(2) 15th October- Designing and Planning of Water Supply Systems (Part.2)

4) Disinfections/ Chlorination

Injection of chlorine to water is conducted to disinfect bacteria and virus in water, and to prevent luxuriousness of algae. Liquid chlorine (contained one ton cylinder or 50kg cylinder), sodium hypochlorite (liquid) or calcium hypochlorite (solid) are used to disinfect.

Generally, because liquid chlorine is the least cost, it is usually used in large scale WTPs. However large scale fans and neutralization facilities for leaked chlorine since it is very dangerous for environment if it leaks. Sodium hypochlorite is frequently used for disinfection because of relative safety, however it cannot be stored for long time due to volatility of gas chlorine. It is usually brought in WTPs by tank trucks, but it is recently made by electrical resolution of salt water. However this method is said to be difficult operating because of the short life of its electrode.

Solid of calcium hypochlorite is only used to disinfect for small scale WTP.

The disinfection is conducted as pre-chlorination injected at inflow point of rapid mixer, intermediate-chlorination injected at outflow point of sedimentation basin and post-chlorination injected at outflow point of rapid filter.

The post-chlorination is essential to disinfect for distribution water and the pre-chlorination is conducted to prevent generation of argue in treatment basins. The intermediate-chlorination is conducted to prevent generation of argue in filters, and injection point is after sedimentation. Generation of trihalomethane can be deterred due to removal of organic materials in sedimentation basin, which generates trihalomethane to be combined with chlorine.

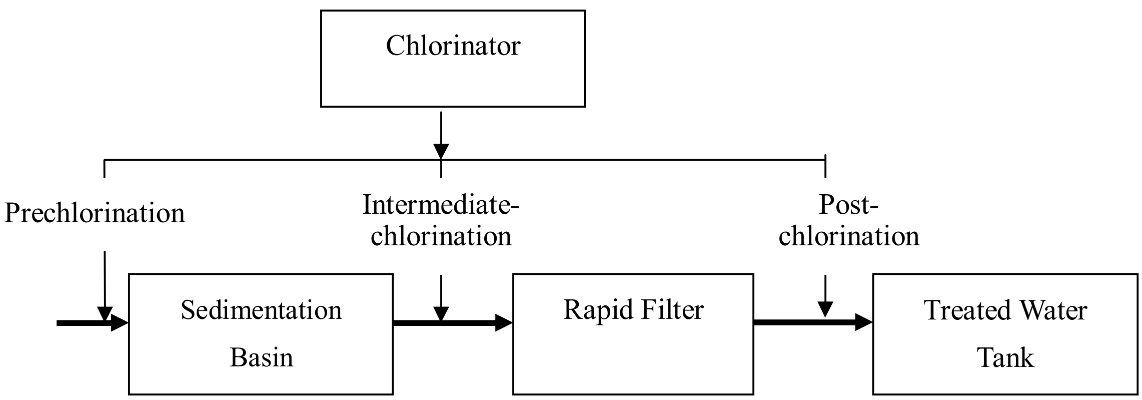


Fig.2-20 Chlorination Points

5) Sludge Treatment Plant

Settled sludge in sedimentation basin and washed water for filters is discharged from WTPs. The drainage water is sometimes returned in the water bodies, which raw water of WTPs is withdrawn from, and if the muddiness of drainage water affects to water usage in down stream, muddiness of drainage water needs to be conducted the sludge treatment.

The treatment includes sludge thickening for sludge withdrawn from sedimentation basin, separation of settled sludge and supernatant for washed water from rapid filters, and dewatering of thickened sludge as shown in Table 2-21. In Japan, WTPs capacity of over 10,000m3/day needs to install sludge treatment facilities.

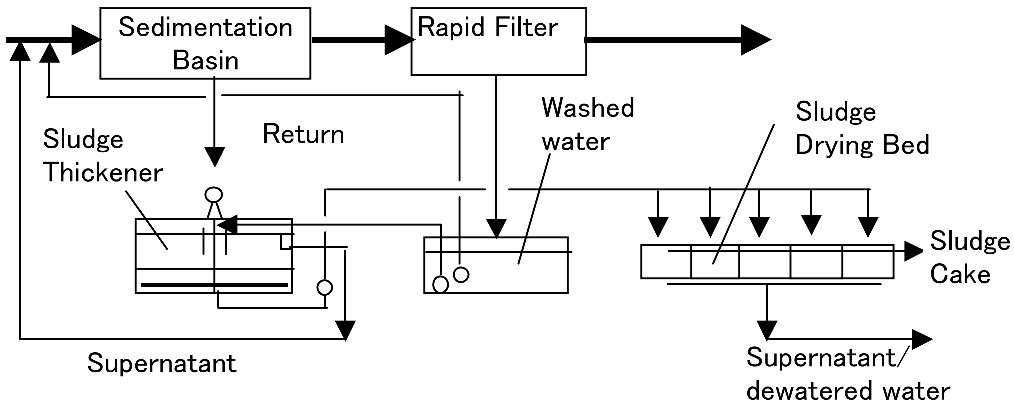


Fig.2-21 Flow Sheet of Sludge Treatment Plant

A sample of sludge treatment amount and capacity of facilities are calculated as following:

Yearly average of treatment quantity; 100,000m^3/day

Average turbidity; 20mg/L、

Average injection rate of alum ($Al_2(SO_4)_3$); 20mg/L

Solid generation amount; 100,000m^3/d x （20g/m^3 ＋20×0.105g/m^3 ＝22g/m^3） ＝ 2,200kg/day

The Inlet solid is removed 95% in sedimentation basin and density of settled sludge is 1%.

Withdrawn sludge amount ; 2,200kg/d x 0.95/0.01/1000＝209m^3/day

The filtration speed of filters is 200m/d and the washing, water quantity is 4m^3/filter m^2, is conducted one time a day.

Filter area; 100,000m^3/d /200m/d＝500m^2、

Washing water quantity; 500m^2x4m^3/m^2＝2,000m^3/d

SS (Suspended Solid) concentration; 2,200kg/d x (1-0.95)/2,000m^3/d＝55mg/L

Thickened sludge density is 3%.

Thickened sludge quantity to be dried in the sludge drying bed; 2,200kg/d/0.03/1000＝73.3m^3/d

Reuse water quantity contained drainage water; 2,000+209-73.3＝2,136m^3/d, it is equivalent to 2% of raw water.

Treatment ability of sludge drying beds is around 20 to 100 kg solid/m^2/year.

Necessary area of drying bed; 2,200kg/d x 365d/year /20 to 100 kg/m^2/year＝8,000 to 40,000m^2.

Since the area for sludge drying bed is large and much manpower is necessary to fill in beds, laying sand and carrying out of dried sludge cake, mechanical dewatering equipment is frequently introduced.

Water contents of dried sludge cake is assumed 80％.

Annual total amount of dried sludge cake; 2,200kg/d /0.2/1,000 x 365d/year＝4,015ton/year

If sludge treatment is implemented, many facilities and much manpower will be necessary and much sludge cake will be generated.

(4) Water Distribution Facilities

1) Flow Pattern of Distribution Water

Distribution System is the facility to distribute treated water in WTP to consumers in the city. Water demand of consumers decreases is in nighttime and increases in morning and evening, therefore distribution water flow pattern is commonly shown as Fig 2-22.

Figure 2-23 shows difference of hourly factor (rates of maximum/ average hourly distribution quantity) followed to difference of daily distribution quantities in Japanese City.

Since Japanese water demand in big cities is around 500L/capita, daily water distribution quantity of 1,000,000m3/day is equivalent to 2,000,000 population of city.

As the figure, hourly factor is 1.4 to 1.5 in the biggest city.

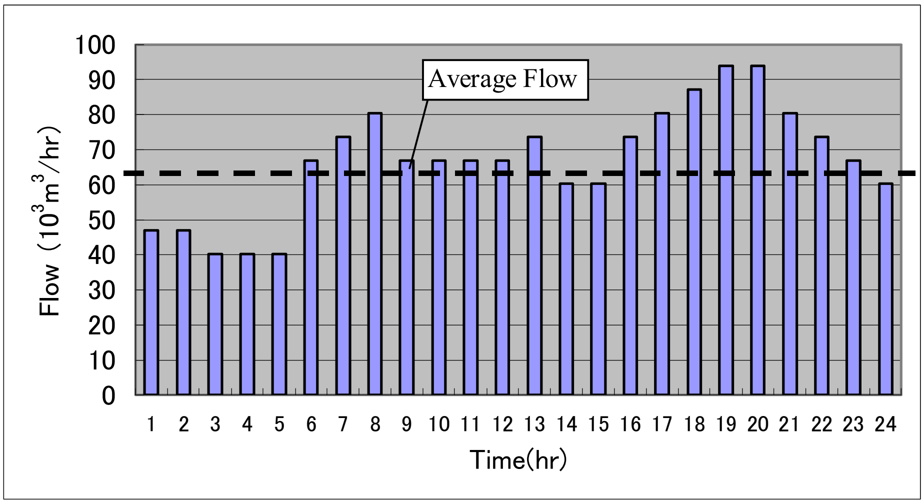


Fig. 2-22 Flow Pattern of Distribution Water

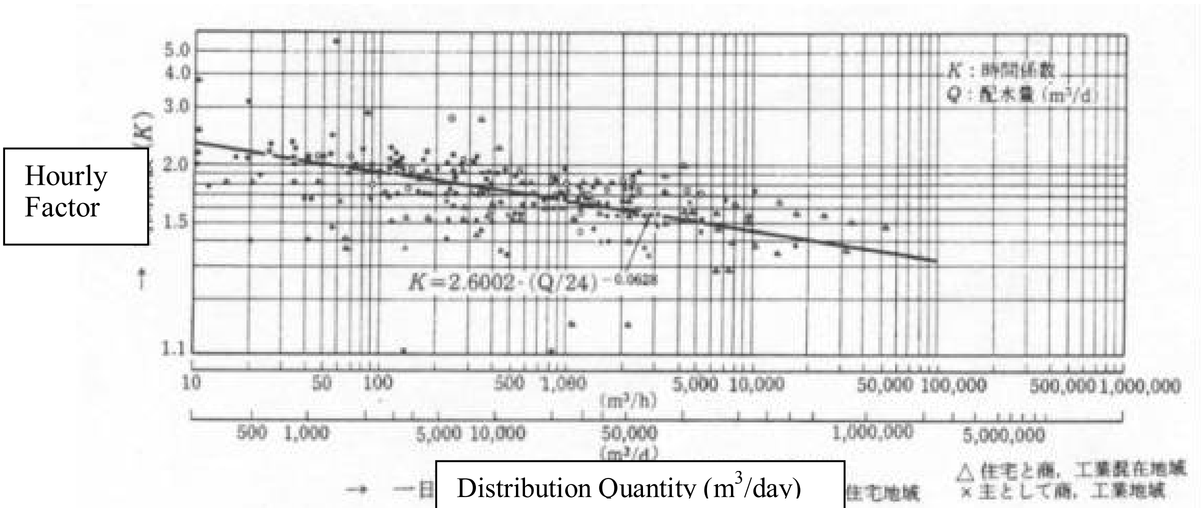


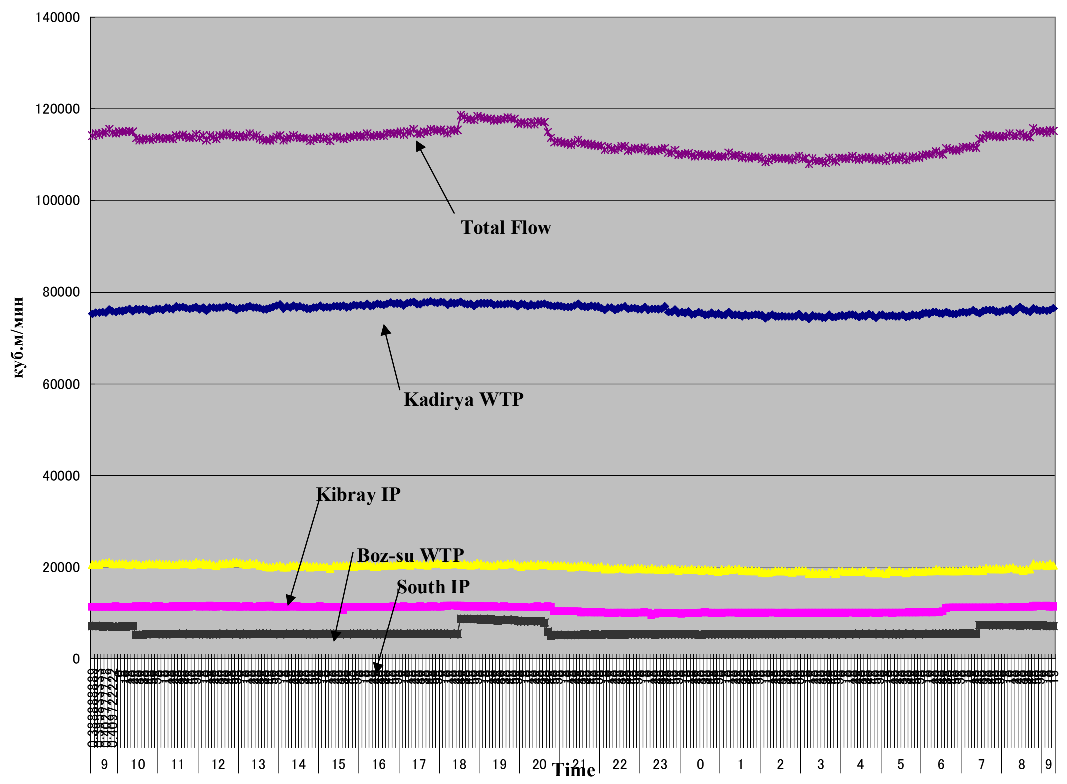
Fig.2-23 Relation of Hourly Factor and Distribution Quantity

2) Flow Pattern of Distribution Water in Tashkent City

The real measured data of distribution quantity in Tashkent City in end of August in 1999 is shown in Fig 2-24 (1). The fluctuation in Tashkent City was very small. It provably means huge leakage in housings and buildings, and increase of the leakage and water consumption at upper stories of apartments because of increased water pressure in the nighttime. Fig2-24 (2) shows measured records of water quantity and pressure. As shown the figure, the hourly flow was almost flat, however the pressure sharply increases in midnight.

It is very strange, because when water flow is almost flat, water pressure should be flat. In this case, the hydraulic situation of pipeline network should be as Fig. 2-25.

Fig. 2-24(1) Flow Pattern of Distribution



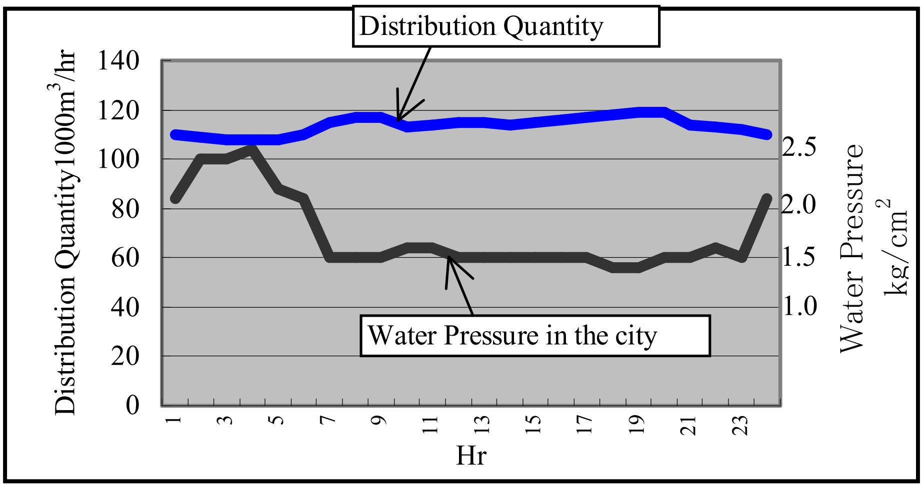


Fig.2-24 (2) Water Distribution Flow and Pressure in Tashkent City

Topologically, ground gradient of length around 5km from kadriya WTP is gentle and that of from 5km to 10km is relatively steep. Distribution pipes should be full water, however it may not be full because of less water distribution water quantity than flow capacity of pipes.

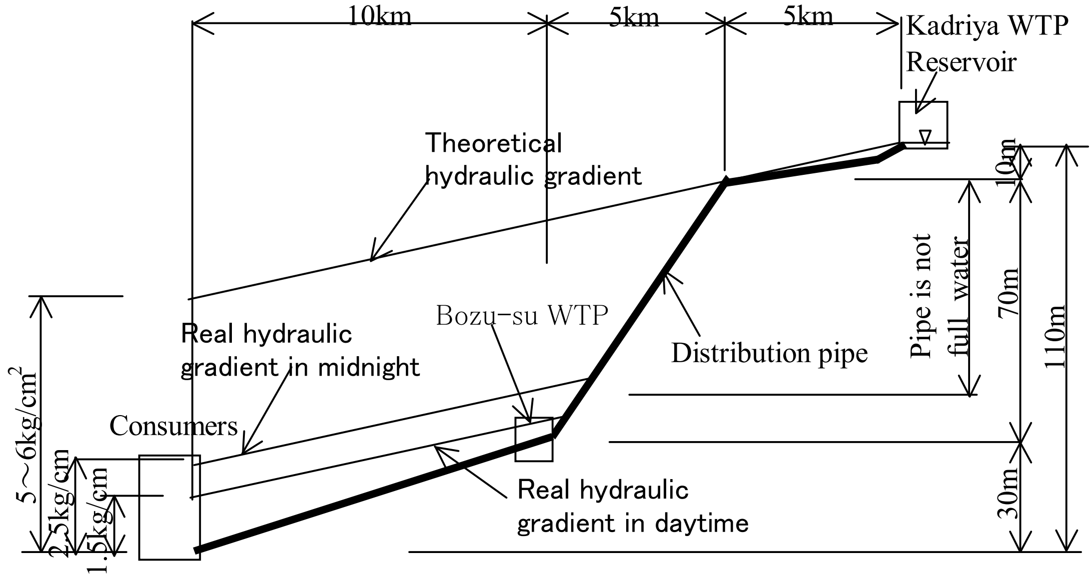


Fig.2-25 Hydraulic Model of Distribution Pipes

3) System of Distribution

When the hourly distribution water quantity fluctuates as shown in Fig.2-21, water volume control is necessary. Volume control is conducted as a control of treatment flow of WTP or a control of distribution flow. However the flow fluctuation of WTP is not suitable for stable water treatment, therefore the control should be conducted as the distribution flow.

In this case, flow regulation is necessary, and so service reservoir need to store the water volume which shows in Fig.2-21 as the volume upper the average flow line. Retention time 4 hours for reservoir is necessary to regulate fluctuating flow when hourly factor is 1.5.

Necessary flow capacity of pipes and other distribution facilities is hourly maximum flow of daily maximum flow.

