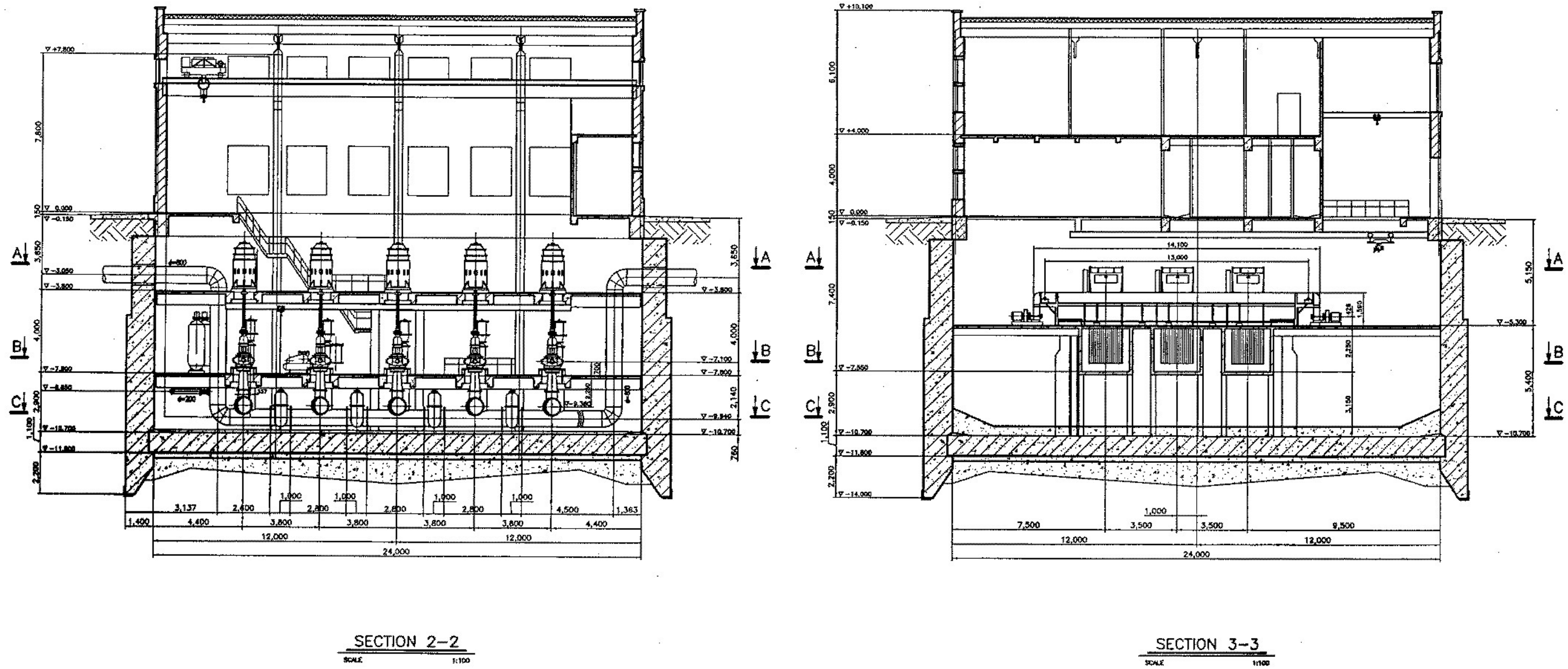


Figure 2.3.8-3

Drawing of Typical Pump Station (Large Size) – 3/3

КОРПОРАЦИЯ РАЗВИТИЯ СТОЛИЦЫ
JAPAN INTERNATIONAL COOPERATION AGENCY
NJS CONSULTANTS CO.,LTD.–JAPAN
NIHON SUIDO CONSULTANTS CO.,LTD.–JAPAN

THE DETAILED DESIGN STUDY OF THE WATER SUPPLY AND SEWERAGE SYSTEM FOR ASTANA CITY
ДЕТАЛЬНОЕ ПРОЕКТИРОВАНИЕ СИСТЕМ ВОДОСНАБЖЕНИЯ И ВОДООТВЕДЕНИЯ В ГОРОДЕ АСТАНЕ

4) Sewers and Manholes

ⅰ) Sewers

Inventory of sewers was investigated. Construction of sewers started in 1951. The inventory of a total sewer length of 226.6km provides information on location, diameter, length, material type, construction year and manhole numbers in each pipeline.

Figure 2.3.9 shows the sewage collection network. Specific feature of the network is as shown below:

- A pressure line basically consists of double lines.
- Pressure lines are made of steel pipe, 14% of total length
- Cast-iron pipe is broadly used, 40% of total length.
- Concrete pipe is relatively low in composition percentage.
- Asbestos-cement has about 20 %, most of them are utilized for small diameter pipeline below 300mm.
- Use of asbestos-cement pipe is not restricted at present, which may cause the lung disease asbestosis.

Table 2.3.10 Composition of Different Pipe Materials

Pipe Material	Length (m)	Percentage	Remarks
Asbestos-cement	45,461.51	20.1	
Cast-iron	85,380.96	37.7	
Ceramics	32,574.45	14.4	
Reinforced concrete	27,929.70	12.3	Mainly gravity collector
Polyethylene	2,240.00	1.0	
Steel	32,264.80	14.2	Mainly pressure collector
Other	727.00	0.3	
TOTAL	226,578.42	100.0	

As for the installation depth of sewers, some pressure lines are installed above the ground.

ii) Manholes

A total of 5,279 manholes were found in the above-mentioned inventory. From this number, average distance between two manholes is calculated approximately 43m. Through the field investigation, numbers of 5,213 manholes were confirmed as described in the next section.

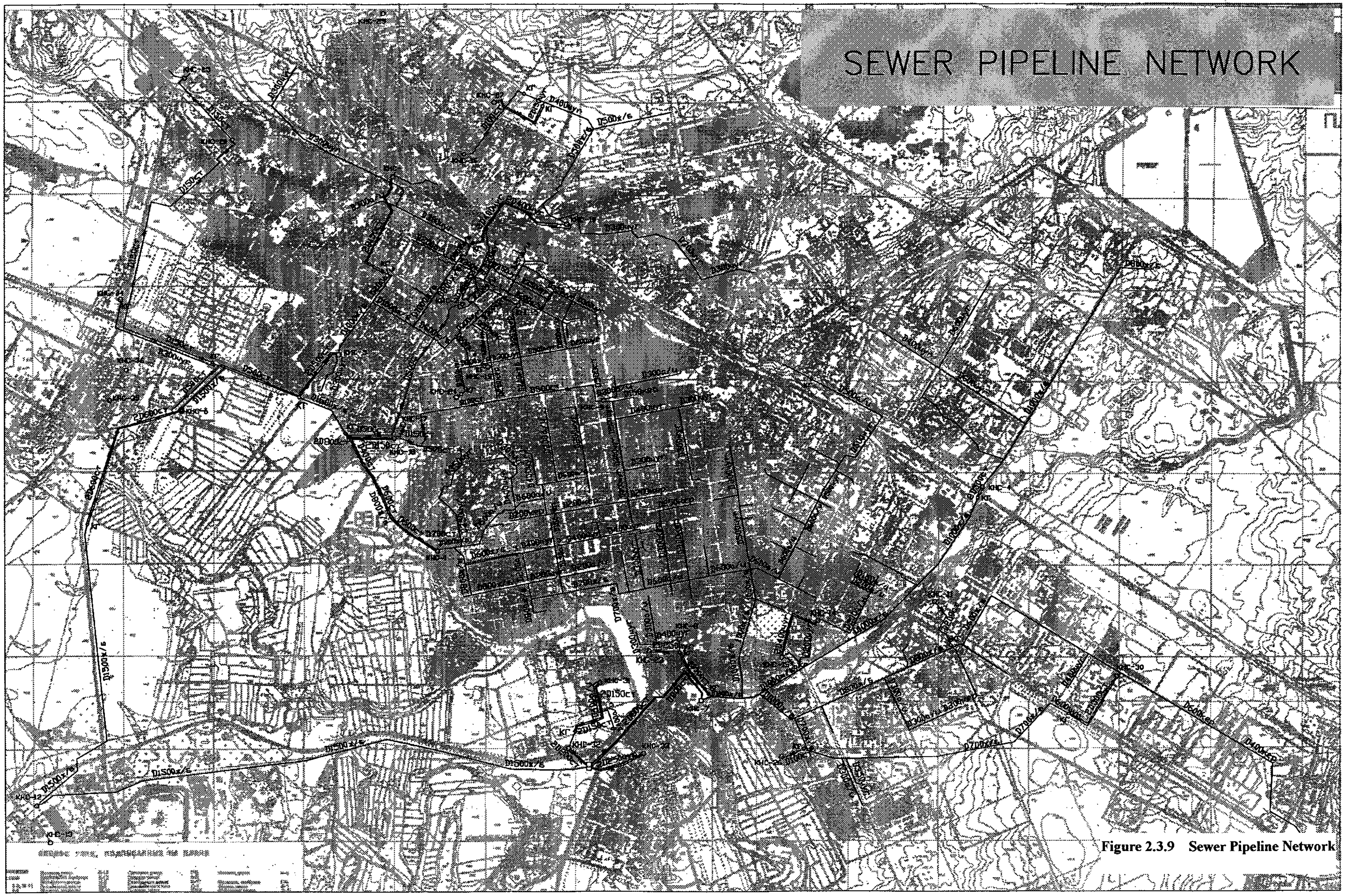


Figure 2.3.9 Sewer Pipeline Network

2.3.3 Field Confirmation

(1) Results of Investigation on Manhole Cover

A Total of 5,213 manhole covers were confirmed through the field investigation against the numbers of 5,279 in the inventory list. Typical example of manhole covers through investigation are shown in Appendix.

In general, status of manhole is not in good condition. The covers on the road are badly worn, remaining shallow groove of cast pattern on the surface. The covers are also rusted seriously when they are located in the pavement even if they have enough groove depth. Only 2% of manholes of total number were judged as "good" condition. Early replacement of all the manhole covers is recommended for the safety.

(2) Result of Sewage and Sludge Quality Examination

Water and sludge quality examinations were conducted during early October in 2002 and during in March 2003 to evaluate existing treatment process and clarify environmental problems.

1) Evaluation of water and sludge quality

Water and sludge quality data are included in Appendix. The following are summary of the evaluation.

i) Sewage treatment

- Inflow sewage quality results are almost the same as those examined by STP laboratory in the past.
- Concentrations of organic substances of the sewage is considered to be standard level of domestic sewage
- Sewage and sludge treatment efficiency is satisfactory.
- Effluent water quality meets design water quality standard.

ii) Sludge treatment

- Raw sludge concentration is very high (5%) because of the operation method of primary sedimentation tank.
- Excess sludge is about 2000mg/l MLSS with the good settlement characteristics.

iii) Taldy kol reservoir

- Water quality is similar to effluent from the STP other than items of nitrogen and phosphorus.

iv) Water in the natural channel at Marshland extended from the STP

- TN and TP at the marshland are remarkably lower than those of Taldy-kol reservoir.
- COD, BOD and SS are almost on the same or slightly higher level comparing with the reservoir water quality.

CHAPTER 3 CONFIRMATION OF THE OUTLINE OF JBIC ASSISTED PROJECT

CHAPTER 3 CONFIRMATION OF THE OUTLINE OF JBIC ASSISTED PROJECT

3.1 General

Fieldwork was conducted to update the information on existing water supply and sewerage systems as discussed in Chapter 2. In addition, discussions on the details of the proposed facilities were made with concerned parties to come up with quantities/specifications by facility.

Because of some development by the ASA since the time of F/S completion and other field findings on the deteriorating conditions of facilities, final confirmation on the scope of work was carried out during the basic design stage.

Based on the results of the basic design (B/D), some modifications of the scope of the work for JBIC assisted project was made between JBIC and Kazakhstan side on February 17, 2003.

The scope of the work agreed in the Minutes on Discussion (M/D) between JBIC and the Government of Kazakhstan signed in February 2002, is in principle maintained except for the following countermeasures:

(1) Omitted Item based on B/D

- Construction of one unit of water distribution pump station at WTP is canceled based on B/D study. Existing water distribution pump station will be used for the water supply to the new government area.
- Construction of one unit of sludge digestion tank at STP is canceled based on B/D study.

(2) The item that Kazakhstan side will undertake

- Rehabilitation of raw water transmission pipe (No II line)

(3) The item that scope of work is reduced

- Operation and Maintenance Equipment: Some construction machines are reduced under the idea that major construction work is contract out.

(4) Some additions within the frame work of M/D in the E/N

- Rehabilitation of existing water distribution pump station instead of the construction of a new pump station at WTP
- The replacement of about 100 km distribution pipes is kept, although pipe diameters increased considerably comparing with previous assumptions.

Table 3.1.1 presents the scope of work for preparation of Detailed Design. Figure 3.1.1

shows location of distribution pipes to be replaced. Refer to Table 3.4.1 for the list of O&M equipment.

Table 3.1.1 Scope of Work for Preparation of Detailed Design

Component	Major Facility		Component Facilities/Equipment	Descriptions
Water Supply	Water Intake Facility (210,000m^3/d)		Intake Tower	Construction; Capacity 210,000 m^3/d x 1 unit (including Mechanical Room, Electrical Room & Staff Room)
			Access Road	Construction; Width 6 m x Length about 300m
			Mechanical Equipment	Procure & Install; Pump: 36.5 m^3/min x 6 units (including 2 stand-by)
			Power receiving and distribution facility	Procurement and installation
	Raw Water Transmission Facilities		Transmission Pipeline	Not Applicable
	Water Treatment Facility (100,000m^3/d)		Distribution Chamber	1 unit with a capacity of 210,000m^3/d including production loss
			Receiving Well	2 wells with a total capacity of 105,000m^3/d including production loss
			Chemical Mixing Tank	2 units with a total capacity of 105,000m^3/d
			Flocculation Basin	6 trains with a total capacity of 105,000m^3/d
			Sedimentation Basin	6 units with a total capacity of 105,000m^3/d
			Rapid Sand Filter	12 units with a total capacity of 105,000m^3/d
			Washing Drain Basin	2 units with each capacity of 1,280m^3; 2 units each of return water and sludge drain pump
			Sludge Thickener	2 units with each capacity of 890m^3 with 2 units of sludge drain pump
			Sludge Drying Bed	6 beds with each dry area of 900m^2
			Cake Yard	600m^2
			Discharge Pool	2 units with each capacity of 1,000m^3
			Chemical Feeding Facility	Alum, Polymer, powdered Activated Carbon for 105,000m^3/d;
			Chlorine Feeding Facility	Chlorine Injection Facility, Chlorination Room
			Administration Building	Served both for proposed and existing water treatment systems (2,430m^2 – 3 stories)
			Measuring/Examination Equipment	Laboratory equipment
			Power receive and distribution facility	Outdoor type transformer 11,35 / 6 kV Duplex
			In-plant Piping System	75mm – 1600 mm x length 5,350 m
			Monitoring & Control System	SCADA; Central monitoring system
	Water Distribution Facility		Distribution Pump Station	M& E equipment partial rehabilitation
			Distribution Pipe	Construction: Pipe diameter 1000mm x length 5.6 km
			Distribution Pipe	Replacement: Pipe diameter 100 to 1000 mm x length 100 km
	Service Facility		Water Meter	Procure & install: Domestic Water Meter 152,000 units and Bulk Meter 1,900units
Sewerage	Sewage Treatment Plant	Sewage Treatment Facility (136,000m^3/d)	Inlet Screen	Replacement of Existing screen facilities
			Lift up Pump	Replacement of Existing Pump of 0.9 m^3/sec x 2units and 0.45m^3/secx2units; Rehabilitation of inlet BLDG
			Inlet Pipe	Replacement of pipes; receiving chamber-pump pit and pump pit-Grit Chamber
			Grit Chamber	Construction of 2 units made of RC
			Primary Sedimentation Tank	Rehabilitation of mech. equip. for existing 6 tanks (dia 28m) and raw sludge pump facilities; Construction of 2 tanks (same capacity as existing one) including raw sludge pump facilities
			Blower Facility	Replacement of 20,000 Nm^3/hr x 5 units, Rehabilitation of Blower Building

<table>
<tr><td rowspan="20">Sewerage</td><td rowspan="16">Sewage Treatment Plant</td><td rowspan="5">Sewage Treatment Facility ($136,000m^3/d$)</td><td>Aeration Tank</td><td>Rehabilitation of Tanks</td></tr>
<tr><td>Final Sedimentation Tank</td><td>Rehabilitation of mechanical equipment for Existing 10 tanks with diameter 28m,
Construction of 2 tanks with the same capacity of existing one</td></tr>
<tr><td>Return Sludge Pump</td><td>Replacement of Pump of 950 m^3/hr x 5units, Construction of pump room</td></tr>
<tr><td>Rehabilitation of Discharge Pump</td><td>Replacement of existing pump of $0.9m^3$/secx2units; $0.45m^3$/secx2units and $80m^3$/hrx2units</td></tr>
<tr><td>In-plant Pipe/Channel</td><td>Dia 200mm – 2000 mm x length 3,000 m</td></tr>
<tr><td rowspan="5">Sludge Treatment Facility</td><td>Rehabilitation of Gravity Thickener</td><td>Rehabilitation of Mechanical Equipment, Replacement of Pump of 80 m^3/hr×4 units, Replacement of Tank Cover (Existing tank; diameter 20m x 2 tanks)</td></tr>
<tr><td>Installation of Mechanical Thickener for Excess Sludge</td><td>Installation of Mechanical Thickener of 75 m^3/hr x 3 units; Construction of Polymer Feeder Facility, Sludge Holding Tank, Thickened Sludge Holding Tank and Thickener Room</td></tr>
<tr><td>Rehabilitation of Sludge Digester</td><td>Installation of Mixer and Replacement of heating equipment in the existing 2 tanks (Volume $2,500m^3$)</td></tr>
<tr><td>Rehabilitation of Digester Equipment</td><td>Replacement of Boiler (4.5t/hr x 2 units); Rehabilitation of Gasholder (2 units)</td></tr>
<tr><td>Sludge Dewatering Unit</td><td>Installation of Dewatering Unit, Polymer Feeder, Sludge Feed Pump and Sludge Cake Convey Equipment; Construction of Dewatering Building (staff room and control room)</td></tr>
<tr><td rowspan="4">Common Facility</td><td>Measuring/Examination Equipment</td><td>Laboratory equipment</td></tr>
<tr><td>Electric Facility</td><td>Lump Sum</td></tr>
<tr><td>In-plant Landscaping</td><td>Lump Sum</td></tr>
<tr><td>Monitoring & Control System</td><td>Lump Sum</td></tr>
<tr><td colspan="2" rowspan="3">Sewers</td><td>Intermediate Pump Station</td><td>Rehabilitation of 17 Pump Stations
Replacement of Mechanical/Electrical Equipments for 17 Pump Stations</td></tr>
<tr><td>Sewers</td><td>Replacement of Pipes of Diameter 100mm to 800mm, Total Length 21 km</td></tr>
<tr><td>Rehabilitation of Manhole Cover</td><td>Replacement of 5,300 Manhole Covers</td></tr>
<tr><td>Common</td><td colspan="3">Procurement of Operation and Maintenance Equipment</td><td>Power Shovels, Excavators, Trucks, Truck Cranes, Machine Tools, Patrol Cars, Generators, Road Pavement Heavy Machines, etc.</td></tr>
</table>

Figure .3.1.1 Location of Pipes to be Replaced

Чертеж 3.1.1 Расположение труб, которые будут заменены

3.2 Water Supply Facilities

Table 3.2.1 summarizes major facilities to be either constructed or rehabilitated/replaced.

Table 3.2.1 Concerned Water Supply Facilities for the Project

Major Facility	Description	Remarks
1. Water Intake Facility	• Construction of one unit of water intake facility at Vyacheslavsky reservoir (Capacity 210,000m^3/d) • Access road construction to meet the regulation for construction of facilities in public water body (sanitary buffer zone) • Intake pump facilities to meet the manner of use of 2 parallel raw water transmission pipelines • Power receiving and distribution equipment	• To ensure 200,000m^3/d of the capacity of water treatment plant, 5% water loss is additionally counted. • Location of the facility was re-studied (out of 100m radius from existing facility). • Depending on reliability of the existing pipelines, required pump capacities are different (oldest pipeline is not used).
2. Raw Water Transmission Facility	• Replacement of pipeline with a total length of 15 km between the WTP and Vyacheslavsky reservoir • Four replacement sections	• Four priority sections were identified based on the leakage records. This portion shall be conducted by Kazakhstan side.
3. Water Treatment Plant	Construction of water treatment facilities within the premises of existing WTP • **Water Treatment Facility** - Receiving Well, Rapid Chemical Mixing Tank, Flocculation Basin, Sedimentation Basin, Rapid Sand Filter and Chlorination Tank • **Wastewater Treatment Facility** – Washing water drainage tank, Sludge thickener, Sludge drying bed and Discharge pool • **Administration Building** • **Measuring/Examination Equipment** • **Power Receiving & Distribution Equipment** • **In-plant Piping System**	• **Water Treatment Facility**:
4.Water Distribution Facility	(1) Distribution Pump Facility: Replacement of distribution pump facilities for water supply to new governmental area (2) Distribution Pipeline: 1) Construction of main distribution pipeline with a length of 5.6 km 2) Replacement of existing distribution pipes with a total length of 100 km	• Distribution pump facilities shall include pump facilities and electrical facilities. • The length of main distribution line was reduced. Further requirements will be managed by Kazakhstan funds. • Reflecting current improvement achieved by ASA in right bank area of the Ishim River, contents of pipes changed from dia 100mm–500mm to dia 100mm–1000mm.
5.Service Facility	Procurement and installation of water meter • Domestic individual meter: 152,000 units • Bulk water meter: 1,900	
6.Monitoring and Control System	• Water Intake Facility • Water Treatment Plant • Water Distribution Pump Facility	

3.3 Sewerage Facilities

Table 3.3.1 summarizes major facilities to be either constructed or rehabilitated/replaced.

