant

The sewage generation amount in 2013 is expected to exceed 136,000 m^3/day (capacity of existing STP). The capacity of STP therefore should be expanded before 2013. The sewage generation in 2030 is projected at 216,842 m^3/day, which means that more than 80,000 m^3/day of the capacity shall be expanded before 2030. In order to reduce pollution load on water bodies, the rapid sand filter process is to be introduced in the expanded facilities. Rapid sand filter process, which is the most popular advanced treatment process, is expected to reduce about 50 % of BOD load of effluent of the STP.

After 2020, residential area will expand within 2 km of the STP site. The sludge drying beds will be demolished and mechanical de-watering facilities are to be introduced in order to reduce offensive odor impact.

Even if the existing sewage treatment plant would be rehabilitated properly, the STP will require rehabilitation again in 20 years, because of the superannuation of the equipment.

(2) Sewage Collection System

The sewage collection system shall be developed to meet the residential area development year by year. Residential sewerage service area is planned to expand to 12,320 ha in 2020, and 14,060 ha in 2030. After 2010, not only sewer pipes in new development area, but also trunk mains should be installed to increase sewage transmission capacity to STP. The pumping stations also shall be reinforced to meet future demand.

G.3.3 Infrastructure Master Plan

(1) Outline of Sewerage Development Plan

As the conclusion of the study, the basic strategy for the sewage system development is shown below.

<u>Sewage Treatment Plant</u>

- The existing STP will be rehabilitated and expanded to meet future demands. Advanced treatment process will be introduced to new expanded facilities.
- The treated sewage will be discharged to Taldy Kol Reservoir, and surplus water will be discharged to the wetland northwest of the reservoir in the same manner as in the present operation. The re-use of treated sewage shall be promoted for irrigational use.

To meet the increasing sewage generation up to 2030, the capacity of the STP shall be increased as shown below.

Development Plan of Sewage Treatment Plant

Item	2010	2020	2030
Incremental Capacity (m^3/day)	0	40,000	42,000
Secondary Treatment Capacity (m^3/day)	136,000	176,000	218,000
Advanced Treatment Capacity (m^3/day)	0	40,000	218,000

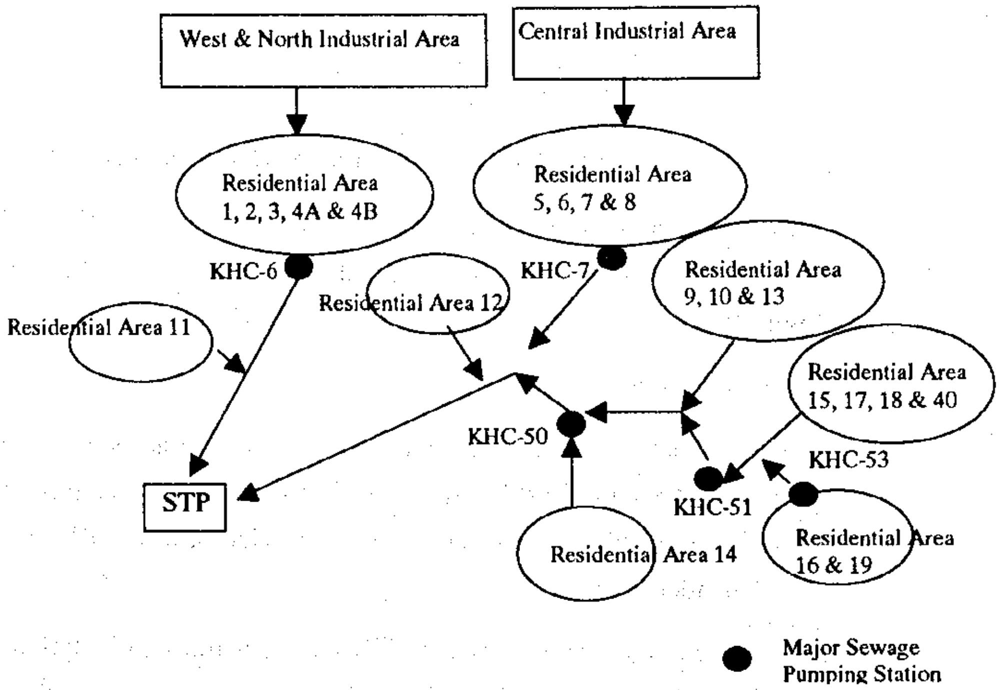
The expansion plan for the sewage treatment plant is shown in Figure G.3.1.

In order to operate at the design treatment capacity, the existing STP shall be rehabilitated, and before 2030, 20 years after the rehabilitation, the STP require full-scale rehabilitation and advanced treatment process.

<u>Sewage Collection System</u>

- The sewerage service area consists of two separate service areas, West Service Area and East Service Area. Each service area has a trunk main connecting directly to STP. Two service areas will be developed independently.
- The sewerage service area will cover both the residential districts and industrial districts. The sewage collection system in the residential districts shall be expanded to service the planned new residential development. The existing sewage collection system in the industrial districts is considered to have enough capacity for the sewage generated in the industrial districts up to 2030. The sewage collection system in the industrial districts will not therefore be mentioned in this Master Plan.
- The number of new pumping stations shall be minimized, in view of efficient operation of the system,

The proposed system diagram of the sewerage system in Astana City up to 2030 is shown below.



Proposed System Diagram of Sewerage System in Astana

The details of the diagram is shown in Figure G.3.2, which shows hourly maximum sewage discharge in typical sewer lines.

Sewer Pipe

Sewer pipes shall be installed to meet area development of residential districts as shown in Figure 4.4.1 in the main report and the following table.

New Installation of Sewer Pipes

	2010	2020	2030
1200 - 1500	3.4 km	7.0 km	0
800 - 1000	9.1 km	13.0 km	0
350 – 600	23.6 km	30.5 km	15.0 km
Total	36.1 km	50.5 km	15.0 km

Pumping Station

From view points of minimization of pumping stations, four pumping stations are recommended for about 8,700 ha of sewerage service area in east side of Astana City. The development schedule of the pumping station is shown below.

New Installation of Pump Station Capacity (hourly peak: m^3/hour)

	2010	2020	2030
KHC-50	2,300	4,700	6,100
KHC-51	1,200	2,900	3,800
KHC-53	-	700	1,200

(2) Outline of Proposed Project

1) Priority Project

Rehabilitation Project for the Existing Sewage Treatment Plant

The project consists of the rehabilitation of pumping facilities in STP; re-construction of grit removal and disposal facilities; rehabilitation of primary and final sedimentation tanks; rehabilitation of aeration tanks; and construction and rehabilitation of sludge treatment facilities. The project shall be completed as early as possible. Considering the implementation schedule, the project could be completed in 2007.

Sewage Collection System Rehabilitation Project.

In all 20 km of sewer pipes, mainly unprotected steel pipes are to be replaced and seventeen sewage pumping stations shall be rehabilitated. The project shall be completed as early as possible. Considering the implementation schedule, the project could be completed in 2007.

Sewage Collection System Expansion Project (1)

Sewage collection system shall be constructed in the area of 4,200 ha to be developed up to 2010. Three pumping stations and approximately 36.1 km of sewer pipes shall be constructed.

2) Sewerage Development Project for 2020

STP Expansion Project (1)

The treatment capacity of 40,000 m^3/day with advanced treatment process shall be expanded to treat the sewage generation volume in 2020. The project should be completed by 2013, when the sewage generation amount exceeds the capacity.

Sewage Collection System Expansion Project (2)

As sewage collection system shall be constructed in the area of 4,300 ha to be developed between 2010 and 2020, new pumps shall be installed in three pumping stations, and one new pumping station shall be constructed, and approximately 50.5 km of sewer pipes shall be constructed. 6 km of trunk main (transmission pipe to the STP) shall be installed before 2015 to supplement the shortage of capacity of the existing trunk main. All works of the project shall be completed before 2020.

3) Sewerage Development Project for 2030

STP Expansion Project (2)

The treatment capacity of 42,000 m^3/day with advanced treatment process shall be expanded to process the sewage generation in 2030. The project shall be completed by 2023, when the sewage generation amount exceeds the capacity.

STP Rehabilitation Project

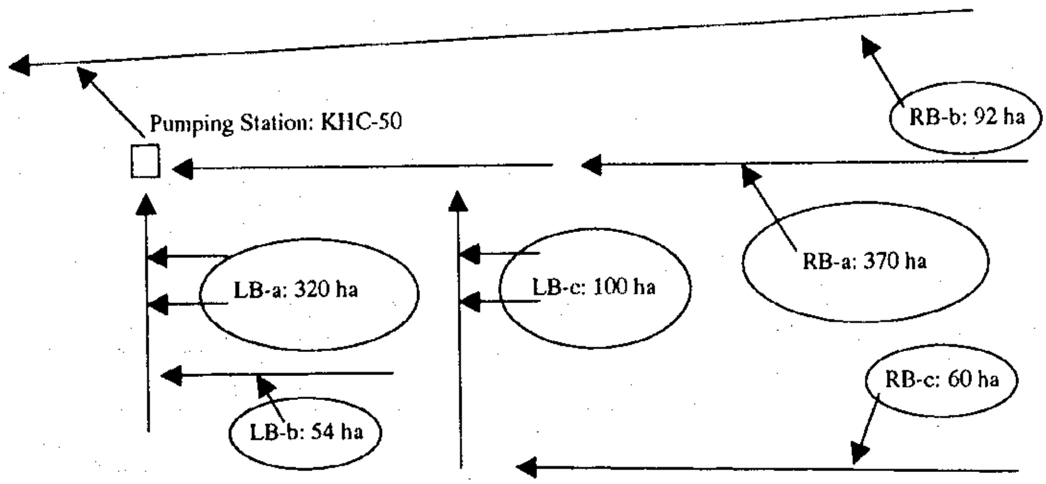
By 2030, rehabilitation of the STP and introduction of advanced treatment process will be required. The project may be carried out in parallel with STP Expansion Project (2). The sludge drying beds will be demolished and mechanical de-watering facilities are to be introduced.

Sewage Collection System Expansion Project (3)

Sewage collection system shall be constructed in the area of 1,700 ha to be developed between 2020 and 2030. New pumps shall be installed in three pumping stations, and approximately 15.0 km of sewer pipes shall be constructed.

G.4 Infrastructure Plan New Town Center

Major sewer pipeline routes are shown in Figure 4.4.2 in the main report. The figure indicates that all the sewage generated in the New City Center area is discharged to the pumping station KHC-50. For the planning of collection in the area, the New City Center area is divided into 6 sub-areas. The proposed system diagram is shown in the figure below.



System Diagram of Sewerage System in New City Center

Sewage generation forecast in each area is shown below.