There are three pattern of distribution method to cities shown as Fig.2-26; pattern-1 installs elevated tank and this can be controlled most easily, however when the difference from reservoir to city is too much, pressure fluctuation in the city is too large; pattern-2 utilizes pumps and pressure tanks, and the control of this type is relatively easy, however the cost of pressure tank is high so this pattern is only introduced for small scale water works; pattern-3 utilizes pumps, and it had been said that the control of this type was difficult, but a revolution and other volume control technologies was so progressed that the control of this type becomes easy.

Water pressure is necessary minimum 2kg/cm^2 for consumer to utilize supplied water. Therefore water pressure on the ground needs to keep approximate 3kg/cm^2 to uplift third floors. In the case of high-rise building, the two methods are usually introduced; boosting by pumps, or utilizing elevated tanks installed on the roof and pumped in the tanks from ground level.

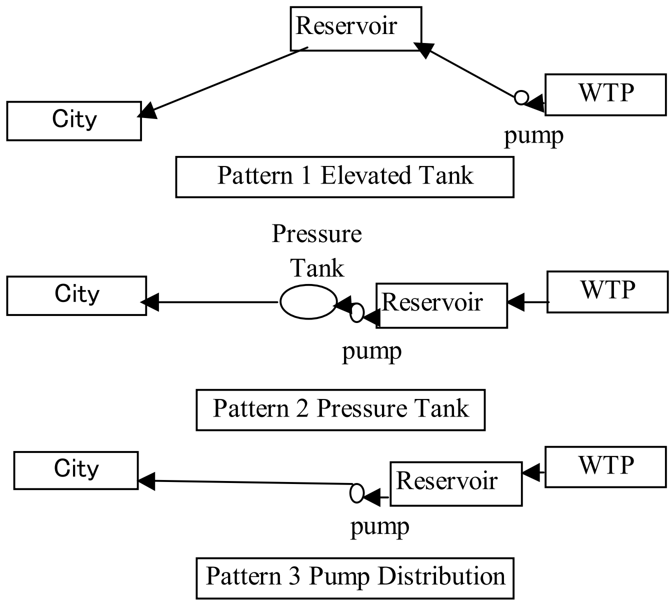


Fig.2-26 Distribution Pattern for Cities

Distribution pipeline network in Tashkent input in Water CAD is shown in Fig.2-27, and in the figure, water pressure contours are drawn.

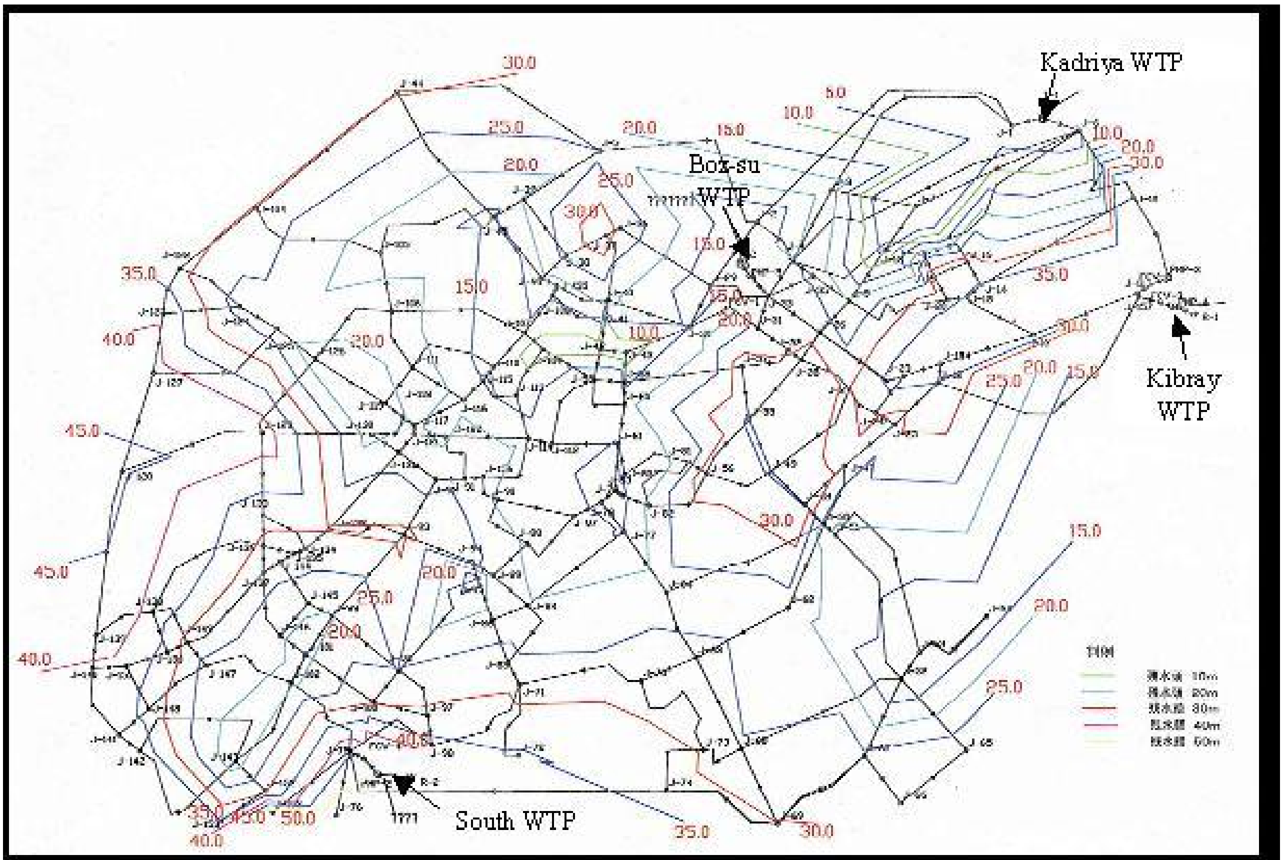


Fig.2-27 Water Distribution Pipe Network in Tashkent City

(5) Control and Monitoring Facilities for Water Supply System

1) Monitoring and control for WTP

An example of monitoring and control for WTP is shown in Fig.2-28. The monitoring items are included water quality by analyzed auto-analyzer, water levels, water pressures, head water loss of each filter, operation situation of each equipment (on/off/out of order) and situation of chemical and chlorine.

These monitoring device and controllers should be installed in control room in WTP.

These remote-Control systems with sufficient monitoring are very important to control WTP adequately and to assign suitable staff.

2) Monitoring and control for distribution system

Fig.2-29 shows a plan to monitor and control distribution system, it measures flow of the main distribution pipe for each distribution district and water pressures of distribution districts, and controls pumps and auto-valves.

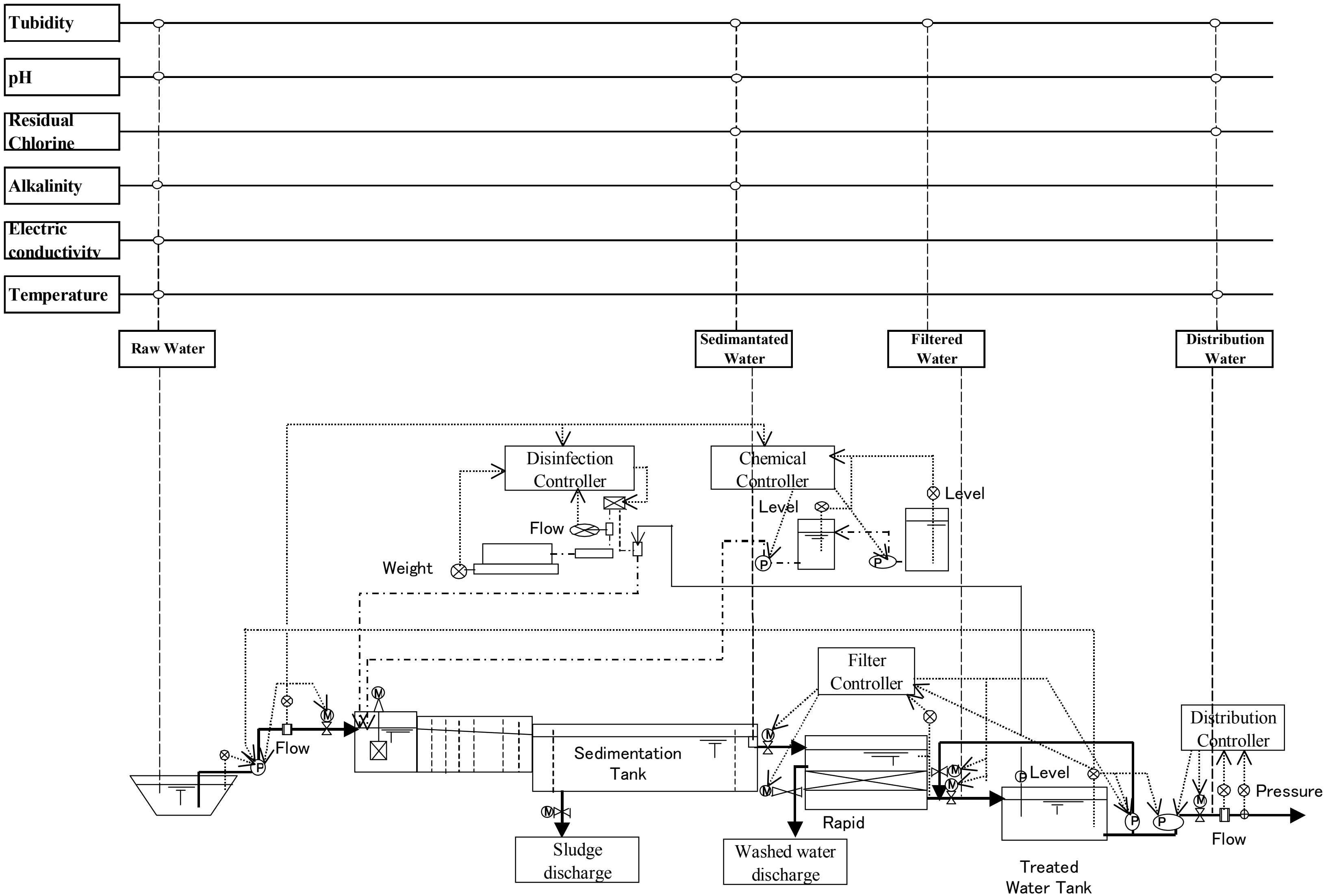


Fig.2-28 Monitoring of water Quality and Control in WTP

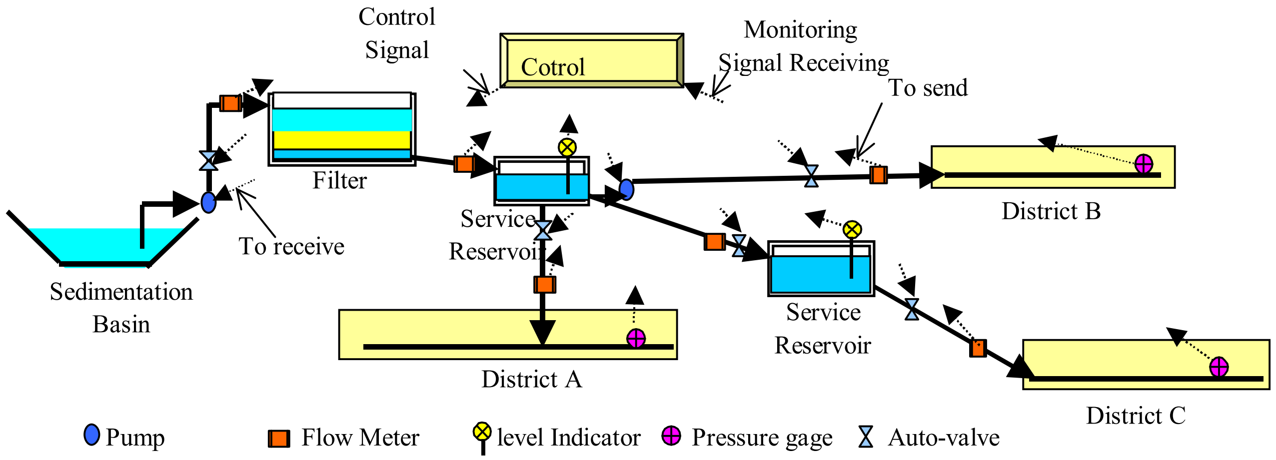


Fig.2-29 Monitoring and Control for Distribution System

(3) 22nd October- Evaluation of Tashkent Water Supply system

1. Layout of System

Fig.1-1 shows the map of Tashkent City neighborhood including Chadvak Lake. The water source including surface water and groundwater is withdrawn from the basins of Chirchik River. Especially, Charvak Dam Lake is important for water source, because the valley of the river is steep and trees are relatively few on the slope. These topography feature means rapid discharge of fallen rains, therefore if the dam was not constructed, floods frequently occur in wet seasons, and flow of the river is very little in dry seasons so the available water flow is very small from Chirchik River. Because Charvak Dam was constructed in 1970, the dam can discharge plenty of water for all seasons.

The discharged water is used for water supply for cities and irrigations withdrawing from intake weirs constructed in the river. Therefore the flow water is utilized as surface water of canals and groundwater, which is provided by the stable flow in the river.

Fig.1-2 shows the location of water supply system of Tashkent City.

Water source of Tashkent City is Boz-su canal and groundwater withdrawn from neighborhood of Tashkent City. The water supply situation in the city is shown in Table1-1.

There are two surface water WTPs and six ground water WTPs for water supply system in Tashkent City, and the total nominal capacity is 2,325,900 m^3/day. It is almost same with the daily maximum distribution amount in 2002.

Table 1-1 Water Supply Situation in Tashkent City

Item	Unit	1999	2002	2002/1999
Service area	km^2	340	340	1.00
Population served	---	2,260,000	2,260,000	1.00
Service rate	%	98.55	98.55	1.00
Number of taps	---	568,768	582,783	1.02
Length of pipes	Km	3,652	3,719	1.02
Total supply capacity	m^3/day	2,296,000	2,325,900	1.01
Annual gross supply water amount	10^3m^3	899,706	754,111	0.84
Daily maximum water distribution amount	m^3/day	2,830,000	2,513,600	0.89
Daily average water distribution amount	m^3/day	2,465,000	2,066,058	0.84
Daily average water distribution per capita	L/capita	1,091	914	0.84
Average/maximum	%	87.1	89.3	1.03

The biggest feature of the city is the very large consumption per capita. It should be included in a group of city with the biggest consumption.

However the distribution amount is decreasing year by year now because various countermeasures including the commodity charge have been introduced.