Table 3.3.1 Concerned Sewerage Facilities for the Project

Major Facility	Description	Remarks
1.Sewage Treatment Plant	Rehabilitation and expansion of the existing sewage treatment plant to ensure treatment capacity of 136,000m^3/d -Sewage Treatment Facility – Inlet Screen, Lift-up pump, Inlet pipe, Grit Chamber, Primary Sedimentation Tank with raw sludge pump facilities, Aeration Tank, Blower Facilities, Final Sedimentation Tank with return sludge facilities, Discharge Pump Facilities, In-plant pipe/channel -Sludge Treatment Facility – Sludge Thickener, Mechanical type Sludge Thickener, Sludge Digestion Tank and its supplementary equipment, and Sludge dewatering equipment and its BLDG with a staff/control room -Measuring/examination Equipment - Electrical Facility - In-plant Landscaping	All units of sludge clarifier both for Primary and Final Sedimentation Tank are deteriorated requiring replacement. But, only 2 units of each tank are considered as agreed in M/D. Inlet facilities are deteriorated requiring replacement, but only original countermeasures are adopted
2.Sewage Collection System	(1)Intermediate Pump Station: Rehabilitation of existing 17 pump stations (2) Sewers: Replacement of existing sewers: 21 km (3)Manhole covers: Replacement at 5,300 points	Replacement of intermediate pump facilities include screen, flow meter and pump unit.
3.Monitoring and Control System	Sewage Treatment Plant Intermediate Pump Station	

3.4 Common Requirements for O&M to Water Supply and Sewerage Project

Among equipment/machine required for operation and maintenance of the facilities are heavy machine for civil work, various kind of vehicles and others.

Table 3.4.1 List of O&M Equipment to be Procured

No.	Item	Type	Specification	No.
1	Bucket Loader	TO-40 Big	Bucket - 2m^3	1
2	Excavator	UDS-114A, Truck Base	Bucket – 0.35-0.65m^3	2
3	Excavator	Made in Japan or Germany		3
4	Frozen Ground Excavator		Blade Length 2.8m	2
	Ditto	Tractor Base MTZ	Blade Length 1.5m	1
	Ditto	Tractor T-150 Base	Blade Length 2.8m	
5	Steam Generator	Base of off-road truck		2

6	Dump-truck		Loading 10t	5
7	Wagon Truck			5
8	Truck Crane	Boom Length 25m	Load 16t	1
	Ditto		Load 10t	2
9	Trailer		Loading 40t	1
	Ditto		Loading 20t	1
10	Channel Washing Machine	KO-514	Base Kamaz	2
	Ditto	KO-514	Base Zil	2
	Ditto	KO-560	Base Kamaz	2
11	Sewer Washing Machine	DTK-260	Base Zil53016	1
12	Vacuum Vehicle	KO-503V		10
13	Flusher	KO-829-1	Base Zil-5301	2
14	Off-road Vehicle			5
15	Pipe Layer	TP12.04	Load – 6-12t	2
16	Compressor	K-2	$10kg/cm^3$	2
17	Welding Transformer	TDM-401		5
18	Generator		Up to 2.2kW	2
	Ditto		Up to 4.5kW	2
	Ditto		Up to 3kW	1
	Ditto		Up to 75kW	1
19	Sub-merged Pump		$20\text{-}100m^3/h$	10
20	Pump + generator		$200m^3/hr$	1
	Ditto		$500m^3/hr$	1
21	Trace Detecting Machine			2
22	Leakage Detecting Machine			2
23	Potable Ultrasonic Water Meter			8
24	Flow Meter gravity and canals		D300-800	2
25	Mobile Laboratory	ETL-35	Truck Base	1
26	Water Meter Testing Factory		D15-50mm	1
27	Passenger Bus			2
28	Truck Crane	Boom length up to 22m		1
29	Maintenance and Repair Center			1
30	Laboratory for Pipe Teleinspection			1
31	Horizontal Boring Machine	UGB-3A	D=0-600mm	1
32	Trenchless Pipe Layer		D=50-600mm	1
33	Groundwater Level Reduction Unit		Up to 15 m	2
34	Polyethylene Pipe Welder		D=50-400mm	2
35	Operation and Maintenance Information Equipment			1
Equipment for the Workshop for Maintenance and Repair of the Pump Equipment and Valves				
36	Vertical Turning Lathe	M-1532		1
37	Horizontal-milling Lathe	M-6T82G		1
38	Vertical-milling Lathe	M-6T13		1
39	Hydraulic Press	M-P6330	P-200-599bar	1
40	Vertical-drilling Lathe	M-2S132		3
41	Tool-grinding Desk Machine	M-3L631		5
42	Screw-cutting Lathe	M-16VT20P.02		4
43	Screw-cutting Lathe	M-1M63N		3
44	Slotting Machine	M-7402		2
45	Jig saw	M-8725		2
46	Guillotine Crank Shears	M-NG-13		2

CHAPTER 4 GENERAL APPROACH AND CONDITIONS AND ASSUMPTIONS FOR FACILITY DESIGN

CHAPTER 4 GENERAL APPROACH AND CONDITIONS AND ASSUMPTIONS FOR FACILITY DESIGN

4.1 General Approach for Facility Design

The scope of the project with JBIC loan amount was agreed between JBIC and Kazakhstan side. Therefore, planning fundamentals and conditions for the facilities that are the outputs of F/S were given conditions for detailed design study. Accordingly, the study focused on the detailed methodologies and specifications of the facilities to come up with the detailed design.

4.2 Approach to Water Supply Component Design

Rehabilitation and construction of concerned facilities should be planned/designed to ensure effective combination of component facilities and comprehensive arrangements with existing facilities.

The following were common consideration for design of water supply facilities:

1) Determination of appropriate/economical facility capacity, though SNiP standard should be referred to.
2) Considering cold climate, easy O&M should be sought such as a provision of roof/cover over the facilities.
3) Priority should be rather given to the quality, however, selection of materials and equipment/machine for easy procurement of spare parts was considered.
4) Construction plan should be prepared in full consideration that rehabilitation work had to be done without disturbing the operation of the existing facilities.
5) Careful consideration should be given on the cold climate in civil work (no use of frozen soil, etc.)

Approach by major facility is described below:

(1) Water Intake Facility

The intake tower, which will be constructed in the reservoir, would be designed to take water at different water levels to ensure stable water intake through the year in quantity-wise and quality-wise. The tower is located 100m far from existing facilities in accordance with the SNiP standard.

High turbid water may be arisen during the construction of the new facilities in the reservoir. The measures to minimize the influence to the existing intake works shall be provided. The location of the new facility would be determined base on the results of topographic survey in the reservoir.

The channel to introduce raw water to the new intake tower would be arranged with the invert level of + 387 m, which is the same bottom level of the existing intake tower (see Figure 4.2.1). The depth of foundation of the intake tower should be determined with sufficient safety in relation to supporting soil strata conditions. The soil bearing force of the planned strata is sufficient enough for supporting the facility based on the existing data and the results of the soil boring test.

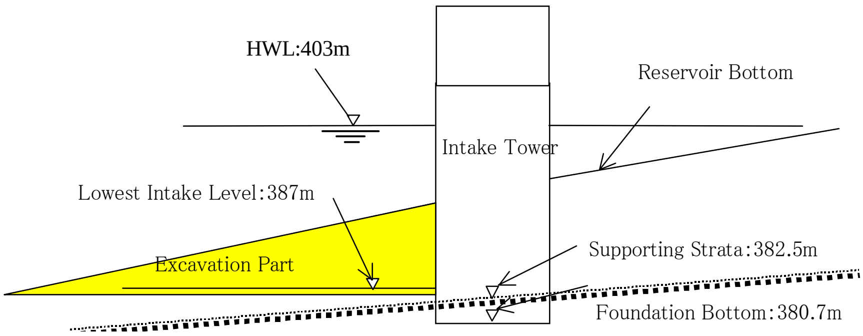


Figure 4.2.1 Water Intake Tower

(2) Water Treatment Plant

A new water treatment plant with a capacity of 100,000 m^3/d should be designed. The treatment process adopted in the existing plant (chemical coagulation, sedimentation and rapid sand filtration) is also adopted for the new plant. The existing distribution reservoirs will be utilized, and a part of existing distribution pump facilities will be replaced to meet the capacity of the new treatment plant (including the supply to new built-up area in the left bank area of Ishim River).

As the measures against cold climate, roof/cover and heating systems to the facilities, where daily O&M work is necessary, shall be provided. As common measures required for cold climate, the following were considered; additional depth of the foundation bottom of the facilities than warm climate area, pile foundation and soil cover.

(3) Construction of distribution pipeline and replacement of existing distribution pipeline

For new distribution pipeline (5.6 km with dia. 1,000mm) and for replacement of about 100 km existing pipelines, construction sections should be identified by Astanagenplan and ASA through the D/D study. The pipeline routes should be selected along the roads for easy maintenance of the pipeline system.

Hydraulic calculation of distribution network should be made for the years of 2010, 2020 and 2030 under the established conditions in M/P.

(4) Procurement and installation of water meter

The target number of water meters to be installed should be 153,900 units (152,000 for households and 1,900 for apartment houses). The manner of installation of the meter in terms of location, plumbing, meter reading should be categorized.

Type and specifications of the meter should be determined based on the present manner of meter installation by ASA.

4.3 Approach to Sewerage Component Design

Rehabilitation and construction of concerned facilities was planned/designed to ensure effective combination of component facilities and comprehensive arrangements with existing facilities. The following are common consideration for design of sewerage facilities:

1) Determination of appropriate/economical facility capacity, though SNiP standard was referred to

2) Considering cold climate, easy O&M was sought such as a provision of roof/cover over the facilities.

3) Priority was given to the quality. In selection of materials and equipment/machine, however, easiness of procurement of spare parts was also considered.

4) Construction plan was prepared in full consideration that rehabilitation work had to be done without disturbing the operation of the existing facilities.

5) Careful consideration on the cold climate in civil work (no use of frozen soil, etc.)

(1) Sewage treatment process

The work was either rehabilitation or expansion by respective unit facilities. The following are required considerations by major facility.

1) Rehabilitation of Inlet Pump Facility and related equipment

Stage construction shall be employed in consideration with the no suspension of sewage treatment operation.

2) Construction of Grit chamber

Alternative facilities were studied for easy operation and maintenance including compact type such as vortex type, aerated type and horizontal flow type.

3) Rehabilitation and Construction of Primary and Final Sedimentation Tank

With regard to the construction of sedimentation tank, the need of the facilities was studied referring to operation condition of the existing facilities, existing data on O&M including water quality examination and design criteria to suite for local conditions.

4) Rehabilitation and Construction of Return Sludge Pump

Findings from field investigation were the basis for design of rehabilitation/construction of the facilities.

5) Rehabilitation and Replacement of Blower Facilities

An appropriate type of blower was selected in consideration of effectiveness and easy O&M under the requirement of a large capacity.

As a common consideration to finalize the scope of rehabilitation/construction, current rehabilitation performed by the ASA was considered and equipment to be procured was determined referring to existing ones for easy O&M by ASA staff.

(2) Sludge Treatment Process

The projection of a total volume of generated sludge that was included in the return water from sludge thickener and sludge dewatering machine should be done. Sludge moisture content ratio and dewatering efficiency were analyzed through field examination to come up with accurate sludge volume.

Sludge treatment facilities comprise sophisticated devices/equipment, thus O&M is rather difficult than sewage treatment facilities. Accordingly, selection of sludge treatment system and type of machine should be made based on a study on O&M technology available and acceptable cost level in Kazakhstan. Alternative study on some sludge treatment systems was made to select the system to meet the local conditions.

In application of sludge dewatering facilities as a first trial in the country, durability, easy repair work and easy procurement of chemicals and consumables required were studied.

(3) Rehabilitation of Existing Intermediate Pump Station

The intermediate pump station is illustrated in Figure 4.3.1. The detail scope for civil/architectural work and pump facilities (mechanical and electrical work) was recommended based on investigations at the planned pump stations.

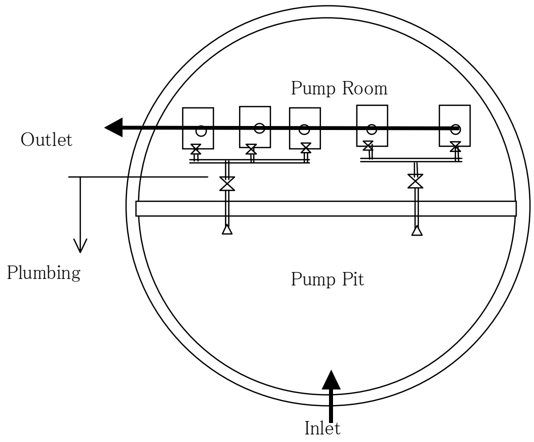


Figure 4.3.1 Intermediate Pump Station

4.4 Approach to Architectural Design

4.4.1 Architectural Design Criteria

Architectural design was implemented in accordance with SNiP code and the International Design Standard.

Amenity room area and Utilities area are calculated in accordance with SNiP 2.09.04-87 “Administrative and Amenity Buildings”.

4.4.2 Design Policies

Design of architectural work was performed under the following policies:

- Functional design to provide efficient management and operation
- Locality (the climate and the customs) should be taken into consideration.
- Local construction methods and local materials should be used as much extent as possible considering the construction term and cost.
- Design should be made to ease the maintenance with a minimum cost.
- Facilities should be not only functional but also pleasant as working environment

4.4.3 Design Elements

The basic design elements consist of four (4) physical characters as follows and these were applied to the plan and design of major buildings:

(1) Rigid Fine Bricks

Rigid fine brick of walls is effective not only in resisting cold weather but also in keeping the fineness as finishing material.

(2) Curved Lines

Building form will consist of not only straight line but also curved line.

(3) Skylight

Open-air feeling is given during long winter season.

4.5 Design and Construction Method

4.5.1 The Regulation for the Structures

All the facilities will follow Kazakhstan structure regulation stipulated in SNiP. In case that there is no description on some items in SNiP, regulation of other countries such as Japan, BS, and US will be applied.

4.5.2 Structures

(1) General Condition

The project site is located at as follows:

- Water Intake Tower: East of city center at 405 m above sea water level
- Water treatment plant: East of city center at 356 m above sea water level
- Distribution pipelines: Whole district of Astana city

The general site terrain is flat, and existing buildings and facilities are on the site.

The climate is severely continental with maximum extreme temperatures as indicated below.

- Absolute maximum summer temperature: +52.0 C
- Absolute minimum winter temperature: -42.0 C
- Annual mean temperature: +1.4 C

However, the above do not serve as a design temperature for structural design. The temperature for frame filling design has been taken on the basis of the coldest five days: -35ºC.

(2) Standard Structural Form and Stability Provision

Most of the buildings with a regular layout was designed as pre-cast reinforced concrete frames (columns and beams), assumed as pin-jointed frames, with pre-cast shear walls providing lateral stability, while in-situ reinforced concrete structure will be provided for civil works. Column base connections were assumed as fixed-based.

Sub-framing was typically one-way ribbed pre-cast slabs onto pre-cast beams. This provides relative flexibility for structural planning, and construction economy, and suited to the site conditions where cold temperatures favor increased off-site fabrication. Where possible, it is recommended that use be made (though shear interlock etc.) of composite action between pre-cast and in-situ concrete to maximize efficiency of material and improve structural integrity. In-situ topping slabs should have a steel reinforcement mesh placed within to improve diaphragm action, integrity and resistance against cracking.

Typical floor-floor heights in multistory buildings will vary depending on the function of each building. All horizontal building services will be designed to run under (not through) beams within the ceiling space.

Steel framing will be considered for large span. For certain irregular or special function buildings, use of in-situ reinforced concrete moment frame or braced steel structures frames may also be considered. For simple one-story and 2-story structures, brick structures may be adopted.

(3) Movement or Expansion Joints

In view of the wide temperature variation range, the provision of expansion joints will typically be provided for spans longer than approx. 60m, in accordance with SNiP (Construction Regulations) 2.03.01-84.

Their use will also be considered in the following circumstances:

- Where the building plan form is highly irregular
- Where differences in the structural framing concept, materials, loads and expected movements are expected to occur

(4) Loading

Design loads shall satisfy requirements for dead load, superimposed dead load, (finishes of floor, wall, and ceiling finishes, fixed equipment), wind, snow, and ground water pressure and any applicable special loads, including cranes, machinery, thermal effects (where building is longer than approximately 60 m). Live loading shall be based on the requirements of SNiP 2.01.07-85:Loads and Impacts.

In general, the minimum floor live loads to be used shall be those stipulated in SNiP 2.01.07-85 Table.3 and Clause 3.7.

The minimum horizontal loads shall generally be those determined from the wind load provisions given in SNiP 2.01.07-85 Table 5 and Clause 6.3.

In all cases, all loads stated below are the typical values, and do not include the relevant partial safety factor (γf) which may be applicable (following ultimate state design methods). No seismic force is applicable at Astana city.

Typical loads for all buildings are shown in Appendix. In all cases, however, actual loads shall be determined from the relevant SNiP standard. Special loads for each building shall be determined separately.

(5) Materials

Concrete

For primary structural members (foundations, columns, beams, slab elements etc.): Type B15, Type B30

(Maximum design concrete compressive stress for calculation, according to SNiP 2.03.01-84 (Rb), is for B15 – 8.5Mpa; B30 – 17.0 MPa. Similarly maximum design tensile stress for calculation (Rbt) is 0.75 – 1.2 MPa)

For less critical elements subject to small stresses (minor sub-framing etc) use of B25 grade may be acceptable.

Concrete Blocks

Lightly loaded load-bearing wall/pit/ elements etc., typical sue B15 (or B7.5 for minor elements)

Reinforcements bars

Main bars, High-yield deformed bars, grade AIII (Rs = 375 N/mm^2)

Links etc. round bars, grade AI (Rs = 230 N/mm^2)

Structural Steel

As per requirements of SNiP II-23-81 (to meet brittleness requirements etc.)

Typical (mild steel): C-245 (R=245 N/mm^2)

(High-yield): C-345 (R=345 N/mm^2)

4.5.3 Foundation Design/Ground Slab Construction

Expected depth of soil freezing is estimated around GL – 2.3m.

The chemical composition of the soil will also be checked to determine what precautions may be necessary to prevent soil corrosion of foundations and other durability concerns. Precautions will follow the relevant requirements of SNiP regulations.

Foundations will be designed to withstand pressures from vertical, horizontal and moment forces.

All foundations will be taken down to a depth below the design soil freezing line. (GL - 2.3m)

Provision of insulation will normally be made by laying on the underside of the perimeter area slab.

Where basements or trenches lie below the water table, expected water pressures will be designed for, and the structure designed to minimize water ingress, with water removal /drainage provisions made for.

Differential settlement shall be minimized (requirements of SNiP 2.02.01-83 to be followed)

Earth pressure forces for designing retaining or underground walls etc will be designed to resist earth and water pressures, calculated in accordance with SNiP requirements. Typical external ground level surcharge live load = 10.0 kN/m^2.

4.5.4 Performance Criteria

a) Durability

Exposed structure shall be considered as subject to a ‘severe’ to a ‘very severe’ environment. Foundations will be designed for a ‘severe’ environment (depending also on aggressiveness of soil) and internal/protected structure for a ‘severe’ environment. All durability requirements shall also follow provisions of SNiP (2.0311-85) and local building regulations.

Minimum concrete cover for slabs, beams, walls and columns etc, and concrete mix-design should meet the above-mentioned SNiP (2.03.01-84) and Kazakh regulation requirements.

The following are concrete minimum cover values taken from SNiP 2.03.01-84, Section 5.5, together with preferred recommended increase to preserve extra durability.

RC foundations: 35mm, or 70mm (where cast directly against soil) (Recommended minimum increase to 50mm and 70mm respectively)

Columns: 20mm (recommend minimum increase to 30mm for internal and 40mm for external)

Beams: 15mm-20mm (recommend min. 25mm internal and 40mm external)

Slabs: 10-20mm (recommend min. 20mm internal and 30mm external)

Note: For pre-cast sections, adjustments to meet increased covers shown above to be by practical adjustment, as much as possible, to steel reinforcement bars, and not to fabricated form/sectional dimensions.

For steel members, full and complete surface treatment and corrosion protection painting shall be applied to external elements (as per SNiP norms in 2.03.11-85).

b) Fire-resistance

Minimum concrete member thickness and over should meet requirements in SNiP 2.01.02-85.