Sewage Generation Amount

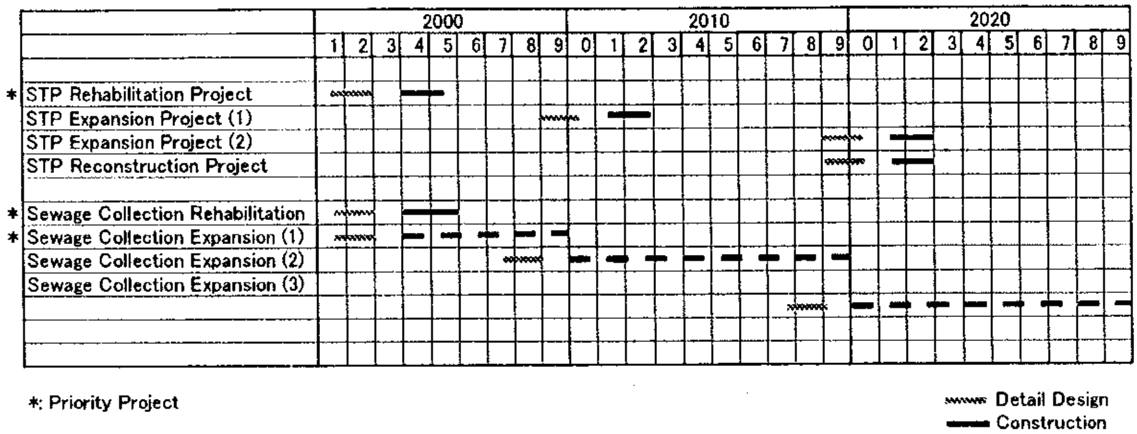
	Area	2010	2020	2030
Left Bank (a)	320 ha	3,260	4,021	4,365
Left Bank (b)	100 ha	1,019	1,256	1,364
Left Bank (c)	54 ha	550	678	736
Right Bank (a)	370 ha	813	938	1,063
Right Bank (b)	92 ha	202	233	264
Right Bank (c)	60 ha	132	152	172
Total	996 ha	5,976	7,278	7,964

Akimat has already started to install sewer pipes in Left Bank (a) area. Sewer pipe installation in the area shall be completed before 2010.

G.5 Implementation Schedule

As described in sub-section G.3.3 (2), seven projects are proposed for the development of sewerage system in Astana City up to 2030. The proposed implementation schedule is shown below.