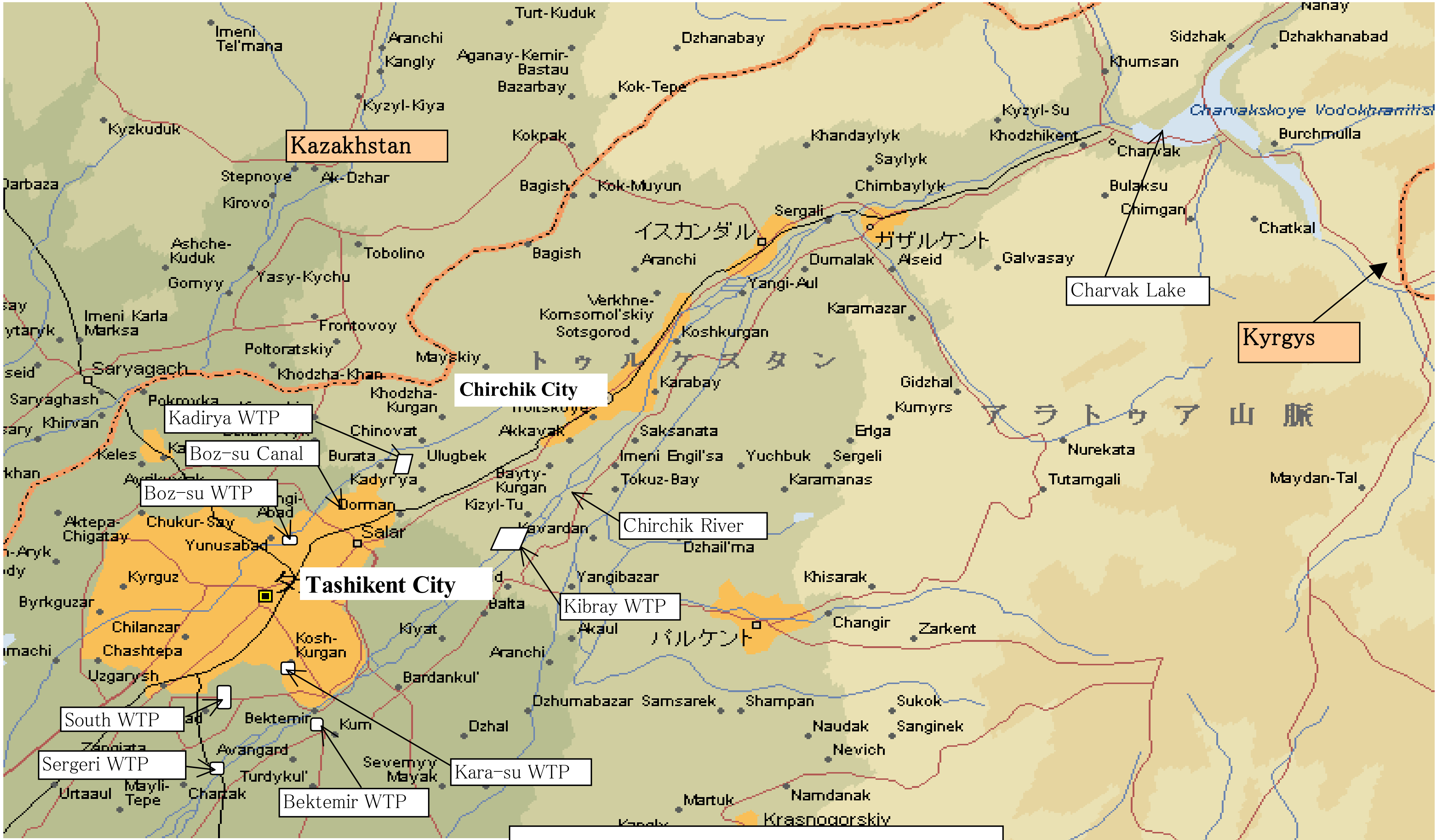


Fig.1-1 Map of Tashkent City Neighborhood

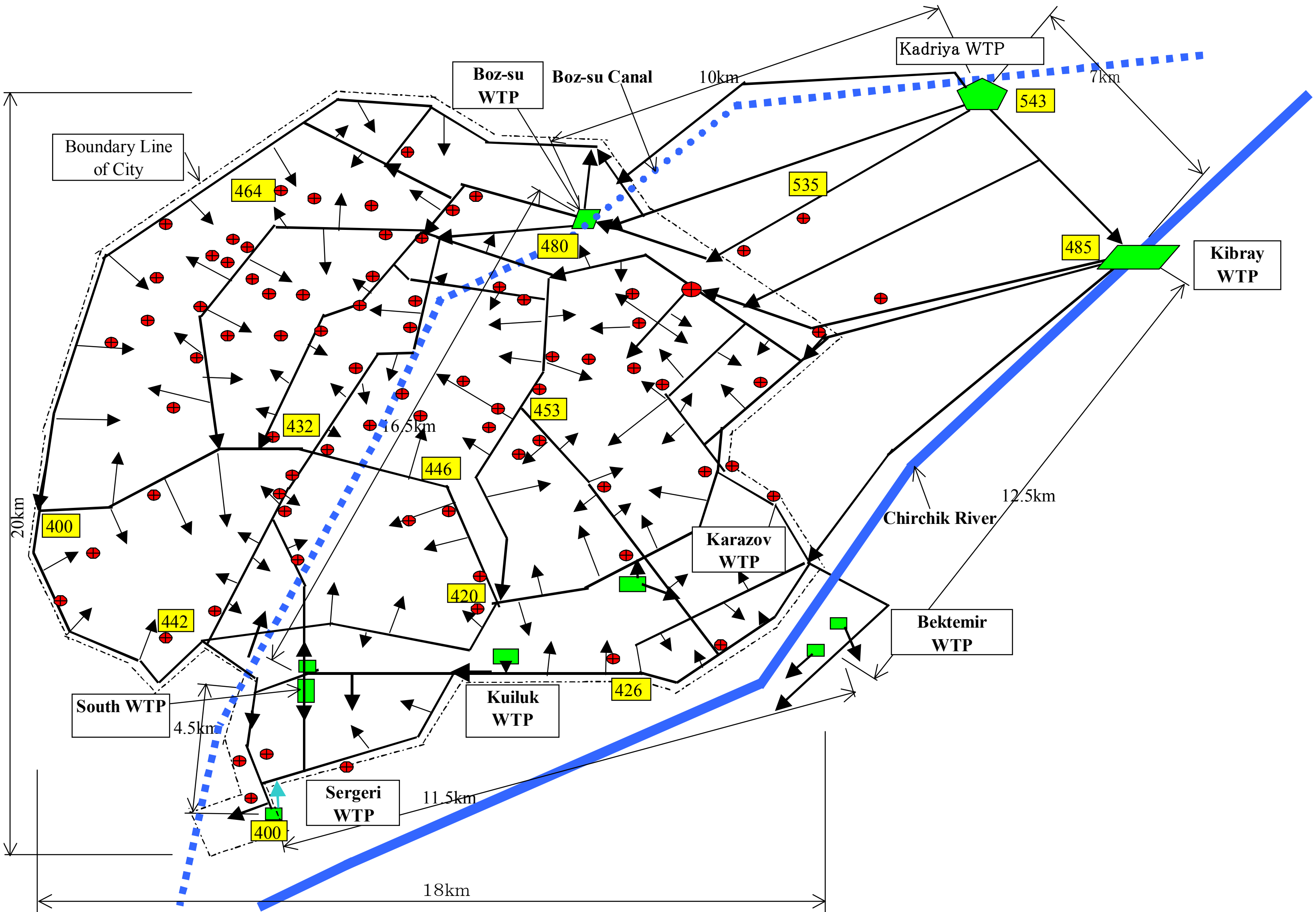


Fig.1-2 Location of Water Supply System

2. Water Consumption in the City.

2-1 Distribution from WTP

Fig. 2-1 shows water distribution amount from WTP in the city. The total daily average distribution amount is 2,465 x10^{3}m^3/day.

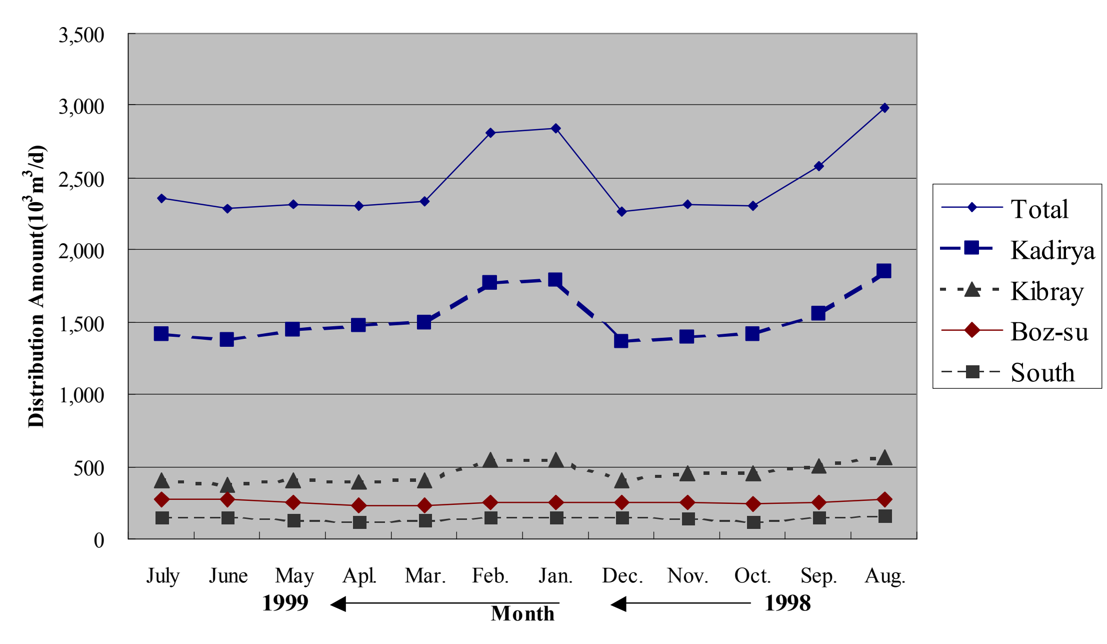


Fig.2-1 Water Distribution Amount from WTP

The maximum monthly distribution amount was appeared in August and other lower peak was appeared in January and February. These increase of distribution quantity is copped with Kadriya and Kibray WTPs. The reason of increasing of distribution water quantity in summer season can be easily understood, however increasing of winter season does not have rational reason. It is said that the insufficient and deteriorated heating system in the city is the reason for winter season's water waste.

Shown in the Figure, the water distribution quantity from Kadriya WTP always exceeded its nominal treatment capacity of 1,375,000m^3/day.

2-2 Water Consumption in the City

Assumption of water consumption in the city by the JICA Study in 2000 is shown in Fig.2-2 (1) to Fig. 2-2 (3). According to the assumption, water supply amount for individual is 61% including distribution of hot water, and that for large consumer is 30%. The rest 9% is assumed as the leakage from distribution pipes under ground as shown in Fig.2-2 (1). However, it was assumed that huge leakage and waste in housing are occurring, and these are assumed 47% out of total distribution water amount as shown in Fig.2-2 (2).

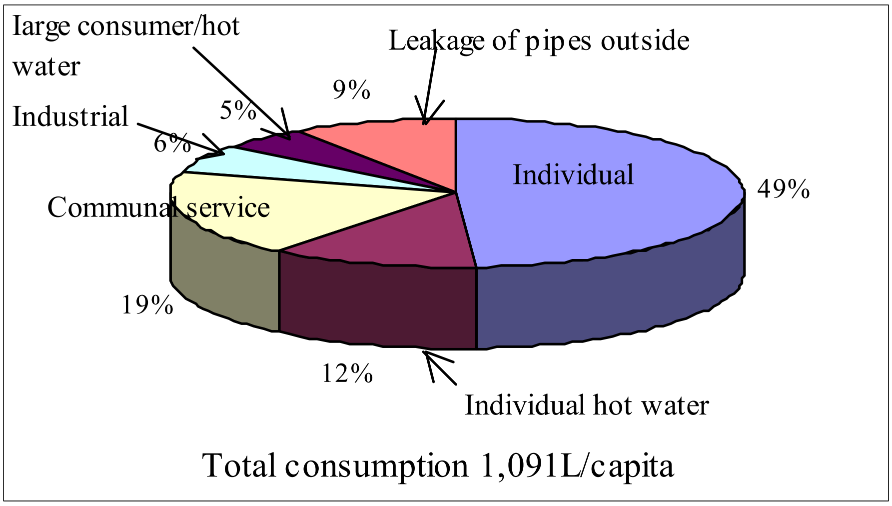


Fig.2-2 (1) Composition of Daily Water Supply

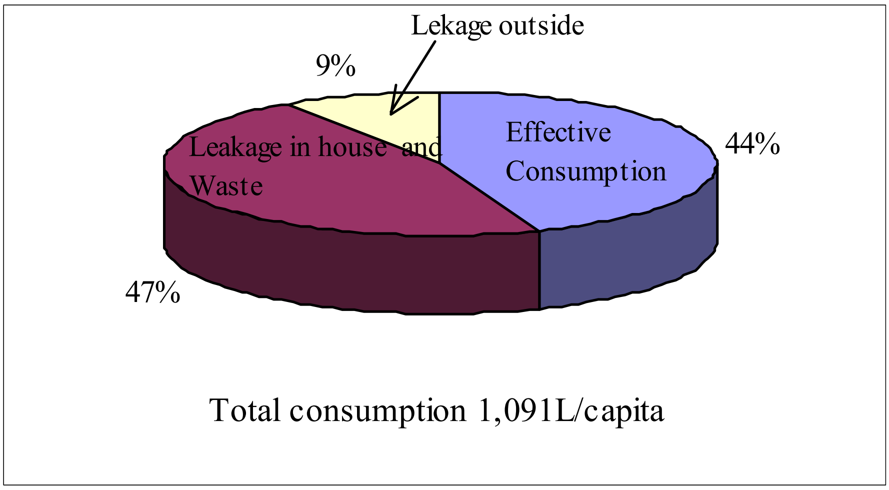


Fig.2-2 (2) Effectiveness of Water Supply

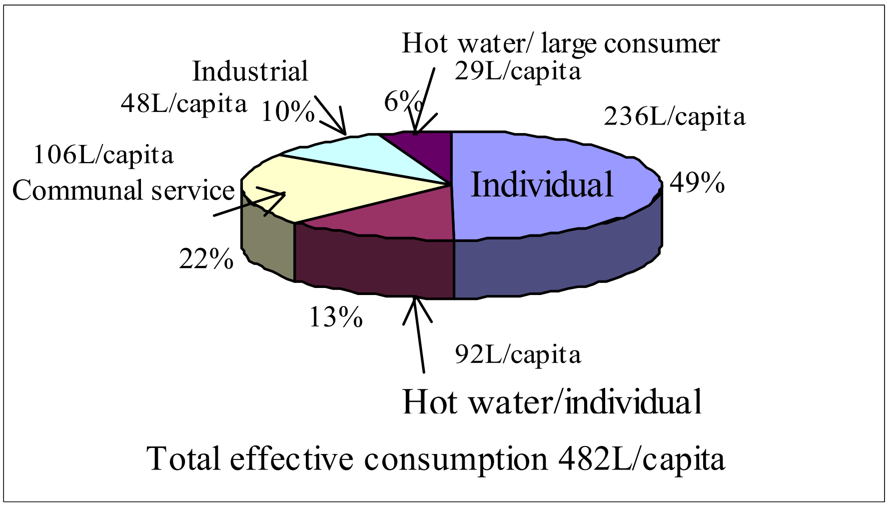


Fig.2-2 (3) Composition of effective Water Supply

In this case, effective water supply is assumed only 44% of total amount, and per capita consumption is 236L/day.

Table 2-1 shows averages of water supply records. It shows water consumption for houses in commodity charge system is 161 L/capita/day of apartment and 203 L/capita/day of detached house.

Table 2-1 Water Consumption Tendency for some Category of Houses

Division	Water meter for each house	Population	Water consumption		Norma L/capita/day
			m^3/capita/month	L/capita/day	
Apartment	Installed	21,056	4.8	161	330
	Uninstalled	62,162	17.5	583	
Detached House	Installed	63,937	6.1	203	190

*Measured during from January to March

The table and Fig.2-2 (1) to (3) means following;

- There is very large difference (approximate 3.6 times) between houses in commodity charge system and houses without meters,
- The real water demand of individual should be less than 200 L/capita/day (161x0.75+203x0.25=172 in winter season, because population living apartment is 75% and the rest is living detached house), however people is additionally consuming hot water,
- The coldwater consumption of individual shown in Fig.2-2 (3) is too large compared with the table, and consumption of hot water should be reduced more,
- The total consumption of large consumers shown in Fig.2-2 (3) is 183 L/capita/day, and it is also considered too large because of economic and industrial situation of the city,
- Total effective consumption of 482 L/capita/day may be too large as future target of water consumption.

Assumption of real distribution quantity for each consumer is calculated in Table 2-2.

In the table, distribution water quantity to the hot water plants is divided to for individuals and large consumers, and 10% of leakage of pipes is assumed. The consumption of individual cold water is increased to meet 914L/capita/day of total consumption.

The value is 471 L/capita/day and it is very similar with the calculation result of assumption of individual consumption. Individual consumers are divided into four categories; the first is living in apartment with water-meter, the second is living in apartment without meter, the third is living detached house with meter, and the fourth is living detached house without meter. The consumption of the first to the third are adopted the figures shown in Table2-1 and that of the fourth is adopted 300L/capita/day which is assumed figure.

Composition of consumption in the case of Table 2-2 is shown in Fig.2-3.

Table 2-2 Assumption of Consumption for each Consumer

Division		Distribution condition	Current record			Hot water distribution	Adjusted value
			Annual	Daily Average	Per Capita		
			10^6m^3/year	m3/day	L/capita/day	L/capita/day	
Distribution water/ based on charge	Individual	Cold	238.8	654,247	289	289	471*1
		Hot				110*1	110
	Public	Cold	66.1	181,096	80	80	80
	Other large	Cold	224.1	613,973	272	116*3	116
	Large	Hot				46*2	46
	Total		529	1,449,315	641	641	823
Leakage of pipes (10%)							91
Distribution water from WTP			754.1	2,066,027	914	914	914

*1 : 914x12%=110 *2 : 914x5%=46 *3 : 272-(110+46)=116 *4 : 914-(80-272-91)=471

Table 2-3 Assumption of Individual Consumption

Division	Meter installation	Consumption (L/capita/day)		
		Each value	Rate (%)	Total value
Apartment (75%)	Installed (12%)	161	9.0	14
	Uninstalled (88%)	583	66.0	385
Detached (25%)	Installed (40%)	203	10.0	20
	Uninstalled (60%)	300	15.0	45
Total			100.0	465

( ): Rates of population

2-3 Saving Water

Mater installation, introduction of tariff systems to exceed water saving, campaign and education for water saving will be progressed rapidly. The result of these actions, following cases will occur.

Water distribution quantity to hot water plants in the city is approximate 300,000m^3/d (135L/capita/d) without winter season, November, December, January, February and March. In winter season, and these in winter season is 520,000 m^3/d (235L/capita/d). It means that the heating water for the city is around 100,000m3/day (45L/capita/d), and most of the water is assumed to be drained by old heating equipment. Therefore countermeasures to reduce the heating hot water should be introduction in below cases, however it is very difficult.

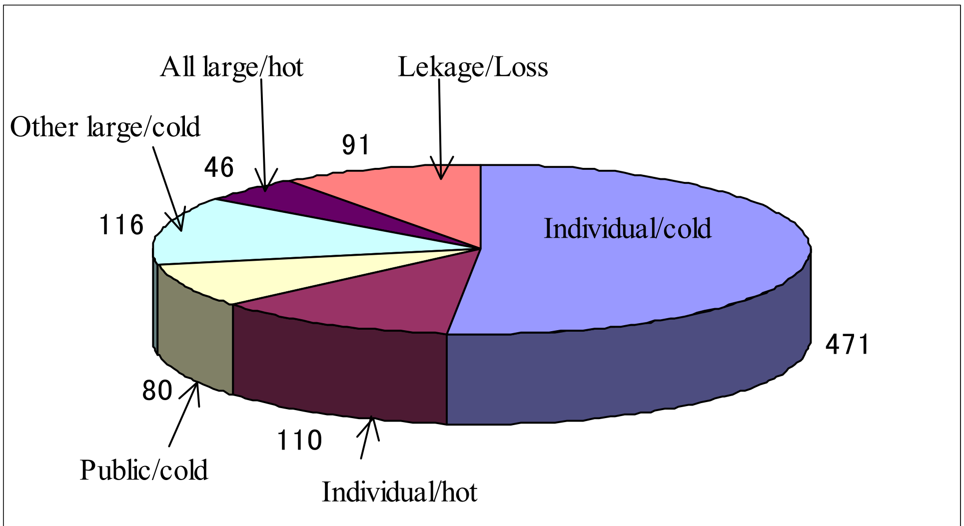


Fig.2-3 Composition of Water Consumption

1) Reduction of cold water consumption for individual;
   - Progress of meter installation
   - Repair of water leakage in housing
   - Stop the water wastage
   - Saving of real water consumption
2) Reduction of cold water consumption for large consumer;
   - Repair of water leakage in building
   - Stop the water wastage
   - Introduction of more efficiency water consumption method
   - Saving of real water consumption
3) Reduction of hot water consumption including heating water;
   - Improvement of hot water supply system
   - Improvement of heating system including in housing
   - Saving of hot water consumption
4) Reduction of leakage from distribution pipes
   - Improvement and repair for old water distribution system

Water consumption will be reduced as the pattern shown in Table 2-4 and Fig.2-4 (1), 2-4(2).