Typical minimum thickness is:

Slab: 220mm (for pre-cast hollow slab type)

Beam: min. width 250mm

Column: min. dimension 300mm (fully exposed)

For steel structures, specified rating fire-protection shall be applied to members supporting occupied floors. Roof or roof supporting steelwork need typically not be fireproofed.

c) Deflection

Deflection requirements should follow SNiP 2.01.07-85 (Section 10, Table 19), which specify maximum deflection/span ratios under un-factored (reduced) imposed loads. Drift/height limitations are also given for horizontal loads.

d) Vibration

To minimize vibration of crane-girders, deflections should be kept to below span/500. Otherwise, normally deflection of steel beams should be below 12mm. For concrete members, checks need not be made for spans up to 12m.

Foundations supporting vibrating machinery should either incorporate vibration isolators in the equipment mounting, or have sufficient dead weight to absorb vibrations (4 x weight of machinery), or be separated from surrounding structure.

e) Acoustic and Thermal Insulation

Where specific requirements exist, structural acoustic and thermal properties shall be utilized as much as possible to provide for efficient and cost-effective design. Examples include increasing slab thickness for acoustic insulation effect where special requirements exist.

4.5.5 Design Methods

Building structures will be designed to meet the ultimate strength requirements of SNiP (RC and steel), including use of appropriate load factors, and for serviceability requirements using unfactored loads. Most unfavorable load combinations are to be considered.

Calculations and frame analysis shall typically adopt 2-D models, except for irregular or exceptional structures, where 3-D analysis shall be performed.

Material constants and design stresses shall be based on appropriate codes.

4.6 Remote Control and Monitoring System

Generally, remote control is effective for the operation of treatment plant and intermediate pump stations, and water pressure control for water distribution pipe network. However, sustainable maintenance work is difficult because of the needs of high level technology and high cost to achieve accurate remote control by sophisticated monitoring equipment. Therefore, the construction of central monitoring system for smooth information treatment is given priority to this Project.

In this connection, the monitoring system covers minimum requirements on flow and operating situations of the facilities.

There was a plan in the basic design stage that a radio communication system connects the ASA headquarters and intermediate pump stations to alert automatically in an emergency case such as pump failure or abnormal water level.

The rehabilitation of 17 intermediate pump stations is one of scope of work in this project although 122 pump stations, including the said 17 intermediate pump stations, are scattered in Astana city. The design work started to manage the monitoring system for the limited 17 intermediate pump stations. Meanwhile operation and maintenance information equipment is listed in the procurement program of O & M Equipment.

However, the adoption of entire monitoring system to cover all pump stations was raised after careful studies. The entire monitoring system was favorable for ASA, because it is superior to two individual systems for the 17 pump stations and the other pump stations from economical, maintenance and operational aspects.

The concrete plan for entire monitoring system covering 122 pump stations will be prepared by ASA in the near future. The procurement of Operation and Maintenance Information Equipment will be made through this Project under O&M Equipment procurement item.

4.7 Pre-Qualification Documents

The construction work will be executed by a single contract to be bound through an international competitive bidding (hereinafter called as ICB) in accordance with the minutes of discussion between JBIC and the government of Republic of Kazakhstan. The bidding procedure, documents preparation, and evaluation of bids will be conducted in accordance with the Guidelines for Procurement under JBIC ODA Loans (hereinafter called as Procurement Guidelines). JBIC has also prepared guides and sample documents in accordance with the provisions of the Procurement Guidelines.

Available guide and sample document for pre-qualification are as follows:

- Sample Pre-qualification Documents under JBIC ODA Loans, November 1999
- Evaluation Guide for Pre-qualification and Bidding Under JBIC ODA Loans, June 2000

In addition, on-going projects financed by JBIC ODA loan in this country conform to the Procurement Guidelines and apply the guides and the samples to the project documentation.

The pre-qualification and the bidding documents for the project are prepared in accordance with the Procurement Guidelines and relevant guides and sample documents consequently.

4.8 Financial and Accounting

It is important for the ASA to establish self-supporting system through the future. Technology transfer for strengthening of capacity building, especially on finance and accounting system will be provided by the JICA Study Team to Kazakhstan side. In this connection, concrete recommendations shall be prepared based on the results of F/S and findings/recommendations by the JICA expert dispatched after F/S. The following subjects are to be considered.

(1) Improvement of financial status

(2) Organizational Improvement in the ASA

4.9 Design Standard and Conditions

Design standard and conditions used for the water supply and sewerage sector in Kazakhstan is SNiP for facility design and GOST for quality to materials and water quality standard. Therefore, these standard and conditions are to be used together with international standards.

The following are briefing on the GOST.

GOST is the National Standard of Russia that plays an important role in the international standardization activities of ISO and IEC. They have been taking a leadership in “Mutual Assistance Conference of Eastern Europe Economy”.

GOST is English name of enacted agency according to ISO Memento 1986, addressed at

USSR State Committee for Standards. Russia is permanent directing country. This standard covers mining/industry, food and drinks production, agriculture and forestry.

The design criteria for water treatment plant and sewerage facility in SNiP and JWWA (Japan) is attached in Table 4.9.1 and Table 4.9.2, respectively. Applied design criteria for this project are also shown in the tables.

Table 4.9.1 Design Criteria for Water Treatment Plant

Process	Unit	Applied Design Criteria	KAZAKHSTAN SNiP PK 4.01.02-2001	JAPAN JSWA	Remarks
Intake Pump Station					
Number of compartment	basin	2	5.88: more than 2	-	
Location of intake mouth	m	0.5m higher than bottom	5.96: 0.5m higher than bottom	Lower than Low water level	
	m	0.2m lower than the lower surface of ice	5.96: 0.2m lower than the lower surface of ice	Lower than Low water level	
Inlet Velocity	m/sec	1.0	5.106: not exceed 1.0	1 - 2	with fish protection equipment
	m/sec	-	5.94: 0.1	-	without fish protection equipment
Stand-by pump number	-	2	7.3: 2	1	
Transmission pipeline number	-	2	7.6: 2	-	
Water Treatment Facility					
Distribution Basin			No Description		
Number of basins	basin	1	-	-	
Detention time	min	3.7	-	-	
Water depth	m	6	-	-	
Receiving Well			No Description		
Number of wells	basin	2	-		
Detention time	min	1.8	-	1.5 or more	
Water depth	m	5.2	-	3.0 - 5.0	
Rapid Mixing Basin					
Type		Hydraulic	Hydraulic, Mechanical	Hydraulic, Mechanical	
Number	basin	2	6.44: 2 or more	-	
Detention time	min	2.1	-	1 - 5	
G value	sec^{-1}	112	-	-	

Table 4.9.1 Design Criteria for Water Treatment Plant

Process	Unit	Applied Design Criteria	KAZAKHSTAN SNiP PK 4.01.02-2001	JAPAN JSWA	Remarks
Flocculation Basin: Buffle Type					
Detention time	min	27.4	6.54: 20 - 30	20 - 40	
G Value	sec^{-1}	60	-	10 - 75	
GT Value	-	98,310	-	23,000 - 210,000	
Velocity	m/sec		6.54: 0.2- 0.3 (beginning)	0.15 - 0.30	
	m/sec		6.54: 0.05 - 0.1 (end)		
Corridor Width	m	0.8-1.2	6.54: 0.7 or more	-	
Turn Number	-	-	6.54: 8 - 10	-	Adjust by G value
Horizontal Sedimentation Basin					
Number	basin	6	-	2 or more	
Width	m	9	6 m or less	-	
Water Depth	m	5.0-4.0	6.68: 6 or less	3 - 4	
Effective settling zone height	m	4.0	6.68: 3 - 3.5	-	
Sludge Depth	m	0.5	-	0.3	
Upper Space	m	0.6	6.73: 0.3 or more	0.3	
Surface Loading	mm/min	27	6.56: 21 - 27	15 - 30	
Velocity	m/min	0.34	6.68: 0.36 - 0.48	0.4 or less	
Required Area	m^2	2,760	6.67: Designed with using formula *1		*1: 2,930 ~ 3,950 m^2
Length	m	50	6.68: Designed with using formula *2		*2: 33.3 ~ 70.0 m
Trough					
Loading	m^3/day/m	350	-	500 or less	
Length	m	4.2	6.75: 2/3 of settling tank		
Distances between axis of pipes	m	1.5	6.75: 3 or more		
Top of trough	cm	10	6.75: 10 over HWL		
Opening	cm		6.75: 5 - 8 above the bottom		
Opening dia	mm	25	6.75: 25 or more		
Opening	m/sec		6.75: 1		
Rapid Sand Filter					

Table 4.9.1 Design Criteria for Water Treatment Plant

Process	Unit	Applied Design Criteria	KAZAKHSTAN SNiP PK 4.01.02-2001	JAPAN JSWA	Remarks
Number	-	12	6.99: Designed with using formula *3		*3: 14 or 15
Reserved filter number	-	2		1 per 10 filters	
Filter Area of each filters	m^2	73	6.99: 100 or less	150 or less	
Total Filter Area	m^2	877	6.98: Designed with using formula *4		*4: 760 ~ 930 m^2
Ultimate head loss	m		6.100: 3 - 3.5		
Effective water depth	m	3.9	6.101: 2 or more		
Upper afford	m	1.9	6.101: 0.5		
Forced or Automation control	hr	24	6.97: 6 or more		
Normal Filtration Rate	m/hr	5-6	6.97: 5 - 6 / 6 - 8		Single layer
Forced Filtration Rate	m/hr	6 - 7.5	6.97: 6 - 7.5	5 - 6.25	Single layer
Filter media					
Material		Quartz sand	6 97: Quartz sand or Crushed expanded clay gravel		
Height of layer	m	0.7	6.97: 0.7 - 0.8 / 1.3 - 1.5	0.6 - 0.7	
Size of media	mm	0.6～0.7	6.97: 0.5 - 1.2 / 0.7 - 1.6	0.3 - 2.0	
Equivalent diameter	mm	0.7	6.97: 0.7 - 0.8 / 0.8 - 1	0.45 - 0.7	
Uniformity coefficient	-	1.5	6.97: 1.8 - 2 / 1.6 - 1.8 (d_{80}/d_{10})	1.30 - 1.70	
Supporting media		PC-Concrete	For lateral pipe		Safety and Economical
Material		Gravel	6.104: Gravel	Gravel	
Diameter	mm	2-25	6.104: 2 - 40	2 - 25	
Thickness	m	0.5	6.104: 0.35 - 0.50 plus pipe diameter	0.20 - 0.50	
Distributing (Drainage) System		Lateral triangle block type	6.103: Tube type	Hoyler, Lateral block, Strainer, Porous board and Lateral pipe type	Safety and Economical
System		Surface (Fix) and Back wash water	Surface (Fix) and Back wash water	Surface (Fix) and Back wash water	
Backwash rate	$m^3/min/m^2$	0.8	6.110: 0.72 - 0.84	0.6 - 0.9	
Washing time	min	7	6.110: 5 - 6	4 - 6	Considering Safety
Expansion rate	%	25	6.110: 25～45	20 - 30	

Table 4.9.1 Design Criteria for Water Treatment Plant

Process	Unit	Applied Design Criteria	KAZAKHSTAN SNiP PK 4.01.02-2001	JAPAN JSWA	Remarks
Rapid Sand Filter					
Surface wash rate	$m^3/min/m^2$	0.2	6.110: 0.18～0.24	0.05 - 0.10	
Surface washing time	min	5	6.110: 5 - 8	4 - 6	
Surface wash head	m	20	6.110: 30～40	10～20	
Sludge treatment					
Drainage Basin					
Number	basin	2	App 9.2: 2 or more	2 or more	
Volume per a basin	m^3	1,260	App 9.2: one backwash volume or more	one backwash volume or more	
Water depth	m	3	-	2 - 4	
Upper height	m	1.5		0.6 or more	
Thickener					
Number	basin	2	-	2 or more	
Diameter	m	18	App 9.9: 18 or less	-	
Water depth	m	3.5	App 9.9: 3.5 or more	3.5 - 4.0	
Upper height	m	0.3		0.3	
Retention Time	hr	16	App 9.11: 10	24 - 48	
Sludge loading	$kg/m^2/day$	20	-	10 - 20	
Sludge Drying Beds					
Number of beds	-	6	-	2 or more	
Water depth	m	1.0	-	1 or less	
Upper height	m	0.5		0.5	

Table 4.9.2 Design Criteria for Sewerage Facilities

Process	Unit	Applied Design Criteria	KAZAKHSTAN SNiP 2.04.03-1985	JAPAN JSWA	Remarks
Sewer Pipe/Pump Station					
Sewer Pipe					
Minimum Flow	m/sec	0.4	2.35: 0.4	0.6	
Maximum Flow (1)	m/sec	8	2.36: 8	3	Metal Pipe
Maximum Flow (2)	m/sec	4	2.36: 4		Nonmetal Pipe
Minimum Diameter (1)	mm	200	2.33: Dia 200	Dia 200	Street
Minimum Diameter (2)	mm	150	2.33: Dia 150		Neighborhood Domestic
Minimum Diameter (3)	mm	150	2.33: Dia 150		Sludge Pipe
Pump Station					
Stand-by Pumps	unit	2	5.4: 2	1	Category I *)
Number of Pressure Pipeline	number	2	5.8: 2	-	Category I *)
Wastewater Treatment					
Inflow					
Design Maximum Flow Ratio	-	1.47	2.7: 1.47	1.3 - 1.8	For 1,000 L/s
Grit Chamber					
Type		Vortex	Vortex	-	
Number of basins	basin	2	-	-	
Hydraulic Load	m^3/m^2/day	5000	-	-	
Retention Time	sec	15	-	-	
Primary Sedimentation Tank			No Description		
Type		Radiation	Radiation	Radiation	
Number of tanks	basin	8	6.58: 2 or more	2 or more	
Hydraulic Load	m^3/m^2/day	30	6.60 - 6.62: 30 by calculation	35 - 70	

Table 4.9.2 Design Criteria for Sewerage Facilities

Process	Unit	Applied Design Criteria	KAZAKHSTAN SNiP 2.04.03-1985	JAPAN JSWA	Remarks
Water depth	m	3.5	1.5 - 5	2.5 - 4	
Retention Time	hr	1.5	-	1.5	
Aeration Tank					
Type		Conventional Activated Sludge	Conventional Activated Sludge	Convention Activated Sludge	
Number of tanks	basin	4	-	2 or more	
Water depth	m	4	6.150: 3 - 6	4 - 6	
Retention time	hr	8	6.144 - 6.146: by calculation	6 - 8	
Secondary Sedimentation Tank					
Type		Radiation	Radiation	Radiation	
Number of tanks	basin	12	-	2 or more	
Hydraulic Load	m^3/m^2/day	25	6.161: 25 by calculation	20 - 30	
Water depth	m	4	1.5 - 5	2.5 - 4	
Retention Time	hr	2	-	-	
Gravity Thickener					
Type		Radiation	Radiation	Radiation	
Number of tanks	basin	2	6.343: 2 or more	2 or more	
Water depth	m	3.5	-	Approximately 4m	
Retention Time	hr	12 - 15	6.344: 12 - 15	-	
Solid Load	kg/m^2/day	-	-	60 - 90	
Digester					
Type		Thermophilic	Thermophilic Type	Thermophilic Type	
Number of tanks	basin	3	-	2 or more	
Diameter	m	17.5	-	10 - 30	

Table 4.9.2 Design Criteria for Sewerage Facilities

Process	Unit	Applied Design Criteria	KAZAKHSTAN SNiP 2.04.03-1985	JAPAN JSWA	Remarks
Water Depth	m	8	6.356: Diameter to Depth: not less than 0.8 to 1	Diameter to Depth: Approximately 2 to 1	
Daily Rate of Loading	%	17	6.350: 17	-	Thickened Sludge 95%
Retention Time	day	6	6.350: 6.0 (calculated by above item)	Approximately 20days	
Gas Holder Retention Time	hr	2 - 4	6.359: 2 - 4	12	
Sludge Dewatering Unit					
Stand-by Units	unit	2	6.385: 2	1	Working Unit Number: 3
Top of trough	cm	10	6.75: 10 over HWL		
Opening	cm		6.75: 5 - 8 above the bottom		
Opening dia	mm	25	6.75: 25 or more		
Opening	m/sec		6.75: 1		
			Note *): In case of the halt and decrease of sewage discharge are not admitted.		

CHAPTER 5 WATER SUPPLY FACLITIES

CHAPTER 5 WATER SUPPLY FACILITIES

5.1 Intake Facility

5.1.1 Design Conditions

(1) Confirmation on the recommendations in F/S

1) "The need of a new intake P/S" (4.4.1 (1), 4-7 F/S)

Pumps and motors were replaced after F/S, however, deterioration of the facilities is noted. There is a difficulty to operate the facilities to meet the fluctuation of demand. Manual control of flow rate also makes it difficult due to too large capacity of each pump. Current flow control by discharge valve has caused energy losses requiring additional power cost.

It was analyzed that the combination use of No. III transmission pipeline (diameter of 1400 mm) and No. II pipeline has enough capacity to lessen the required head of intake pumps. Namely, such a combination use of the two pipelines and introduction of less head pumps allow the pump station to save considerable power cost.

For automatic flow control and operational cost saving, provision of new pumps/equipment and construction of concerned facilities are requisites.

2) "Locational restriction of a new intake facilities under sanitary buffer zone." (4.4.1 (1), 4-7 F/S)

In Chapter 10, SNiP (PK 4.01.02-2001), provision of sanitary protection zones is stated to protect water resource from contamination, indicating that any kind of construction work shall not be allowed within the first zone, i.e. the area in a circle with a radius of 100m at the origin of existing intake P/S in case of water source reservoir. The location of the P/S recommended in the F/S was examined and re-arranged based on the results of topographic survey and soil investigation.

3) Intake Pump Capacity

F/S proposed that the capacity of new intake pumps required should be 200,000 m^3/day, which is same as existing ones, though their present capacity is much more than the requirement.

The present nominal capacity of existing water treatment plant, however, is 200,000 m^3/day. It is decided that the treatment capacity of WTP should maintain the capacity, even after completion of a new plant. Considering water loss in the transmission pipeline, additional water amount with 5 % of the water treatment capacity is assumed; Intake amount arrived at 210,000 m^3/day (200,000 m^3/day x 1.05).

4) Location of Equipment

In the F/S, location of electrical equipment is planned to install on the ground floor of the intake pump station. This arrangement will contribute not only for ease of operation but also for safety of equipment against inundation. Location of pumps shall be at the pump room below the low water level of the reservoir due to easy and reliable starting without pump priming unit.

5) Type of Inlet

The water quality in the Vyacheslavsky reservoir shows the sign of eutrophication. In addition, the change of water level in the reservoir is large. Water quality of reservoir usually differs by water depth; therefore suitable depth for water intake shall be selected considering seasonal and hydrological conditions. Because of these reasons, multi-intake ports is applied for the intake P/S, as proposed in F/S.

6) Intake tower structure

The caisson construction method is commonly used for this kind of construction work in water as proposed in the F/S. It was also confirmed that the caisson method is popular for the construction of sewage intermediate pumping stations in Kazakhstan. Therefore, the caisson method is applied and detailed design was prepared referring to the results of soil survey at the site.

(2) Considerations on SNiP

In SNiP (PK 4.01.02-2001), following requirements are stipulated to formulate the function of water facilities.

- Item 5.88: Inside of water receiving facilities shall be divided into two or more compartments, and equipment to prevent ice scum and garbage shall be provided.
- Item 5.96: Intake mouth shall be set at 0.5 m higher than the bottom level of the reservoir and also 0.2 m lower than the lower surface of ice cover.

- Item 5.97: Equipment to remove ice or ice scum shall be considered.
- Item 5.106: Inlet speed at the low water level shall not exceed more than 1 m/sec when fish protection equipment will be installed. If not, it shall be less than 0.1 m/sec.
- Item 7.3: Intake pumps shall be installed with two units of stand-by.
- Item 7.6: Transmission pipeline shall be installed double.

(3) Considerations on other conditions

1) Request by ASTANA SU ARNASI (ASA)

- Structural arrangement of the intake facilities shall be made so that the intake capacity can be increased easily in the future.
- The influence to the existing intake facility by turbid water generated during construction stage shall be minimized.

2) Request by ISHIM RIVER BASIN DEPARTMENT

Isim River Basin Department, the management agency of the Vyacheslavsky reservoir, requested the following:

- The facility to protect fish shall be provided for intake at the P/S.

3) Operation Methodology for Existing and New Pump Station

The transmission pipelines of No. III (D1400mm) and No. II (D1000mm) should be used simultaneously for operation of new pump station. The management of the existing intake water facilities shall be properly done for emergency use after construction of new intake facilities.

5.1.2 Design Policy

As a result of discussions among concerned parties and considerations stipulated above, following design policies were established for the new intake facilities.

(1) Capacity

Design intake capacity shall be 210,000 m^3/day including 5 % of water loss in the transmission pipeline to meet nominal treatment capacity of WTP, 200,000 m^3/day.

(2) Layout

Location of P/S affects to the cost, especially for excavation of an intake channel and construction of an access road. Regulation stipulated in SNiP, however, does not allow construction of the proposed P/S within 100 m radius from the existing P/S because the proposed P/S is not considered as an expansion of existing P/S.