Implementation Schedule



FIGURE

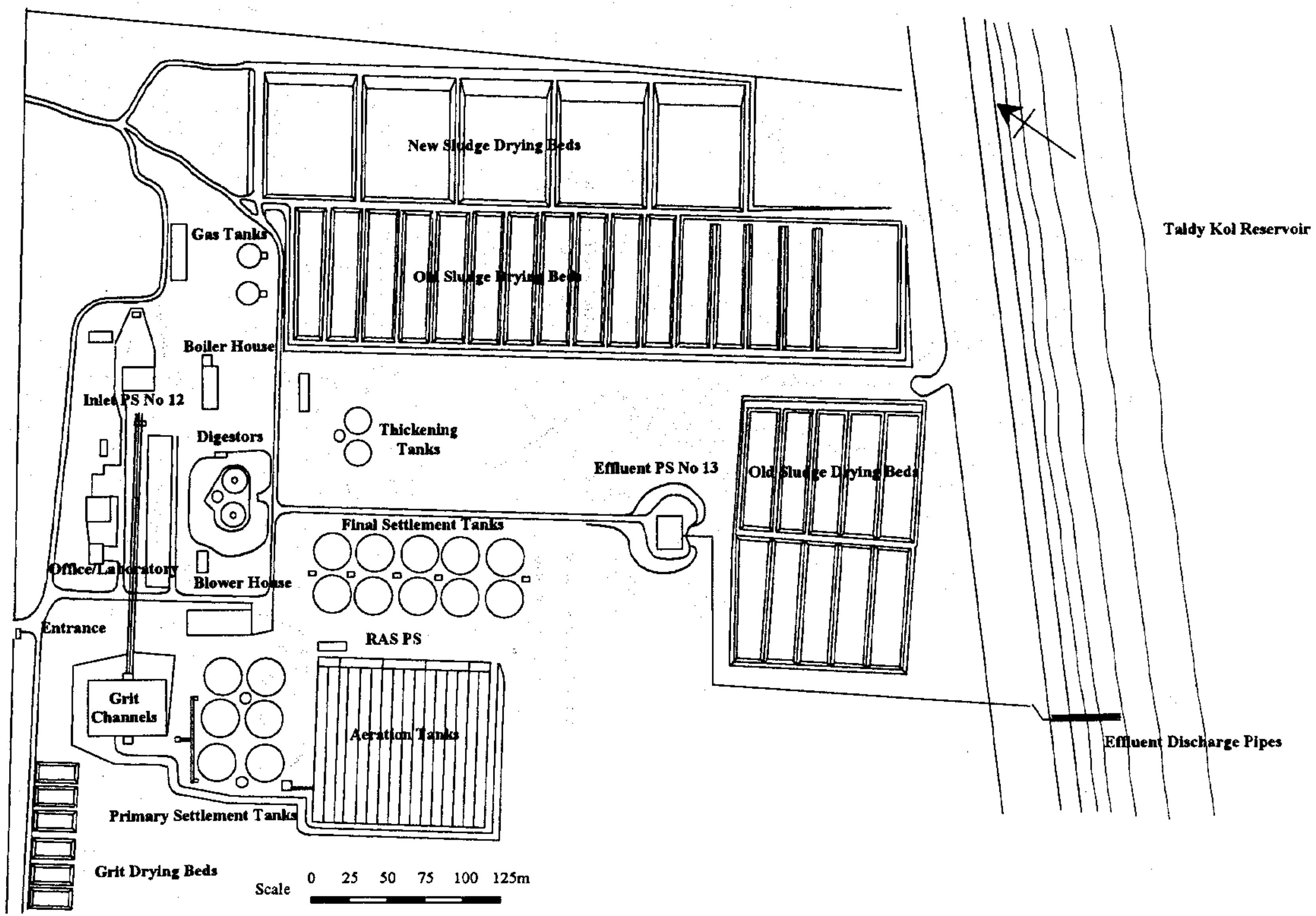


Figure G.1.1 Layout of Existing Sewage Treatment Plant

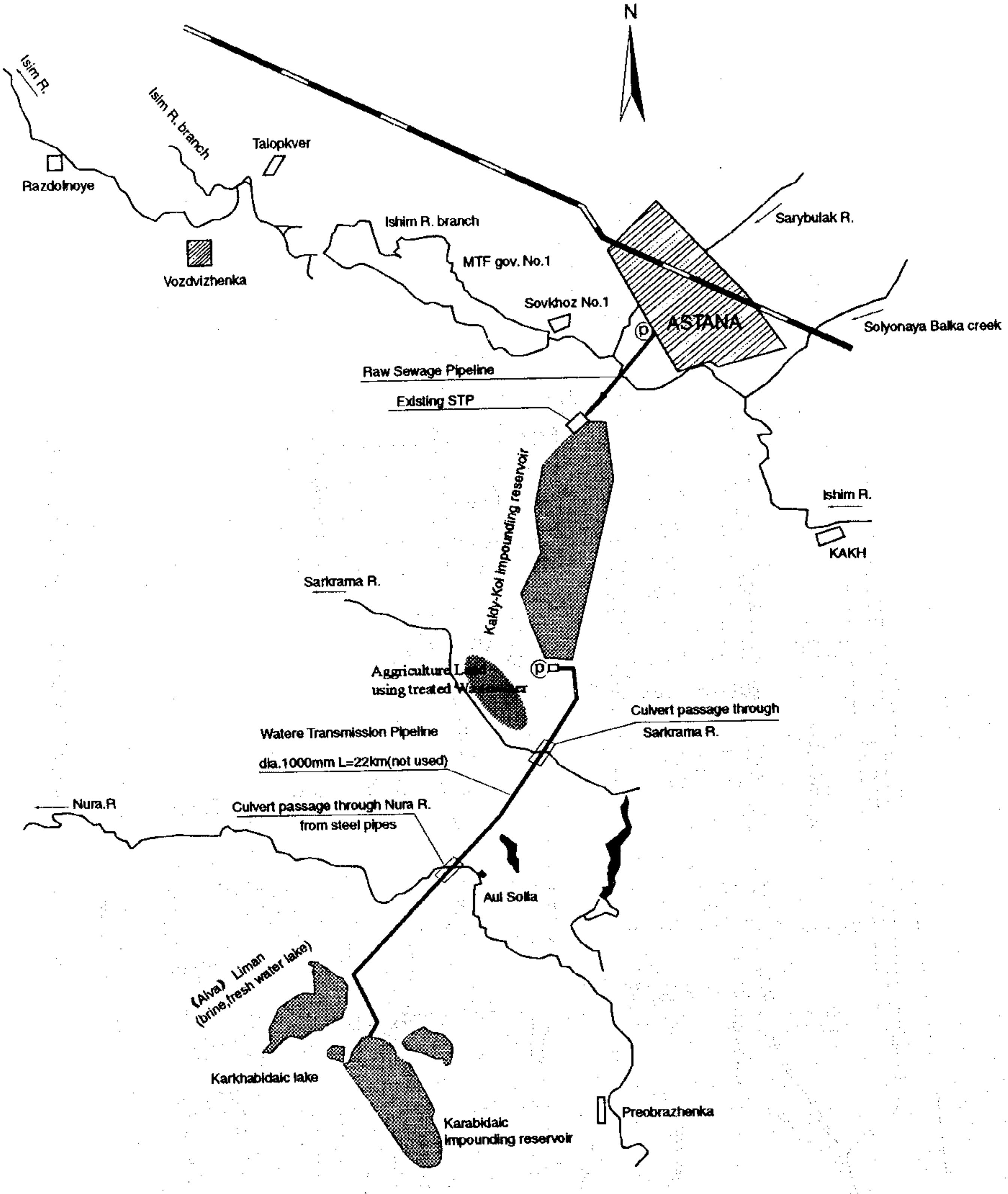


Figure G.1.2 Layout of Transmission System for Irrigation in Soviet Union Era

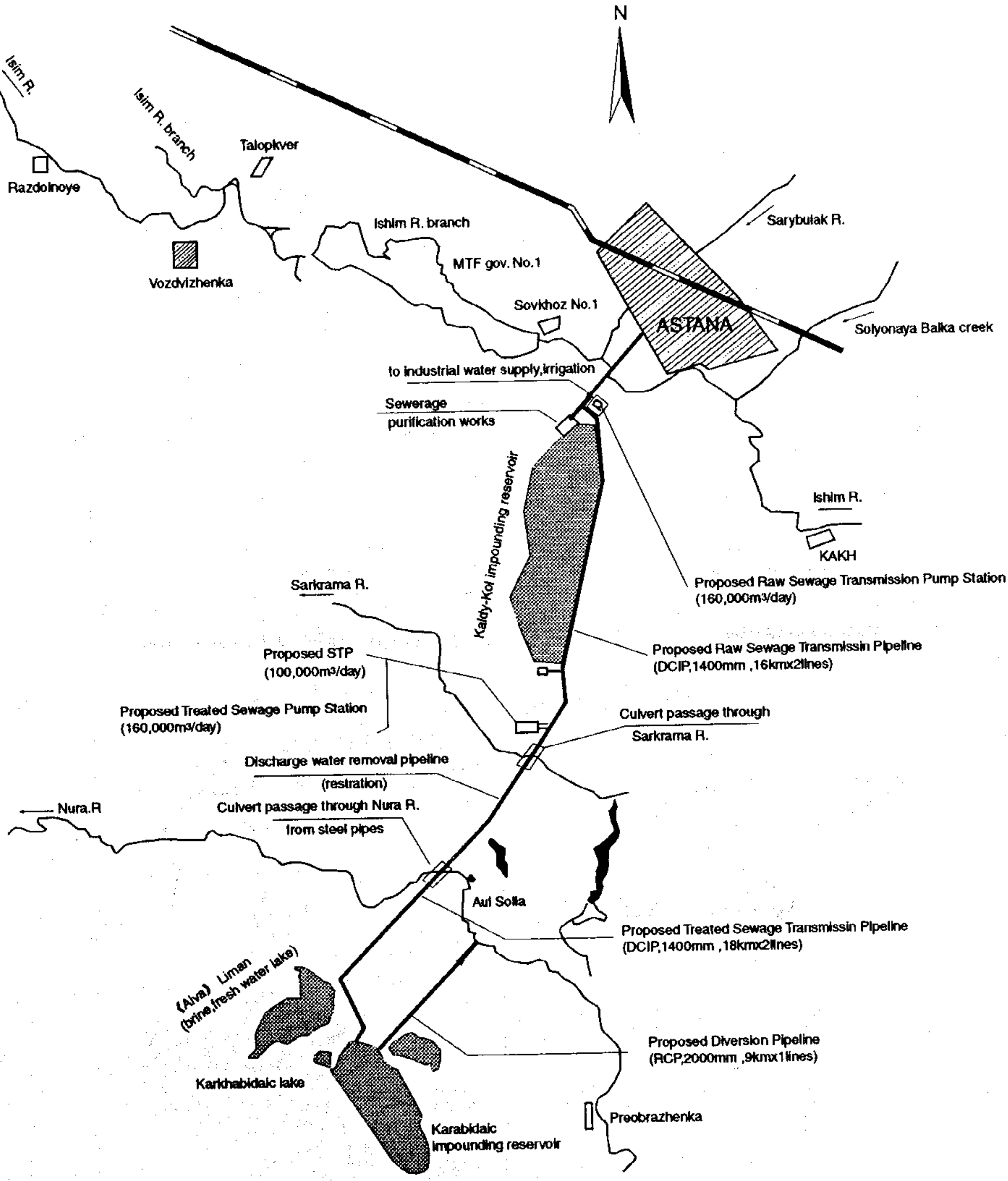
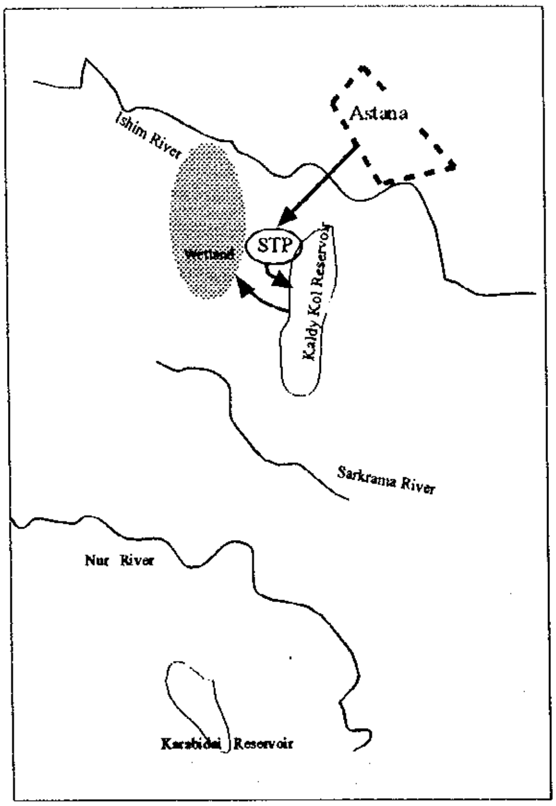
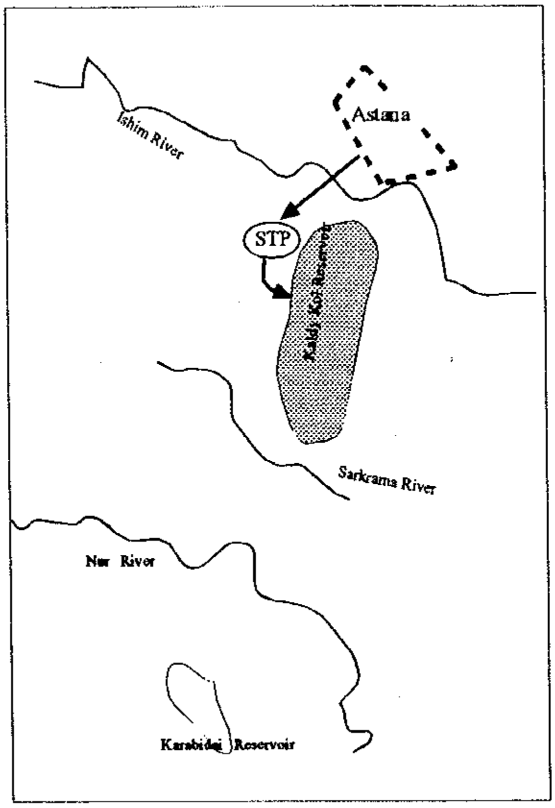


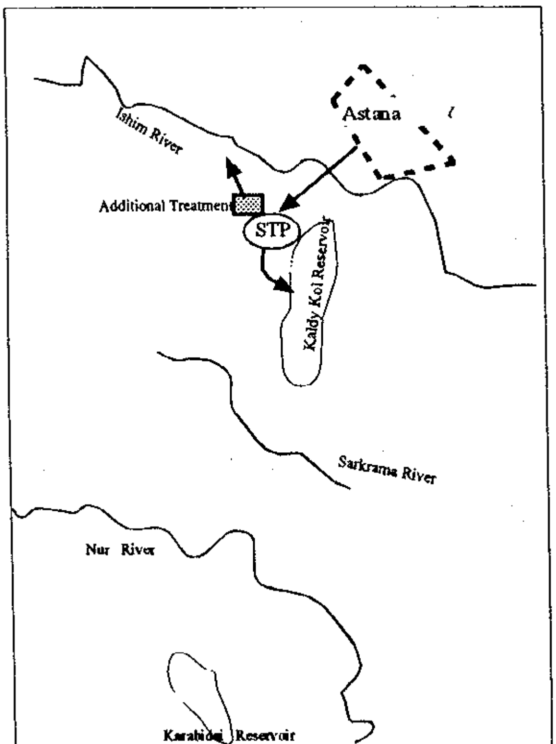
Figure G.1.3 Proposed Layout of Sewerage System in Pre-feasibility Study