Table 2-4 Reduction of Water Consumption for each Consumer

Item	Division	2003	2004	2005	2006	2007	2008	2009	2010
Population ($x10^3$)		2,156	2,157	2,157	2,158	2,159	2,160	2,161	2,162
Meter Installation Rate (%)	Individual	20	30	50	75	100	100	100	100
	Large	95	97	99	100	100	100	100	100
Water Consumption (L/capita/d)	Individual/cold	470	395	332	279	235	223	212	201
	Individual/hot	76	74	71	69	67	65	63	61
	Heating	34	33	32	31	30	29	28	27
	Indi.-hot total	110	107	103	100	97	94	91	88
	Large/cold	196	186	177	168	160	156	153	150
	Large/hot	46	45	43	42	40	39	38	37
	Leakage	92	91	89	88	87	85	84	83
	Total	914	823	745	677	619	598	578	559
Distribution Quantity (m^3/d)		1971	1775	1607	1462	1336	1292	1250	1209

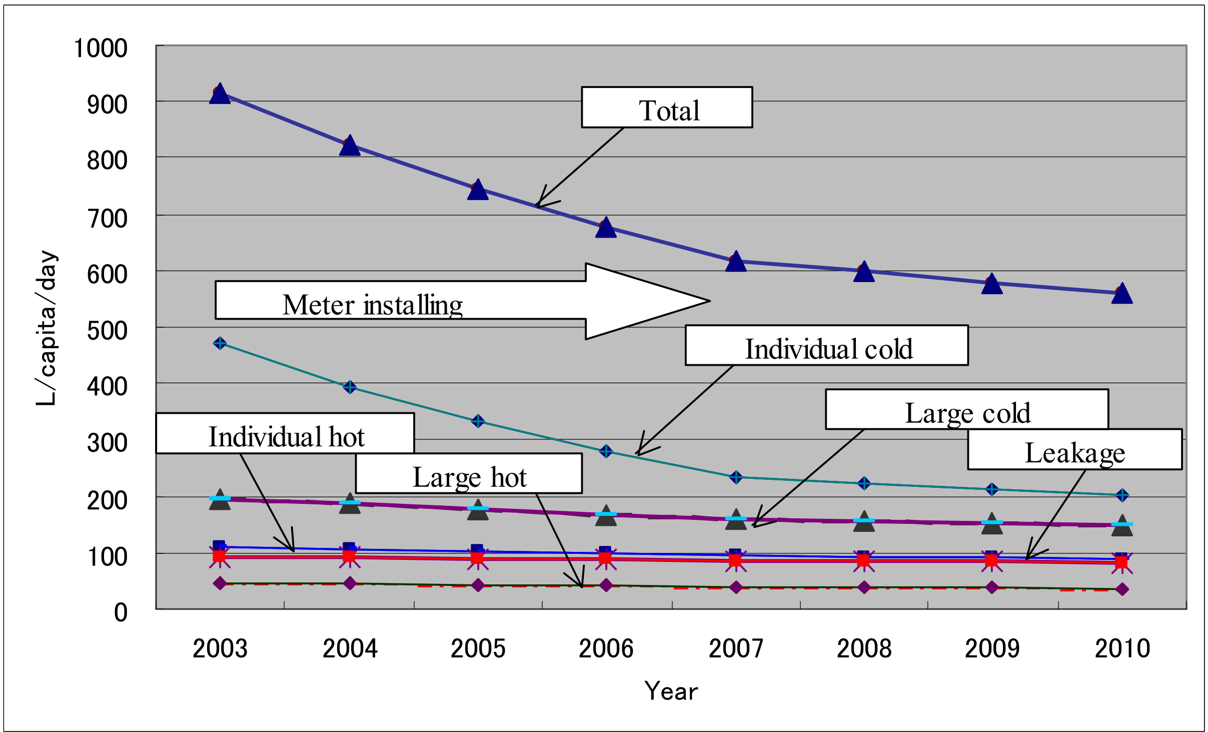


Fig.2-4 (1) Reduction of Water Consumption for Each Consumer

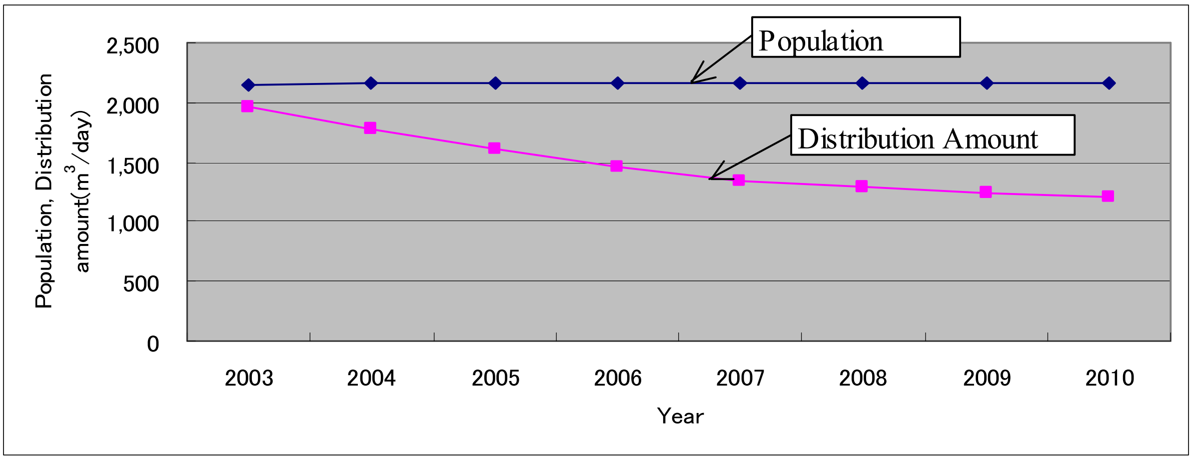


Fig.2-4 (2) Population and Water Distribution Quantity in the City

3.Water Treatment Facilities

Last time, JICA team did not investigate the water supply system in Tashkent City so detailed that the team may misunderstand present system and situation. However we want to evaluate the system and situation frankly, according to our understanding of the system and situation.

3-1 Water Intake and Coagulation Sedimentation Facilities in Kadriya and Boz-su WTP

Kadriya and Boz-su WTP are withdrawing raw water from the Boz-su canal directly. Kadriya WTP has two flocculation basins and sedimentation basins; the flocculation basins are concrete structures and sedimentation basins are excavated ponds (No.1 canal is old canal).

Boz-su WTP has one flocculation channel and two sedimentation basins, and these sedimentation basins are also excavated ponds.

Withdrawn sludge generated from sedimentation basin is discharged in the Boz-su canal in both WTP.

Evaluation calculations of these facilities are shown in Table 3-1.

As shown in the table, volumes of sedimentation basin are enough for treatment, however rapid mixing of raw water should be insufficient because the mixing in the withdrawing cannels from the canal is assumed too weak for mixing and it may cause insufficient coagulation.

Additionally, the volume of flocculation basin in Kadriya WTP is too small for proper flocculation, but the volume of sedimentation basins are so huge that it may be no problem for treatment.

Table 3-1 Evaluation Calculation of Coagulation Sedimentation Facilities

Facility	Item	Unit	Kadriya		Boz-su	
Design Quantity		m^3/d(m^3/hr)	1,375,000(57,292)		235,600(9,817)	
Rapid Mixing Tank		----	----		----	
Flocculation Basin	Dimension	m	W8xL25xh4	W6xH3xL125	W4xWh3xL150	
	Volume	m^3	800	2250	7200	
	Retention time	min	3.2		44	
Sedimentation Basin	Dimension	m	W50-250xh1.5-9xL1500	W250xh1.5-5xL600	W40xH2.6xL368	W40mxW3.6mxL368
	Surface area	m^2	112,500	120,000	14,000	14,720
	Volume	m^3	1,000,000	500,000	37,100	52,900
	Retention time	hr	26.2		9.2	
	Section Velocity	mm/sec	5-8		11	

3-2 Rapid Sand Filtration Facilities

Table 3-2 shows evaluation calculations for rapid filters at Kadriya and Boz-su WTP.

As shown the table, the design value of the filters are similar with Japanese standard. Water consumption for washing the layer is larger than Japanese case for lack of surface washing.

Table 3-1 Evaluation Calculation of Rapid Filter

Facility	Item	Unit	Kadriya		Boz-su	
Design Quantity		M^3/d(m^3/hr)	1,375,000(57,292)		235,600(9,817)	
Type			1	2	1	2
Filter number		----	24	24	6	12
Flocculation basin	Dimension	m	----	----	W6.25xL10	Dia.8.2m
	Area (max150)	m^2	Average:113.4	166	60.9	52.8
	Total area	m^2	6705.6		999	
	Filtration speed (<240*1)	min	205		236	
Layer	Gravel Layer (0.2-1.0m)	m	Lower gravel layer: total 0.5-1.0m, upper layer: three level total 0.25m, total 0.75-1.25m		Three layers total 1.5m(0.5m+0.5m+0.5m)	
	Filtration Layer (total: 0.6-0.8)	m^2	Light media 0.5-0.7m+ Quartz sand 0.5-0.6m, total 1.0-1.1m		Light media0.2m+ Quartz sand 0.6m, total 0.8m	
Layer washing	Back wash velocity (0.6-0.8)	m/min	0.7		0.7	
	Washing time Total (8-10)	min	Approximate 15		12 to 15	
	Water consumption (4-6)	m^3/m^2	10.5m^3/time		8.4 to 10.5m^3/time	

( ) Japanese standard, *1: minimum 10% of stand-by filters is necessary

If the filtration speed is 200m/day and the washing layer is conducted one time a day, the rate of washing water consumption in Kadriya WTP is $10.5m^3/m^2/d/200m/dx100$ = 5.3%.

The design of rapid filter is sufficient as the filter which filtrates the water treated by coagulation sedimentation facility. However the coagulation (alum dosing) is not conducted in these WTP when turbidity of raw water is less than 15mg/L

It is said that the removal rate of particles (suspended solid) by the rapid filter is only around 50% when coagulation is not conducted. Therefore it is common sense for water supply engineers in many countries that coagulation is essential for rapid filter.

3-3 Other Facilities

(1) Coagulation Facilities

Because these two WTPs are using lumps of solid alum, the lumps need to dissolve in water.

Mechanical mixers and steel tanks are utilizing to dissolve in Boz-su WTP, and concrete tanks and air bubbling are also utilizing in Kadriya WTP the lumps. Some countries such as Japan use liquid alum or similar coagulant, because liquid coagulant is producing by large-scale factories in these countries industrially. In those cases, coagulant is delivered by tank-lorries and dissolving of alum does not need.

Because exact and timely injection according to decision of laboratory engineer is important, the injection facilities should regulate its discharge quantity.

Gravity distribution facilities and centrifugal pumps are utilized to inject coagulant in the both WTP. Regulation of feeding quantity needs to conduct by manual and its accuracy is not sufficient. For this purpose, adjustable constant volume pump is generally utilized.

If a WTP is introduced the progressed auto-control system, auto-adjustable constant volume pumps are used and injection volume is adjusted in proportion to treatment quantity automatically. Additionally, the injection rates can be adjusted from the control room in this case.

(2) Disinfection Facilities

The liquid chlorine charged in cylinders in used for disinfection at WTPs in Tashkent City.

The system of disinfection is almost same with other countries, and the function should be sufficient.

However, liquid chlorine such a dangerous material to utilize that a large-scale neutralization facility should be installed. There is no facility to prevent severe leakage accident without a water pool in WTPs.

Sodium hypochlorite is better than liquid chlorine in the view of safety, however the chlorine concentration of it is maximum 12%, so the cost utilizing it is generally higher than liquid chlorine by the deliver cost.

(3) Electrical Facilities including Control Facilities

1) Operation of Equipment

Equipment such as pump should be able to conduct automatic or remote control. Pumps at WTPs in Tashkent City may be able to conduct such operation, however electrical facilities have already been so deteriorated that almost pumps is operated manually.

Water consumption in the city will decrease in the future, and hourly flow fluctuation will expand as shown in Fig.3.3.

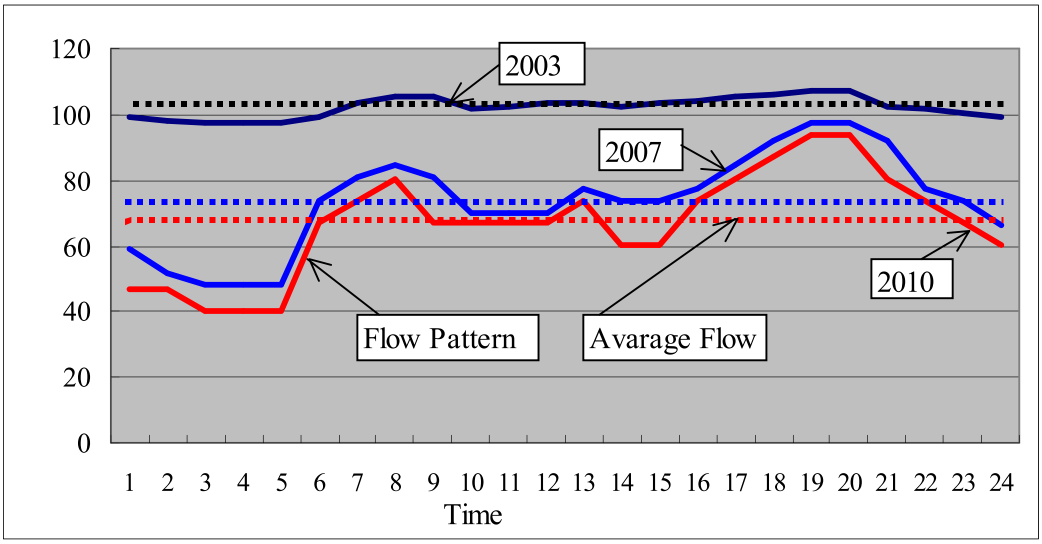


Fig.3.1 Flow Patten of Distribution Water

The total treatment quantity in WTPs should meet with average distribution flow, and the difference between treatment quantity and distribution flow will need to regulate in reservoirs. In that case, pumps must be operate, on and off, frequently, and auto-control for pumps will be necessary.

2) Necessity of Monitoring System and Auto-control System

Monitoring for control condition is essential to make auto-control and remote control, e.g. auto-control for pumps cannot conduct without information of water level.

WTPs in Tashkent City had some monitoring and control systems, however most of these facilities have been malfunction.

System of these facilities was already mentioned in another document.

4. Water Distribution Facilities including Transmission Facilities

4-1 Pipe-line Network and transmission

Basically, treated water at WTPs is transmitted by the transmission facilities from WTPs to distribution pipelines directly in the city. The distribution pipe network in the city is huge, and each WTPs are transmitting water in network.

Water pressure control is the most important role for distribution system. The water pressure in the city should be kept within 3 kg/cm^2 to 5 kg/cm^2, because buildings, 4 or 5 stories, should be distributed directly and too high pressure of pipelines should increase water leakage.

Large distribution networks are difficult to control these water pressures, therefore, in this case, the network should be divided several blocks as shown in Fig. 4-1.

It should be decided based on simulation of flow and pressure calculation, which will be imputed in some models formulated in this study.

4-2 Service reservoir

Shown as Fig.3-1, if the water distribution amount transmitted from WTP is daily average flow, water flow exceeding average flow need to store for volume regulations.

Reservoirs in the city are listed in Table 4-1 and located in WTPs and booster pump stations (P/S). For these WTPs and pump stations, pump pits for withdrawing water are necessary. The minimum necessary retention time should be 30 minutes, and it shows in the table as “necessary”.

Therefore total effective volume for existing reservoirs is approximately 100,000m^3/day.

If the flow pattern will be change as Fig,3-1 in 2010, necessary retention time will be 1.9 hrs shown as Fig.4-2. However total retention time for distribution system is commonly 4 to 12 hours for stable operation, and the total retention time should be 4 hours.

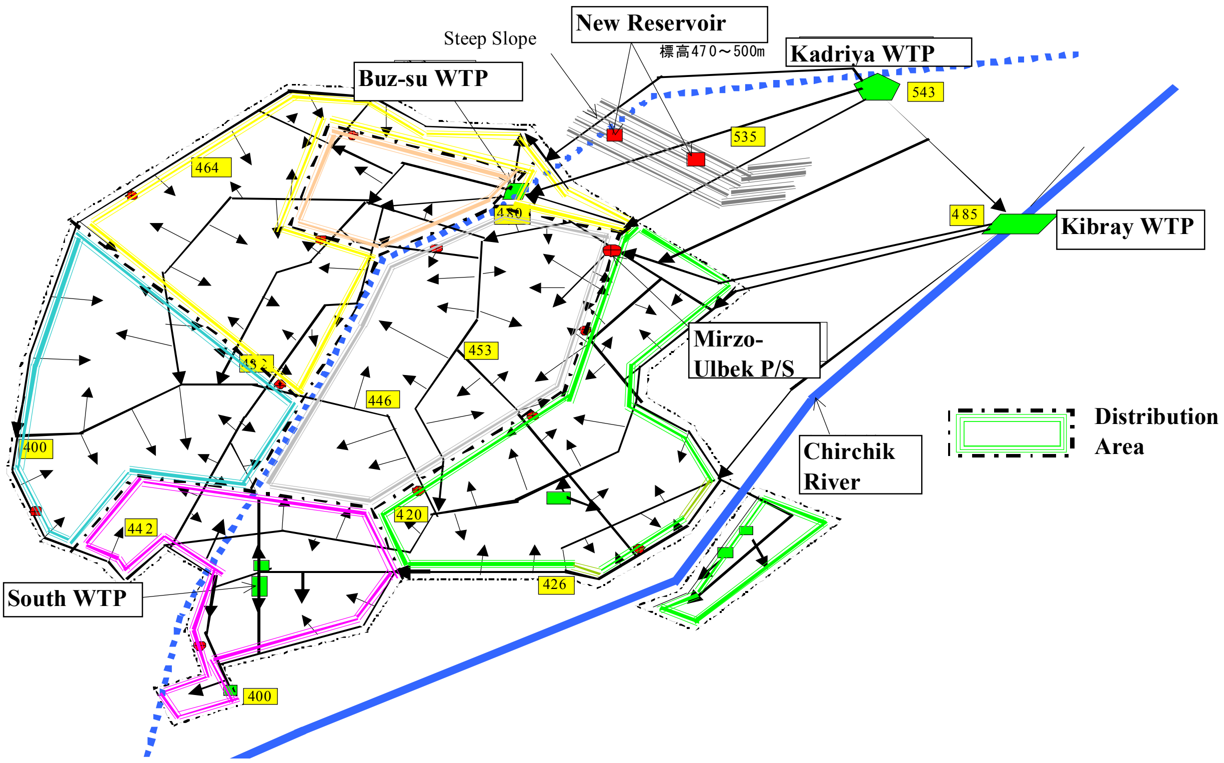


Fig.4-1 An Example of Division for Water Distribution Pipe-line Network

Table 4-1 Volumes of Reservoirs in the City

Name		Plant Capacity(m^3/day)	Reservoir volume(m3)		
			Existing	Necessary	Effective
WTP	Boz-su	236,600	29,900	5,000	24,900
	Kadirya	1,375,000	30,000	30,000	0
	Kibray	455,200	10,000	9,500	500
	Sergeri	40,000	4,000	900	3,100
	Bektemir	25,000	2,750	550	2,200
	Karazov	52,000	0	1,100	0
	South	113,200	10,000	2,400	7,600
P/S	Mirz Uzbek	(30,000)	25,000	650	24,350
	Chiranzar	(7,200)	25,000	150	24,850
	Sergeri	(3,000)	12,000	70	11,930
Total		*1 2,261,000	148,650	50,320	99,430

In this case, the total distribution flow is assumed 65% of current flow. The necessary volume of reservoirs is calculated below;

2,000,000m^3/d x 0.65 x 4/24 = 1,300,000m^3/day x 1/6 = 220.000m^3

Necessary expansion volume of reservoirs is shown below.