Figure 5.1.1 shows the locations of existing facilities and topography around the existing P/S. As shown in the figure, the location of the new P/S was examined at three candidate sites toward east of the existing P/S. Location of new P/S was finally determined at just outside of the sanitary buffer zone.

(3) Facilities

New intake P/S shall be facilitated with a staff room and an electric room at the upper architectural part. Its submerged portion shall be made of RC structure to accomodate pump room and multi-storied intake mouths.

Electrical equipment shall be arranged on the ground floor, above reservoir's surcharge water level. Since the new P/S is constructed in the reservoir, an access road is necessary.

(4) Design Water Level

During the B/D stage, JICA Study Team received the information about operation rule of the Vyacheslavsky reservoir from the Ishim River Basin Department, Committee for Water Resources, Ministry of Agriculture as follows:

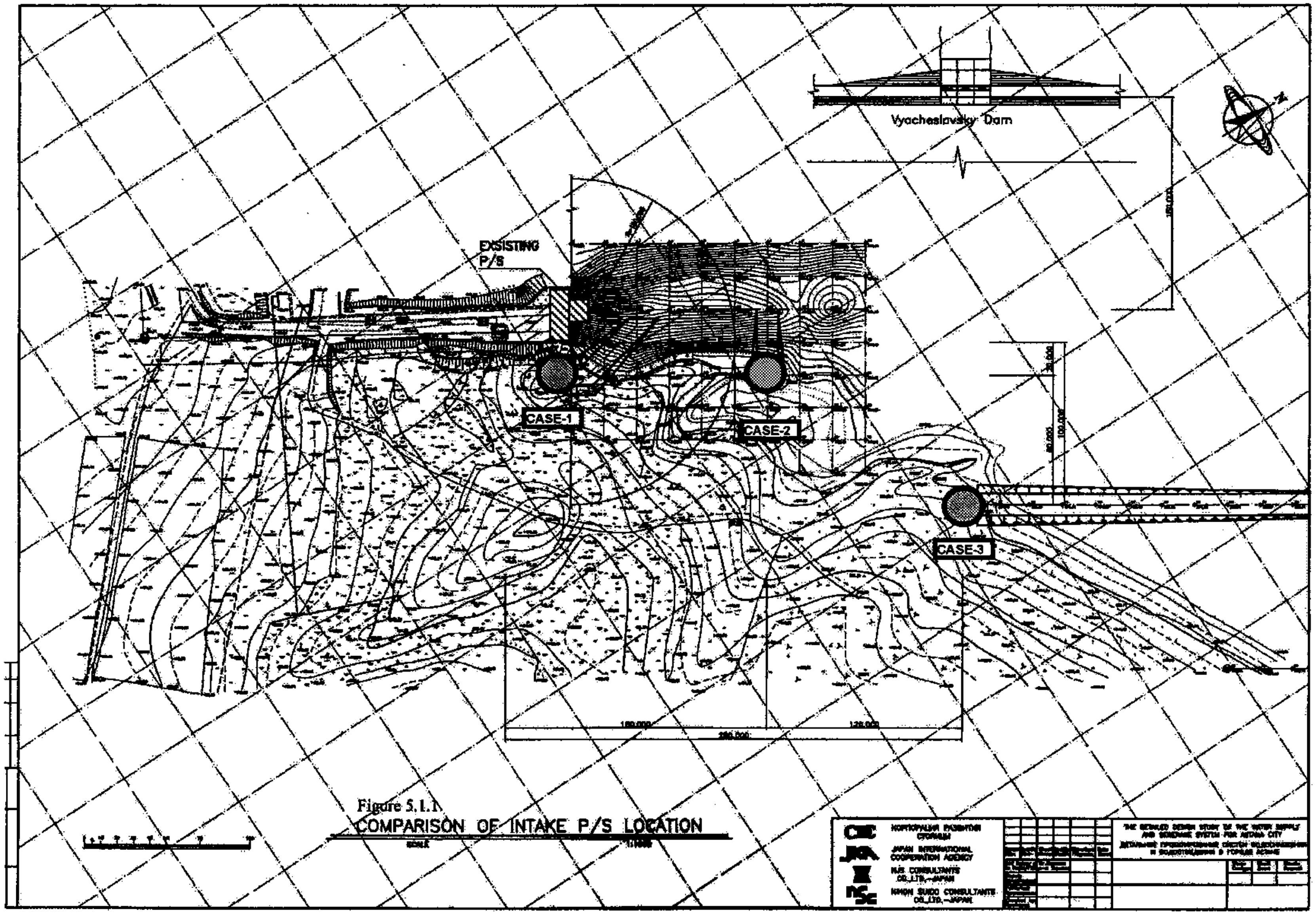


Figure 5.1.1
COMPARISON OF INTAKE P/S LOCATION

- Maximum Water Level (surcharge level): 404.40m
- Normal Water level: 403.00m
- Low Water Level: 391.00m

Above water levels are applied in the detailed design with following planned floor levels:

- Structure Bottom Level: 387.00m (equal to bottom level of existing P/S)

(5) Others

During construction period, the excavation method minimizing water contamination shall be adopted and additionally some turbid water protection measures shall be introduced such as enclosing by silt protection sheets.

The new intake facility shall be connected to existing water transmission pipeline No. III, and No. II through interconnection pipes.

Main body shall be set at the O_1a layer, which has been confirmed its 100 ton/m^2 of bearing capacity during F/S stage. The level of foundation layer was decided after the soil survey in this study and a stability calculation for main structure.

5.1.3 Design Details

(1) General

The difference between high and low water level, 13.4 m as maximum, is large, and inclination of ground under the water level is small. Therefore, it is costly to locate the intake facility on the shore requiring high cost for excavation of a water intake channel. Considering these conditions, the location of the new intake facility was decided in the reservoir as mentioned above.

Asphalt paved access road with a length of about 280m will be constructed between existing access road near existing P/S and the proposed intake tower.

An electrical room, control room, staff room and equipment loading space will be provided in the New P/S.

A sub-station building (approximately 15 m x 9 m) was designed next to the existing power sub-station and new electric cables will be installed in a conduit provided along new access road. Detailed description of the proposed electrical equipment will be given in the relevant section. In addition, a guard house and a surge control house was designed for the new P/S.

(2) Structure

1) Construction Method

A comparison of construction methods for main structure/tower is presented in Table 5.1.1. As shown in the table, it is recommendable that the main body shall be constructed by the open caisson method because of following reasons:

- Major construction work shall be conducted in water-surrounded circumstances.
- Open caisson method is popular in Astana.

The shape of plan should be circle because of introduction of the caisson method.

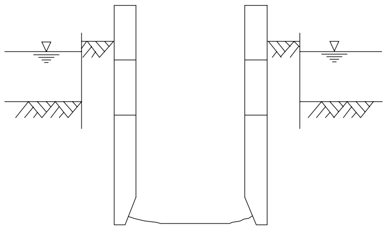
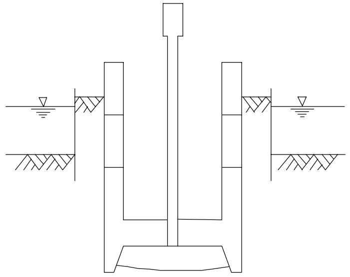
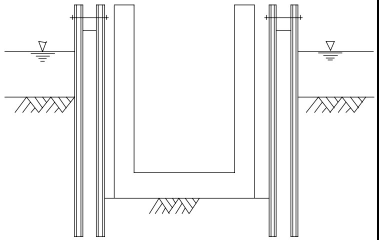
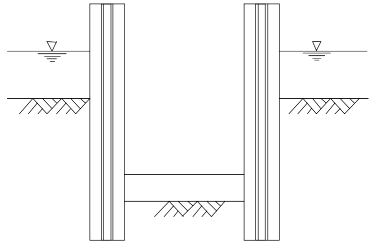
The structure of the P/S was decided taking into account of adopted pump type (dry type). Main points of consideration are as follows:

- Possible introduction of submergible pumps was examined, but it was concluded that such a pump type is not appropriate for large capacity P/S like this project. Thus, inside of the tower shall be kept dry to install dry type pumps. To ensure the smooth water intake, inlet piping shalll be provided from inlet mouths to pumps.
- Dimensions of structures including diameter of the tower and level of floors are designed to accommodate pumps and piping on the basement and motors on the ground floor, and to secure enough openings to install larger pumps, valves and pipes.
- One opening will be provided on the floor for installation of pumps and other materials. Pumps shall be handled with hoists provided at beam.

2) Arrangement of rooms and equipment

Electric rooms, control room, staff room and equipment loading space were designed to be located above the flood water level. Considering the installation space for electric cables, the floor level of these rooms was set at +409.00 m, 4.6 m above the normal water level. Raw water will be pumped through an integrated header pipe in a core column and two discharge pipelines. Two butterfly valves are provided to enable a single transmission pipeline to send design water to WTP in case of emergency. Traveling hoists are installed over equipment loading space and in the pump room to ease loading and installation of equipment.

Table 5.1.1 Comparison of Construction Methods for Intake Tower

Method / Item	Caisson		Double Sheet Pile Cofferdam	Cast-in-situ Diaphragm Wall
	Open Caisson	Pneumatic Caisson		
Conceptual Drawing				
Advantage	Many P/S were constructed by this method in Astana. Less cost Suitable for geologicl condition of the site. Suitable for planned depth.	Deep structure can be constructed. Perfect water intrusion prevention.	Popular method. Relatively high cost. Rectanglar shape can be adopted.	Safe construction work. Diaphragm wall can be used as wall of main body. Rectanglar shape can be adopted.
Disadvantage	Shape is restrected as circle or oval. Construction ground is required in the Reservoir.	Higher cost. Advanced construction management technology is required. Long construction period. It is not necessary when open caisson method can be adopted	Difficult to drive sheet pile to bedrock or hard soil layer.	High Cost. Hard to construct diaphragm wall in bedrock. Long construction period.
Cost	100	120	100 (Difficult to construct)	150
Judgement	Adopt			

3) Pump Room

A circular shape structure plan was selected for the new intake tower. The inside diameter of the tower was designed at 20 m considering that the pump number required is six including two stand-by and a room for two pumps in the future. The distances between pump casings are secured at around 3m and the distance between a pump casing and wall is about 3m from the core column wall and 4m from the peripheral wall.

(3) Specification of Pumps

Intake pump capacity is influenced greatly by the operation method of the facility. Water levels at the reservoir and the water treatment plant as well as differences between the two facilities are shown in Table 5.1.2.

A transmission pipeline No.3 of D1400mm is being used presently. However, another pipeline No.2 of D1000mm can be used together with the No.1 pipeline after rehabilitation by ASA. The design of new intake pump must be prepared taking into consideration economy and operational efficiency. By using the two pipelines simultaneously, required pump head can be reduced considerably.

Table 5.1.2 Water Level of Reservoir and Water Treatment Plant

Water Level		Difference
Vyacheslavsky Reservoir	Water Treatment Plant	
High Water Level: + 403.0 m	+363.4 m	- 37.6 m
Low Water Level: + 391.0 m	+363.4 m	- 27.6 m

Existing intake pump capacity is as follows: 6300 m^3/hr x 95.0 mH x 1250 kW x 3 units (stand-by 2 units).

Based on hydraulic calculations, water head losses of some cases utilizing No. III and/or No. II pipelines and new/existing pumps are shown in Table 5.1.3. The total heads of new pumps are 35 m and existing pumps are 90 m.

Table 5.1.3. Required Total Head in Each Case

Conveyance Pipeline		New Intake Pumps	Existing Intake Pumps	Required Total Head
No. II (1000 mm)	No. III (1400 mm)			
O	O	O		35m
	O		O	90m
O			O	450m*

* Only 100,000 m^3/day of water can be sent with 90 m head.

Based on the calculations, it was decided that new intake pumps shall be operated using two raw water transmission pipelines of No. II and No. III, and the existing pump be operated in case of emergency. The new pumps are utilized with low voltage motors, and an automatic valve control system is also adopted to get the following advantages.

- Reduction of operation cost by remarkable saving of electricity consumption.
- Reduction of initial cost.
- Prolonging lifetime and reduction of leakage of pipelines under the operation of distribution system with low-water pressure.
- Precise and easy operation by automatic valve control system.

Six units of intake pumps including two units of stand-by will be installed according to the requirements by SNiP. The capacity of new intake pump is as follows (Details shall be referred to in Section 5.7 Mechanical Facility): Pump specifications: 36.5 m^3/min. x 35 m head x 280 kW x 6 units (2 units stand-by).

In accordance with the requirement by SNiP, two raw water discharge pipeline with a diameter of 1,400 mm (Steel Pipe) will be installed to connect the new intake tower and the existing raw water transmission pipelines.

(4) Intake Mouth

Several intake mouths are provided at different elevations so that raw water from different depth can be taken selecting better water quality in the reservoir. Installation of screen to prevent from incoming of fish is obliged by SNiP and inflow velocity shall be less than 1 m/sec. Therefore, minimum area of intake gate was planned as 3 m^2. A metal-seated butterfly valve will be installed at each intake mouth.

(5) Construction Method

The open caisson method with soil mounding is applied for intake tower construction after detailed examination of construction methods based on soil conditions.

The order of construction has been planned as following:

1) Install the curtain in the water for contamination protection in the surrounding area of construction site.

2) Construct the access road and parking space.

3) Install temporary pier made of steel frames and lining plates in the surrounding point of intake tower.

4) Drive steel sheet piles in a circular alignment with a diameter of 35 m from the center of Tower. These piles are sustained by H framed piles, which is driven in the circular.

5) Fill up the inside of the circle with soil for the caisson construction.

6) Construct a bottom part of caisson on the ground.

7) Excavate the inside of caisson to sink the caisson down into ground. When the bottom of caisson reaches at design level, the bottom is leveled and steel bars are arranged and connected. Finally, base concrete will be casted.

8) Excavate filled soil between caisson outer surface and sheet piles.

9) Pull out and remove sheet piles and H frame.

10) Extend temporary pier and excavate channel for intake.

11) Construct the intake building during the excavation.

12) Remove temporary pier and construct a bridge from filled access road to the intake tower.

13) Install mechanical and electrical equipment.

Openings of the tower for water intake shall be temporally closed by steel plate, and valves shall be installed inside to prevent inflow of water during the construction work. To minimize the contamination affected by turbidity to the raw water for existing P/S, plastic or fabric submerged curtain and coagulant dosage shall be provided around the construction site during the construction work.

(6) Connection Pipelines

In compliance with the regulation stipulated in SNiP, two connection pipelines will be installed between a new intake pump station and existing raw water transmission pipelines. Diameters of these connection pipelines are 1400mm. Both of these connection pipelines shall be used simultaneously to prevent stagnation and freezing of water in the pipelines. Minimum invert level will be kept at G.L.-2.8 m (refer to subsection 5.2.3). A flow meter and a control valve shall be provided to control flow.

Figure 5.1.2 shows the conceptual plan of pipe connection. Though the two connection pipelines are connected with the raw water transmission pipelines in compliance with the regulation of SNiP, the part of the flow meter and the control valve shall be closed usually to in order to secure effective and accurate flow control.

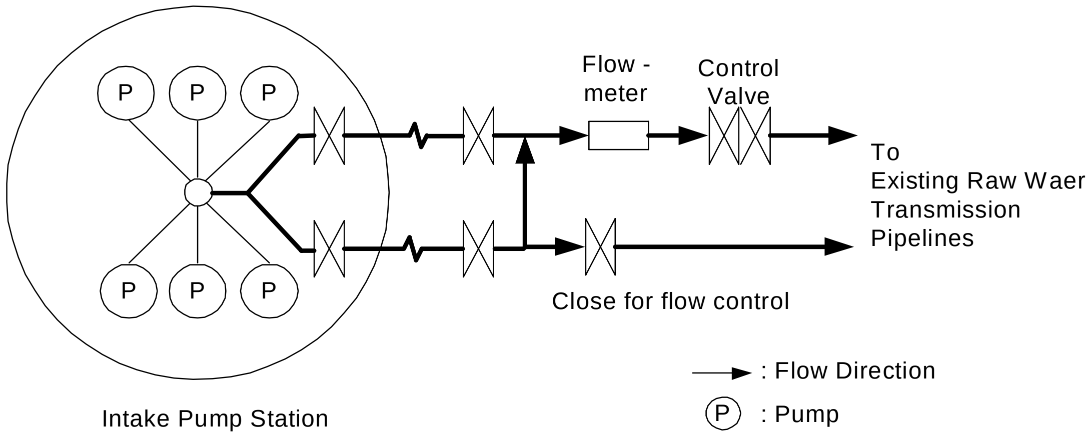


Figure 5.1.2 Connection between Intake P/S and Connection Pipeline

(7) Connection to Raw Water Transmission Pipelines

As mentioned above, new two connection pipelines (D1400mm x 2) will be installed for connection between the intake P/S and existing raw water transmission pipelines Nos. II and III. Water through the connection pipelines shall be smoothly flow into both of the existing raw water pipelines. It shall also be considered that the existing intake P/S is used in case of operation failure of new P/S.

Taking into account of such a requirement, the following plan was decided for connection from P/S to raw water transmission pipelines.

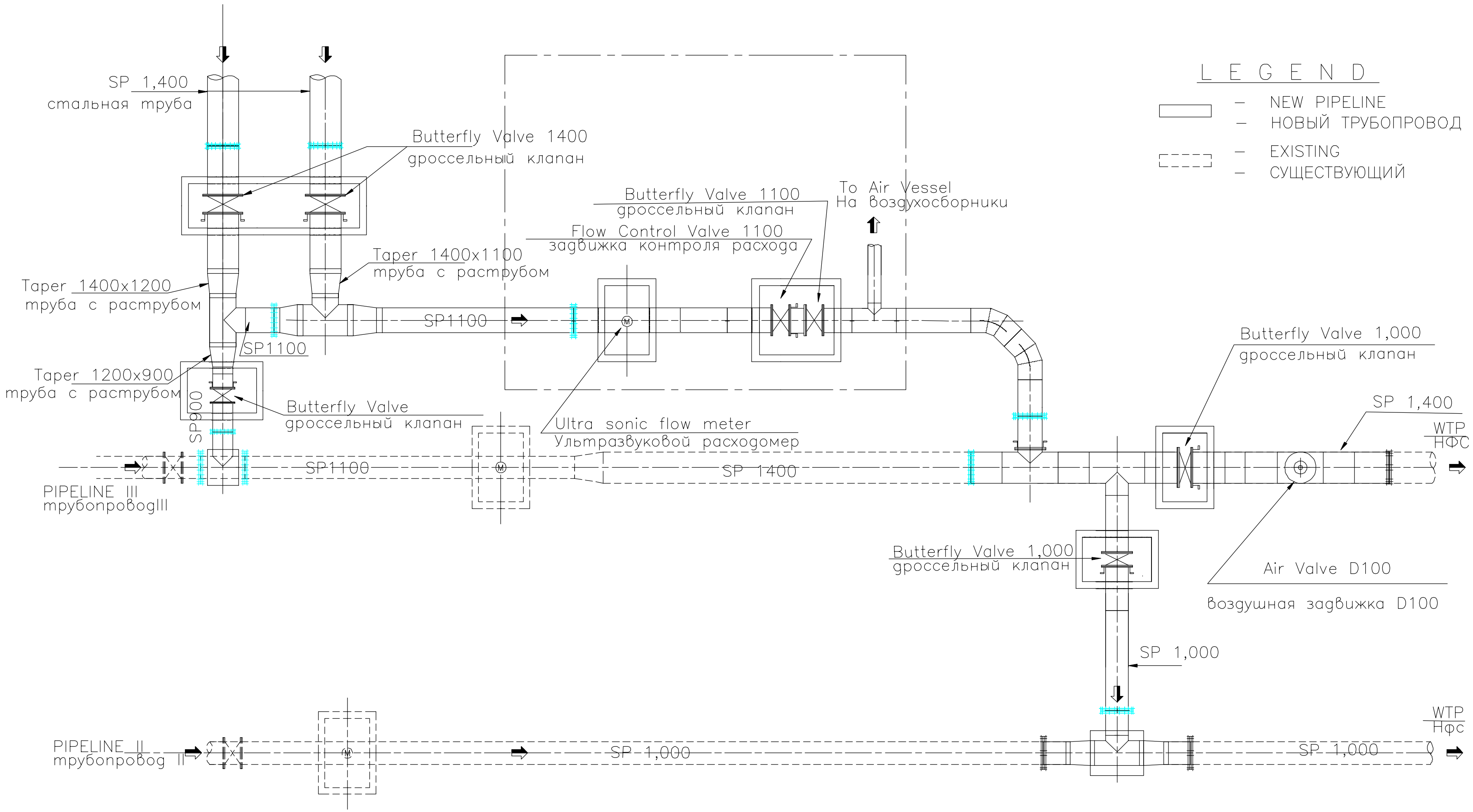


Figure 5.1.3 Connection from P/S to Raw Water Transmission Pipeline

5.2 Raw Water Transmission Pipeline

5.2.1 Selection of Sections for Rehabilitation

As stated in previous Chapter, the rehabilitation work of the Raw Water Transmission Pipeline No.2 was eliminated from the scope of work of the JBIC assisted Project as a result of discussions between JBIC and the Kazakhstan side. Therefore, the Kazakhstan side shall carry out the rehabilitation of the Raw Water Transmission Pipeline using their own fund.