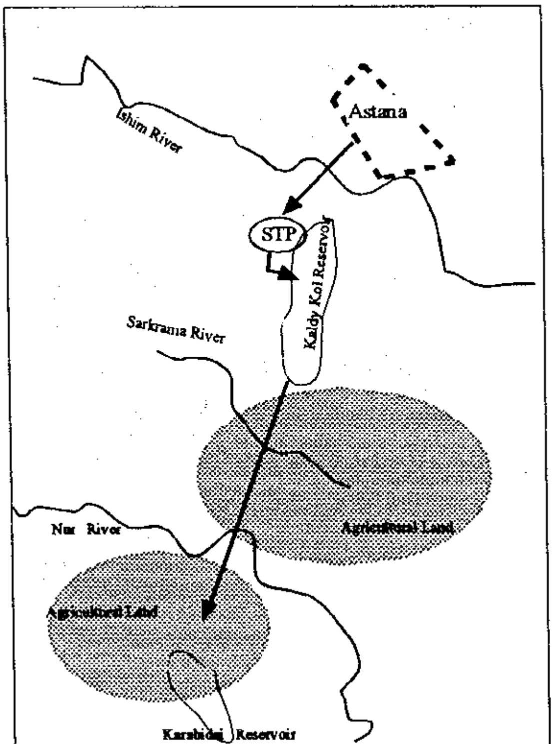
Alt -1 Discharge to Wetland



Alt -2 Expansion of Taldy Kol Reservoir



Alt -3 Discharge to River



Alt -4 Discharge to Agricultural Land

STP :sewag treatmen plant

Figure G.2.1 Alternatives for Sewerage System

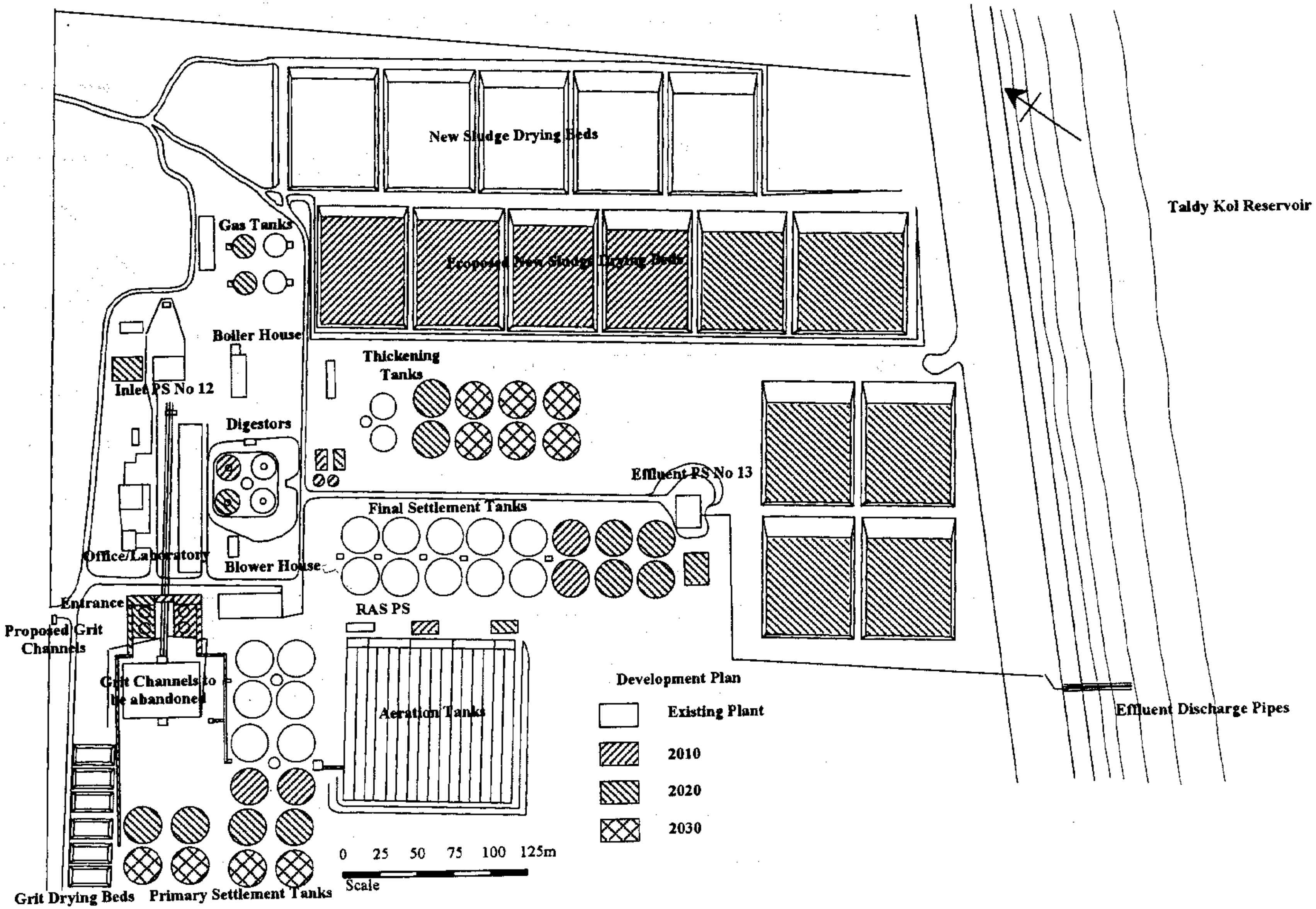


Figure G.3.1 Expansion Plan for Sewage Treatment Plant

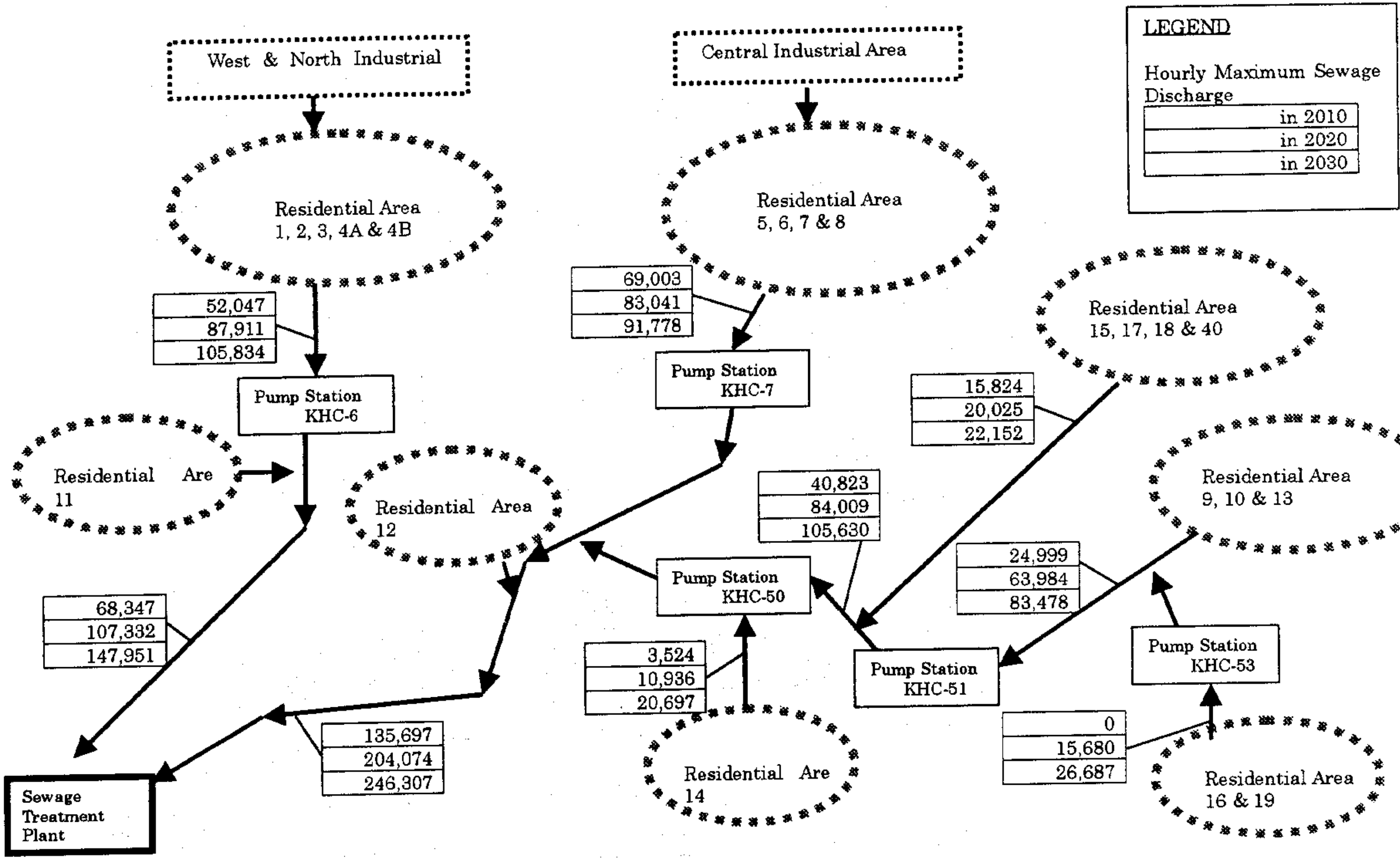


Figure G.3.2 Systematic Diagram of Proposed Sewage Collection System

CHAPTER H
POWER AND HEAT SUPPLY

SUPPORTING REPORT H: POWER AND HEAT SUPPLY

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H.1 Present Conditions of Power and Heat Supply

H.1.1 Present Conditions

(1) Electric Power and Heat Energy Sector related to ASTANA City Development

Astanaenergyservice (AES) registered as an opened joint-stock company in January 1999 produces heat and electric energy and sale those energies to users of Astana City.

AES controls the following four companies in performing their activities:

- Electric power and heat energy generating station for TETs-1 (JV TETs-1)
- Electric power and heat energy generating station for TETs-2 (JV TETs-2)
- Heat supply company (TOO Teplotranzit)
- Electricity distribution and supply company (TOO Gorodskie elktroseti)

In addition, AES issue bills and collects fees for heat and electricity, maintains the power and heat supply systems and facilities and implements works for rehabilitation and expansion of the systems.

(2) Historical Trend and Present State of Electric Power Supply

1) Historical Trend of Electric Power Supply

Most of the electric power required for Astana City is generated by TETs-2 and approximately 5% of the whole electricity requirement is supplied from Ekibastuz through a Ekibastuz – Astana 500 kV single transmission line.

There are two large sized thermal power stations in Ekibustuz, one is Ekibustuz GRES 1 coal-fired thermal power station with the total installed capacity of 4,000 MW and the other is Ekibustuz GRES 2 coal-fired thermal power station with the total installed capacity of 1,000 MW. At present, as the plant operation rates of the two thermal power stations are below 50%, there is sufficient amount of allowance to supply electricity to Astana City. Although TETs-1 generates electricity, the power is only consumed for operation of the own facilities in TETs-1.

Figures H.1.1 and H.1.2 show the historical trends of electric power demand and the maximum electric power in Astana City.

Peak electric power demand was 1,198,096 MWh in 1995 but gradually decreased to 935,776 MWh in 1997 because of decline of industrial activities and decreasing population. The declining trend was reversed from 1998 with the annual growth rate of 8.5%. The electric power demand in 1999 reached 1,156,829 MWh with the annual growth rate of 13.9% due mainly to the rapid expansion of Astana City which became the new capital of Kazakhstan in late 1997.

The figures of maximum electric power (peak load) in the years of 1994, 1995 and 1996 were in the range of 191 and 196 MW, though the peak load decreased to 160MW in 1998. The peak load was apparently improved in the year of 1999 and reached 180 MW.

Figures H.1.3 and H.1.4 show the monthly electric power demand and monthly maximum electric power in 1999.

Electric power consumption and maximum electric power were greatly influenced by seasonal temperature difference. In winter, the monthly electric power consumption and monthly maximum electric power became the highest and dropped to a half or below in summer.

Figure H.1.5 shows a typical daily load curve recorded on 23rd February 1998, showing that the electric power consumption is almost constant from 8 o'clock to 23 o'clock.

This load curve is a typical of lighting peak type, in which the peak demand is recorded between 20 o'clock and 23 o'clock. The daily consumption was stable from the morning to the midnight, and the load dropped at 1 o'clock to about 85% of the daytime level.

Figure H.1.6 shows the historical trend of load factor from 1994 to 1999. Due to relatively small fluctuation of daily electric load, the load factors of 1998 and 1999 were approximately 0.75.

2) Present State of Electric Power Supply

TETs-2 is the main supplier of electric energy to Astana City, while approximately 5% of the whole electricity requirement is purchased through KEGOC (Kazakhstan Electricity Grid Operation Company) network.

Average electricity tariff is Tenge 3.84/kwh, while the electric power generation cost is approximately Tenge 0.8/kwh at the sending end. Fuel cost of coal is approximately Tenge 700/t (with VAT), whereas fuel cost of heavy oil is approximately Tenge 15,400 /t (with VAT).

At the end of December 1999 TETs-1 and TETs-2 had 6 sets of steam turbine generators with the total installed capacity of 262 MW.

3) Power Supply Network

The electric power for Astana City is supplied by 110 kV transmission lines from two power sources, one is TETs-2 and the other is 500 kV central substation of KEGOC (Kazakhstan Electricity Grid Operation Company). The TETs-2 and 500 kV central substation of KEGOC are connected with 110 kV transmission lines as shown in Figure H.1.7.

All of electric power required for Astana City is supplied by TETs-2 and AES (*Astanaenergyservice*) buys electric power from other power generation companies through 220/110 kV transformers of the KEGOC central substation, when the electric power supply is insufficient due to periodical inspection of some unit or trouble of some electric power generation unit of TETs-2.

Records show that electric power supply other than TETs-2 was 8.8% and 2.7% of the entire electric power supply in 1997 and 1998 respectively.

Voltage grading is as follows:

110 kV - 10 kV (35 kV or 6 kV) – 0.4 kV

The outline of electric supply facilities

110 kV transmission lines	all overhead	142.8 km
110 kV substations for distribution	17 (locations)	620.2 MVA
110 kV substations for big customers	6 (locations)	382 MVA
6 kV-10 kV/0.4 kV transformers	534 (locations)	
	785(units)	281.76 MVA
10 kV distribution lines		811.43 km
0.4 kV distribution lines		1,270.64 km

4) Problems of electric power supply to be solved are:

i) Aging and deterioration of substation facilities

Fifteen years or more have passed since the commissioning of 21 (about 62%) sets in the total 34 transformers of 110 kV substations, and the progress of aging and deterioration is considerable.
In addition, as a lot of breakers are of oil-type, maintenance works takes a long time. (AES has the modernization plan.)

ii) Breakdown of underground power distribution lines

Many underground power distribution lines are becoming aged and deteriorating, and many of those cables have been directly laid underground (about 90%). Therefore, when trouble occurs, it takes time to explore an accident point and to restore the damaged cables, which prolongs the power failure. (It is preferable to lay cable in trench.)

iii) Spectacle obstruction with overhead transmission lines

As the entire 110 kV transmission lines in the city are an overhead type, they tend to impair the townscape especially in the central area of the city. (110 kV transmission lines for new installation and replacement will be underground type in trench or duct in the said area.)

iv) Transmission losses

The transmission loss rate in 1998 was 32.7%. The transmission losses are classified into two, one is technical loss and the other is non-technical loss. In 1998, the technical loss and non-technical loss were 14% and 19% respectively. Main reason of non-technical loss was nonpayment for the electricity charge and others were stealing of electrical power, etc. The high loss rate needs to be lowered. (AES has the modernization plan to improve especially non-technical loss, for example, a watt- hour meter installation of each apartment house.)

(3) Historical Trend and Present State of Heat Energy Supply

1) Historical trend of Heat Energy Supply

The heat energy is supplied by means of hot water and steam from electric power and heat energy generating stations TETs-1 and TETs-2. The average annual heat energy supply amount was 2,539 x 1000 Gcal (TETs-1---612 x 1000 Gcal, TETs-2---1,927 x 1000 Gcal) during the past five year, as shown in Table E.1.1.

Table E.1.1 also shows that heat supply amount decreased gradually from 1995 to 1997 because of decline of industrial activities and decreasing population and then the amount reached a peak in 1999, as was the case for the electricity demand.

In 1999, total generated heat amount was 2,721 x 1000 Gcal (TETs-1---600 x 1000 Gcal, TETs-2---2,121 x 1000 Gcal) which was 14% higher than that of 1998.

Table H.1.1, Figures H.1.8 and H.1.9 show that heat supply had peak in December, January and February because ambient temperature was very low, and those tables also show that the maximum monthly supply amounts were 168 x 1000 Gcal/month in December 1997 at TETs-1 and 409 x 1000 Gcal/month in February 1995 at TETs-2.

Typical heat distribution to each category on January 1, 2000 shown in Table H.1.2 and Table H.1.3 indicates that approximately 60% for residents, 20% for office building and 20% for others such as industries.

According to the data received from TETs-1, the lowest heat supply amount throughout the day was 12 o'clock to 16 o'clock and the highest amount was between 16 o'clock with 24 o'clock with their difference being about 20% as shown in Figure H.1.10.

2) Present State of Heat Supply

The main sources of steam / heat supply to industrial enterprises and residential houses are supplied by TETs-1 and TETs-2. TETs-1 supplies heat energy only in the winter season, whereas TETs-2 supplies heat energy throughout the year.