220,000m^3/day – 100,000m3/day = 120,000m^3/day

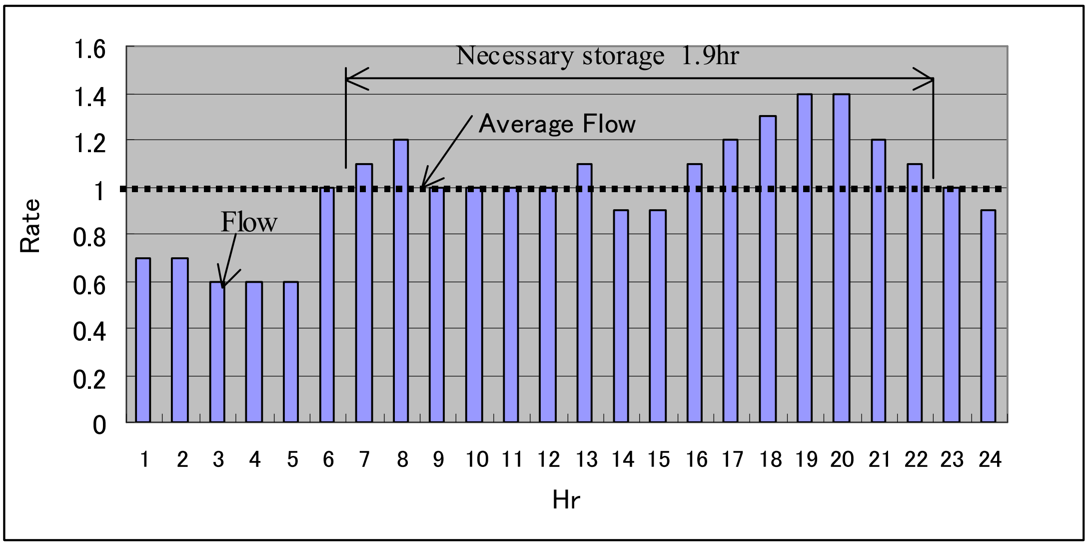


Fig.4-2 Necessary Storage Volume

4-4 Pipe Materials

Water supply pipes managed by Tashkent Vodokanal are listed Table 4-2. Shown as the table, the rate of aged pipes is high and 65% of pipe material is steel, and additionally majority of steel pipes were not installed lining. 34% of pipe material is cast iron, and most of joint for these pipes area not flexible and can become causes for leakage.

Therefore annual number of the incidents of leakage from the pipes is much, exceed 8,000 in 1998.

Currently, several material for water supply pipes, which are steel, ductile iron, vinyl chloride and polyethylene are utilized.

Comparison of these materials for pipes is shown in Table 4-3, and suitable pipe materials for water supply pipes are shown in Table 4-4.

Vinyl chloride and polyethylene pipes are used for small diameters pipes because of low cost and easy execution, and if the durability is required, lining steel pipes or stainless steel pipes.

Ductile iron pipes are mainly used for middle size of pipes because of strong and endurable features. However for large diameter pipes, the cost of ductile iron pipes are so high that lining steel pipes are utilized.

Table 4-2 Composition of Water Supply Pipes

Diameter (mm)	Length (km)
19 to 30	87,689
38 to 150	1,567,952
100 to 350	1,074,443
300 to 500	198,799
600 to 700	201,981
800 to 900	56,494
1000 to 1200	248,625
1400 to 1800	105,698
Total	3,541,681

Material	Length (km)
Steel	2,330,984
Cast iron	1,203,695
Others	7,002
Total	3,541,681

Note) Record in 1998

Diameter (mm)	Total Length (km)	Pipe Length by Pipe Age (km)				
		>5	>10	>20	>30	<30
<50	87	2.1	1	13.5	27.5	42.9
50	336.2	12.1	2.9	54.3	110.9	156
63	18.2	0.1	0.3	1.2	5.1	11.5
75	97.6	13.5	1.9	12.9	41.1	28.2
100	555.2	71.1	27.9	102.1	255.9	98.2
125	26.8	1	0.2	1.7	14.5	9.4
150	477	74.7	34.2	116.8	167.5	83.8
200	376.5	36.5	37.8	97.8	144.2	60.2
250	88.9	2.9	5.4	29.3	18.7	32.7
300	505.3	24.2	82.6	155.2	172.4	70.9
325	70	20.6	22.8	22.8	2	1.8
350	22.9	0.9	3.9	7.7	3.4	7
400	131.3	21.2	20.4	40.2	32.8	16.7
500	56.5	9.2	12.1	12	16	7.2
600	173.8	7	17.5	43.5	70.4	35.4
700	21.1	-	1.9	12.2	3.8	3.2
800	31.3	3.9	11.3	6.3	9.4	0.4
900	20	-	0.2	1.9	11.9	6
1,000	86.3	14.6	3.9	27	38.7	2.1
1,200	148.9	20	9.2	31	88.3	0.4
1,400	91.2	2.1	17.8	39.2	29.7	2.4
1,600	11.6	-	-	0.2	11.4	-
1,800	3.9	-	1.7	2.2	-	-
Total	3,437.50	337.7	316.9	831	1,275.60	676.4

Note) Record in 1998

Table4-3 Comparison of Materials for Pipes

Material	Advantage	Disadvantage	Adoptable diameter
Steel	-Strong and endurable -Strongest to shock and pressure -Easy for processing -Stable lining for small diameter	-Weak to corrosion -High cost for lining -Easy to generate electric corrosion	15-50 >800
Ductile iron	-Strong and endurable -Strong to shock and pressure -Joint is flexible and expansive -Easy for execution -Relative corrosion resistance	-Heavy -Joint protection is necessary -High cost for small and large diameter	100-1000
Vinyl chloride	-Excellent corrosion resistance -Low cost for small diameter -Light and easy to execution -Easy for processing -Stable inner roughness	-Weak to shock in low temperature -Weak to heating and ultraviolet -Low strength -Joint protection is necessary	13-150
Polyethylene	-Excellent corrosion resistance -Very flexible -Easy for execution for small diameter -Stable inner roughness -Relative strong and endurable	-Anstable joint for large diameter -Relative high cost	15-500

Table 4-4 Selection of Suitable Pipe Materials for Each Diameter

Diameter range	Suitable pipes
13-25	Vinyl chloride pipe, galvanized steel pipe, polyethylene pipe, vinyl lining steel pile, stainless pipe,
25-75	Vinyl chloride pipe, galvanized steel pipe, vinyl lining steel pile
75-150	Vinyl chloride pipe, ductile iron pipe
150-500	Ductile iron pipe, polyethylene pipe
500-800	Ductile iron pipe
800-1500	Lining steel pipe, ductile iron pipe
>1500	Lining steel pipe

(4) 29th October- Introduction of Technology:

1) Introduction of Water CAD,

2) Design and Plan for groundwater Intake

---

1) Introduction to Water Cad

WaterCad: Water distribution model software developed by Haestad Methods, Inc.

1. Objectives of Using WaterCad in the Study

- To study/analyze water flow and pressure in existing distribution network of Tashkent City.
- To develop/recommend appropriate distribution network as well as system operation of Tashkent water supply though various analyses/simulations.
- To enhance technical capability of Vodokanal through the above activities together with technical workshop.

2. Feature of WaterCad

WaterCad has many powerful and versatile project tools to analyze/simulate distribution pipe network. Not only demand variation, but also operation of reservoir/tank, pump and valve can be incorporated into the model.

Water Cad supports several methods of exchanging data with external applications.

(1) Laying out the Network

- Using Pipe layout toolbar helps easily laying out the water distribution network. Reservoir/s, tank/s, pump/s, junctions, pipes and valves are placed onto drawing pane. Pipelines are automatically placed according to placing Junction.
- As an alternative, drawings of network in a .DXF format (.DWG format in the AutoCad version) can be used as a background drawing in laying out a scaled network.

(2) Easy Data Entry (add/delete/edit)

1) Entering Data through various options

Four (4) ways to enter and modify element data are provided in WaterCad:

- Dialog Box: enables to input required data by element; especially required parameters of related facility (reservoir/tank, pump, valve) can be entered according to dialog style.
- Flex Table: powerful tool as described hereafter.
- Database Connections: creates connections to import and export model data using common database and spreadsheet.

- Alternative Editors: will be used for creating alternatives from base alternatives.

2) Selective unit system and friction loss method
- Unit: SI and others
- Friction loss method: Chezy's, Colebrook-White, Hazen-Williams, Darcy-Weisbach and Manning Formula

(3) Performing Various Analyses/Simulations

1) Steady State Analysis

Generally, water distribution for Average Daily Demand/Maximum Daily Demand will be analyzed.

2) Extended Period Simulation (EPS)
- PS can be conducted for any duration to be specified.
- Tank levels fluctuation, pump operation, valves open/close, and demands change throughout the day can be simulated.
- Variation in demand over time can be modeled using demand patterns. Demand patterns are multipliers that vary with time. Demand patterns at each node can combine different patterns of water use (residential, commercial, fire flow, etc.).

3) Water Quality Analysis
- Computing Water Age (Travel time from source/reservoir)
- Analyzing Constituent Concentrations (Chlorine residuals in the system over time)
- Performing a Trace Analysis (Percentage of water from a specific source node)

4) Cost Estimating

Cost Manager in WaterCad is a tool for tracking the costs associated with a water distribution construction project.

(4) Powerful Reporting Tools

1) Reports by element

Every element can generate a report in the same general format, which includes the name of the calculated scenario and series of tables describing the element's properties and result in detail.
- Detailed Report
- Table
- Graph

2) Tabular Reports (Flex Tables)

Tabular Reports are an extremely powerful tool in WaterCad. These reports are not only good presentation tools, but also very helpful in data entry and analysis. When data must be entered for a large number of elements, clicking each element and entering the data are tedious and time consuming. However, using Flex tables can make it easier, since entering/editing the data is done on same tables.

- Using tabular report, elements can be changed using the global edit tool, or filtered to display only the desired elements.
- Values that are entered into the table will be automatically updated in the model.
- The tables can also be customized to contain only the desired data.
- Columns can be added or removed, or duplicates of the same column with different units can be displayed.
- The tabular reports can save an enormous amount of time and effort.
- The tables can be printed or copied into a spreadsheet program such as EXCEL.

3) Plan View (Full View/Current View)

Full View will create a plan of the entire system regardless of what the screen shows, while Current View will create a plan of exactly what is displayed in the window t that moment. These views can be printed or copied to the clipboard, and can be exported to AutoCad or other compatible software with creating a.DXF file.

4) Contouring

Contouring enables to generate contours for reporting attributes such as elevation, pressure and hydraulic grade. Contour interval as well as color code by index values or ranges of values can be specified.

5) Element Annotation

Element annotation enables to label network attributes in the plan view and control which values are displayed, how they are labeled and how units are expressed.

6) Color Coding

Color Coding enables to review results in the plan view by color-coding the elements based on attributes or range of values.

(5) Versatile Scenario Management

Scenario Management tools enable to create a New Alternative, edit and create scenarios, calculate and compare scenarios.

Scenarios can calculate multiple "What If?" situations in a single project file.
Traditionally, there have only been two possible ways of analyzing the effects of change on a software model:

- Change the model, recalculate, and review the results
- Create a copy of the model, edit that copy, calculate, and review the results

Although either of these methods may be adequate for a relatively small system, the data duplication, editing, and re-editing becomes very time-consuming and error-prone as the size of the system and the number of possible conditions increase. Additionally, comparing conditions requires manual data manipulation, because all output must be stored in physically separate data files.

Effective scenario management tools need to meet these objectives:

- Minimize the number of project files the modeler needs to maintain (one, ideally)
- Maximize the usefulness of scenario through easy access to things such as input and output data, and data comparisons
- Maximize the number of scenarios to simulate by mixing and matching data from existing scenarios (data reuse)
- Maximize the amount of data that needs to be duplicated to consider conditions that have a lot in common

A single project file enables to generate an unlimited number of "What If?" conditions, edit only the data that needs to be changed, and quickly generate direct comparisons of input and results for desired scenarios.
The process of working with scenarios is similar to the process of manually copying and editing data, but without the disadvantages of that duplications and troublesome file management. The process allows to cycle through any number of changes to the model, without fear of overwriting critical data or duplicating important information. Of course, it is possible to directly change data for any scenario, but an audit trail of scenarios can be useful for retracing the steps of a calibration series or for understanding a group of master plan updates.

There are thirteen alternative types in WaterCad Ver. 6, which comprise Physical /Active

Topology/Demand /Initial Settings/Operational/Logic Control Set/Age/Constituent/Trace/Fire Flow/Capital Cost/Energy Cost/User Data.

(6) Working with Data from External Sources

Water Cad supports several methods of exchanging data with external applications, preventing duplication effort and allowing saving time by reusing data already present in other locations. For instance, exchanging data with databases or GIS system, or converting Cad linework to pipe network.

There are multiple ways of importing data from other sources into WaterCad.
One or more database connections can be set up to bring in information stored in many standard database and spreadsheet formats. GIS information can be brought in through connections to ERSI shapefiles. Drawings of network in a .DXF format (.DWG format in the AutoCad version) can be used as a background drawing in laying out a scaled network.

Importing data available from other distribution model software are:

- Previous WaterCad/Cybernet Versions
- EPANET Files
- KYPIPE Data

3. A Simple Example Using WaterCad

A simple example using WaterCad is presented as below. Pipe network comprises six (6) junctions, ten (10) pipelines and one each of reservoir (source), tank and pressure reducing valve (refer to Figure-1). The model was calculated as [Extended Period Simulation] based on composition of the following demand patterns. Input data/outputs for junction and pipe are shown in Table-2 and 3, respectively. Some detailed results are presented hereafter.

Table-1 Demand patterns

Time from Start	Multiplier		
	Residential	Commercial	Fire Flow
3:00	0.4	0.6	0
6:00	1.0	0.8	0
9:00	1.3	1.6	0
12:00	1.2	1.6	0
15:00	1.2	1.2	0
18:00	1.6	0.8	1.0
21:00	0.8	0.6	0
24:00	0.5	0.4	0

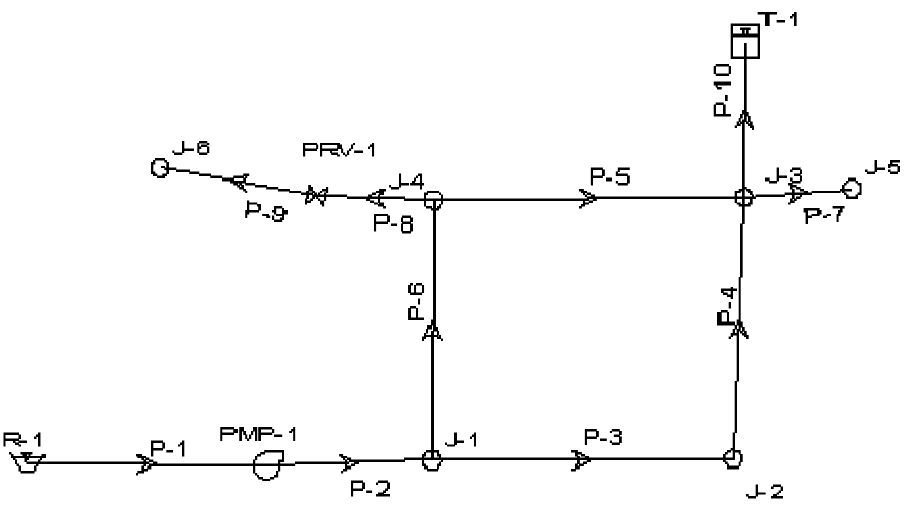


Figure-1 Model Pipe Network

Table-2 Pressure Junction Result at 9:00

Label	Zone	Elevation (m)	Demand (l/min)	Type	Pattern	Demand (Calculated) (l/min)	Calculated Hydraulic Grade (m)	Pressure (kPa)
J-1	Zone-1	*184*	*38*	Demand	Composite	54	226.89	419.55
J-2	Zone-1	*185*	*31*	Demand	Composite	43	226.24	403.36
J-3	Zone-1	*184*	*34*	Demand	Composite	48	225.99	410.74
J-4	Zone-1	*183*	*34*	Demand	Composite	48	226.01	420.68
J-5	Zone-1	*185.5*	*350*	Demand	Composite	455	225.5	391.26
J-6	Zone-2	*165*	*2,356*	Demand	Composite	486	204.81	389.45

Note: Figures in Italic show input data.

Table-3 Link Result at 9:00

Label	From Node	To Node	Diameter (mm)	Length (m)	Material	Hazen-Williams C	Discharge (l/min)	Velocity (m/s)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
P-1	R-1	PMP-1	*1,000*	*0.01*	*Ductile Iron*	*130*	1,028	0.02	0	0
P-2	PMP-1	J-1	*150*	*58.5*	*Ductile Iron*	*130*	1,028	0.97	0.42	7.23
P-3	J-1	J-2	*150*	*555.5*	*Ductile Iron*	*130*	386	0.36	0.66	1.18
P-5	J-3	J-4	*150*	*521.5*	*Ductile Iron*	*130*	-55	0.05	0.02	0.03
P-6	J-4	J-1	*150*	*343.4*	*Ductile Iron*	*130*	-588	0.55	0.88	2.58
P-8	J-4	PRV-1	*150*	*500*	*Ductile Iron*	*130*	486	0.46	0.9	1.81
P-9	PRV-1	J-6	*150*	*31*	*Ductile Iron*	*130*	486	0.46	0.06	1.81
P-10	J-3	T-1	*150*	*100*	*Ductile Iron*	*130*	-104	0.1	0.01	0.1

Note: Figures in Italic show input data.