During the basic design stage, however, the Study Team examined the leakage record from 1997 to 2002 together with field observation for the selection of priority sections for future rehabilitation work to be done by Kazakhstan side.

It was summarized that most leakages were found at several parts of the pipeline as shown on Figure 5.2.1. Thus, four (4) sections with a total of 15 km are designated for rehabilitation as follows:

Section 1:	1.5 km
Section 2:	7.5km
Section 3:	2.5km
Section 4:	3.5km
Total	15.0km

Schematic plan of sections of the pipeline for rehabilitation is also presented in Figure 5.2.1.

5.2.2 Rehabilitation Work

Rehabilitation work of the pipeline in the designated sections is to replace the existing pipes with new pipes using local fund of Kazakhstan.

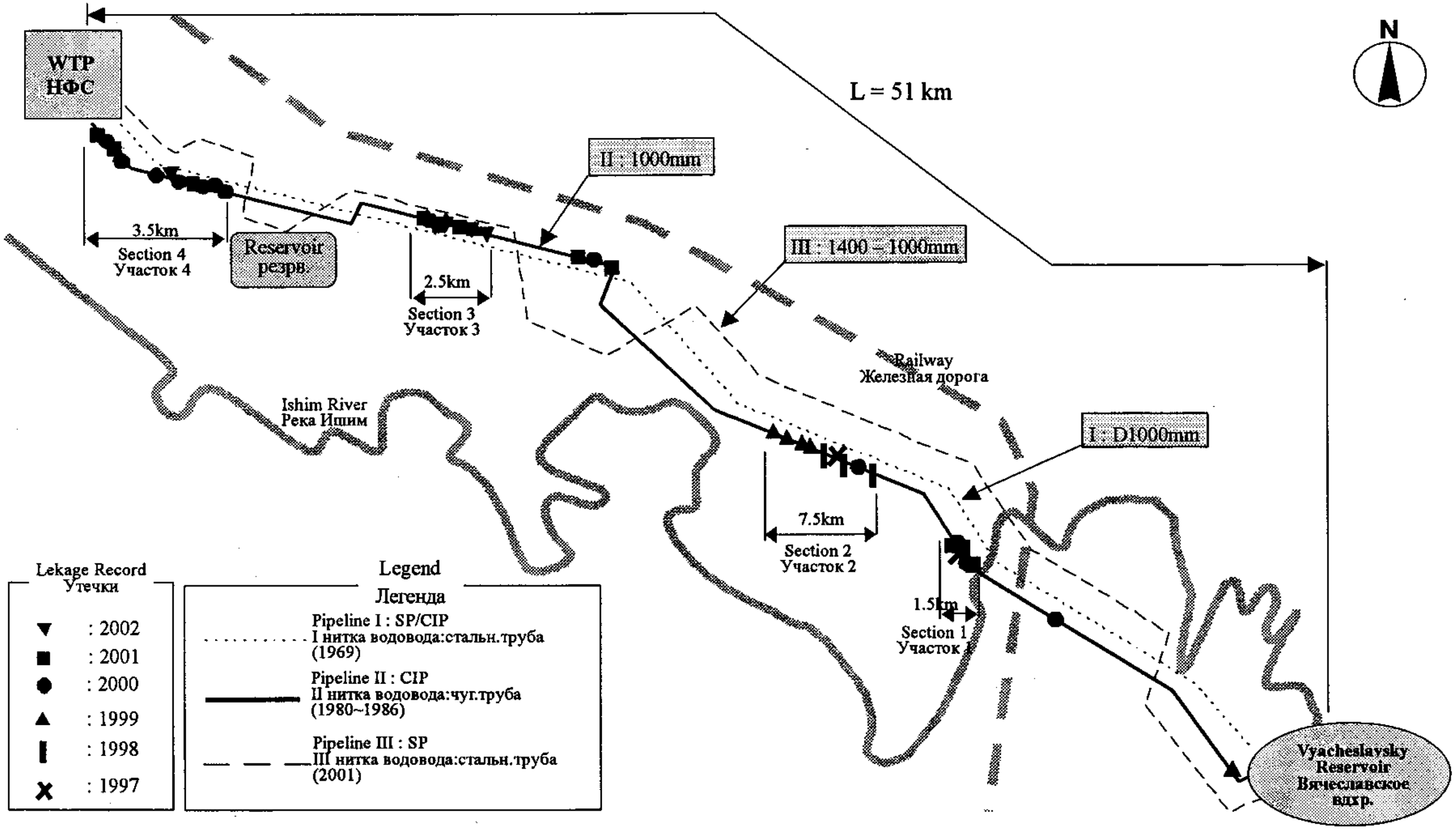


Figure 5.2.1 Sections for Rehabilitation of Raw Water Transmission Pipeline

Чертеж 5.2.1 Восстанавливаемый участок водовода сырой воды

5.2.3 Topographic and Hydraulic Conditions

Longitudinal profile of the pipeline route from the Intake P/S to the WTP is shown in Figure 5.2.2. The figure also shows hydraulic conditions calculated in case of 210,000 m^3/d utilizing the two pipelines No. II and No. III simultaneously.

The calculation is as follows:

(1) Hydraulic Calculation Formula

Hazen-Williams' formula is used for hydraulic calculation. This formula is very similar to the equation presented in SNiP, and commonly used in the field of water works.

$$H = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$$

H: Head loss (m)

C: C value (New pipe: 120, Old pipe: 110)

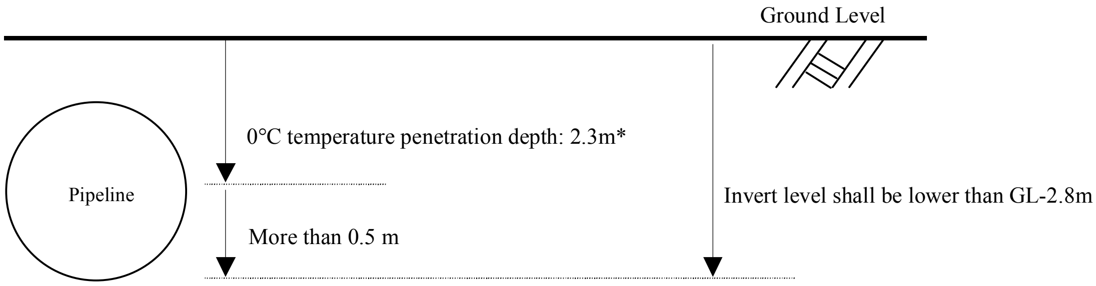
D: Pipe diameter (m)

Q: Water flow (m^3/s)

L: Pipeline length (m)

(2) Invert Level

Based on "SNiP: 4.01-02-2001-8.42 PUBLIC WATER SUPPLY SYSTEMS AND STRUCTURES" and "Reference Manual to SNiP - Construction Climatology", invert level of underground pipes shall be lower than -2.8 m deep.



* Astana is located within contour line of 230cm of 0°C temperature penetration depth in SNiP.

(3) Result of Calculation

As a result of hydraulic calculation for a flow of 210,000 m^3/d under some cases; each individual pipeline, No.II and III, and as a single pipeline in combination of the both lines, no negative pressure is observed for whole the pipeline length in each calculation. The result of calculation is also shown on Figure 5.2.2.

5.2.4 Measures against Water Hammer Phenomenon

This section presents the recommendation for design work, especially against a water hammer phenomenon.

(1) Water Hammer

As analyzing characteristics of the transmission pipelines, operation/control of the pump station was examined. The pipelines were often damaged by the surge phenomenon due to the irregular installation level and poor measures against the phenomenon.

Loss of power supply to the boosting system will cause surging and water hammer in the transmission pipeline.

When flow velocity in the pipeline changes within a short period, the water pressure in the pipeline changes rapidly. If the pressure becomes negative, the water in the pipe may evaporate forming cavities and causing water column separation, which intensifies the pressure on collapse of the cavity. This phenomenon is called a water hammer and the intensity depends on many factors such as pipe length, pump characteristics, etc. Measures for preventing water hammering must be taken to prevent damages of pipelines.

(2) Conditions for Analysis

Conceivable methods for preventing water hammer are as follows:

- Providing a flywheel to the pump
- Installing a surge tank (conventional/one-way) in the pipeline
- Installing a pressure water tank (air vessel) at the pump and/or pipeline

In consideration of the magnitude of the water mass in the pipeline, the option to use a flywheel will not be applied because the size of the required flywheel will be too big to start pumps. A surge tank system is practicable. At present, pipeline No. III is connected to a one-way surge tank with a capacity of 1,000m^3 located at the peak 5.2km far from the WTP. But this tank is not used because of a trouble of inlet float valves. A pressure water tank may be used as a suitable option.

Longitudinal profile of the pipeline route from the Intake P/S to the WTP is shown in Figure 5.2.3. The figure includes water pressure gradient in case of 210,000m^3/d transmission using pipelines No. II and No. III.

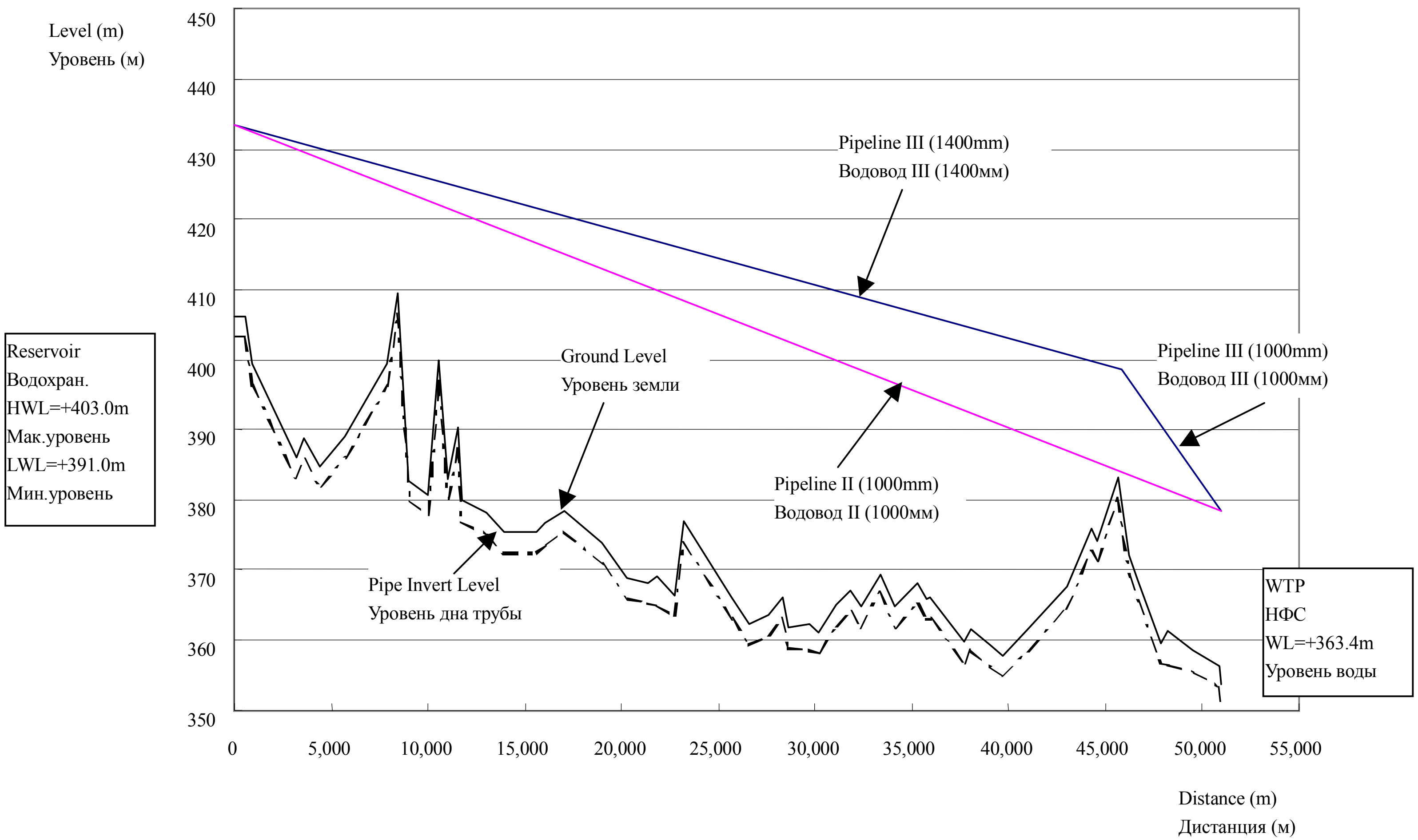


Figure 5.2.2 Longitudinal Profile of Raw Water Transmission Pipeline

Чертеж 5.2.2 Продольный профиль прокладки водоводов

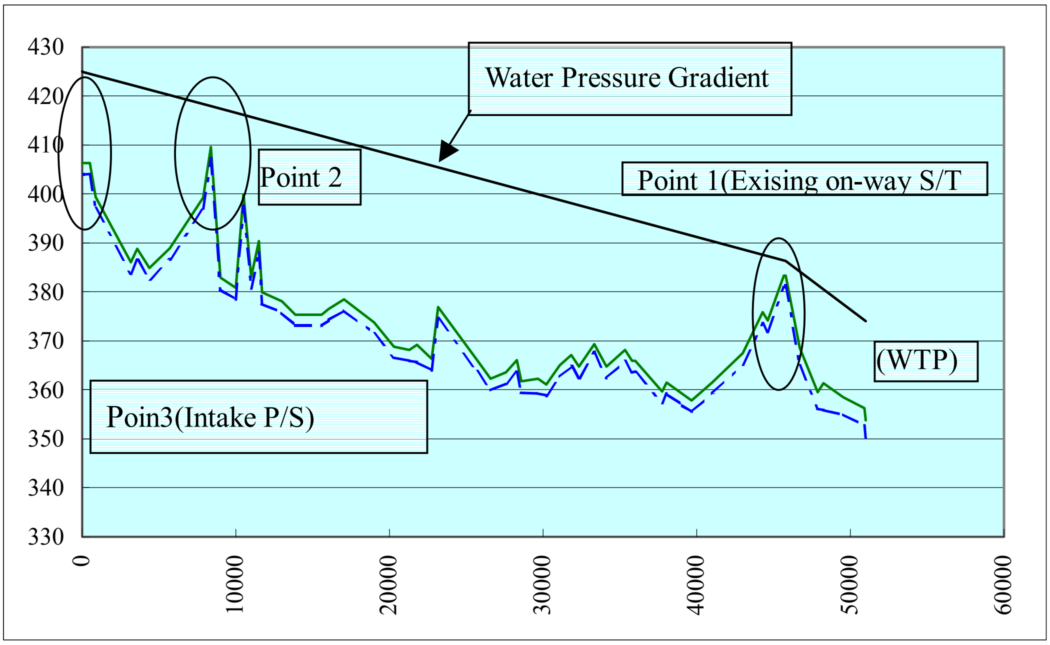


Figure 5.2.3 Longitudinal Profile of Raw Water Transmission Main

The points to pay attention in this profile are Point1: Intake P/S, Point2: the peak at 8 km from Intake P/S and Point3: the peak at 5.2km from WTP. Therefore, the followings are proposed practical measures against water hammer taking account with present condition of those sites:

- Point 1: Existing one-way surge tank located on the peak at 5.2km from WTP
- Point 2: New one-way surge tank located on the at the peak at 8 km from Intake P/S
- Point 3: New pressure water tank (air vessel) located at the Intake P/S

Criteria for analysis are as follows:

- Flow: 210,000m^3/day
- Pump: 36.5m^3/min x 34mH x 1,500rpm x 320kW x 4
- P1: One-way surge tank
  - Surface area: 265m^2 x 1
  - Water level: +384m
- P2: One-way surge tank
  - Surface area: 265m^2 x 1 (Same as existing surge tank)
  - Water level: +410m
- P3: Air-vessel
  - Surface area: 20m^2 x 2
  - Initial water level: +409m

- Time for calculation: 500sec.

(3) Results of Analysis

The following five (5) cases were studied.

- Case 1 No countermeasure is provided
- Case 2 P1: Existing one-way surge tank only
- Case 3 P1: Existing one-way surge tank + P2: New one-way surge tank
- Case 4 P1: Existing one-way surge tank + P3: Air-vessel at intake
- Case 5 P1: Existing one-way surge tank + P2: New one-way surge tank + P3: Air-vessel at intake

Results of analysis are shown as follows:

1) Case 1: Large negative pressure is occurred through all pipeline length.

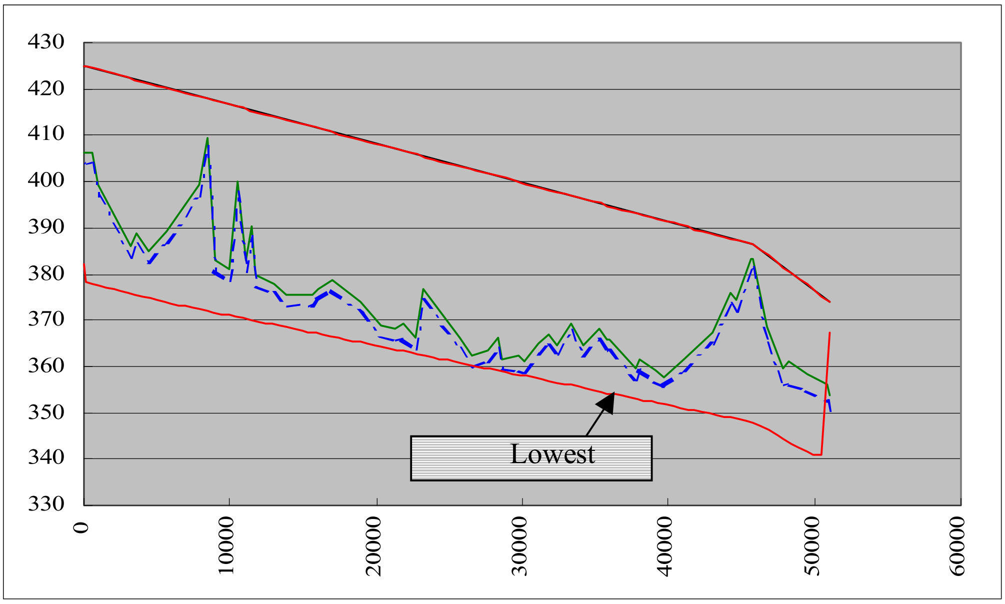


Figure 5.2.4 Case 1: No Measure is Provided

2) **Case 2:** Downstream of Point 1 has no problem, while a large negative pressure is observed upstream of Point 1

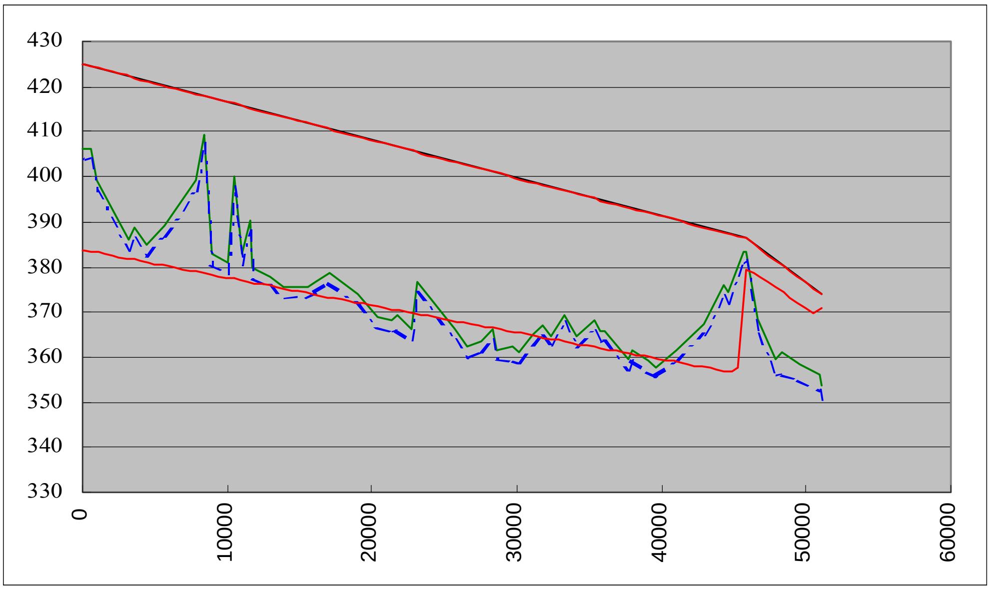


Figure 5.2.5 Case 2: P1 - Existing One-Way Surge Tank

3) **Case 3:** Downstream of Point 2 has no problem. But, a large negative pressure is occurred upstream of Point 2.

Figure 5.2.6 Case 3: P1 - Existing One-Way Surge Tank + P2 - New One-Way Surge Tank

4) Case 4: Downstream of Point 1 has no problem. But, negative pressure on the Point 1 and Point 2 cannot be canceled due to small size of air vessel.