Design heat capacity of TETs-1 is 732 Gcal/h and usual heat supply amount is in the range of 300 to 330 Gcal/h. Optimal heat supply amount of TETs-2 is 540 Gcal/h, though recent data show that the amount was 465 Gcal/h as peak load in winter season.

Generation cost of heat energy by TETs is approximately Tenge 465/Gcal, while the sale price of heat energy is Tenge 1,468 /Gcal.

3) Heat Supply Network

The existing central district heating system in Astana City including the connection lines between TETs-1 and TETs-2 are shown in Figure 4.5.2 in the main report. The heat supply network is composed of steel pipelines of 380 km long in total and the diameters of steel pipes are in the rage of 50 mm to 1,000 m.

In order to distribute hot water to each user evenly, five pump stations with pressurizing pumps are in service. In addition, No.6 pump station is now under construction.

Most of main pipelines are covered with mineral wool insulation material and galvanized or non-galvanized steel plate lagging have been laid above the ground level. The life of the pipeline is about 10 to 12 years, while the life of underground pipe laid directly under the ground is said to be around 7 years due to water content and corrosive substance in the soil.

The period of space heating is about seven (7) months from October to April next year and hot water for living services is supplied throughout the year. Similarly, steam for industrial usage is supplied throughout the year although the supply amount is as little as 30 t/h.

The hot water supply pipes constitute a regional heat supply network and the hot water is supplied to apartment houses, public offices, general office buildings, commercial buildings, etc. Only a few of the important government office buildings have their own heat generating facilities for emergency in addition to the heat supply from the heating system.

There is a plan to place underground piping instead of the existing above ground pipelines from the viewpoint of townscape. Among the entire hot water pipelines in the city, the existing hot water pipelines including supply and return pipelines at the pump stations (heat center) HC-1 and HC-5 will be replaced to underground pipelines from 2000 to 2005. The works will be carried out approximately 3.6 km in length within 2000.

The central district heating system was designed to supply ample heat energy even in the lowest atmospheric temperature like -35°C. TETs-1 and TETs-2 supply approximately 70% of heat energy required for Astana City through the central district heating system and also covers about 80 % of population in Astana City.

There is the following reasons why AES does not supply heat energy to the remaining 30 % of users in Astana City through the central district heating system:

i) Long distance from supply point to user's area thereby requiring high construction cost of pipeline, high supply cost and a long time for pipeline construction

ii) Questionable from the viewpoint of stable supply. About three years ago, heat supply from the central district heating system was not stable because of lack of budget for material preparation and uncertainty of fuel coal receiving. As a result, independent sector had their own mini-boilers for keeping stable operation.

iii) User's expected heat supply period is earlier than the heat supply standard

Some independent sectors with mini-boilers and many new users are now requesting AES to supply heat energy from the central district heating system.

The reasons may be as follows:

i) Now the central district heating system has high reliability

ii) Independent sectors with mini-boilers must pay high price for fuel procurement.

iii) Some trouble will happen within a few years after the commissioning when appropriate routine maintenance is omitted for mini-boilers.

4) Problems of heat supply facilities to be solved are:

i) The district heating system by AES

As mentioned in item 3), heat supply reliability for the existing central district heating system has been improved At present, AES has received many requests to use the hot water from the AES network for new buildings as well as the buildings of the independent sectors having their hot water boilers. (As the trend is continued in future, AES will be highly requested to expand the existing district heating system and increase the capability of heat supply for the district heating facilities such as boilers, heat exchangers and pumps. This item includes in the short-term development needs.)

ii) System of distribution pipelines

The amount of water consumption per year of the pipeline network was about 6,500,000 tons. Among the total consumption of water, leakage from the pipelines accounted for approximately 40%. In order to reduce the water consumption, it is required to investigate service life extension of underground pipelines.

iii) Hot water saving

The same water leakage occurs in small sized branch pipes in buildings too. An idea to provide a closed cycle of hot water system in each building or each building block with a heat exchanger and circulating pumps should be considered. (The idea includes new district heating system.)

iv) Installation of calorie meter or water flow meter

Installation of calorie meters or water flow meter to improve charge collection rate needs to be promoted. (AES has the modernization plan to collect reasonable bill of hot water usage by means of a flow meter.)

v) Installation of user's control equipment

As there is no equipment for controlling indoor temperature, there is a possibility that room temperature becomes excessively high in winter. If indoor thermostat is installed for each user, volume of hot water will be reduced. (This item includes in the district heating system.)

vi) Improvement of townscape with underground pipeline

Adoption of underground pipe is effective not only in the townscape viewpoint but also for reducing heat loss in the extremely cold season, since the temperature at underground is normally higher than that of exposed outside air. There is an idea to maintain the pipe in good condition with appropriate protection method such as giving the steel pipe with polyethylene coating together with heat insulation. In 1999, there was experimentally test of underground piping with double tubes of 400 m in length by Teplotranzit, at present the test result is not yet reported.

(4) Electric Power and Heat Energy Generating Stations TETs-1 and TETs-2

1) TETs-1

TETs-1 is one of the two electric power and heat energy generating stations in Astana City, though all the electric power generated by TETs-1 with the installed capacity of 22 MW is consumed for itself in operating the plant, excluding heat energy generating and sending. The major facilities of TETs-1 consist of four (4) sets of steam generating boilers, six (6) sets of hot water boilers and three (3) sets of steam turbine generator sets. The total installed heat supply capacity of electric power and heat energy generating plants and hot water boilers is 732 Gcal/h, though three sets of hot water boilers with heavy fuel oil firing are only operated at the time of extremely cold ambient temperature in winter as the unit price of fuel is higher than coal.

In 1999, No.1 old boiler of 50 t/h capacity with coal and heavy fuel oil firing was replaced with 65 t/h capacity with coal firing boiler. For No.2 boiler, the same replacement works was completed at the end of 2000. Although fuels required for operating the remaining two boilers (No.3 and No.4) were coal and heavy oil, the modification works were completed at the end of 2000 so as to use coal without an aid of heavy oil except for a boiler in starting.

As the most of the facilities except No.1 and No.2 boilers have been operated 30 years or more since their first commissioning, their retirement will be required in future within 10 to 15 years, when No.1 old boiler replacement needs to be taken into consideration.

The annual technical water consumption of TETs-1 was 1,803,000 m^3 in 1999, while no technical water consumption was recorded in June, July, August and September. Major consumption of the technical water in December was to make up the losses in the hot water circulating system (approximately 35%), cleaning of filters for water treatment facilities (approximately 29%), spray water of scrubber in flue gas cleaning system (approximately 25%) and bearing cooling water system (approximately 10%).

As unit cost of heavy oil is considerably high compared to that of coal, TETs-1 have made effort to change fuel for steam generating boilers from coal plus heavy oil to coal only.

2) TETs-2

TETS-2 supplies both electric power and heat energy to Astana City throughout the year.

Major facilities of TETs-2 consists of five (5) sets of 420 t/h steam generating boiler, and three (3) sets of each 80 MW turbine generator for electric power generation as well for steam supply to the hot water heating system as turbine extraction steam. Heat capacity from three sets of steam turbines through extraction steam for district heating system and industrial steam supply is approximately 540 Gcal/h. Hot water heated up in the range of 115 to 130°C is supplied to hot water circulating pipelines distributed in the city by the hot water circulating pumps.

As the most of the major facilities except No.5 boiler have been operated more than 15 years, some of them 21 years, since their first commissioning. It is required to prepare high maintenance cost every year for steam generator trouble due to high ash content of coal and to improve de-rated steam turbines.

Although water source of making up water losses in the hot water circulating system was drinking water, they changed the water source to technical water in 1999. As a result, drinking water consumption of 6,708,000 m^3 in 1998 was reduced to 4,471,000 m^3 (67%) in 1999. In the meantime, technical water consumption of 1,993,000 m^3 in 1999 was the lowest consumption records throughout past five (5) years and approximately 74% of water consumption of 1998.

There is no waste water treatment facility except for an oily water separator, which separates oil content from oily water in heavy oil handling facilities. Bearing cooling water of which water source is technical water is discharged to a tributary of Ishim River through oily water treatment facility of the city, because some amount of oil from some lubricating system in electric power and heat generating facilities leaks into the cooling water system.

Fuel for generating electric power and heat energy is domestic coal transported by railways from Ekibastuz located approximately 300 km east from Astana City and the coal arrives twice a day in maximum and the maximum total receiving amount is approximately 9,200 t/day. In December 1999, average coal consumption per day was 4,800 t.

Although unit price of the coal is relatively low, the coal quality is not high because of extremely high ash content. The typical coal quality and chemical compositions are shown below.

Low calorific value	4,000 kcal/kg
Ash content (proximate analysis)	40%

Ultimate analysis

C	42.8 %
H	2.7 %
O	7.5 %
N	0.7 %
S	0.7 %
Others	45.6 %

Ash collected from the boiler bottom hopper and other portions is transported to an ash disposal pond by means of pressurized water and the water in the pond is re-used for the ash transportation.

There is the following permissible level of air quality established at ground level in Astana City as the general requirements for air pollution control. TETs-1 and TETTs-2 have to control the flue gas emission as well as other matters based on the annual emission amounts of various kinds of items to be controlled subject to the approval by the environmental control department of Astana City.

Permissible Level of Air Quality

Total Suspended Particles (TSP)	0.5 mg/m^3
Nitrogen Dioxide (NO_2)	0.085 mg/m^3
Nitrogen Oxide (NO)	0.4 mg/m^3
Sulfur Dioxide (SO_2)	0.5 mg/m^3
Carbon Oxide (CO)	5.0 mg/m^3
Fluoride Hydrogen (HF)	0.02 mg/m^3

Flue gas emission and other items to be controlled by TETs-1and TETs-2 are as follows:

Flue gas emission control items	VO_5, NO_2, NO, SO_2, CO, Ash
Other than flue gas	Heavy oil, dust derived from coal, Acid liquid and Alkaline liquid

Although TETs-2 keeps the annual emission amounts approved by the environmental control department of Astana City, emission standard of total suspended particles less than 150 mg/ Nm^3 shown in the table of Required Emission Standards for Coal Fired Boiler in Sub-Section H.2.6 would not be attained judging from 40% of ash in fuel coal and visual check of flue gas discharging condition at the flue gas stack of TETs-2.

Tables H.1.4, H.1.5, H.1.6 and H.1.7 show particulars of No.1 and No.2 electric power and heat energy generating stations (TETs-1 and TETs-2).

3) Problems of electric power and heat generating plant to be solved are as follows:

i) Old power and heat generating facilities of TETs-1 and TETs-2

For TETs-1, the most of the facilities except No.1 and No.2 boilers have been in service for 30 years or more, their retirement will be required in future within 10 to 15 years.

For TETs-2, three sets of steam turbines and electric generators have been in service for 17 to 21 years and four sets of steam boilers in total five sets have been in service for 15 to 21 years.