Detailed Report for Tank: T-1

Scenario Summary	
Label	2000 l/min 3-Hr Fire Flow at J-6
Physical Alternative	Base-Physical
Demand Alternative	Average Daily with 2000 l/min Fire Flow
Initial Settings Alternative	Base-Initial Settings

Scenario Summary	
Operational Alternative	Base-Operational
Age Alternative	Base-Age Alternative
Constituent Alternative	Base-Constituent
Trace Alternative	Base-Trace Alternative
Fire Flow Alternative	Base-Fire Flow
Cost Alternative	Base-Cost
User Data Alternative	Base-User Data

Calibration Summary			
Demand	<None>	Roughness	<None>

Geometric Summary			
X	3,060.60 m	Elevation	0.0 m
Y	3,063.19 m	Zone	Zone-1

Operating Range Summary			
Maximum Elevation	226.0 m	Maximum Level	26.0 m
Initial HGL	225.0 m	Initial Level	25.0 m
Minimum Elevation	220.0 m	Minimum Level	20.0 m
Base Elevation	200.0 m		

Storage Summary			
Section Type	Constant Area	Circular Tank Shape?	true
Diameter	8.00 m	Average Area	50.3 m^2
Inactive Volume	0.00 m^3	Total Active Volume	301.59 m^3

User Data			
Date Installed		Date Retired	
Inspection Date		SCADA ID	
Observed Level	0.00 ft	Lining	
Condition		Metered	false
Clearwell Storage	false	Elevated Tank	false

User Data	
Existing	false

History:

Location Description:

Calculated Results Summary

Time	Calculated Hydraulic Grade (m)	Calculated Level (m)	Pressure (kPa)	Calculated Percent Full (%)	Calculated Volume (m³)	Inflow (l/min)	Outflow (l/min)	Current Status
0.00 hr	225.00	25.00	244.55	83.3	251.33	675	-675	Filling
1.00 hr	225.81	25.81	252.43	96.8	291.86	509	-509	Filling
1.32 hr	226.00	26.00	254.33	100.0	301.59	0	0	Full
2.00 hr	226.00	26.00	254.33	100.0	301.59	0	0	Full
3.00 hr	226.00	26.00	254.33	100.0	301.59	0	0	Full
4.00 hr	226.00	26.00	254.33	100.0	301.59	0	0	Full
5.00 hr	226.00	26.00	254.33	100.0	301.59	0	0	Full
6.00 hr	226.00	26.00	254.33	100.0	301.59	0	0	Full
7.00 hr	226.00	26.00	254.33	100.0	301.59	0	0	Full
8.00 hr	226.00	26.00	254.33	100.0	301.59	0	0	Full
9.00 hr	226.00	26.00	254.33	100.0	301.59	-104	104	Draining
10.00 hr	225.88	25.88	253.12	97.9	295.36	-69	69	Draining
11.00 hr	225.79	25.79	252.31	96.6	291.21	-46	46	Draining
12.00 hr	225.74	25.74	251.77	95.6	288.42	34	-34	Filling
13.00 hr	225.78	25.78	252.16	96.3	290.45	23	-23	Filling
14.00 hr	225.81	25.81	252.43	96.8	291.83	15	-15	Filling
15.00 hr	225.82	25.82	252.61	97.1	292.76	48	-48	Filling
16.00 hr	225.88	25.88	253.17	98.0	295.65	33	-33	Filling
17.00 hr	225.92	25.92	253.55	98.7	297.61	22	-22	Filling
18.00 hr	225.95	25.95	253.81	99.1	298.92	-1,377	1,377	Draining

Calculated Results Summary								
Time	Calculated Hydraulic Grade (m)	Calculated Level (m)	Pressure (kPa)	Calculated Percent Full (%)	Calculated Volume (m³)	Inflow (l/min)	Outflow (l/min)	Current Status
19.00 hr	224.30	24.30	237.73	71.7	216.31	-1,147	1,147	Draining
20.00 hr	222.93	22.93	224.34	48.9	147.49	-970	970	Draining
21.00 hr	221.78	21.78	213.02	29.6	89.30	1,032	-1,032	Filling
22.00 hr	223.01	23.01	225.07	50.1	151.23	853	-853	Filling
23.00 hr	224.03	24.03	235.03	67.1	202.43	688	-688	Filling
24.00 hr	224.85	24.85	243.07	80.8	243.71	704	-704	Filling

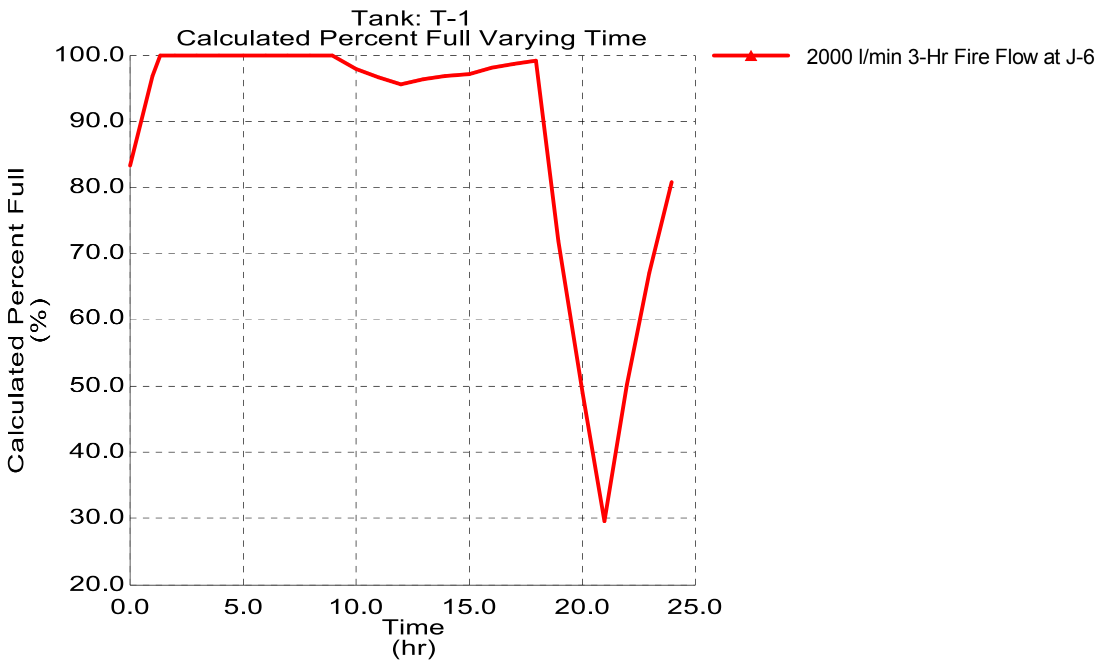


Figure-2 Tank Volume in Percent

Detailed Report for Pump: Pump-1

Scenario Summary	
Label	2000 l/min 3-Hr Fire Flow at J-6

Scenario Summary			
Physical Alternative	Base-Physical		
Demand Alternative	Average Daily with 2000 l/min Fire Flow		
Initial Settings Alternative	Base-Initial Settings		
Operational Alternative	Base-Operational		
Age Alternative	Base-Age Alternative		
Constituent Alternative	Base-Constituent		
Trace Alternative	Base-Trace Alternative		
Fire Flow Alternative	Base-Fire Flow		
Cost Alternative	Base-Cost		
User Data Alternative	Base-User Data		

Calibration Summary			
Demand	<None>	Roughness	<None>

Geometric Summary			
X	3,026.46 m	Upstream Pipe	P-1
Y	3,033.01 m	Downstream Pipe	P-2
Elevation	193.0 m		

Pump Definition Summary			
Pump Type	Standard (3 Point)		
Shutoff Head	30.00 m	Shutoff Discharge	0 l/min
Design Head	27.40 m	Design Discharge	3,800 l/min
Maximum Operating Head	24.80 m	Maximum Operating Discharge	7,500 l/min

Initial Status			
Initial Pump Status	On	Initial Relative Speed Factor	1.0

User Data

Initial Status			
Date Installed		Date Retired	
Inspection Date		SCADA ID	
Observed Flow	0.00 gpm	Rated Power	0 Hp
Efficiency	0.00 %	Condition	
Manufacturer		Model	
Serial Number		Metered	false
Variable Speed	false	Existing	false

History:

Calculated Results Summary

Time	Control Status	Intake Pump Grade (m)	Discharge Pump Grade (m)	Discharge (l/min)	Pump Head (m)	Relative Speed	Calculated Water Power (kW)
0.00 hr	On	198.00	227.28	1,085	29.28	1.0	5.18
1.00 hr	On	198.00	227.39	919	29.39	1.0	4.41
1.32 hr	On	198.00	227.73	409	29.73	1.0	1.99
2.00 hr	On	198.00	227.73	409	29.73	1.0	1.99
3.00 hr	On	198.00	227.76	361	29.76	1.0	1.75
4.00 hr	On	198.00	227.76	361	29.76	1.0	1.75
5.00 hr	On	198.00	227.76	361	29.76	1.0	1.75
6.00 hr	On	198.00	227.46	819	29.46	1.0	3.93
7.00 hr	On	198.00	227.46	819	29.46	1.0	3.93
8.00 hr	On	198.00	227.46	819	29.46	1.0	3.93
9.00 hr	On	198.00	227.31	1,028	29.31	1.0	4.92
10.00 hr	On	198.00	227.29	1,063	29.29	1.0	5.08
11.00 hr	On	198.00	227.28	1,086	29.28	1.0	5.19
12.00 hr	On	198.00	227.27	1,094	29.27	1.0	5.22
13.00 hr	On	198.00	227.28	1,083	29.28	1.0	5.17
14.00 hr	On	198.00	227.28	1,075	29.28	1.0	5.14
15.00 hr	On	198.00	227.29	1,060	29.29	1.0	5.06
16.00 hr	On	198.00	227.30	1,044	29.30	1.0	4.99
17.00 hr	On	198.00	227.31	1,034	29.31	1.0	4.94
18.00 hr	On	198.00	226.73	1,875	28.73	1.0	8.79
19.00 hr	On	198.00	226.58	2,105	28.58	1.0	9.81

Calculated Results Summary

Time	Control Status	Intake Pump Grade (m)	Discharge Pump Grade (m)	Discharge (l/min)	Pump Head (m)	Relative Speed	Calculated Water Power (kW)
20.00 hr	On	198.00	226.45	2,282	28.45	1.0	10.59
21.00 hr	On	198.00	226.87	1,682	28.87	1.0	7.92
22.00 hr	On	198.00	226.99	1,503	28.99	1.0	7.11
23.00 hr	On	198.00	227.10	1,338	29.10	1.0	6.35
24.00 hr	On	198.00	227.26	1,114	29.26	1.0	5.32

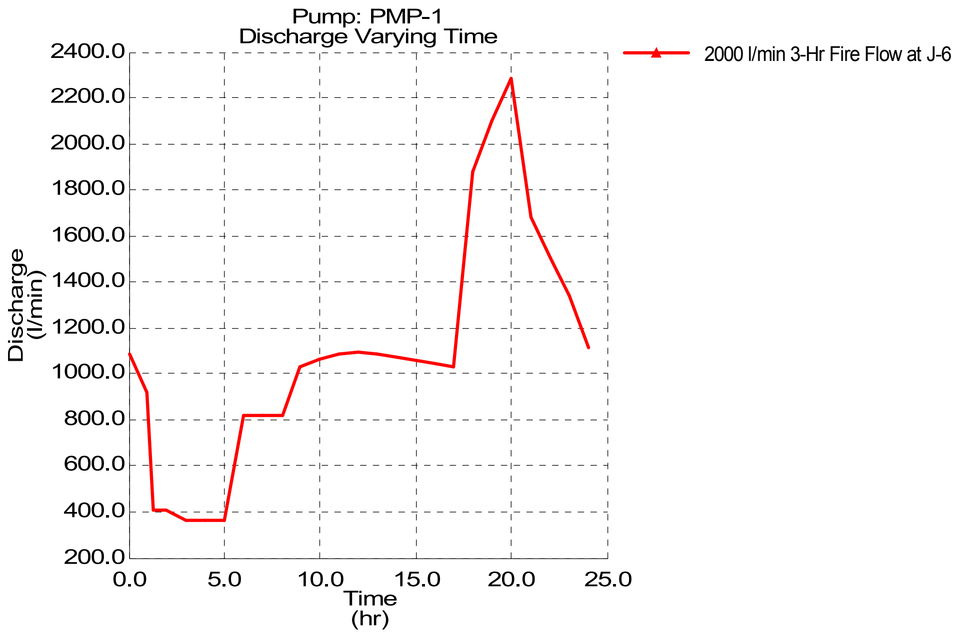


Figure-3 Pump discharge

Detailed Report for Pressure Pipe: P-6

Scenario Summary	
Label	2000 l/min 3-Hr Fire Flow at J-6
Physical Alternative	Base-Physical
Demand Alternative	Average Daily with 2000 l/min Fire Flow
Initial Settings Alternative	Base-Initial Settings
Operational Alternative	Base-Operational

Scenario Summary	
Age Alternative	Base-Age Alternative
Constituent Alternative	Base-Constituent
Trace Alternative	Base-Trace Alternative
Fire Flow Alternative	Base-Fire Flow
Cost Alternative	Base-Cost
User Data Alternative	Base-User Data

Calibration Summary			
Demand	<None>	Roughness	<None>

Pipe Characteristics			
Material	Ductile Iron	Hazen- Williams C	130.0
Diameter	150.0 mm	Minor Loss Coefficient	0.0
Check Valve?	false	Length	343.40 m
From Node	J-4	To Node	J-1

Elevations			
From Elevation	183.00 m	To Elevation	184.00 m

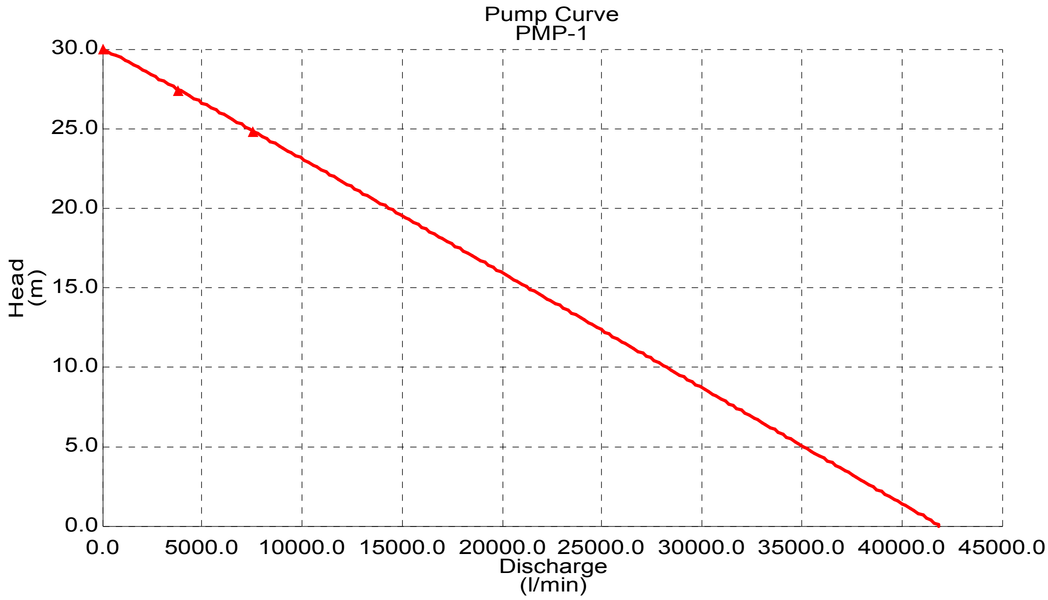
Initial Status	
Initial Status	Open

User Data			
Date Installed		Date Retired	
Inspection Date		Observed Flow	0.00 gpm
Lining		Pipe Class	
Exterior Coating		Nominal Diameter	0.00 in
Condition		Skeletonized	false
Metered	false	Existing	false

History:

Calculated Results Summary

Time	Control Status	Discharge (l/min)	Velocity (m/s)	Upstream Structure Hydraulic Grade (m)	Downstream Structure Hydraulic Grade (m)	Calculated Friction Headloss (m)	Calculated Minor Headloss (m)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)
0.00 hr	Open	-576	0.54	225.96	226.81	0.85	0.00	0.85	2.47
1.00 hr	Open	-493	0.47	226.41	227.05	0.64	0.00	0.64	1.86
1.32 hr	Open	-234	0.22	227.49	227.65	0.16	0.00	0.16	0.47
2.00 hr	Open	-234	0.22	227.49	227.65	0.16	0.00	0.16	0.47
3.00 hr	Open	-206	0.19	227.58	227.70	0.13	0.00	0.13	0.37
4.00 hr	Open	-206	0.19	227.58	227.70	0.13	0.00	0.13	0.37
5.00 hr	Open	-206	0.19	227.58	227.70	0.13	0.00	0.13	0.37
6.00 hr	Open	-468	0.44	226.60	227.18	0.58	0.00	0.58	1.69
7.00 hr	Open	-468	0.44	226.60	227.18	0.58	0.00	0.58	1.69
8.00 hr	Open	-468	0.44	226.60	227.18	0.58	0.00	0.58	1.69
9.00 hr	Open	-588	0.55	226.01	226.89	0.88	0.00	0.88	2.58
10.00 hr	Open	-608	0.57	225.90	226.84	0.94	0.00	0.94	2.74
11.00 hr	Open	-621	0.59	225.83	226.81	0.98	0.00	0.98	2.84
12.00 hr	Open	-623	0.59	225.81	226.80	0.98	0.00	0.98	2.87
13.00 hr	Open	-618	0.58	225.84	226.81	0.97	0.00	0.97	2.82
14.00 hr	Open	-613	0.58	225.87	226.82	0.96	0.00	0.96	2.78
15.00 hr	Open	-604	0.57	225.92	226.85	0.93	0.00	0.93	2.70
16.00 hr	Open	-596	0.56	225.96	226.87	0.91	0.00	0.91	2.64
17.00 hr	Open	-590	0.56	225.99	226.88	0.89	0.00	0.89	2.59
18.00 hr	Open	-1,477	1.39	220.59	225.45	4.85	0.00	4.85	14.14
19.00 hr	Open	-1,540	1.45	219.74	224.98	5.24	0.00	5.24	15.27
20.00 hr	Open	-1,598	1.51	218.99	224.60	5.62	0.00	5.62	16.35
21.00 hr	Open	-894	0.84	223.90	225.81	1.92	0.00	1.92	5.59
22.00 hr	Open	-805	0.76	224.55	226.14	1.58	0.00	1.58	4.60
23.00 hr	Open	-723	0.68	225.12	226.41	1.30	0.00	1.30	3.77
24.00 hr	Open	-590	0.56	225.88	226.77	0.89	0.00	0.89	2.59



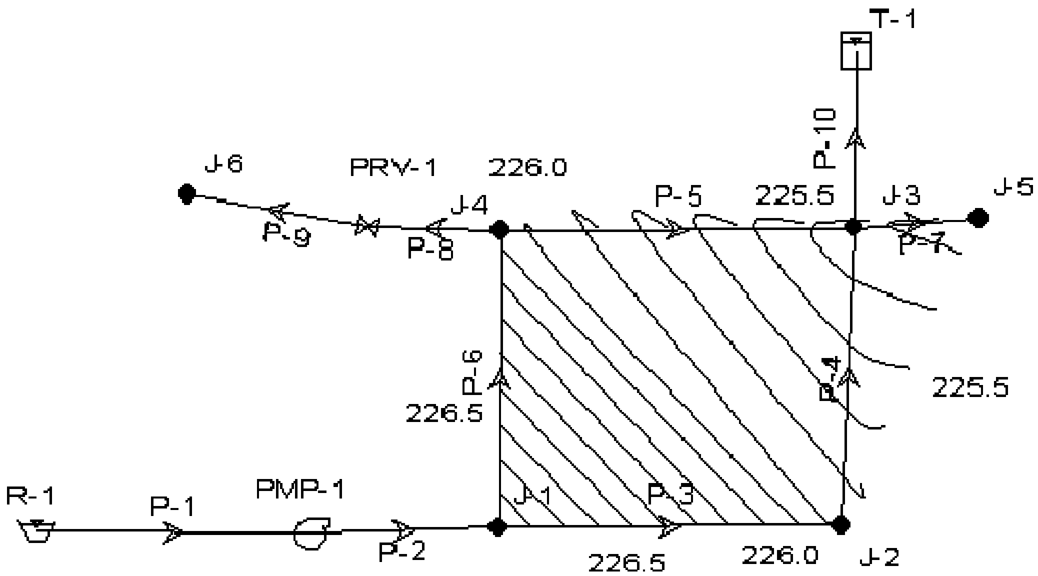


Figure-4 Contouring Hydraulic Grade Level

2) Design and Plan for Groundwater Intake

1. Objectives and Flowchart of Groundwater Development

The objective of groundwater development is to achieve **'Stable Water Supply of Safe Water'**.