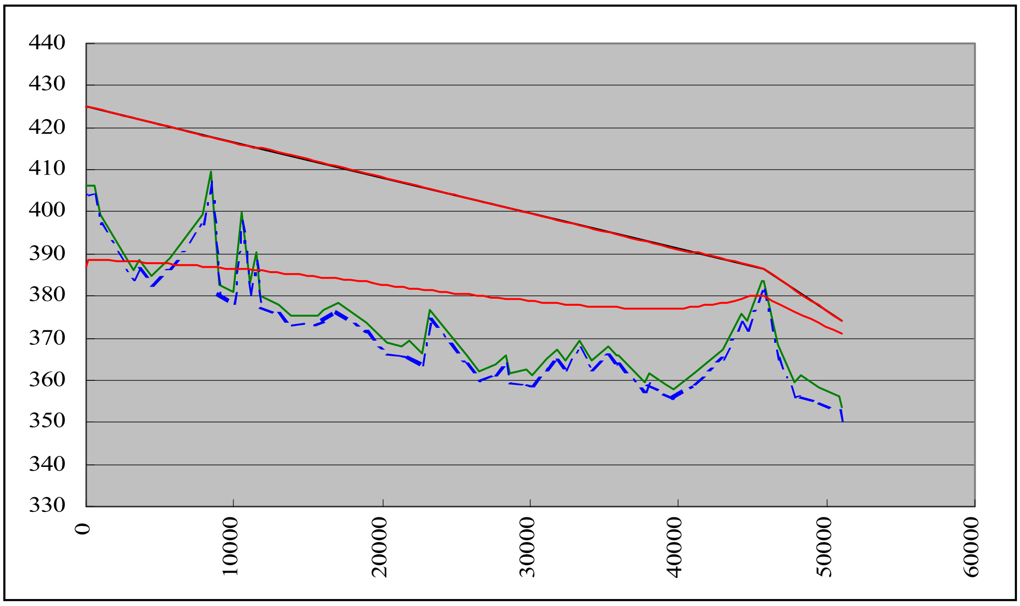


Figure 5.2.7 Case 4: P1 - Existing One-Way Surge Tank + P3 - Air-Vessel at Intake P/S

5) Case 5: There is no problem along the pipeline route in this case.

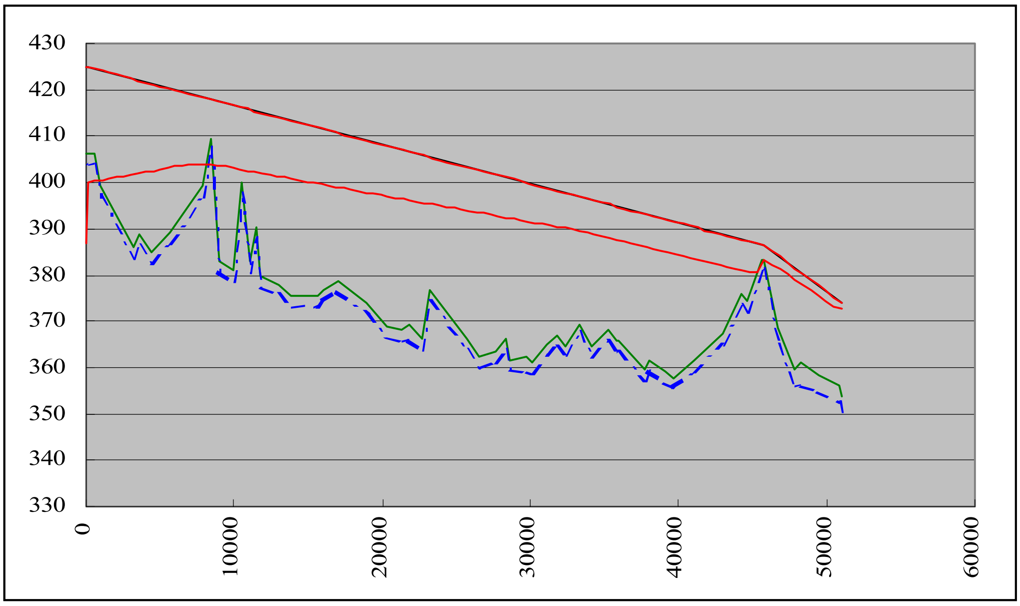


Figure 5.2.8 Case 5: P1 - Existing One-Way Surge Tank + P2 - New One-Way Surge Tank + P3 - Air-Vessel at Intake P/S

(4) Recommended Measures

According to the above-mentioned examinations, measure proposed in Case 5 is recommendable against water hammer caused by sudden stop of intake pump. Among the required facilities, the air-vessel at the point 3 is proposed for the Project as auxiliary facility for new intake pumps. The one-way surge tank at the point 2, however, shall be constructed together with the rehabilitation work of the raw water transmission pipeline No. II. In addition, the one-way surge tank at the point 1 shall also be rehabilitated.

Instead of providing the new one-way surge tank at the point 2, provision of air valves at peaks of pipelines stretching over all section will be an alternative plan. This alternative, however, is not recommendable because of unreliability of functioning of air valves, especially in a winter season.

As a result of the examination, the JICA team strongly recommend that the one-way surge tank at the point 2 be constructed together with the rehabilitation work of the raw water transmission pipeline No. II and existing surge tank at the point 1 before operation of the proposed P/S.

5.3 Water Treatment Plant

5.3.1 Recommendations in F/S

(1) "To meet the water demand for the year 2010, a capacity of approximately 100,000 m^3/day of additional WTP should be constructed to recover the lost capacity at the existing plant."

A new WTP with a capacity of 100,000 m^3/day is needed to cope with increase of demand and with decrease of existing plant's capacity.

(2) "The existing WTP will continue operations until the commissioning of the New WTP (No.3) which is intend to replace WTP No.1."

Existing plant shall not be abolished until new plants with sufficient capacity are to be completed. Existing facilities, however, shall be rehabilitated one after another to maintain their capacities at some level. This rehabilitation work is out of scope of this project.

(3) "Proposed Water Treatment Facilities for New Water Treatment Plant"

Outlines of proposed water treatment facility in F/S is presented in Table 5.3.1. Considering raw water quality and planned treatment capacity, proposed process in F/S is regarded appropriate. Treatment method conforms to regulation of SNiP.

Table 5.3.1 Outlines of Proposed Water Treatment Facilities

Name of Facility	Type
Receiving Well	RC Rectangular Tank
Rapid Mixing Tank	Hydraulic Mixing Type
Flocculation Tank	3 Step Horizontal Flow Type
Sedimentation Basin	Horizontal Flow Type with Sludge Collector
Rapid Sand Filter	Down Flow Type
Administration Building	RC, 3 stories
Distribution Pump Building	RC, Ground and basement floors

(4) "Proposed Automatic Operation and Monitoring System"

Automatic operation is applied to the Rapid Sand Filter for filtering and backwashing processes, and to distribution pumps for speed control by discharge pressure. As for monitoring, major operating information is monitored at the Central Monitoring Room in the administration building.

(5) “Buffer zones”

Required buffer zones specified in SNiP shall be secured.

5.3.2 Design Policy

As a result of discussions and consideration stipulated above, following design policies were established for the new water treatment facility:

(1) Treatment Capacity

Treatment capacity of the new plant is 100,000m^3/day. All facilities were designed based on that capacity. Facilities from receiving wells to filters, however, were designed for 105,000m^3/day taking account of production loss.

(2) Water Treatment Method

Regarding treatment method, the clause 6.10 of SNiP 2.04.02-84 recommends following two methods against present raw water quality and planned treatment capacity:

- Horizontal Sedimentation Tanks – Rapid Filters
- Contact Pre-filters – Rapid Filters (two-step filters)

The latter method employs meshed drum filters, and it is not recommendable because it is expected that the meshed drum filter be easily clogged with algae in the eutrophicated reservoir water.

The method composed of up-flow reactor clarifiers and rapid filters is not recommendable because of low turbidity of raw water except the snow-melting season.

Existing plant employed former method and accomplished rather good treatment results.

Considering regulation of SNiP and present performance of the existing plant, the former method is adopted.

(3) Wastewater and Sludge Treatment Method

At present, backwash water from filters and drainage from sedimentation basins are discharged to the river without treatment. It, however, shall not be discharged to the river without treatment because of environmental reason. Because of this reason, wastewater and sludge treatment facilities shall be provided in the Project.

Upon completion of the Project, all backwash water from existing and new filters will be sent back to a distribution well through a washing drain basin, which buffers shock load caused by backwashing.

Sludge drained from sedimentation basins of the new plant will be led to thickeners and thickened sludge will be dried up at sludge drying beds. Supernatant of the thickener and wastewater from the drying beds are led to a discharge pool and then discharged to a drain pipeline. Washout wastewater with settled sludge from the existing plant will be led to the sludge drying beds directly because settled sludge is compressed during one-year operation.

(4) Design Policy

The following principles was applied in the detailed design of proposed water treatment facilities:

- Present operation and maintenance situation shall be considered and full dependence on mechanical equipment shall be avoided.
- Economic aspects shall be considered important. Extravagant equipment shall not be introduced.
- Mechanization and automation are appropriate only where operations are not readily accomplished manually, or where they greatly improve the reliability assuring safe and stable water supply.
- Hydraulically based devices that use gravity for works such as rapid mixing and flocculation are preferred to mechanised and/or automated equipment in consideration of the available favourable topography of the plant site.
- Indigenous materials and products such as filter sand, gravels for concrete, concrete products etc. that are easy and safe for use in construction should be used to reduce costs, and to bolster the local economy and expand industrial development, as far as they fulfill required characteristics and performance.

5.3.3 Design Details

(1) Design Capacity and Design Calculations

Treatment capacity is 100,000m^3/day except facilities from receiving wells to filters, which will be designed for 105,000m^3/day taking account of production loss. Most of facilities will be housed and equipped with heating system for ease of operation and maintenance in winter season.

Approximate dimensions and structure of each facility is as shown in Table 5.3.2. These dimensions are decided based on the design calculation taking into account of design criteria specified in SNiP. Adopted design criteria are summarized in Chapter 4. Design calculations are attached as Appendix. Figure 5.3.1 shows the layout plan of proposed facilities. Hydraulic profile of facilities and the process flow diagram are shown in Figure 5.3.2.

Table 5.3.2 Dimensions and Structures of Facilities

Facility	Design capacity and structure
Distribution chamber	10.2 m width x 10.0 m length x 7.4 m depth x 1 unit
Receiving well	4.2 m width x 7.2 m length x 6.5 m depth x 2 basins
Rapid mixing basin	4.2 m width x 4.2 m length x 4.3 m depth x 2 basins
Flocculation basin	9.0 m length x 1.2 m width x 3.7 m depth x 12 channels 9.0 m length x 1.5 m width x 3.7m depth x 12 channels 9.0 m length x 2.3 m width x 3.7 m depth x 12 channels
Sedimentation basin	9.0 m width x 50.0 m length x 4.0 m depth x 6 basins
Rapid sand filter	5.8 m width x 12.6 m length x 12 filters x 118 m/day
Chlorine mixing channel	2.8 m width x 50.0 m length x 3.8 m depth x 1 basin
Distribution pump room	(Existing) 12.0 m width x 78.0 m length
Administration building	15.0 m width x 54.0 m length x 3 floors
Washing drain basin	12.4 m width x 34.5 m length x 3.0 m depth x 2 basins
Thickener	18.0 m diameter x 3.5 m depth x 2 basins
Sludge drying bed	20.0 m width x 45.0 m length x 1.0 m depth x 6 beds
Cake yard	20.0 m width x 30.0 m length
Discharge pool	11.8 m width x 34.5 m length x 3.0 m depth x 2 basins
Chemical room	12.0 m width x 23.4 m length x 3 floors
Chlorination room	included in the above room
In-plant piping	75 - 1600 mm 5,350m
Miscellaneous	Paving, planting, gate and fencing, guard house, etc.

(2) Design Water Level

Design water levels in each facility were decided based on the hydraulic calculation attached as Appendix. In the hydraulic calculation, water level of existing clearwater reservoir was set at 357.0 m, and water level of the distribution chamber was set at 363.4m.

(3) Distribution Chamber

Raw water is transmitted with three raw water transmission pipelines. In order to control the flow to existing, new and future plants, a distribution tank will be provided. The tank is divided into three compartments at the outlet side of the tank, and weirs control the flow to each plant.

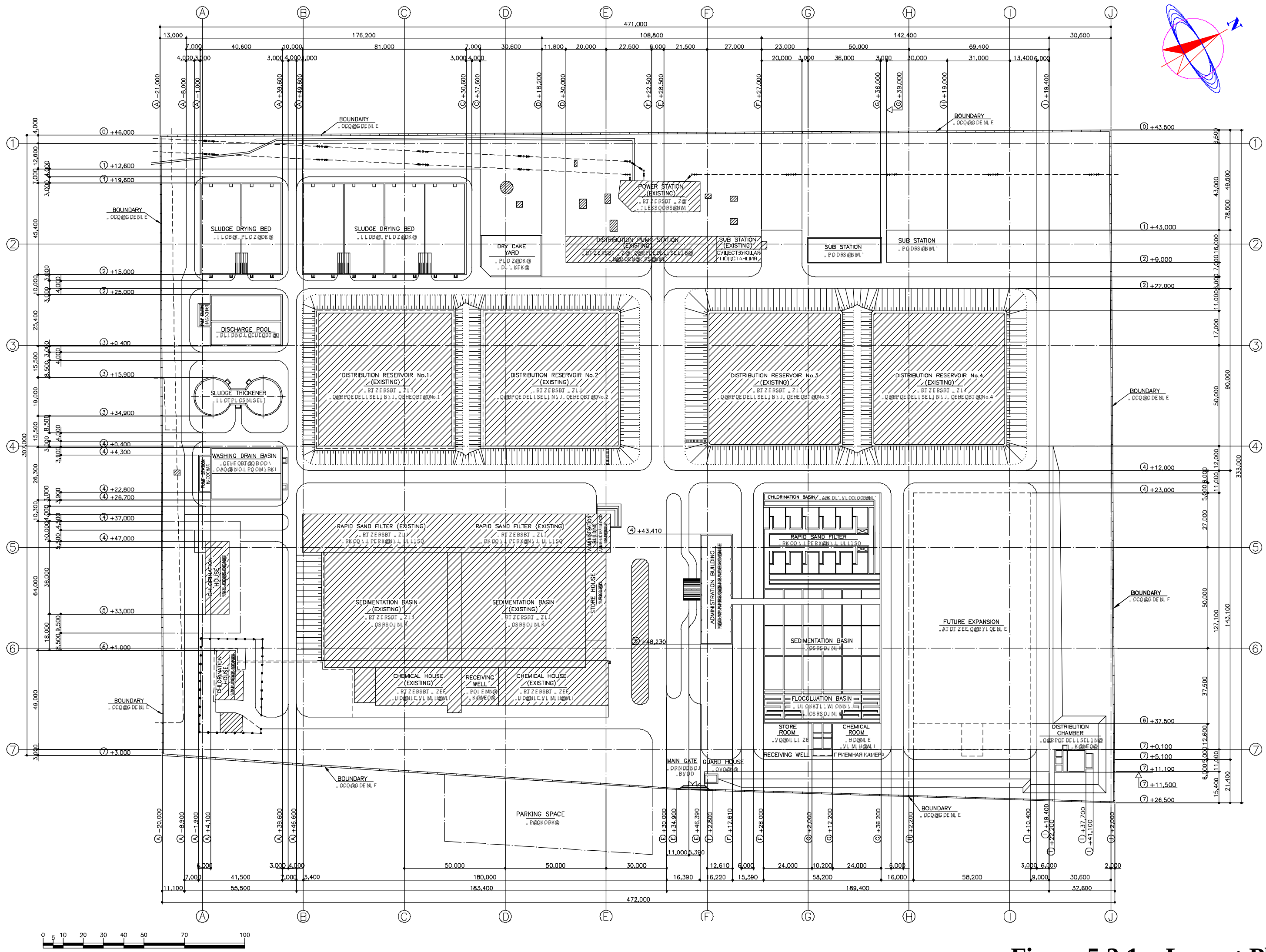


Figure 5.3.1 Layout Plan of WTP

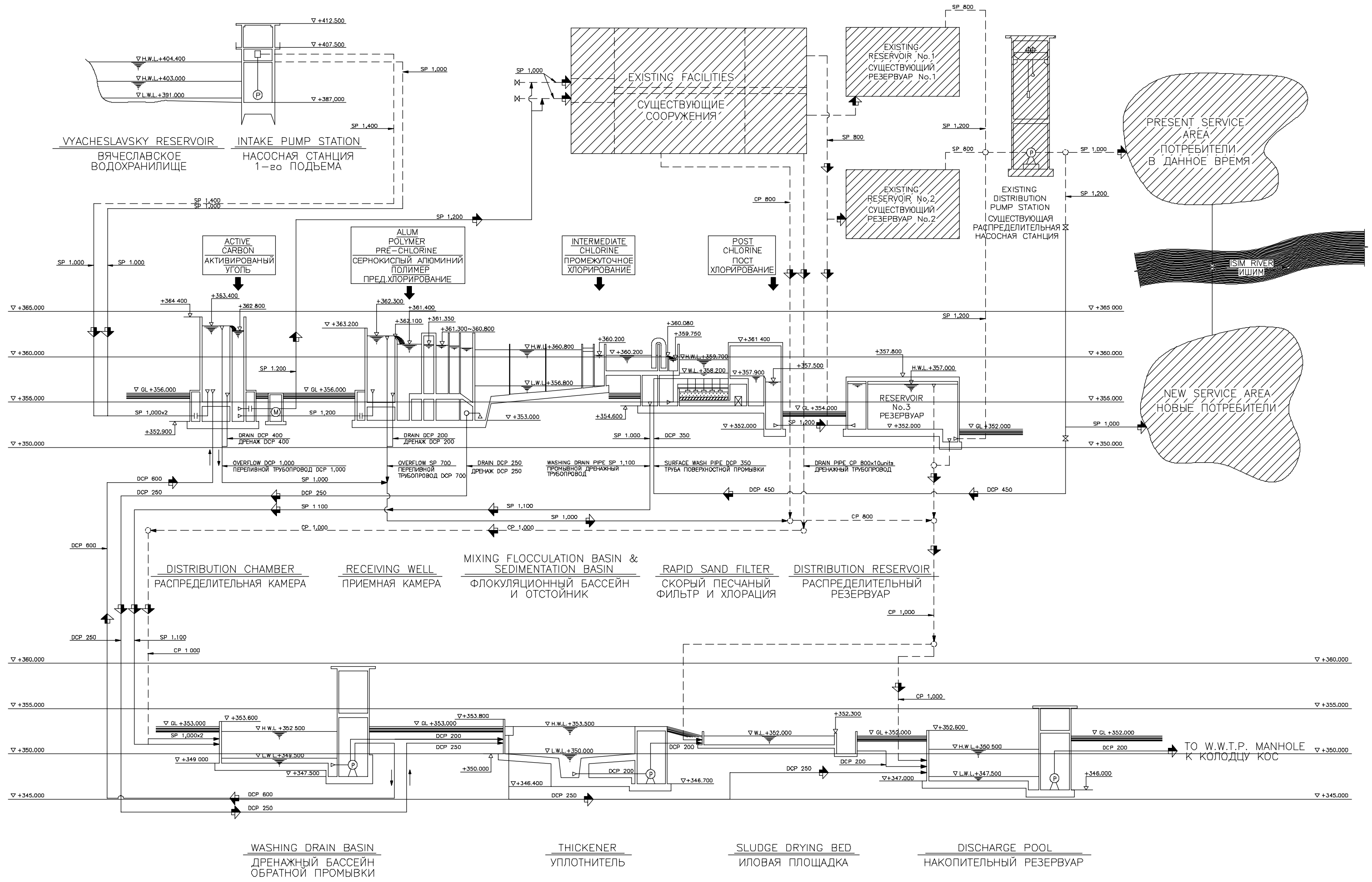


Figure 5.3.2 Process Flow Diagram and Hydraulic Profile

1) Type	:	RC Rectangular tank Adjustable mechanical overflow weir flow control
2) Dimensions	:	10.2 m width x 10.0 m length x 7.4 m depth x 1 unit
3) Attachment	:	Powdered activated carbon dosing equipment

(4) Receiving and Rapid Mixing Wells

After distribution tank, raw water will flow into receiving wells provided at the each head end of two water treatment series. Coagulation as a pre-treatment process of the rapid filtration will be applied at the receiving well so that the destabilization of charges on colloids and suspended solids, including bacteria and viruses may be achieved, followed by the treatment processes of flocculation, sedimentation, filtration, and disinfection.

The coagulation process is achieved by a rapid mixing system which disperses 10 percent alum solution, $Al_2 (SO_4)_3$ $18H_2O$ and 0.5 percent polymer solution as a coagulant uniformly throughout the entire mass of water. Distinctive types of rapid mixing equipment are shown in Table 5.3.3.

The advantage of hydraulic mixing is to simply apply raw water potential head generated by the raw water intake pumps. Making best use of that advantage, the rapid mixing with hydraulic jump at the weir will be provided at the receiving well. The facility is equipped with a baffle wall and a weir.