In order to keep high reliability of each facility, it is highly required to conduct periodical special inspection to prolong their service life Moreover, it is very important to make plan to replacement of old facilities with new ones taking into consideration of increase of electric power and heat energy demand in future. (This item includes in the TETs-2 extension.)

ii) Coal unloading facility in TETs-2

As there is only one coal unloading facility in TETs-2, number of the unloading facilities should be increased at least to two thereby shortening the unloading works. (This item includes in the TETs-2 extension.)

iii) Technical water saving

The source of bearing cooling water for TETs-2 is technical water and the water is discharged without re-use after passing through the bearing cooling water heat exchangers. In order to minimize technical water consumption, the cooling water system should be a closed cycle in which the cooling water is taken from lower temperature side of the condenser cooling circulating water system and returned to high temperature side of the condenser. Of course, oil leakage from lubricating oil system of each facility should be eliminated. (This item includes in the TETs-2 extension.)

iv) Drinking water saving

The source of compressor cooling water for TETs-2 is drinking water and the water is discharged without re-use after passed through compressor. In order to minimize drinking water consumption, the system water should be the same closed cycle as the above bearing cooling water system. (This item includes in the TETs-2 extension.)

v) Maintenance works of boilers

As ash content of the coal for boilers of TETs-1 and TETs-2 is as high as approximately 40%, there is a possibility for occurrence of slagging of boiler furnace tubes, fouling of boiler tubes in the middle and low combustion gas temperature zone and erosion of boiler tube surfaces. Most of boilers of TETs-1 have been operated for 23 to 37 years and boilers of TETs-2 have been in service for 15 to 21 years. In this connection, it is highly required to consider appropriate maintenance works to keep their reliability and to extend their operation life as well as the extension plan taking into consideration of their operation life time.

H.1.2 Planned and Scheduled Improvements

AES (*Astanaenergyservice*) has prepared a report showing the development of heat and power supply system of Astana City for the period up to 2005.

Major items in the report are to supply electricity to new substation in New City Center from Airport switching substation with new 110 kV transmission lines, to supply heat energy to New City Center from TETs-1 and TETs-2 through the new extension pipelines, to construct 115 MW electric power. The heat energy generating plant at TETs-2 as extension project including reconstruction and modernization of the existing facilities and energy saving measures.

The followings are planned and scheduled improvement items by AES or Astana City.

(1) Electric Power Supply Network

1) 110 kV transmission lines from Airport switching substation to new 110 kV/ 10 kV substation located on New City Center on the left bank of Ishim River and the 110 kV/ 10 kV substation will be newly constructed. The construction works will be completed in 2001.

2) The following two alternatives are presently under consideration.

Alternative 1: reinforce the existing 110 kV transmission lines from the KEGOC's 500 kV substation to the WESTERN substation

Alternative 2: reinforce the existing 110 kV transmission lines from TETs-2 to the AIRPORT substation

3) AES is planning to conduct a feasibility study regarding 110 kV transmission lines and distribution lines in the entire area of Astana city including the new developing area, mainly located on the left bank of Ishim River.

(2) Heat Energy Supply Network

1) New pump station (HC -6) on the right bank of Ishim River is under construction. The construction work is going to continue in 2001.

2) A plan to replace 500/500mm pipelines to 700/700 mm is now in progress to meet the increasing demand of heat from TETs-1.

3) Among the entire existing hot water pipelines of the central district heating system in the city, those including supply and return pipelines at the pump stations (heat centers) HC-1 and HC-5 will be replaced to underground pipelines from the year 2000 to 2005. The works was carried out approximately 3.6 km in length in 2000.

4) At the end of August 2000, AES started to select a consultant for executing the feasibility study regarding heat distributing pipeline network in the new development area of Astana city including investigation of appropriate protection methods of underground pipelines to extend the life time.

5) Construction of heat supply extension pipelines from the existing central district heating system to new developing areas such as New City Center, District Nos. 12 and 14 so as to supply heat energy from TETS-1 and TETs-2. (This item is under planning by AES.)

(3) Electric Power and Heat Energy Generating Facilities

1) No.2 boiler of TETs-1 was replaced from the old boiler capacity of 50 t/h to 65 t/h boiler with coal firing. The replacement works was completed at the end of 2000. The fuel of the old 50t/h boiler was coal and heavy oil.

2) Modification works of boiler burners and automatic operation of boilers No.3 and No.4 of TETs-1 were finished at the end of 2000, thereby allowing coal firing in normal load operation without aid of heavy oil. There is a plan to modify No.8, No.9 and No.10 hot water boilers from heavy oil firing to natural gas firing when natural gas is available. At present, those boilers have little chance to operate because the heavy oil unit price is very high compared with that of coal.

3) In addition to the existing two cooling towers in TETs-2, one cooling tower is under construction, because No.1 cooling tower is badly deteriorated thereby reducing cooling effect of condenser cooling water and increasing the water consumption. After completion of No.3 cooling tower, TETs-2 will recondition No.1 cooling tower.

4) New construction of 115 MW coal fired conventional electric power and heat energy generating plant in near future

(4) Planned and Scheduled Improvement prepared by Present M/P

Refer to Sub-Section H.3 Power and Heat Supply Development Plan for the planned and scheduled improvement prepared by Present M/P.

H.1.3 Assessment of Short Term Development Needs

Major developing areas up to 2010 are New City Center, District No.17, District No.9 and District name of Station 40.

The followings are development needs to generate electric power and heat energy and supply them to users in accordance with demand of each development area as a short term.

(1) Installation of new electric powers and heats energy generating plant in TETs-2 to respond electricity and heat energy demand at the developing areas.

Although there is sufficient amount of allowance of electricity supply to Astana City from Ekibustuz located 300 km east of Astana City through the 500 kV single transmission line. A new installation of electric power and heat energy generating plant in Astana City is required because of the following reasons.

1) Because Astana City is the new capital of the Republic of Kazakhstan, electricity supply must be of high reliability.

2) There are many plans to expand the existing city size, and accordingly, not only demand of electricity but also of heat energy will increase. In this regard, the most effective way to produce electric energy and heat energy is by electric power and heat energy generating plant, because the efficiency of such plant is higher than an ordinary thermal power plant.

3) When the entire electric power demand of Astana City is supplied by the facilities located in Astana City such as TETs-1 and TETs-2, electricity from Ekibustuz will be used as back up reserve thereby increasing electricity supply reliability to the entire users of Astana City.

4) When some amount of electricity is continuously received from the 500 kV transmission line throughout the year, there is a possibility of interruption of electricity supply by some trouble of the transmission line. The transmission line of 500 kV from Ekibustuz to Astana is a single line and approximately 300 km long.

5) As four steam generators in total five at TETs-2 have been in operation for 15 to 21 years since their first commissioning and three steam

turbines have been in service for 17 to 21 years since their first commissioning, new additional facilities will be effective for giving the chance of better maintenance of those facilities for improving aging and deterioration and prolonging their lifetime.

6) When new facilities are installed in TETs-2, there will be new employment opportunities requiring high level of professional skills, which may contribute to a growth of Astana City.

In the meantime, there are a number of advantage to install new facilities in TETs-2 as follows:

1) There is enough space in the plant to install new facilities, because buildings prepared in the 1990s for installation of 185 MW are still available.

2) As there is surplus capacity in the existing coal receiving facility, the facility is capable of handling additional coal quantity.

3) Domestic coal with low price can be procured without difficulty.

4) It is questionable to use natural gas for the electric power and heat generating plant before 2006.

5) Boiler capacity may be reduced if the existing boiler outlet common header is connected to new boiler outlet. Refer to Figure H.1.11.

6) The existing flue gas stack could be utilized for new boiler without new construction of flue gas stack.

7) As there are sufficient number of operation and maintenance engineers as well as office staff, they can manage, operate and maintain a new heat and electric energy plant without elaborate

(2) Extension of district heat pipes from the existing central district-heating network to the developing areas including New City Center

(3) New construction of 110 kV transmission lines to the developing areas such as Airport switching substation to New City Center and new transmission lines from TETs-2 to Airport switching substation as the increase of transmission capacity and the replacement of the existing old transmission lines

(4) New construction of 110 kV/ 10 kV substations such as New City Center, District No.17 and High-tech Park in District I

(5) Supply of electricity required for extension of the existing water treatment plant, sewage treatment plant and new provision of south-north line of light railway transit (LRT) through the existing 110 kV/ 10 kV substations

H.1.4 Formulation of Urgent Development Project

There are four items for candidate urgent development projects as given below:

(1) Coal fired electric power and heat energy generating plant as extension of TETs-2.

(2) Construction of 110 kV new transmission lines from TETs-2 to Airport switching substation

(3) Construction of new transmission lines from Airport switching substation to New City Center including 110 kV/ 10 kV substation in New City Center.

(4) Extension of the district heating pipelines from the existing central district heating system to New City Center.

For item 3), Astana City is planning to start the construction from 2001. For item 4), the pipeline construction will be started with their own budget soon after the investigation which was started by AES because the item is also a very urgent matter.

In order to respond to new electric power and heat energy demand in the developing areas in Astana City and to make a chance for replacement or modification of old facilities or systems, constructions of coal fired electric power and heat energy generating plant as the extension of TETs-2. The 110 kV transmission lines from TETs-2 to Airport switching substation were proposed here as an urgent development project.

To fulfill the construction of the plant and the transmission lines in time, a Feasibility Study of the project is required immediately.

(1) Items to be executed in the Feasibility Study

1) Reviewing of Present M/P

2) Organization relating to electric power and heat energy sector

3) Existing situation of electric power and heat energy generation and supply

4) Plan of rehabilitation and modernization for the existing facilities

5) Material transportation from foreign countries to the site

6) Availability of fuel, maximum receiving amount and unit price including natural gas fuel

7) Comparative study of other plants
Alternative plans, such as 150 MW or 185 MW output plans will be examined in the Feasibility Study while 115MW turbine generator and 420 t/h boiler are proposed here.

8) Conceptual design and particulars of equipment
Conceptual design shall be carried out for deciding particulars of equipment of major facilities such as boiler, turbine, generator, coal storage and handling facilities, ash treatment facility, cooling tower system, water treatment facility, waste water treatment facility, central control room, electrical equipment, etc.

9) Environmental assessment

10) Project implementation schedule

11) Project cost estimation

12) Economic analysis of the project

13) Financial analysis of the project

(2) Outline of Electric Power and heat Energy Generating Plant

1) Rated output

Rated output	Electric power	115 MW (Max. 125MW)
	Heat energy	approx. 175 Gca/h

2) Type of heat energy and electric power generation facility
Conventional steam turbine plant with extraction steam for industrial and district heating services

3) Steam generator

Natural or forced circulation, drum type coal firing steam generator (the steam generator should be of appropriate construction for natural gas firing modification with the least modification cost)

Capacity.. approx. 420 t/h

Steam pressure at boiler outlet........................ 140 kg/ cm^2

Steam temperature at boiler outlet.................. 560 Centigrade

Number of set.. 1

4) Steam turbine

Double-cylinder types with two controlled steams extractions for industrial and district heating

Rated output .... approx. 115 MW

Inlet steam pressure.. 130 kg/cm^2

Inlet steam temperature .... 555 Centigrade

Turbine extraction steam pressure
for industrial service.. approx.13 kg/cm^2

Turbine extraction steam pressure
for district heating... approx. 0.5~2.0 kg/cm^2

Number of set 1

5) Generator

Three phase, 50 Hz, 3,000 rpm, hydrogen-cooled type with excitation system.

Rated output .... approx. 115 MW

6) Kind of fuel

Coal (Natural gas will be used with boiler modification when natural gas is available as boiler fuel.)

7) Time period of the first commissioning........... Beginning of 2006

8) Related facilities including:

Boiler ancillary equipment, steam turbine ancillary equipment, generator ancillary equipment, coal receiving facilities, coal unloading facilities (two more), ash treatment facilities, water treatment facility, waste water treatment facility, cooling tower and condenser circulating water system, electro-static precipitator, flue gas desulfurization facility, heavy fuel oil storage facility and transfer system, compressed air system, hot water heaters, hot water circulating pumps, etc.

9) Location... TETs-2 as the Extension Works

10) Others

- The existing boiler and turbine houses will be utilized as new boiler and turbine houses.

· The existing coal-receiving yard will be used for coal receiving for new boiler with two sets of additional installation of coal unloading facilities.