The checkpoints of this objective are as follows:

1) To be taken stably groundwater for water supply plan

The pumping amount of the well is basically depended on the well capacity. The well capacity is affected by the distribution and permeability of aquifer and the digging technology. Even if the pumping wells have high capacity, there is impossible to take planed groundwater amount by well interference when the wells are located close to another wells.

2) To be taken safe groundwater satisfied water quality standards for human health

Water supply enterprise has obligation to supply safe water satisfied water quality standards for human health. When water is not satisfied water quality standards, residents are endangered their human health.

3) To be not impacted on surrounding environment by groundwater intake

Excessive groundwater taking destroys the water circulation in the region, and there is a possibility to generate drying up of existing wells, the subsidence, and saline water intrusion etc.

The generalized flowchart of groundwater development plan, investigation and design are as follows:

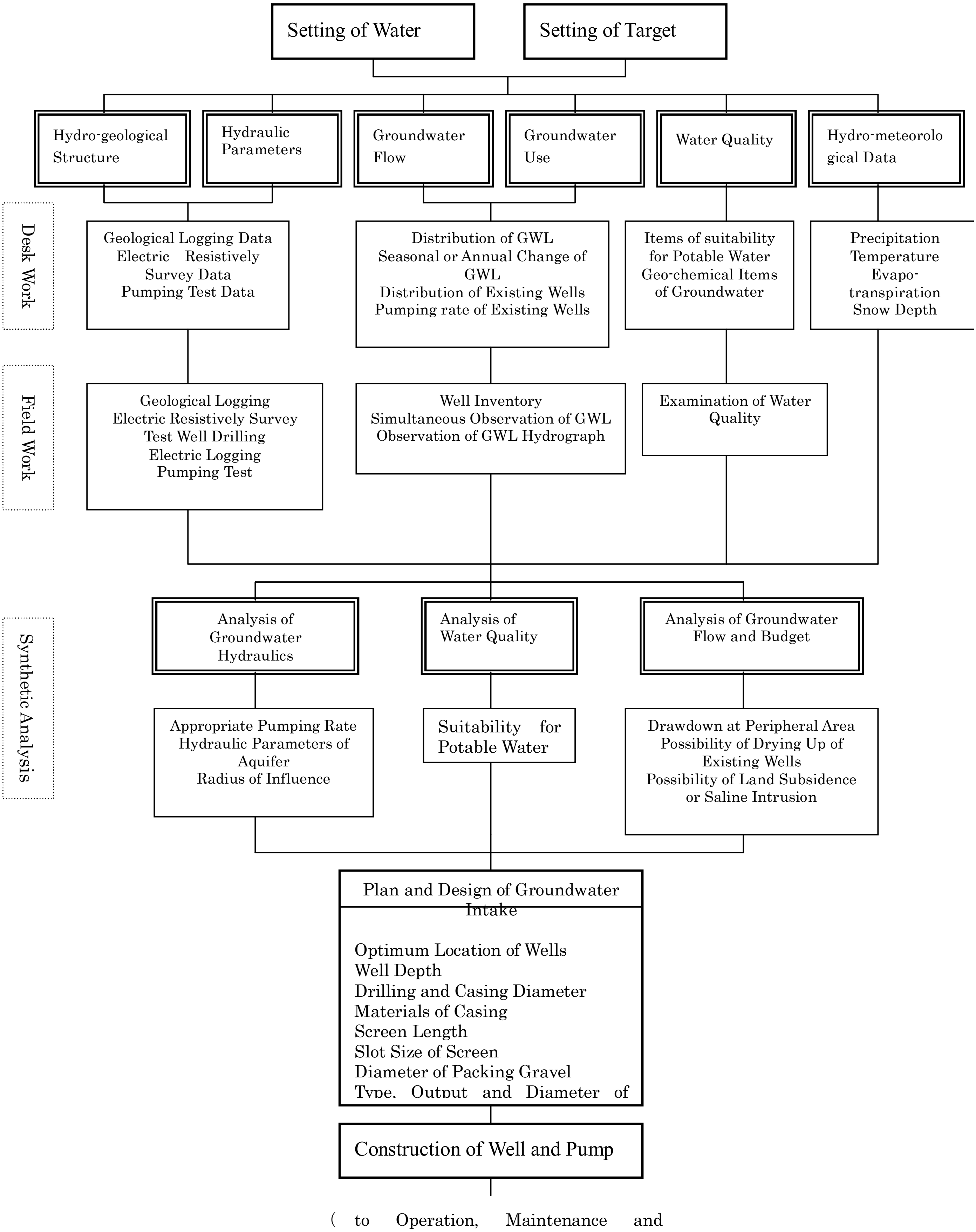


Fig-1 Flowchart of Groundwater Development Plan, Investigation and Design

2. Investigation Methods of Groundwater Development

1) Preliminary Investigation

It is important to collect the following data in the stage of the preliminary investigation (desk work).

(1) Geological Maps
(2) Hydro-geological Maps
(3) Geological Logging Data
(4) Repots of Electric Resistivity Survey
(5) Reports of Well Construction
(6) Contour Maps of Groundwater Level
(7) Hydrograph of Groundwater Level and River Discharge
(8) Distribution Maps of Existing Wells
(9) Lists of Existing Wells
(10) Data of Water Quality Analysis
(11) Hydro-meteorological Data (Precipitation, Temperature, Evapo-transpiration, Snow Depth)

2) Field Investigation

The field investigation methods of groundwater development are as follows.

(1) Electric Resistivity Survey

Electric resistivity survey is a major geophysical method used in groundwater exploration efforts. In a resistivity survey, a direct current is sent through between two metal electrodes. Because earth materials offer resistance to passage of a current, some voltage loss will occur as current flow from one electrode to another. Measurement of earth materials by this method can be apprehended hydro-geological structure (refer to Fig-2 and 3, Tab-1).

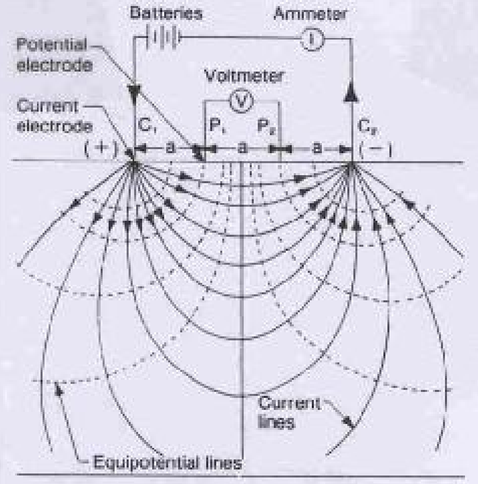
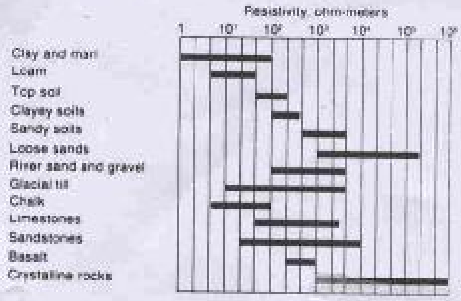


Fig.-2

Figure 8.14. For surface application of the electric resistivity method, a Wenner electrode arrangement is common for groundwater exploration. Current is induced to flow between the two current electrodes and is measured at the potential electrodes. *(Minning, 1973)*

Tab-1

Table 8.3. Ranges of Resistivity Values for Various Earth Materials



(After Culley et al., 1975; McNeill, 1980b)

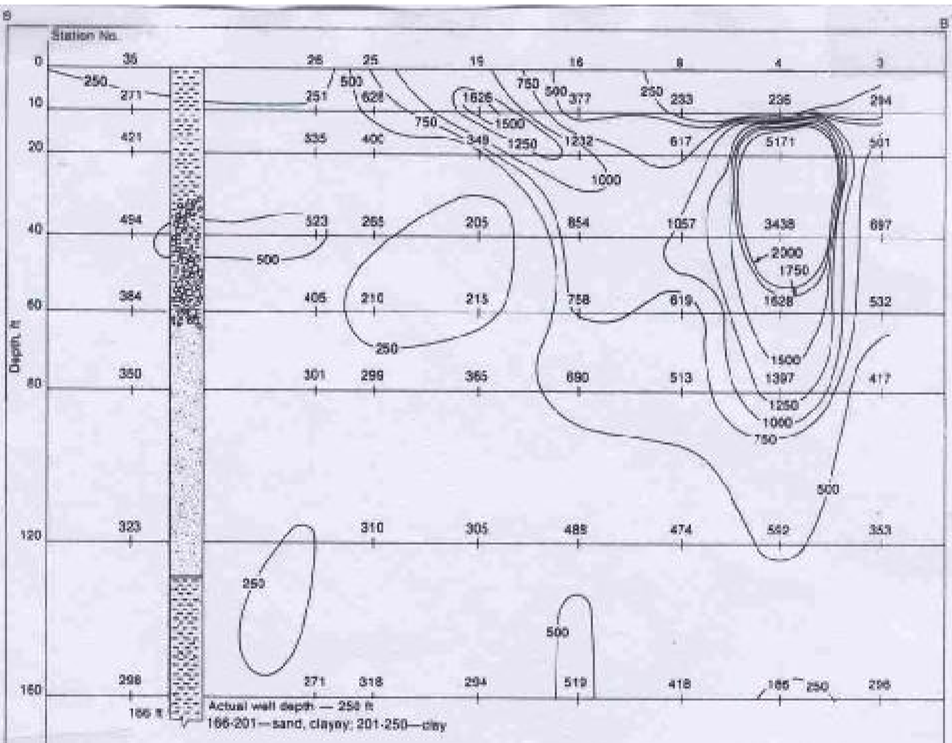


Fig.-3

Figure 8.16. Profiles, or cross sections, of corrected resistivity. The readings indicate a thick sequence of saturated sand and gravel near the eastern border of the site. *(Keck Consulting Services, Inc.)*

(2) Borehole Resistivity Logs

Borehole resistivity logs provide a useful tool for assuring good well design and construction. A good log gives a detailed picture of the character and thickness of variable strata at the well site and an indication of the water quality by measuring the apparent resistivity and/or self potential of the materials surrounded the well bore (refer to Fig-4 and 5).

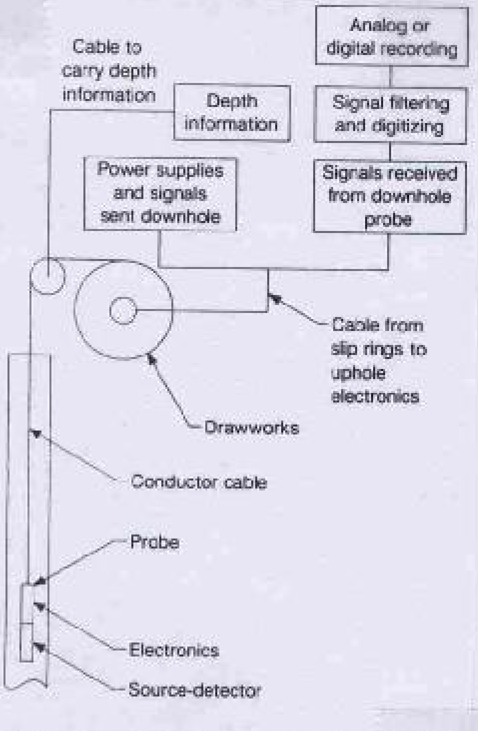


Figure 8.17. The basic components of a geophysical well-logging system. *(Daniels, 1984)*

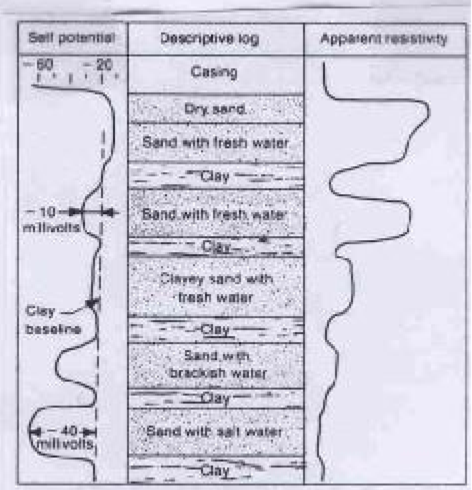


Fig.-5

Figure 8.24. Idealized SP curve and resistivity curve showing electric-log responses corresponding to alternating sand and clay strata; sands are saturated with fresh water, brackish water, and salt water. Note relative deflections of SP curve opposite fresh-water and salt-water sands. In general, the resistivity and SP curves move in opposite directions if the drilling fluid is less saline, or fresher, than water in the formation. This is not the case for the upper sand layer, where the water in the formation has less total dissolved solids, and therefore is less active chemically, than the drilling fluid.

(3) Pumping Test

Pumping tests may be conducted to determine (a) the performance characteristics of a well and (b) the hydraulic parameters of aquifer. Pumping test is included the following methods.

(A) Step Drawdown Test – to be determined appropriate pumping rate and well efficiency (refer to Tab.-2 and Fig.-6)

(B) Continuous Time Drawdown Test – To be determined hydraulic parameters of aquifer (refer to Fig.-7 and 8).

(C) Recovery Test – Same the above

Table.-2

Table 16.6. Discharge and Drawdown Data from Typical Step-Drawdown Test

Yield gpm	Yield m^3/day	Drawdown ft	Drawdown m	s/Q
514	2,801	13.0	4.0	0.0253
1,066	5,810	27.0	8.2	0.0253
1,636	8,916	43.4	13.2	0.0265
1,885	10,273	61.5	18.8	0.0326
2,480	13,516	82.5	25.2	0.0333
3,066	16,710	101.5	30.9	0.0331
3,520	19,184	120.5	36.7	0.0342

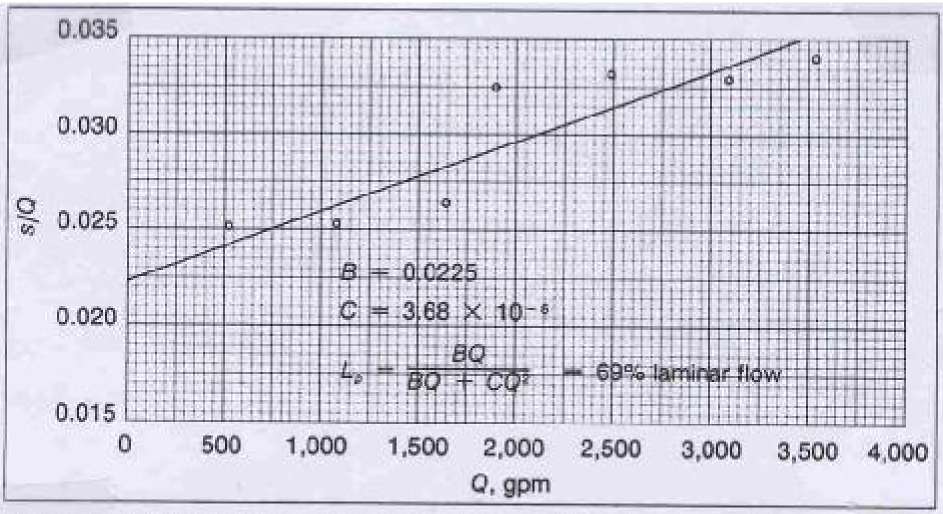


Figure 16.15. Values for B and C in the step-drawdown equation can be determined from a graph where s/Q is plotted against Q.

Fig.-6

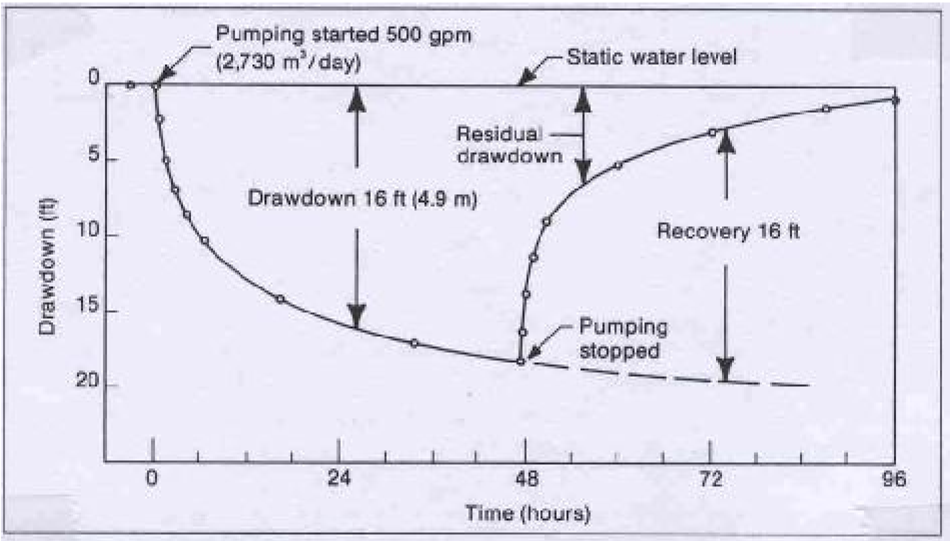


Figure 9.37. Typical drawdown and recovery plots for a well pumped for 48 hours at a constant rate of 500 gpm (2,730 m^3/day) followed by a 2-day period for water-level recovery.

Fig.-7

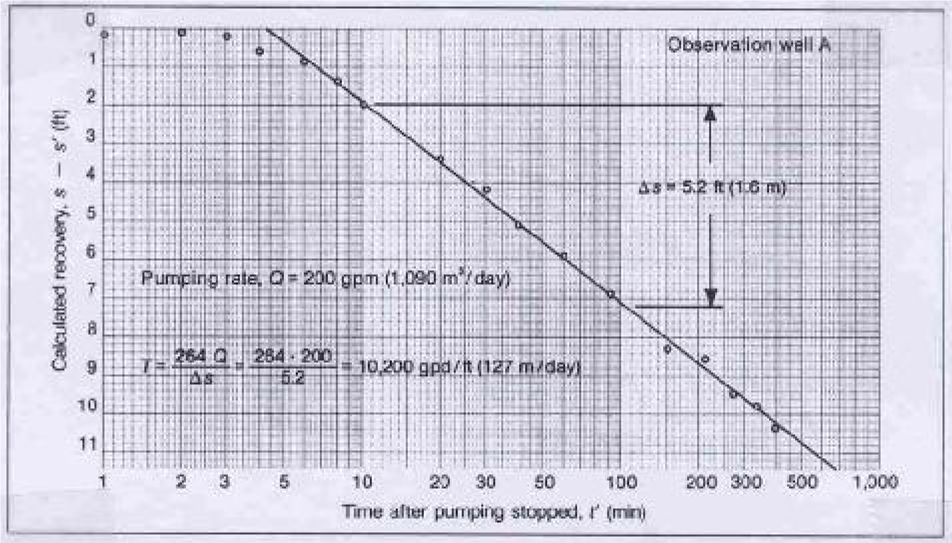


Figure 9.40. Time-recovery plot for observation well becomes a straight line when plotted on a semilog diagram, similar to the time-drawdown diagram for the preceding pumping period.

Fig.-8

(4) Water Quality Analysis

The mainly purposes of water quality analysis are as follows.