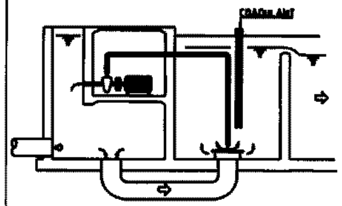
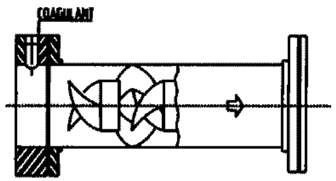
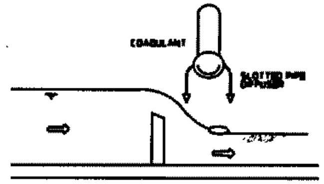
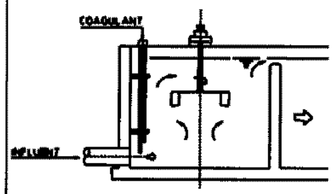
In addition, pre-chlorination will be applied using gas chlorinators from time to time, for removal of iron and/or manganese and for algal control.

The detention time and effective depth of receiving well are designed to be 3.5 minutes and 5.0 m, respectively. Further, the detention time and effective depth of mixing chamber are designed to be 2.1 minutes and 4.4 m, respectively.

The applied design parameters of the pre-treatment process are summarised in the following:

1) Type	:	Receiving well with hydraulic rapid mixing by weir
2) Dimensions	:	Receiving well; 4.2 m width x 7.2 m length x 6.5 m depth x 2 basins Mixing well; 4.2 m width x 4.2 m length x 4.3 m depth x 2 basins
3) G value for rapid mixing	:	$112s^{-1}$ ($> 100s^{-1}$)
4) Applied chemicals	:	Chlorination------- Liquid chlorine (solution) Coagulant--------- Alum (10 percent solution) Flocculant--------- Polymer (0.5 percent solution)

Table 5.3.3 Comparison of Rapid Mixing Process

Type of Rapid Mixing	In-line Jet Mixer	Static In-line Mixer	Hydraulic Mixing	Mechanical Mixing
Typical Drawings				
Design Criteria (for reference only)	G value = 500 to 1,000 $^{s-1}$ Pressure = 0.7 kg/m^2 Time = 0.5 sec.	G value = 500 to 1,000 $^{s-1}$ Headloss = max. 600 mm Time = 1-3 sec.	Headloss = 300-600 mm (300 mm provides G-value of 1,000^{s-1} at 20 degree)	G value = 500 to 1,000 $^{s-1}$ Time = 1 min. Required Power = 2.5 kW per 1 m^3/s of raw wagter. .
Advantages	1. No additional headloss 2. Controllable degree of mixing 3. Less power consumption 4. Effective mixing	1. No moving part 2. Low maintenance cost	1. No moving part 2. No clogging problems 3. No external energy 4. Low maintenance cost 5. Combination with flow mesurement 6. Easy monitoring for chemical feed	1. No additional headloss 2. Adjustable mixing effects
Disadvantages	1. Clogging of nozzle 2. Difficulty in applying to extra large pipes. 3. Complexive contruction schedule.	1. Inflexible mixing effects for fluctuation of treatment capacity. 2. Performance relys on the manufacture. 3. Clogging problems for chemocals or algae. 4. High loss of head	1. Inflexible mixing effects for fluctuation of treatment capacity. 2. High loss of head.	1. Lack of instantaneous mixing characteristics 2. Short-circuiting 3. O&M for mechanical parts

(5) Flocculation Basin

Flocculation is the process of gentle and continuous agitation, during which action suspended particles in the water coalesce into larger masses, so that they may be removed from the water in subsequent treatment processes, particularly by sedimentation and filtration. Flocculation follows directly after the rapid mixing process, and, like rapid mixing, the agitation may be induced either by mechanical or hydraulic means.

The most common methods for flocculation are categorized into hydraulic flocculation and mechanical flocculation processes, which are further classified into horizontal and vertical flocculation units as summarized in Table 5.3.4. Mechanical flocculators are characterized by their flexibility for the fluctuating water treatment capacity and controllable mixing intensity, because of their greater versatility; that is, the speed of the mechanically operated paddles can be adjusted to suit variations in flow, temperature, or raw water quality. However, the principle elements of mechanical flocculation system comprise agitator impellers, drive motors, speed controllers and reducers, transmission system, shafts and bearings which will require intricate operation and maintenance procedures.

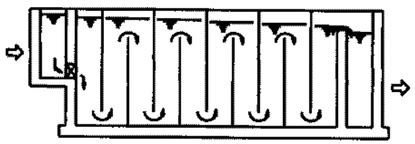
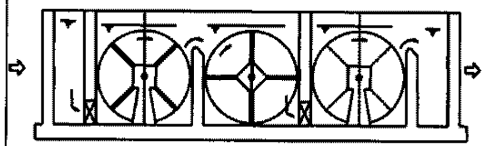
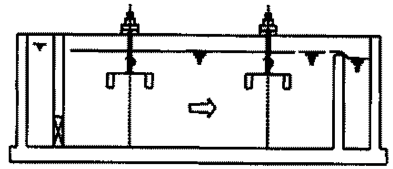
Considering present situation of the existing plant, the proposed plant will be operated at full designed capacity immediately from its commissioning. This means that fluctuations of flow for treatment capacity are expected to be minimal, and the designed flow rates can easily maintain sufficient head losses in the channel for mixing.

Therefore, as gravity flow energy is available, the recommendation for this plant is to use hydraulic flocculation system that requires neither mechanical equipment nor a continuous power supply.

The applied design parameters for the flocculation process are;

1) Type	:	Horizontal-flow baffled channels
2) Number	:	6 trains with 3 staged tapered flocculation
3) G value	:	60 sec^{-1} (10 to 75 sec^{-1})
4) Detention time	:	Approx. 30 min (20 – 40 min)
5) Dimensions (for each train)	:	9.0 m length x 1.2 m width x 3.7 m depth x 2 channels 9.0 m length x 1.5 m width x 3.7 m depth x 2 channels 9.0 m length x 2.3 m width x 3.7 m depth x 2 channels In the channels baffle walls will be provided for effective processing.

Table 5.3.4 Comparison of Flocculation Process

Type	Hydraulic System	Mechanical Flocculagtors	
	Baffled Channel	Horizontal Shaft with Paddles	Vertical Shaft with Blades
Typical Drawings			
Performance - Flocculation - Reliability - Operation Flexibililty - Capital Cost - Construction - Maintenance - Flow Condition	Good to excellent Good to excellent Moderate to poor Low Easy Low cost and easy Near plug flow	Good to excellent Good to excellent High Moderate to High Moderate High Short circuiting	Fair to good Good Good High Easy to moderate Moderate Short circuiting
Advantages	1. Simple and effective floc formation 2. Low O&M cost 3. No moving parts	1. Good floc formation 2. Effective/adjustable flocculation effects 3. No loss of head	1. Good floc formation 2. Adjustable flocculation effects 3. No loss of head 4. Easy to input high energy 5. Easy maintenance for mechanical part
Disadvantages	1. Inflexible mixing effects for fluctuation of treatment capacity. 2. High (0.3 to 0.6 m) loss of head 3. Limited eanergy input	1. Precise installation of treatment capacity. 2. High O&M cost 3. Regular O&M 4. Short circuiting	1. Many units reuired 2. Short circuiting

(6) Sedimentation Basin

The sedimentation or clarification process in water treatment processes is provided for the settlement and removal of a majority of the settlable solids of heavy and large suspended particles from water, prior to the subsequent filtration process. The sedimentation is greatly dependent on the adequate pre-treatment processes, including coagulation and flocculation. The efficiency of the sedimentation basin is determined by the surface-loading ratio *(Q/A)*, where *Q* is the rate treatment capacity, and *A* is the surface area of the sedimentation basin. The subsequent loading on the filters accordingly has a marked influence on their capacity; the time length of filter runs in relation to the filter washing schedules, and the quality of the filtered water.

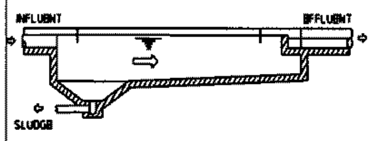
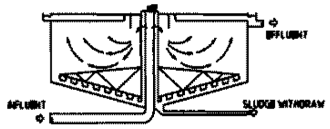
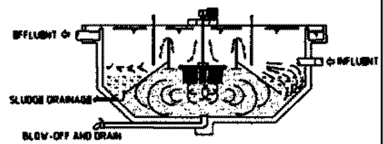
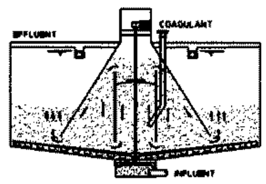
As tabulated in Table 5.3.5, the sedimentation system is classified into four major types: horizontal flow sedimentation units; up-flow sedimentation units; solids contact/slurry recirculation units; and sludge blanket clarifier units.

Horizontal flow sedimentation process is commonly used in municipal water supply systems. It is based on gravity flow separation process, in which a settling basin provides a quiescent environment that enables particles of specific gravity heavier than water to settle to the bottom of the tank. The outstanding feature of horizontal flow tanks is the flexibility to tolerate shock loads in terms of both quantity and quality of raw water. In fact, rectangular sedimentation unit can handle higher flow rates than the original design capacity for short periods without significant deterioration of settled water quality. Consequently, the flexibility and predictable performance brings about easy and stable operation and low cost maintenance.

Up-flow sedimentation process is usually applied to small-scale community plants due to easy operation and maintenance. When the raw water characteristics and hydraulic conditions are stable, it is recommendable. Water quality of the Vyacheslavsky Reservoir, however, is not stable during spring season so that the up-flow sedimentation process is not recommendable.

Sludge contact process, or slurry recirculation process, is a kind of modified up-flow process combining pre-treatment processes of coagulation, flocculation, and settling in one tank. The unit circulates high density, and stable micro-flocs by means of density flow developed by low lift pump blades installed in the coagulation/flocculation zone. The inflowing micro-flocs, developed in the coagulation zone, are absorbed by the circulating flocs, and subsequently precipitate in the settling zone (so called seeding effects).

Table 5.3.5 Comparison of Sedimentation Process

Type of Clarifier	Horizontal Flow Sedimentation Unit (rectangular basin)	Up Flow Sedimentation Unit (radial-upflow)	Solids Contact/Slurry Recirculation Unit	Sludge Blanket Clarifier Unit
Typical Drawings				
Design Criteria (for reference only)	1. Surface loading : 0.83-2.5 m/h 2. Water depth : 3-5 m 3. Detention time : 1.5-3 h 4. Width/length : 1/3 ~ 1/5 5. Weir loading : < 400m^3/m.d	1. Surface loading : 1.3-1.9 m/h 2. Water depth : 3-5 m 3. Settling time : 1-3 h 4. Weir loading : 250 m^3/m.d	1. Flocculation time : approx. 20 min. 2. Settling time : 1-2 h 3. Surface loading : 2-3 m/h 4. Weir loading : 350 m^3/m.d	1. Flocculation time : aprpox. 20 min. 2. Settling time : 1-25 h 3. Surface loading : 2-3 m/h 4. Weir loading : 7.3 to 15 m/m.h 5. Upflow velocity : <10 mm/min. 6. Slurry circulation rate : up to 3-5 times the raw water inflow rate
Advantages	1. More tolerance to shock loads in Tu and Temp. 2. Predictable performance under most conditions 3. Easy operation and low maintenance costs 4. Easy adaptation to high-rate settling modules for future expansion	1. Economical compact geometry 2. Easy sludge removal 3. High clarification efficiency	1. Incorporates coagulation/flocculation and clarification in one unit 2. Good flocculation and clarification efficiency due to a seeding effects in case of stable raw water quality 3. Tolerates slightly limited changes in raw water quality and flow rate	1. Incorporates coagulation/flocculation and clarification in one unit 2. Compact and economical design 3. Tolerates limited changes in raw water quality and flow rate 4. Preferable to highly turbid raw water
Disadvantages	1. Subject to density flow creation in the basin 2. Requires careful design of the inlet and outlet structures 3. Usually requires separate flocculation facilities	1. Problems of flow short-circuiting 2. Less tolerance to shock loads in Tu and Temp. 3. A need for more careful operation 4. Limitation on the practical size of the unit 5. May require separate flocculation facilities	1. Requires greater operator skill 2. Less reliability than conventional due to a dependency on one mechanical part 3. Subject to upsets due to thermal effects 4. Time consuming for seeding sludge preparations	1. Very sensitive to shock loads 2. Sensitive to temperature change 3. Several days required to build up the necessary sludge blanket 4. Plant operation depends on a single mechanical part 5. Requires greater operator skill 6. Ineffcient treatment in lower treatment capacity due to difficulty of maitaining sludge blancket properly 7. Difficuly of algae contained raw water due to float to surface
Proper Application	Most municipal and industrial water works Particularly suited to larger capacity plants	Small to mid-sized municipal and industrial treatment plants Best suited where the rate of flow and raw water quality are constant	A plant that treats a steady quality and quantity of raw water	Flocculation/sedimentation treatment of raw water with a constant quality and rate of flow Plant treating a raw water with a low content of solids

Notes : The reactor clarifiers and the sludge blanket type clarifiers are often considered to be in the same category.

The seeding effects used with relatively high turbid raw water enable high efficiencies for those pretreatment processes included in the separate compartment formed by steel members provided in the tank. A higher rate of surface loading can be applied than in conventional horizontal or up-flow units. Nevertheless, the operation and maintenance is not necessarily easy to control. The optimum operational conditions are dependent on several parameters, such as raw water turbidity, pH, temperature, alkalinity, and slurry concentration, that should be monitored by properly trained, or experienced, skilled operators and/or engineers. The submerged steel members installed inside the tank must be periodically cleaned and painted to prevent corrosion problems.

In the context of constantly high turbid raw water, sludge blanket clarifiers may be applicable. However, the actual turbidity of raw water is not more than 30 mg/L in last 5 years. Hence, both sludge contact and/or sludge blanket clarifiers could not maintain the sludge blanket in optimum condition so that these sedimentation system are not appropriate for the raw water quality.

Taking account of aforementioned characteristics of each sedimentation system, the horizontal flow sedimentation process was applied for new plant. The applied design parameters for the sedimentation process are:

1) Type : Rectangular plug flow, horizontal flow
2) Number : 6 trains with mechanical sludge collector
3) Dimensions : 9.0 m width x 50.0 m length x 4.0 m depth x 6 basins
4) Retention time : 2.7 hrs (1.5 – 4.0 hrs) (water depth 4.0m)
5) Surface loading : 24.6 mm/min (15 – 30 mm/min)
6) Passing velocity : 0.33 m/min (< 0.4 m/min)
7) Collecting trough loading : 350 m^3/m/day (< 350 m^3/m/day)

Surface loading and calculated surface area for low turbidity water stipulated in the design criteria published in Kazakhstan, Japan and United States are presented below:

Design Criteria	Kazakhstan SNiP PK4.02.01-2001	JWWA "Waterworks Facility Design Criteria"	AWWA "Water Treatment Plant Design"
Surface loading for low turbid water	21-27 mm/min 24-32 mm/min (1	15-30 mm/min	23-28 mm/min (800-1,000 gpd/ft^2)
Calculated Sedimentation Area	2,930-3,950 m^2 (1,(2 2,280-3,030 m^2 (1,(3	2,430-4,860m^2 (3	2,600-3,170m^2 (3

(1: Considering dosing of flocculant.

(2: Calculated with the formula written in SNiP Item 6.66. Considering coefficient of flocculant.

(3: Calculated with the formula, designed treatment flow divided by surface loading

In SNiP, the width of sedimentation basin is limited to 6 m. This limitation seems to be introduced to prevent turbulent flow in the basin by decreasing the Reynolds Number. However, there still be a problem of density flow, which decreases sedimentation efficiency by causing a short-circuit flow.

The designed sedimentation basin has a width of 9 m, which exceeds the limitation of SNiP. This width was adopted to reduce required area and construction cost. Its Reynolds Number, however, is within the desirable level. In addition, baffle walls were provided to the designed basins. Both of JWWA and AWWA criteria suggests providing baffle walls at the inlet zone and effluent zone, further intermediate zone to diminish influence of the density flow while SNiP does not specify about baffle walls. In the designed plan, baffle walls were set at the inlet, intermediate and effluent zone to secure sufficient sedimentation effect.

(7) Rapid Sand Filters

Filtration is the last safeguard process in the water treatment system to secure physicochemical safety through the combination of physical, chemical, and in some instances biological process for separating the carried over minute impurities from settled water by passage through porous media.

The considerations for design of rapid sand filtration process include; type of filter rate control; composition of filter media, characters of media and filter depth; filtration rate; washing arrangements, and auxiliary arrangements.

i) Filter layer and filtration media

During the basic design stage, character of current filter media (sand, gravel) at the existing water treatment plant was found not to be suitable for filtration because effective diameter and uniformity coefficient are 0.7-0.76 mm and 2.3 - 2.4, respectively, while filter depths is 1.0 m. These values do not conform to requirements specified in SNiP.

The Study Team investigated about availability of sand for filter media, and it was found that suitable quarts sand is available from eastern districts of Kazakhstan. Since it is produced of crushing stone, effective size of sand can be selected in compliance with the requirements as filter media. Proposed filter layer depth for the project is 70 cm. Filter media will be laid as single-layer. According to SNiP PK 4.01.02-2001 Table 21, characters of filter media required for filter layer with a depth of 0.7 - 0.8 m are; 0.7 - 0.8 mm of effective size and 1.8 - 2.0 of non-uniformity coefficient. Other characteristic, such like detrition loss, specific gravity and ignition loss are not specified in SNiP.

The required filter area and number of units are interrelated. The maximum size of filter bed should be limited to 120 m^2 based on the regulation stipulated in SNiP to avoid uneven flow of backwash water.

The applied design parameters for the filter media and filtration rate are:

Filtration rate	118 m/day (for 12 filters, normal operation) 142 m/day (for 10 filters with 1 for backwashing and 1 for suspended)
Filter media	700 mm thick silica or quarts sand layer Effective Size: 0.7 mm, Uniformity Coefficient (d_{60}/d_{10}): <1.5
Nos. of filters	12 units
Dimensions per unit	5.8 m x 12.6 m (= 73.1 m^2/unit < 120 m^2)

ii) Filter Washing Arrangements

Backwashing is provided to remove the suspended materials that have been deposited in the filter bed during the filtration cycle. Since the backwashing effect influences to the efficiency of filtration process, it is required to wash the filter media sufficiently. The applied single-layer filter tends to remain suspended materials at surface of the layer especially and they cause mudball formation with improper backwashing action. Thus, auxiliary scouring measure is required to prevent formation of mudball and to wash filter media sufficiently.

There are two common auxiliary scour measures; one is the surface washing and the other is air scouring. For the thinner layer with finer filter media, which is commonly adopted in Japan and United States, the former is suitable, and the latter is used for thick layer with granular filter media, which is common in Europe.

With regard to backwashing, existing plant applies washing with pumped water tapped from clearwater reservoirs. While, the self-backwashing type washing system, in which wash water will be reversed from other filters without pumps, is applicable in the proposed plant because of sufficient number of filter units. It is applied for designed plant because energy for pumps can be saved, and auxiliary equipment is relatively less.

The applied design parameters for the filter wash arrangement are as follows:

Backwash rate	0.60 m^3/m^2/min	
Auxiliary wash	Surface wash	0.15 m^3/m^2/min
Backwash water	Self-backwashing	

iii) Filtration Rate Control (refer to Table 5.3.6)

An integral requirement for the sustainable operation of filters is to distribute the settled water evenly into each filter, and to backwash them regularly, if the loss of head reaches the designed level or after 24 to 48 hours of filter-run, dependent on the settled water quality. Unscheduled backwashing is inevitable in situations where the turbidity of the settled water exceed the desirable level. The water level in each filter unit rises as necessary to accept an equal portion of influent and indicates head loss. There are two types of self-backwashing filter control device. The one is the flow control by valves and the other is flow control by siphons, and the flow control by siphons is applied. The applied filter control system is:

1) Filtration system : Constant-rate filter with influent splitting and varying water level
2) Influent control : Fixed weirs
3) Effluent control : Control weirs

iv) Number of Filters

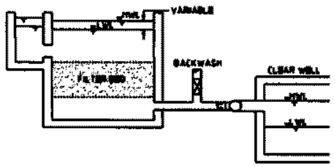
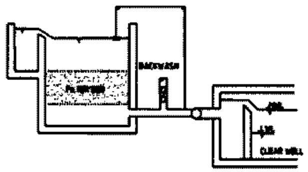
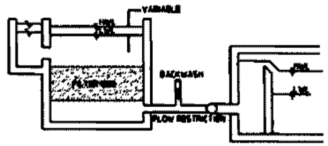
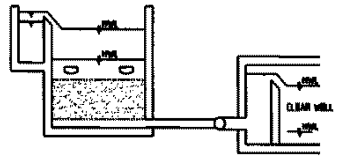
Number of filters and auxiliary filters in the design criteria published in Kazakhstan, Japan and United States are as follows:

Design Criteria	Kazakhstan	JWWA	AWWA
	SNiP PK 4.02.01-2001	”Waterworks Facility Design Criteria”	“Water Treatment Plant Design”
Filter number	14 or 15(1	2 filters or more	4 filters or more
Number of auxiliary filter	1 (20 filters or less)	1 filter per 10 filters for maintenance	1 filter for maintenance

(1: Calculated with the formula in SNiP Item 6.97 under condition that total filter area is 877 m^2.