· The existing flue gas stack will be used for discharging flue gas from new boiler.

· The existing ash disposal area will be used for disposing ash from the new boiler.

· As the proposed steam generator capacity is not enough for the proposed steam generator at the rated load, steam required for the steam turbine will be taken from boiler common steam header.

(3) Outline of 110 kV transmission lines from TETs-2 to Airport switching substation

1) Type of the transmission line...................... Overhead-cabling type

2) Approximate length.................................... 35 km long

(4) Work Schedule (The plant construction work schedule is shown here, the transmission line construction schedule will be shorter than this construction schedule.)

Loan Agreement	:	Start in Sep. 2001
Contract of Consultant	:	2 months
Site Survey and Preparation of Tender Documents	:	6 months
Tender Announcement and Tendering	:	3 months
Evaluation and Negotiation of Bids	:	3 months
Approval of Award of Bids	:	1 month
Civil Work to Steel Structure (S/S)	:	10 months
S/S to Drum Lifting	:	7 months
Drum Lifting to Hydrostatic Pressure Test	:	8 months
Hydrostatic Pressure Test to Initial Firing	:	7 months
Initial Firing to Commercial Operation	:	7 months
Total	:	54 months

(5) Project Cost

1) Electric power and heat energy generation plant

The estimated total project cost is US$ 130.2 million

Refer to H.2.7 Project Cost Estimation in detail.

2) 110 kV transmission lines from TETs-2 to Airport switching substation

The estimate total project cost is US$ 6.1 million, breakdown is as follows:

- 110 kV transmission line construction cost............. US$5.5 million
- Mandatory spare parts and consumable................. US$0.23 million
- Consultant fee... US$0.15 million
- Contingency.. US$0.22 million

Total... US$6.1 million

H.2 Basic Concepts for Power and Heat Supply Development Plans

H.2.1 Electric Power Demand Forecast

(1) Forecast Methodology

Methodologies of electric power demand forecast may be classified into two; one is a macroscopic forecasting method in which the electric power demand for Astana City is forecasted as a large area, the other is a microscopic forecasting method which finds the distribution of high and low electric power demand areas in Astana City individually. The latter method enables district-wise distribution of electric power demand, which is essential to the power system planning.

In the macroscopic forecasting, there are a few methods for electric power demand forecast some basic data is listed below:

i) Data of economic growth index
ii) Data of average power consumption per capita
iii) Others (For example, trend of electric power growth rate)

For microscopic forecasting method, the following data of each district will be utilized are as follows:

i) Population of each district
ii) Commercial floor area of each district
iii) Office floor area of each district
iv) Unit electric power consumption in Industrial area
v) Other special or public facilities floor area

(2) Electric Power Demand Forecast and Peak Load Forecast based on Macroscopic Method

There are a few methods for the long-term macroscopic demand forecasting from which to analyze the general situation of future electrical demand.

In this demand forecasting, the following two basic data are utilized for two different calculation methods.

- Data of economic growth index
- Data of average power consumption per capita

1) Electric Power Demand Forecast Utilizing Economic Growth Index

One of the most common and popular methods to estimate the nationwide power demand is to use the data of GNP or GDP. For the demand forecast of Astana City, data of GRDP (Gross Regional

Domestic Products) is used as the economic growth index instead of GNP or GDP.

Basic conditions are as follows:

- Forecasting Period:
  From 2000 to 2030 (30-years)
- Basic data: GRDP per capita and their annual growth rate

Table below shows GRDP per capita and their annual growth rate.

GRDP per Capita and the Annual Growth Rates

Unit: Tenge x 1000

	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020	2025	2030
GRDP per capita	40	47	86	159	149	160	267	358	421	455	490	519
Annual Growth Rate (%)		17.5	83.0	84.9	-6.7	7.38	10.7	6.4	3.3	1.6	1.5	1.2

Actual Power Production and Their Growth Rates

Table below shows actual power generation and the annual growth rates.

Actual Power Generation and Their Annual Growth Rates

Unit: MWh

	1994	1995	1996	1997	1998	1999	2000
Actual Power Generation	1,162,832	1,198,096	1,076,480	935,776	1,015,200	1,156,829	1,289,342
Annual Growth Rate		**3.03%**	-10.15%	-13.07%	**8.49%**	**13.95%**	**11.45%**

In order to obtain the average annual growth rate of power generation from the above table, data of the positive growth rates such as 3.03%, 8.49%, 13.95% and 11.45% are selected. As a result, the average annual growth rate is 9.23%.

Power Demand Elasticity

Power demand elasticity is calculated as shown below:

When the growth rate of power production is 9.23% and the annual growth rate of GRDP per capita for the years between 2000 and 2005 is forecast as 10.7% and the power demand elasticity is calculated as 0.863.

Power Demand Elasticity = Growth Rate of Power Production / Growth Rate of GRDP per Capita

Annual Growth Rate of Electric Power Demand

The annual growth rate of electric power demand is calculated as follows:

Annual growth rate of electric power demand = Annual growth rate of GRDP per capita x Power demand elasticity

Table below shows the necessary data for calculation and calculated annual growth rate of electric power demand.

Annual Growth Rate of GRDP per Capita, Power Demand Elasticity and Annual Growth Rate of Electric Power Demand

Year	2000	2005	2010	2015	2020	2025	2030
Annual Growth Rate of GRDP per Capita	7.38%	10.7%	6.4%	3.3%	1.6%	1.5%	1.2%
Power Demand Elasticity	0.863	0.863	0.863	0.863	0.863	0.863	0.863
Annual Growth Rate of electric power demand	6.37%	9.23%	5.52%	2.85%	1.38%	1.29%	1.04%

Electric Power Demand Forecast based on Economic Index

The electric power demand is thus calculated based on the projected growth rates and the electric power demand of 1.157 GkWh in 1999:

Table below shows the calculation results.

Calculation Results of Electric Power Demand Forecast

	2000	2005	2010	2015	2020	2025	2030
E.P.Demand Forecast Gkwh/Year	1.231	1.914	2.504	2.882	3.086	3.290	3.465
E.P. Demand Forecast (Average) MW	**141**	**218**	**286**	**329**	**352**	**376**	**396**

Peak Load Forecast

The past data of the load factor for the electric power supply system in Astana is calculated as follows:

Load Factor = Annual total production MWh ÷ Peak load MW ÷ 8,760 hours

The annual electric power production, peak load and calculated load factors are shown in the table below.

Annual Total Production, Peak Load and Calculated Load Factor

Unit of Annual total production : MWh

	1994	1995	1996	1997	1998	1999
Annual total production	1,162,832	1,198,096	1,076,480	936,776	1,015,200	1,156,829
Peak load MW	191	192	196	177	151	180
Load factor	0.695	0.712	0.627	0.604	0.767	0.734

The load factor of 0.75, which is an average value of 1998 and 1999 was used as the mean load factor in the following calculation.

Peak Load Forecast

Peak load forecast is calculated as follows:

Peak Load Forecast = Annual electric power demand forecast ÷ Mean load factor ÷ 8,760

Table below shows annual electric power demand, load factors and calculated peak load.

Annual Electric Power Demand, Load Factor and Calculated Peak Load

Year	2000	2005	2010	2015	2020	2025	2030
E.P. Demand (Gkwh)	1.231	1.914	2.504	2.882	3.086	3.290	3.465
Load factor	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Peak Load (MW)	**188**	**291**	**381**	**439**	**470**	**501**	**527**

2) Electric Power Demand Forecast Utilizing Annual Average Power Consumption per Capita

Basic conditions are as the following

- Forecasting Period: From 2000 to 2030 (30-Years)
- Basic data: Annual power generation per capita

The data of annual average power generation per capita of several countries are shown in the table below.

Annual Average Power Generation per Capita of Several Countries

Year	1990	1992	1997	1999
Kazakhstan	**5,202**	**5,774**	**3,743**	**3,850**
Russia	7,313	6,659		
Ukraine	5,750	4,731		
China	589	650	917	
Korea	3,053	3,348		
Japan	7,167	7,192	8,227	
France	7,977	7,140	8,117	
Italy	3,841	4,525	4,372	
USA	12,184	12,160	13,198	

In the meantime, the actual data of annual average power generation per capita of the years 1991 to 1999 in Astana City are shown in the following table.

Data of Annual Average Power Generation per Capita in Astana City

	1991	1992	1993	1994	1995	1996	1997	1998	1999
Annual Electric Power Generation 1000 x MWh	1,581	1,561	1,302	1,163	1,198	1,076	936	1,015	1,157
Population x 1000	288	292	290	286	284	279	275	275	318
Annual Power Generation per Capita kWh	5,490	5,346	4,490	4,066	4,218	3,857	3,403	3,691	3,638

Population and annual average power generation per capita

As the annual average electric power generation per capita in 1999 in Astana City was 3,638 kWh, 3,700 kWh was adopted as that of 2000 and also 5,800 kWh was adopted for the year 2030 which was almost the same as that of 1992 in Kazakhstan as shown above. Other figures for the years of 2005, 2010, 2015, 2020 and 2025 are decided by proportional allotment.

Table below shows population, annual average power generation per capita and average electric power demand forecast calculated by the following formula:

Average electric power demand forecast = Population x Average power generation per capita

Population, Average Power Generation per Capita and Calculated Demand Forecast

Year	2000	2005	2010	2015	2020	2025	2030
Population x 1000	322	400	490	590	690	750	800
Average power generation per capita Wh	3700	4050	4400	4750	5100	5450	5800
Calculated average demand forecast GkWh	1.191	1.620	2.156	2.803	3.519	4.088	4.640
Calculated average demand forecast MW	**136**	**185**	**246**	**320**	**402**	**467**	**530**

Peak Load Forecast

As per the calculation of electric power demand forecast and peak load forecast utilizing economic growth index, the load factor of 0.75 was adopted. The same figure was used for the following calculation.

Peak Load Forecast = Electric power demand forecast ÷ Mean load factor ÷ 8,760

Table below shows electric power demand, load factor and calculated peak load.

Electric Power Demand, Load Factor and Peak Load

Unit of E. P. Demand: GkWh

	2000	2005	2010	2015	2020	2025	2030
E.P. Demand	1.191	1.620	2.156	2.803	3.519	4.088	4.640
Load Factor	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Peak Load	**181MW**	**247MW**	**328MW**	**427MW**	**536MW**	**622MW**	**706MW**

(3) Electric Power Demand Forecast and Peak Load Forecast based on Microscopic Method

General Principle

A microscopic electric power demand forecast is made to clarify the electric power demand of each district of Astana City as well as the entire demand of Astana City. As a result, new substation locations will be decided taking into consideration of concentrated demand areas in Astana City.

The following data have been utilized for the electric power demand forecast.

- Population of each district
- Commercial floor area of each district
- Office floor area of each district
- Unit electric power consumption at industrial area
- Other special or public facilities or buildings

In order to calculate electric power demand at each district area, the following district numbering and name of district are used as per Figure 3.4.1.

District No. 1 to 19 including 4A and 4B

Northern industrial district

Central industrial district

Industrial district Station 40

Planning district I to IX

Power consumption per capita

Table H.2.1 shows actual output of electric power energy, average power consumption per capita and also percentage of total effective power demand for production of electric energy of TETs-2. In order to calculate electric power demand based on population as one of categories and electric power production at TETs electric generator end from the sum of every category of power demand at user end. A 45.0 W/capita as average power consumption per capita and 46.0 % as the power demand conversion value from user end to electric generator end were utilized for calculation of power demand in 2000. The average power consumption per capita of 45.0 W/capita in 2000 will be increased with increasing annual income of people living in Astana City.

The following table shows the estimated average power consumption per capita which were calculated with the same increase rate as the average power generation per capita used for the electric power demand forecast utilizing annual average power consumption per capita as shown in sub item 2), item (2), Sub-section H.2.1.

Average Power Consumption per Capita

Unit: W/capita

Year	2000	2010	2020	2030
Average power consumption per capita	45.0	54.0	62.0	70.0

The total effective power demand of 46.0% in 2000 will be improved with improving of technical loss, commercial loss and power plant consumption for electric power and heat production.

The following table shows the estimated effective power demand.

Total Effective Power Demand

Unit: %

Year	2000	2010	2020	2030
Production of Electric Energy at Generator End of TETs	100	100	100	100
Power Plant Consumption for Power and Heat Production	-17.5	-17.0	-15.5	-14.0
Technical Loss, Non-technical Loss and Others	-36.5	-30.5	-27.5	-27.5
Total Effective Power Demand	46.0	52.5	57.0	58.5

Table H.2.2 shows electrical demand data of industrial sector. The table is prepared to calculate average power demand of industrial sector per work force and shows that average power demand of industrial sector per work force (person) capita is 1.40 kW/work force. Electric power demand of industrial sector is calculated based on industrial sector work force in 2000, 2010, 2020 and 2030 and the above average power demand of industrial sector per work force.

Table H.2.3 shows basic data for microscopic electric power demand forecast. In this table, floor areas of office, commercial and other building are treated as gross floor area which includes toilet, warehouse, passage ways, etc.

Tables H.2.4, H.2.5, H.2.6 and H.2.7 show average power demands based on population, office floor area, commercial floor area and average power demand of industrial sector respectively.

Table H.2.8 shows average power demand of electrical facilities proposed by Present M/P. The data on the table were added to the category of "Industry" on the Tables H.2.9, H.2.10, H.2.11 and H.2.12.

Tables H.2.9, H.2.10, H.2.11 and H.2.12 show average power demand of each category and the sum in 2000, 2010, 2020 and 2030 respectively. Table H.2.13 shows average power demand at each district in 2000, 2010, 2020 and 2030.

Table H.2.14 shows calculation result of microscopic power demand forecast including maximum power demand forecast.

Table below shows the calculation results of maximum electric power demand forecast by means of both macroscopic and microscopic methods.

Maximum Power Demand Forecast

Unit: MW

	2000	2005	2010	2015	2020	2025	2030
Macro. Econo. Index	188	291	381	439	470	501	527
Macro.Population	181	247	328	427	536	622	706
Micro.	226	* 295	362	*425	485	*530	570
Proposed	**226**	***295**	**362**	***425**	**485**	***530**	**570**

Note: * show expected values taken from the given data of the years 2000, 2010, 2020 and 2030.

The above data are shown in Figure H.2.1 as a bar graph.

(4) Conclusion of Electric Power Demand Forecast

It is usual practice to adopt a microscopic method when electric power demand forecast in short term is calculated and the calculation results are checked with calculation results obtained from macroscopic electric power demand forecast.

The following table shows features of the used demand forecast methods.

Features of Load Demand Forecast Methods

	Appropriate for term	In case of short term forecast	Probable errors in
Macroscopic M. by Economic Index data	Long Term Forecast	Check microscopic method results with these results	GRDP per capita Annual growth rate of power generation
Macroscopic M. by Population	Long Term Forecast	Check microscopic method results with these results	Population growth Average power generation per capita
Microscopic M.	Short Term Forecast	Use this method	Basic data of population, commercial, and office floor area, population of industrial workers Average power consump. per unit for the above basic data

In the meantime, when long-term demand forecast is required, macroscopic demand forecast is adopted rather than microscopic demand forecast because the results might be distorted by cumulated errors. As the electric power demand forecast in this Present M/P requires not only the load demand of the entire Astana City but also district-wise load demand, microscopic load demand forecast was made for 30 years.

As the result of the above three electric power demand forecasts, the calculation result based on microscopic method are regarded as most applicable on the following grounds even in the year range from 2010 to 2030:

- Although three projections show almost similar results up to 2015, there is a considerable amount of difference between the two macroscopic methods in 2030 with the difference 179MW, while the microscopic locates 43 MW higher than that of the lower macroscopic result. When the calculation results of the microscopic demand forecast are compared with those of the macroscopic demand forecast based on economic index, both results are almost same throughout the years. Therefore the calculation results of the microscopic method are applicable for the electric power demand forecast.

  The macroscopic calculation based on population will be therefore used, as the high forecast whereas the macroscopic calculation based on economic index will be adopted for the low forecast in 2020 and 2030.

- As the microscopic demand forecast includes electric power demand forecast at each district, the data are immediately applicable without any correction.

H.2.2 Heat Energy Demand Forecast

(1) Forecast Methodology

The methodologies of heat energy demand forecast may be classified into two similar as in that of electric power demand forecast; one is macroscopic forecasting method, and the other is microscopic forecasting method.

The same data as in the power demand forecasting would be utilized, for the micro- and macro-scopic methodologies.

(2) Heat Demand Forecast and Peak Load Forecast based on Macroscopic Method

General Principle

In this demand forecasting, the following two basic data are utilized for two different calculation methods, as in the electric power demand projection.

· Data of economic growth index

· Data of average heat consumption per capita

1) Heat Demand Forecast Utilizing Economic Growth Index

Basic Condition

· Forecasting Period: From 2000 to 2030 (30-years)

· Basic data: GRDP per capita and their annual growth rate

Table below shows GRDP per capita and their annual growth rate.

GRDP per Capita and Their Annual Growth Rates

Unit: Tenge x 1000

	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020	2025	2030
GRDP per Capita	40	47	86	159	149	160	267	358	421	455	490	519
Annual Growth Rate (%)	-	17.5	83.0	84.9	-6.7	7.38	10.7	6.4	3.3	1.6	1.5	1.2

Actual Heat Generation and Their Growth Rates

Table below shows actual annual heat generation and their annual growth rates.

Actual Annual Heat Generation and Their Annual Growth Rates

Unit: Gcal

	1995	1996	1997	1998	1999	2000
Annual Heat Generation	2,641,668	2,513,441	2,142,375	2,380,065	2,721,105	2,760,614
Annual Growth Rate (%)	-	-4.85	-14.76	11.09	14.33	1.45

In order to obtain average annual growth rate of heat generation from the above table, data of plus growth rates such as 11.09%, 14.33% and 1.45% are selected. As a result, the average annual growth rate is 8.96%.

Heat Demand Elasticity

Heat demand elasticity is calculated as shown below:

Heat demand elasticity = Growth rate of heat production / Growth rate of GRDP per capita

When the growth rate of heat production was 8.96% and the annual growth rate of GRDP per capita for the years between 2000 and 2005 was forecast as 10.7%, the heat demand elasticity was calculated to the 0.837.

Annual Growth Rate of Heat Demand

Annual growth rate of heat demand was calculated as follows:

Annual growth rate of heat demand = Annual growth rate of GRDP per capita x Heat demand elasticity

Table below shows the necessary data for calculation and calculated annual growth rate of heat demand.

Annual Growth Rate of GRDP per Capita, Heat Demand Elasticity and Annual Growth Rate of Heat Demand

	2000	2005	2010	2015	2020	2025	2030
Annual Growth Rate of GRDP per Capita (%)	7.38	10.7	6.4	3.3	1.6	1.5	1.2
Heat Demand Elasticity	0.837	0.837	0.837	0.837	0.837	0.837	0.837
Annual Growth Rate of Heat Demand (%)	6.18	8.96	5.36	2.76	1.34	1.26	1.00

Heat Demand Forecast Based on Economic Index

The heat demand was calculated as follows:

Heat demand (Average) = Heat demand of previous year x (1+Annual growth rate of heat demand of the objective year)

Heat demand in 1999 was 2,721,105 Gcal/year. Table below shows the calculation results of the heat demand forecast.

Calculation Results of Annual Heat Demand Forecast

Unit; G kcal

	2000	2005	2010	2015	2020	2025	2030
Annual Heat Demand Forecast	2,889	4,437	5,761	6,601	7,055	7,511	7,894

Peak Load Forecast

Load factor is calculated as follows:

Load Factor = Annual total production [Gcal] ÷ Peak load [Gcal/hour] ÷ 8,760[hour]

Table below shows calculated results of the past load factors.

Annual Total Production, Peak Load and Calculated Load Factor

		1995	1996	1997	1998	1999
Annual Total Production [Gcal]		2,641,668	2,513,441	2,142,375	2,380,065	2,721,105
Peak Load [Gcal/h]	TETs-1	296	294	332	240	239
	TETs-2	-	472	400	419	484
	Total	-	766	732	659	723
Load Factor		-	0.375	0.334	0.412	0.430

Load factor of 0.421, which is an average value of 1998 and 1999 was used for the following calculation.

Peak Load Forecast

Peak load forecast is calculated as follows:

Peak Load Forecast = Annual Heat Demand Forecast ÷ Mean Load Factor ÷ 8,760 hour

Table below shows heat demand forecast, load factor and calculated peak load.

Heat Demand Forecast, Load Factor and Calculated Peak Load

	2000	2005	2010	2015	2020	2025	2030
Heat Demand Forecast [1000 X Gcal/year]	2,889	4,437	5,761	6,601	7,055	7,511	7,894
Load Factor	0.421	0.421	0.421	0.421	0.421	0.421	0.421
Peak Load Forecast [Gcal/hour]	783	1,203	1,562	1,790	1,913	2,037	2,140

2) Heat Demand Forecast Utilizing Annual Average Heat Consumption per Capita

Basic Condition

- Forecasting Period: From 2000 to 2030 (30 – Years)
- Basic data: Annual average heat consumption per capita

Table below shows annual actual heat generation, population and annual heat consumption per capita.

Annual Actual Heat Generation, Population and Annual Heat Consumption per Capita

	1995	1996	1997	1998	1999
Annual Actual Heat Generation [Gcal]	2,641,668	2,513,441	2,142,375	2,380,065	2,721,105
Population [x 1,000]	284	279	275	275	318
Annual Heat Consumption per Capita [Gcal/capita]	9.302	9.009	7.790	8.655	8.557

The annual average heat consumption per capita of 8.663 Gcal, which was an average value of 1995 to 1999 was used for the following calculation.

Population and Annual Average Heat Consumption per Capita

Table below shows population, annual average heat consumption per capita and average heat demand forecast calculated by use of the following formula:

Average Heat Demand Forecast = Population x Annual Average Heat Consumption per Capita

Population, Annual Average Heat Consumption per Capita and Calculated Annual Average Heat Demand Forecast

	2000	2005	2010	2015	2020	2025	2030
Population [x 1,000]	322	400	490	590	690	750	800
Annual Average Heat Consumption per Capita [Gcal]	8.663	8.663	8.663	8.663	8.663	8.663	8.663
Calculated Annual Average Demand Forecast [x1,000 Gcal]	2,789	3,465	4,245	5,111	5,977	6,497	6,930

Peak Load Forecast

As per the calculation of heat demand forecast and peak load forecast utilizing economic growth index, the same load factor is adopted for the calculation of peak load forecast.

Peak Load Forecast = Annual Heat Demand Forecast ÷ Mean Load Factor ÷ 8,760 hour

Table below shows heat demand, load factor and calculated peak load.

Heat Demand, Load Factor and Calculated Peak Load

	2000	2005	2010	2015	2020	2025	2030
Heat Demand [x 1,000 Gcal]	2,790	3,465	4,245	5,111	5,977	6,497	6,930
Load Factor	0.421	0.421	0.421	0.421	0.421	0.421	0.421
Peak Load [Gcal / hour]	757	940	1,151	1,386	1,621	1,762	1,879