Twelve (12) filters are proposed for the new water treatment plant, although required filter number is 14 or 15 by calculation with the formula stipulated in SNiP. Both of JWWA and AWWA do not regulate about number of filters. They specify that the number shall be decided to maintain sufficient filtration flow even if one filter is out of service for maintenance. Operation with 12 filters satisfies the required filtration rate as SNiP regulates in Item 6.97 in emergency case, in which one filter is out of service and another is in backwashing. To avoid cost increase and to make operation and maintenance easier, the Study Team proposes that the filter number be 12.

Table 5.3.6 Comparison of Filteration Process

Type of Filters	Constant Rate Filtration	Constant Level Filtration	Declining Rate Filtration	Constant Rate Filter with Influent Splitter and Varing Water Level
Typical Drawings	 (Flow meter & flow modulation valve)	 (Influent control, level sensor & modulation valve)	 (No influent control, no modulation valve an orifice plate)	
Main Equipment	1. Inlet gate 2. Outlet valve (flow modulation valve) 3. Flow meter 4. Backwash valve 5. Surface wash valve(Air scouring vlave) 6. Washout gate 7. Washwater pump (elevated tank) 8. Surface wash pump(Air blower)	1. Inlet gate 2. Concentric siphon 3. Partialisation box 4. Outlet valve 5. Backwash valve 6. Surface wash valve(Air scouring valve) 7. Washout valve 8. Washwater pump 9. Surfave wash pump(Air blower)	1. Inlet gate 2. Flow restriction (orifice plate) 3. Outlet valve 4. Backwash valve 5. Surface wash valve(Air scouring valve) 6. Washout gate 7. Washwater pump (elevated tank) 8. Surface wash pump(Air blower)	1. Inlet gate 2. Outlet valve 3. Backwashing and surface washing sytem (Air scouring system) 4. Washout channel 5. Surface wash pump(Air blower)
Filter Washing System	Backwash by elevated wash tank/pump Surface wash/Air scour wash	Backwash by elevated wash tank/pump Surface wash/Air scour wash	Backwash by elevated wash tank/pump Surface wash/Air scour wash	Backwash by elevated wash tank/pump Surface wash/Air scour wash
Advantages	1. A widely accepted filtration Process	1. A widely accepted filtration Process	1. Simple control 2. Low maintenance Cost	1. Simple control 2. Low maintenance cost 3. Limited use of mechanical equipment
Disadvantages	1 High capital cost 2. Highest maintenance cost 3. Easily damages on flow meter/flow modulation valve	1. High capital cost 2. High maintenance cost	1. Requires more than six units of filters in one module 2. Potential of initial turbidity break through	1. Deeper filter cells
Proper Application	Most plants with qualified operators and Support personnel	Most plants with qualified operators and support personnel	Middle capacity plants in developing countires	Middle/large capacity plants in any countries

v) Underdrain System (refer to Table 5.3.7)

The major requirements for the filter underdrain system are the support of the filter media, and the uniform distribution of backwash water across the entire filter bed. In many instances, bases can be with reinforced concrete slabs with plastic strainers, pre-cast concrete perforated lateral concrete block, or simple perforated-pipe lateral systems. The pre-cast perforated concrete block is applied in this project. This type of underdrain system has been applied in many water treatment plants worldwide, especially in North America. It has advantages in construction cost, easy in-situ manufacturing and simple installation work.

(8) Chemical Applications and Chlorination

Alum and polymer as coagulants, powdered activated carbon as temporary deodorant (maximum dosing period - one month) and liquid chlorine as disinfectant are recommended to be employed in the proposed WTP as same as the existing one. The dosage rate (in mg/l) and application points of each chemical are proposed as shown in Table 5.3.8 taking account of operational conditions of the existing WTP facilities.

All of the equipment and facilities for chemical applications and chlorination are provided in housings, i.e. Chemical houses and Chlorination room, which will be constructed next to the proposed water treatment plant.

Table 5.3.8 Chemical Dosage

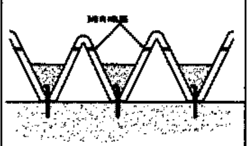
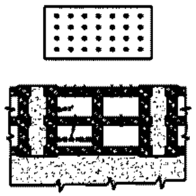
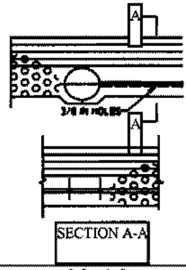
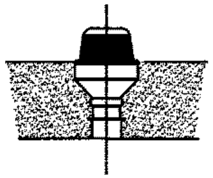
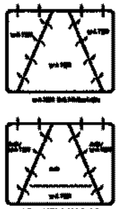
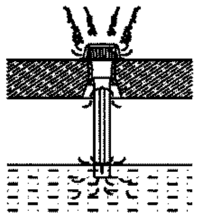
(unit: mg/L)

	Max.	Ave.	Min.	Dosing Points
1) Alum	30	7.5	1.0	Receiving well
2) Polymer	0.1	0.05	0.025	Ditto
3) Powdered activated carbon	20	-	5	Distribution basin (1 month /year)
4) Pre chlorine	5.0	2.0	1.0	Distribution chamber
5) Intermediate chlorine				Alternative for pre-chlorine at the effluent channel of sedimentation basins
6) Post chlorine	1.5	1.0	0.5	Effluent chamber of filter units

i) Alum Feeding Facility

Alum will be delivered with bags containing 50 kg of aluminum sulphate $Al_2 (SO_4)_3 18H_2O$. According to the water quality records of the existing WTP, the maximum dosage is not likely to exceed 30 mg/l with a 10 percent solution. The flow of alum solution is manually controlled according to the alum demand and to the actual raw water flow. It is noted that the existing WTP system is using alum at an average rate of 4.74 mg/l, and hence the design is safe and satisfactory. Since dissolved alum is sent from the existing chemical rooms by coagulant transfer pump, a coagulant storage tank is facilitated in new Chemical Room.

Table 5.3.7 Comparison of Underdrains

Type	Ordinal Backwash Filters				Airscour and Backwash Filters	
	Precast concrete laterals	Dual-parallel lateral blocks (tile blocks)	Pipe laterals	Strainer	Dual-lateral blocks (polyethylene blocks)	Strainer
Typical Drawings						
Headloss at Ordinary Backwash Rates	1 - 1.5 m	0.6 - 1.8 m	0.9 - 1.5 m	1 - 2 m	0.6 - 1 m *1	0.4 - 0.6 m *2
Orifice Size (Diameter) (For reference only)	8 - 10 mm	4 - 6 mm	6 - 10 mm	0.25 - 0.75 mm	6 mm	0.25 - 0.75 mm
Particulars	1. 0.3 m lateral spacing 2. 75 mm orifice spacing on either side of the lateral 3. Maximum lateral length of 4.8 mm	1. 0.3 m lateral spacing 2. 516 or 193 orifices per m2 area 3. Maximum lateral length of 15 m	1. 0.3 m lateral spacing 2. Orifices are spaced 75-100 mm. apart and 45degree down-angle from the horizontal on both sides of the lateral 3. Maximum lateral length of 6 m	1. Plenum or lateral bottom 2. Strainers spaced 150 - 200mm apart 3. A space less than 250mm for the lateral	1. 0.3 m lateral spacing 2. 247 dispersion orifices per m2 of bed area 3. Maximum jointed lateral length is 15 m 4. Gravel layers required on top of the blocks	1. The preferred height of the plenum bottom is 0.6 m 2. Durable and proven types of strainer should be selected 3. A gravel bed is usually not required above the strainers

*1-under simultaneous air and water backwash at 0.9m/min. constant air rate and, 0.6 and 0.8 m/min. backwash rate
*2-under 0.8 m/min. wash rate

The alum feeding facility consists of with dimensions of 3.9 m x 5.5 m x 3.5 m (depth). Tank will be made of reinforced concrete with suitable acid resistant lining.

ii) Storage of polymer and powdered activated carbon

Because consumption amount of both chemicals is relatively small and period of dosing is limited, powdered activated carbon and Polymer will be stored sufficient for one-year operation for the former and for a half year, which is regulated by SNiP, for the latter against water treatment volume of 105,000 m^3/day.

The chemical storage for each facility is provided with suitable loading equipment to accommodate the specified maximum daily consumption of polymer and powdered activated carbon.

iii) Chemical Room

The chemical rooms for alum, polymer and powdered activated carbon locates right hand of the receiving well. The dosing equipment for alum, polymer and powdered activated carbon are located at the first floor, and the storage powdered activate carbon are located at the second floor.

1)	Chemical Tanks		
	Dimensions		
	Alum	:	3.9 m x 5.5 m
	Activated Carbon	:	3.9 m x 5.5 m
2)	Room for alum, polymer and powdered activated carbon dosing facility		
	Dimensions	:	12.0 m width x 23.4 m length

iv) Chlorine Dosing Facility

Chlorine will be supplied as liquid chlorine in one-ton cylinder. The facility will include all equipment for storage, handling, dosing and injection of chlorine, together with safety equipment. The operation of the chlorinators will be controlled manually.

Chlorination equipment will be for pre, intermediate and post chlorination. Pre-chlorination will be conducted for oxidization of iron, manganese, ammonium-nitrogen and other organic substances, for killing algae, and for disinfection of raw water. Intermediate chlorination will be done for same purpose in case of rather contaminated raw water to avoid production of trihalomethane and musty smell.

The pre- and intermediate chlorine will be dosed at the receiving well and outlet of sedimentation basin. Dosing rate shall be controlled by checking the effect of chlorination.

The same equipment will be used for pre- and intermediate chlorine injection because both of them will not be done simultaneously.

Post chlorination will be conducted for disinfection purpose and be adjusted to retain necessary residual chlorine concentration in the distribution network.

Evaporator will be equipped for feeding evaporated chlorine.

Chlorine will be extracted from a cylinder loaded on a weighing machine being measured its consumption. Cylinder pit and water spraying piping are equipped for chlorine leakage.

1) Pre and intermediate chlorine injector : 7 to 22 kg/hr x 2 (1 for standby)
2) Post chlorine injector : 2 to 7 kg/hr x 2 (1 for standby)

v) Chlorination Room

The new chlorination room is located in chemical room. It is equipped with ventilation fans on the wall to prevent to chlorine accumulation and also heating apparatus to maintain temperature stable in the room. Chlorine cylinder pit and water spaying piping is provided at the chlorination room for neutralization of chlorine gas in case of emergency. Cylinder storage capacity of the house is limited to two cylinders due to safety reason. Most of the cylinders will be stored in the existing chlorination house.

Dimensions

Chlorine measuring room	:	9.0 m width x 5.7 m length
Chlorinator room	:	9.0 m width x 5.7 m length

(9) Sludge Treatment Facility

In the proposed plant, settled sludge in sedimentation basins is drawn out by gravity periodically and fed to thickeners for thickening. The thickened sludge is transferred to sludge drying beds by pump and dried there. Supernatant, which is effluent from thickeners and sludge drying beds, flows into the discharge pool by gravity and is discharged to sewage by pumps. Dried sludge is stored at the cake yard and is transferred to a disposal area.

The backwash water from rapid sand filters is once stored at the washing drain basin and returned to the distribution chamber by pumps.

Since the settled sludge of the existing sedimentation basins is so thickened in the basin that it will be transferred to the sludge drying beds directly. The capacity of the thickeners will be designed to cope with discharge from the new plant, and its solid loading is set at 20 $kg/m^2/day$ with proper allowance.

i) Washing Drain Basin

The backwash water from both the existing and new filters flows into the washing drain basin and returns to the distribution basin by pump after 1-hour detention. The total capacity of the basin is more than the total amount of the backwash water discharged in one washing process. The basin is equipped with pumps for returning water and sludge drainage.

1) Capacity : 1,280 m^3 per basin (3m water depth)
2) Dimension : 12.4 m width x 34.0 m length x 3.0 m depth x 2 basins
3) Return water pump : 11.0 m^3/min x 17 m x 55 kW x 2 (1 for standby)
4) Sludge drainage pump : 2.2 m^3/min x 6 m x 5.5 kW x 2 (1 for standby)

ii) Sludge Thickener

The sludge thickener is the facility that receives the sludge settled in sedimentation basins and concentrates it effectively. The sludge generation is assumed equivalent to about 15 percents of the total production capacity. The thickener is equipped with drainpipe, sludge feeding equipment, supernatant drainage equipment, rake and sludge discharge pump.

1) Solid loading : 20 kg-DS/day
2) Dimension : 18.0 m diameter x 3.5 m depth x 2 units
3) Capacity : 1,780 m^3 (890 m^3 x 2 units, water depth 3.5m)
4) Sludge drainage pump : 1.3 m^3/min x 6 m x 3.7 kW x 2 (1 for standby)

iii) Sludge Drying Bed

The sludge drying bed is the facility that dries the discharged sludge from the sludge thickener efficiently. The bed is equipped with drainage facility to accelerate dry the sludge.

1) Solid loading : 20 kg-DS/m^2/day
2) Dimension : 20.0 m width x 45.0 m length x 1.65 m depth x 6 beds
3) Area : 5,400 m^2 (900 m^2 x 6 beds, water depth 1.0m)

iv) Cake yard

The cake yard has a capacity to store the amount of discharged sludge for one-year.

1) Dimension : 20.0 m width x 30.0 m length x 1 unit
2) Capacity : 212 m^3/year

v) Discharge Pool

The discharge pool will store supernatant of the sludge thickener and the sludge drying bed. From the discharge pool, drained water is sent to drain pipeline by pumps continuously.

1) Dimension : 11.8 m width x 34.5 m length x 3.0 m depth x 2 units
2) Capacity : 1,000 m^3/unit
3) Discharge pump 1.3 m^3/min x 8 m x 3.7 kW x 2 units (1 for standby)

(10) In-Plant Piping Work

In-plant pipelines in the premises of the water treatment plant consist of underground piping between structures or process units carrying liquids to various destinations of the plant as tentatively summarized in following table:

	Diameter	Length
	75 – 1600 mm	5,350 m

(11) Distribution Pump Station

There are eight distribution pumps for drinking water in the existing pump station. Among of them, two pumps were recently converted from use for technical water to use for drinking water distribution to meet increase of drinking water demand. The pump is the horizontal double suction volute type.

Judging from the status of existing pumps and water demand, grouping of pumps was considered to have variable and reliable operation. The following specifications for the distribution pumps were recommended.

1) Type : Horizontal double suction volute pump (dry pit type)
2) Large : Capacity: 66.7 m^3/min (4,000 m^3/hour)
(Nos. 4 and 7) Number: 2 units
Small : Capacity: 41.7 m^3/min (2,500 m^3/hour)
(No. 8) Number: 1 unit
3) Head : 55.0 m

(12) Administration Facilities

i) Administration Building

The administration building, which is the central building of the water treatment plant, is RC structure three-story building. The major facilities include a central control room, a laboratory, an electrical room, a general offices including manager room, staff office of each section, meeting room. The building has a connection bridge on second floor to the sedimentation basin for convenience of daily maintenance work.

1) Total area : 2,430 m^2
2) Dimensions
   1st floor : 15.0 m width x 54.0 m length
   2nd floor : 15.0 m width x 54.0 m length
   3rd floor : 15.0 m width x 54.0 m length

ii) Security and Fencing

Existing fence encloses the whole plant area. However, due to deterioration, it needs replacement. In the project, front side of the premises of the plant will be replaced together with the main gate at the entrance. Existing main gate will be replaced to prevent illegal access and to record license plate numbers of vehicles entering the premises. Total length of replacement of fence is approximately 770 m.

For security reasons, a guardhouse is placed at the entrance of the plant. Lighting and communication equipment are placed at the guardhouse in addition to the plant lighting system. Only one entrance will be provided for effective control of visitors, staff and delivery of consumables and materials to the treatment plant. While it may be an inconvenience and possibly a health concern for delivery of hazardous chemicals not to have a separate entrance, from the security standpoint the inconvenience is inevitable to protect public drinking water facilities.

Dimensions of the guardhouse is as follows:

1) Total area : 24 m^2
2) Dimensions 4 m x 6 m

iii) In-plant Road

In-plant road will be completely re-paved with asphalt pavement after construction of the new plant and in-plant piping work including the site for the existing plant. Road width will be 6 m and 4 m, and estimated total pavement area is approximately 14,000 m^2. L-shape road curb will be provided for rainwater drainage.

iv) Plantation

Transplantation of existing plants in the premises, which will be obstacles against construction works, will be carried out as far as possible.

(13) Distribution Piping

Present piping status outside of existing distribution pump is complicated due to repeated repair and extension works. In addition to present complicated status, a new distribution main shall be added for water supply to the new government area. Taking opportunity of implementation of the Project, it is recommendable to clear the present complicated piping arrangement by introduction of new header pipes for connection of existing distribution mains as illustrated in Figure 5.3.3.

Order of the piping work shall be considered carefully so that interruption of water supply is minimal. Implementation order of the work is tentatively planned as follows:

1) Construction of the new power substation and removal of existing power substation
2) Construction of the new header pipe - 1.
3) Replacement with new pumps (Nos. 7 and 8).
4) Connection of pumps (Nos. 6, 7 and 8) with the header pipe - 1. During this work, water supply shall be continued with pumps Nos. 1 to 5.
5) Connection of existing distribution mains with the header pipe –2 in order from northern side. During this work, pumps Nos. 6, 7 and 8 shall be operated.
6) Replacement of pump No. 4 and connection of pumps Nos. 1 to 5 with the header pipe –1 after completion of connection work of existing distribution mains with the header pipe - 2.

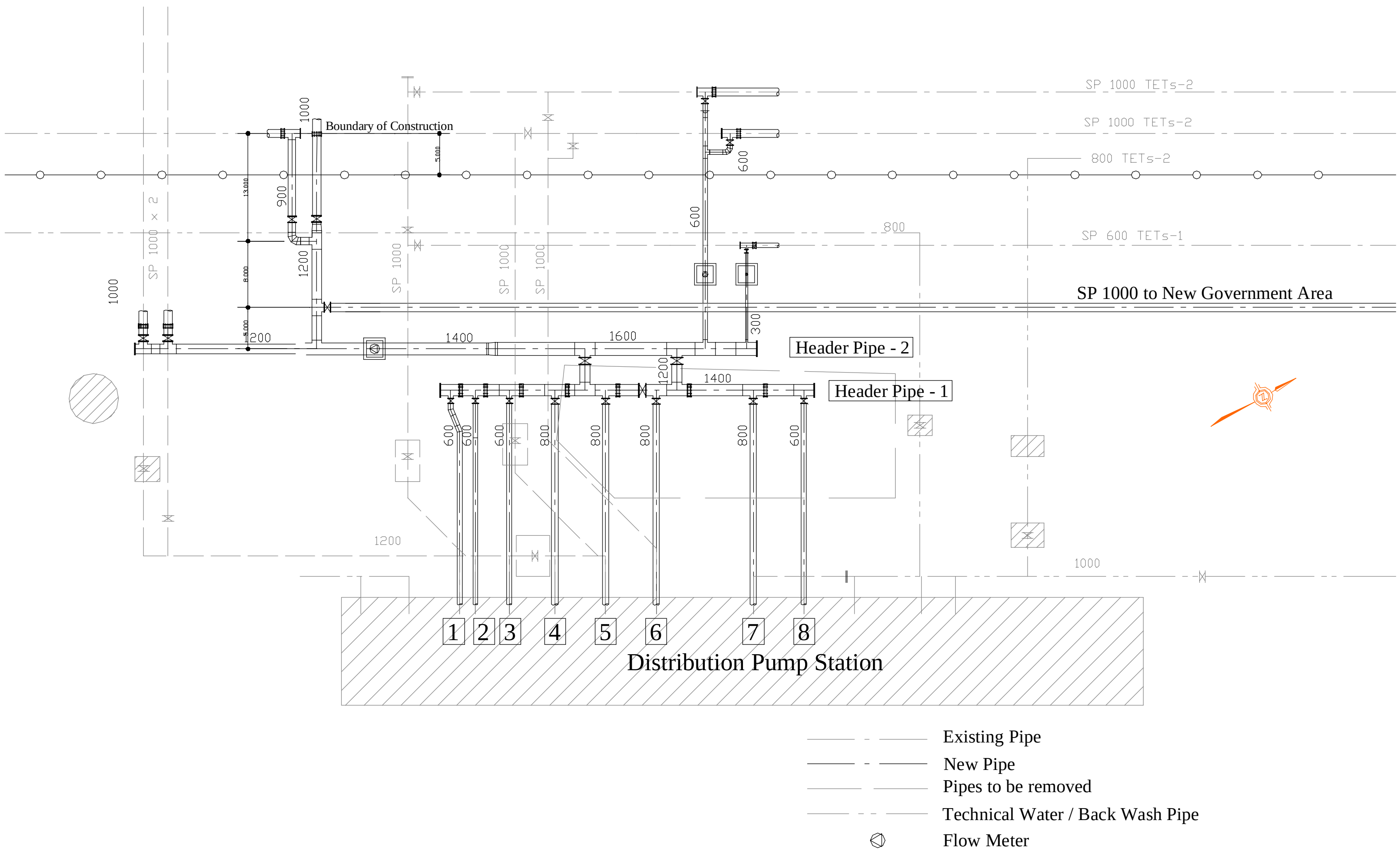


Figure 5.3.3 Connection with Distribution Mains