(a) To be confirmed of the suitability for drinking water standards

(b) To be understood of groundwater origin and flowing process

The water quality analysis of geo-chemical items is displayed as Tri-linear diagram and a hexa diagram, and the groundwater circulation process is understood by the difference between plotted position and shape (refer to Fig-9 and 10).

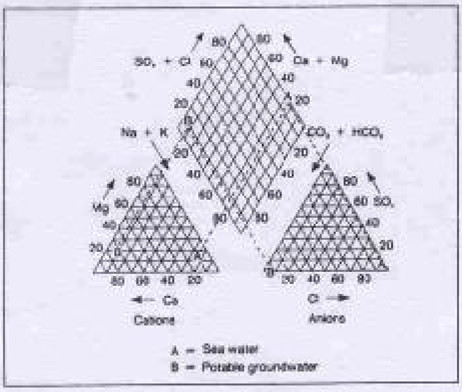


Fig.-9 **Figure 6.12. Chemical analyses of water represented as percentages of total equivalents per liter on the trilinear diagram developed by Hill (1940) and Piper (1944).**

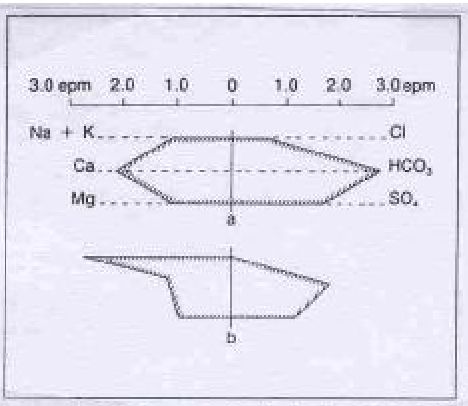


Fig.-10 **Figure 6.13. Pattern analysis developed by Stiff (1951) that can be used to trace similar formation waters over large areas.**

(5) Groundwater Simulation

Ground water simulation is reproduced actual groundwater flow on a numeric model (refer to Fig-11), and new pumping plan is input to this model, the change in groundwater flow can be forecasted. This method is effective for well distribution planning and influence of groundwater environment (drying up of existing wells, land subsidence, saline intrusion etc.).

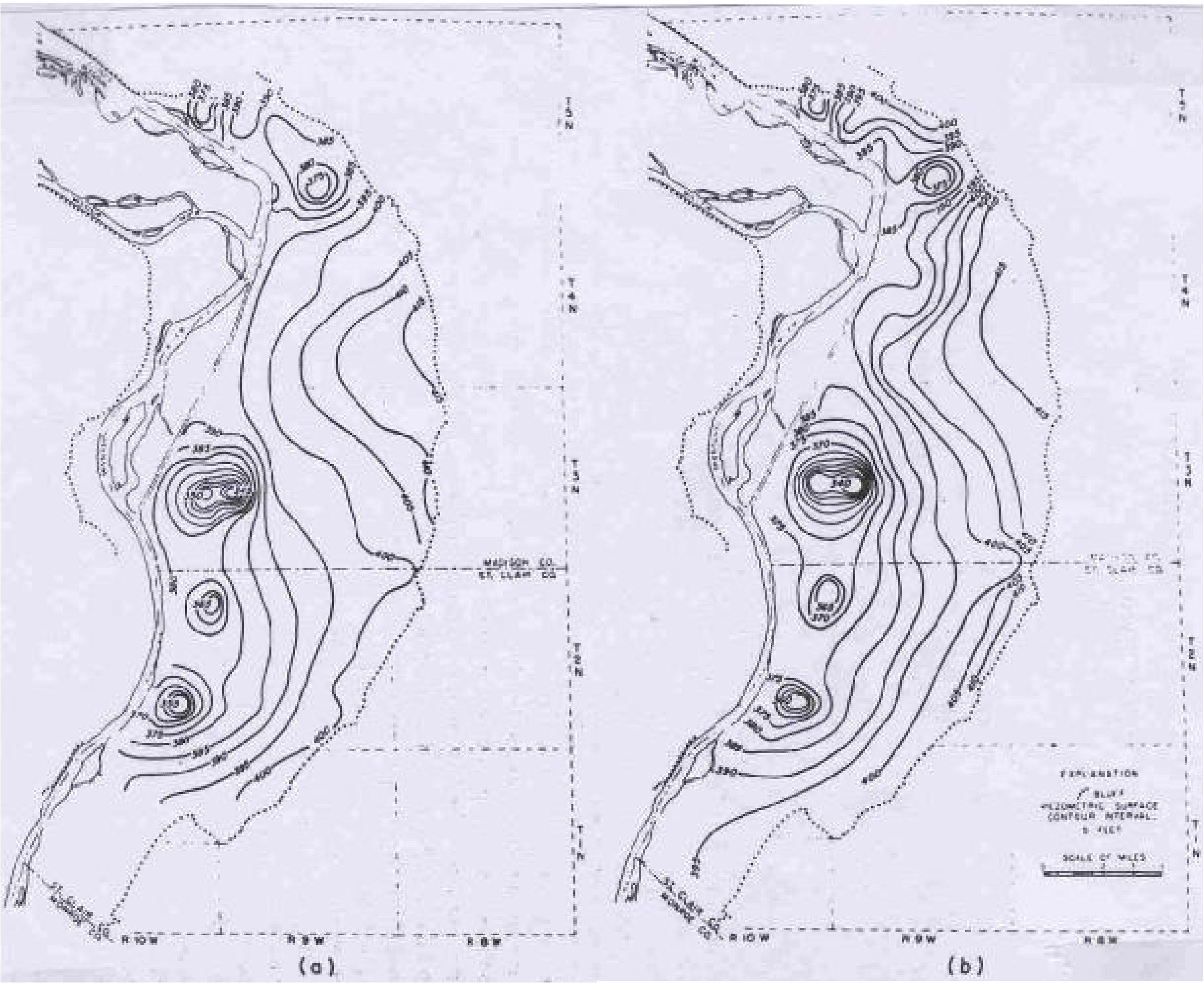


Fig. 8.24 Elevation of piezometric surface, December 1959, actual (*a*) and based on analog computer results (*b*) in East St. Louis, Illinois, area. (*From Schicht, 1965.*)

Fig.-11

3. Water Well Design

Design and Plan for Groundwater Intake is executed based on the investigation result as mentioned above. The mainly items of well design are as follows.

1) Distribution of Wells

Pumping up is reduced groundwater level of the peripheral area. When plural wells are existed in surrounding each other, well interference will be occurred (refer to Fig-12).

The radius of influence of a well can be calculated from the pumping rate, transmissibility and storage coefficient by Theis formula. When the hydraulic parameters of aquifer are not obtained, the radius of influence of a well can be generally calculated by the following experience formula.

$R = 3000 – 5000\ r$

$R = 3000\ Sw\ K^{1/2}$ (Siechart's formula)

Where, R : radius of influence (m)

r : radius of well (m)

Sw : drawdown (m)

K : permeability (m/sec)

Practicably, the radius of influence of a well is said as 100-300m in unconfined groundwater and 500-700m in confined groundwater. The well interference is not generated when the wells are located away twice as long as the radius. In the case of Tashkent City Water Supply, the pumping wells are obviously too adjacent to each other.

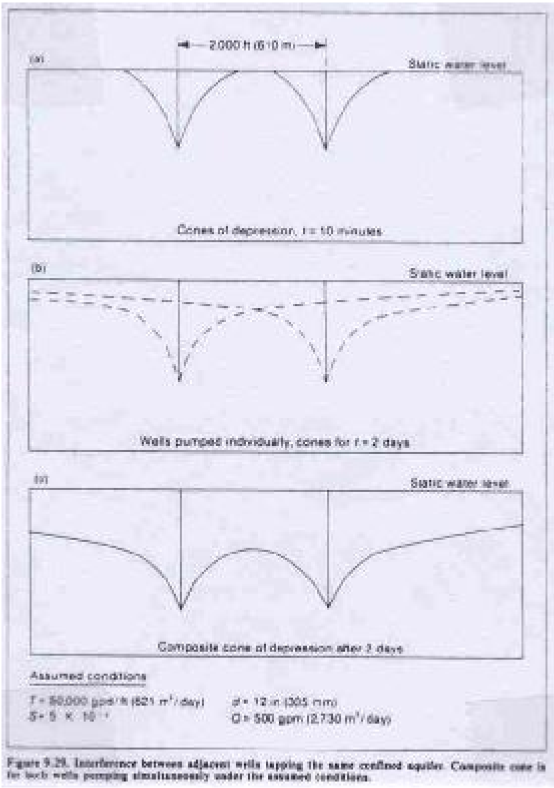


Fig.-12

2) Well Depth, Well Diameter, Position of Screen

Well depth, drilling diameter, casing diameter, screen length and position of screen are determined by planed pumping rare and hydro-geological condition.

3) Materials of Casing and Packing Gravel

The materials of casing, the slot diameter, and the packing gravel diameter are determined by the pumping rate, the grain size composition of the aquifer and the economic condition. Poor distribution of screen openings causes excessive convergence of flow near the individual openings, and may produce twice as much drawdown as necessary (refer to Fig-13). When slot size and/or packing gravel diameter is too large, the soil particle flows in the well, and the adverse effect is caused for the pump and the water quality.

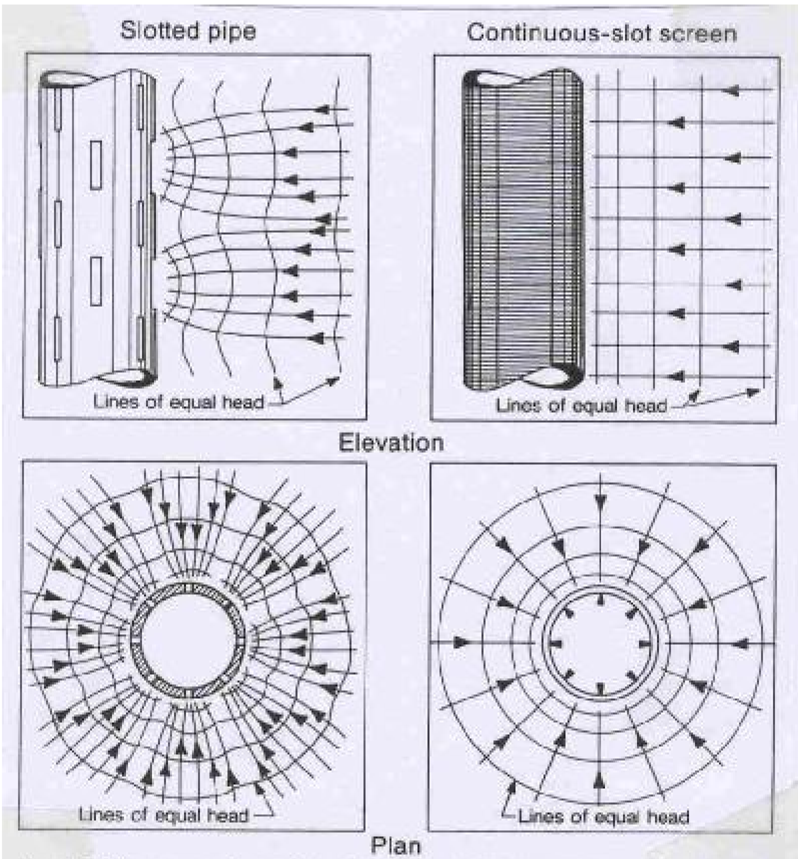


Figure 9.32. Flow nets around screen devices. Water approaches openings along lines indicated by arrows. Flow lines for slotted pipe converge to individual slots; flow lines for continuous-slot well screens are less distorted.

Fig.-13

4) Pump Facilities

The type, diameter and output of pump is determined by planed pumping rare and groundwater level and head (refer to Fig-14).

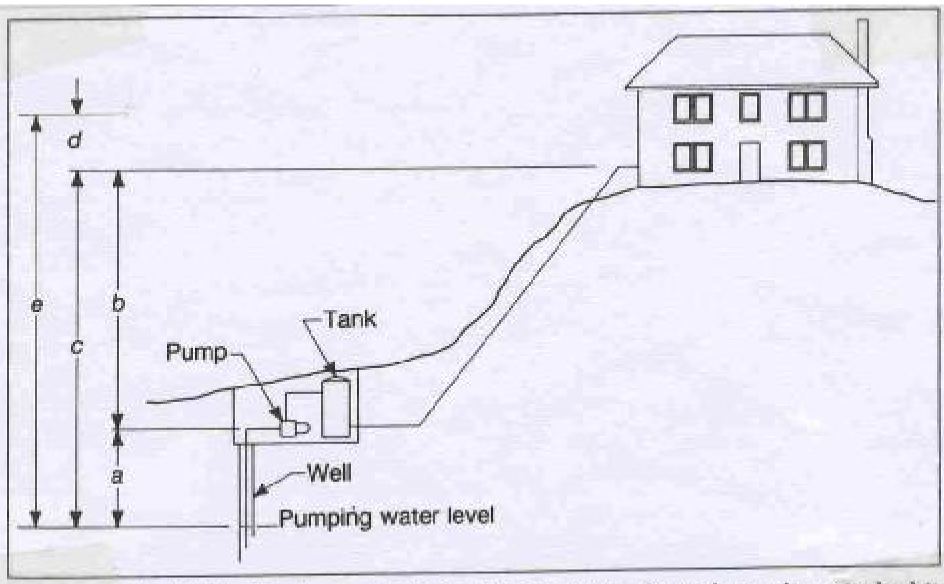


Figure 17.1. The individual head components of a pumping system, where *a* is pumping water level to discharge; *b* is above-ground lift; *c* is total head; *d* is friction head; and *e* is total dynamic head.

Fig.-14

4. Operation, Maintenance and Rehabilitation

The maintenance and management of the well is important to intake the groundwater continuously and stably. The decline of the well performance is appeared to decrease the pumping rate and reduce the groundwater level in the well. The periodical measurements of the pumping rate and groundwater level are very effective to find the decline of the well performance at the early stage.

The decline of the well performance is caused by the incrustation, the electric corrosion, the sedimentation of soil particles, etc. The methods of rehabilitation of wells are as follows (refer to Fig-15 and 16).

(1) Surging
(2) Swabbing
(3) Back Washing
(4) Jetting
(5) Acid Treatment

The example of rehabilitation effect is shown Fig-17. Moreover, the artificial groundwater recharge is effective method for the increasing of groundwater resources (refer to Fig.-18).

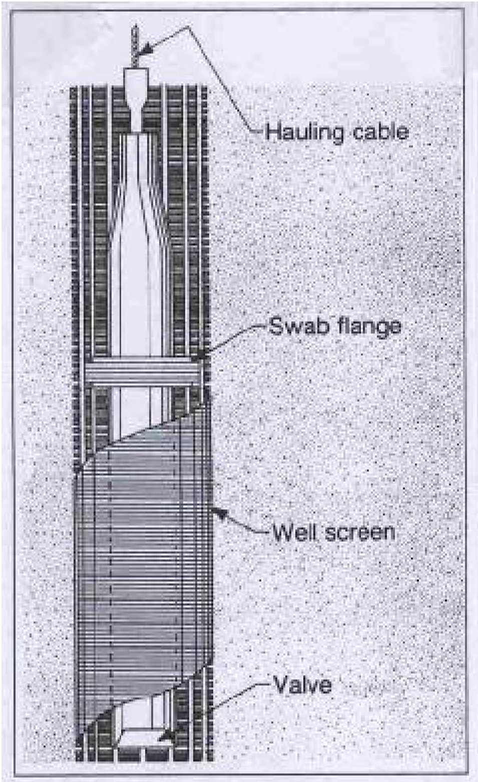


Fig.-15 Equipment of Swabbing Method

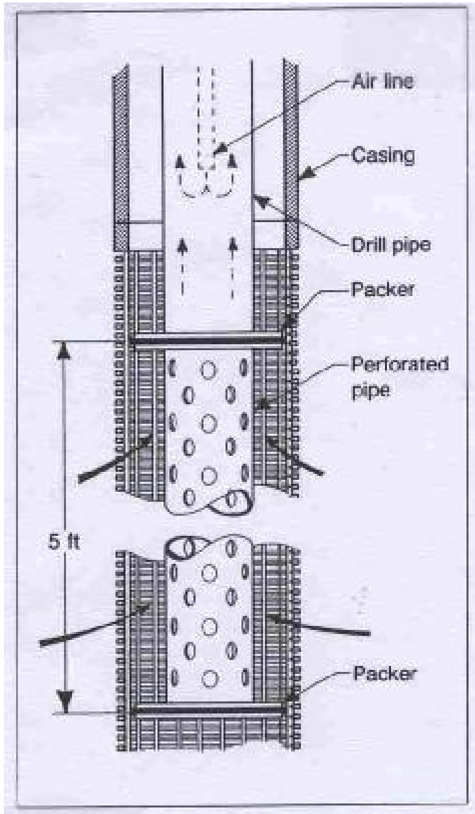


Fig.-16 Equipment of Air Lift Method

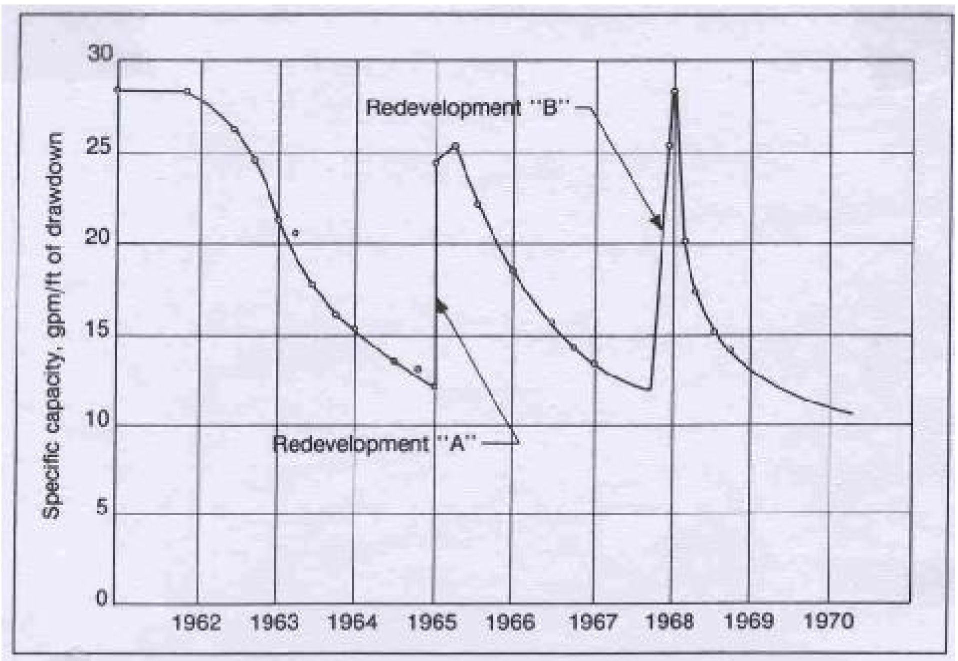


Fig.-17 Example of Well Rehabilitation Effect

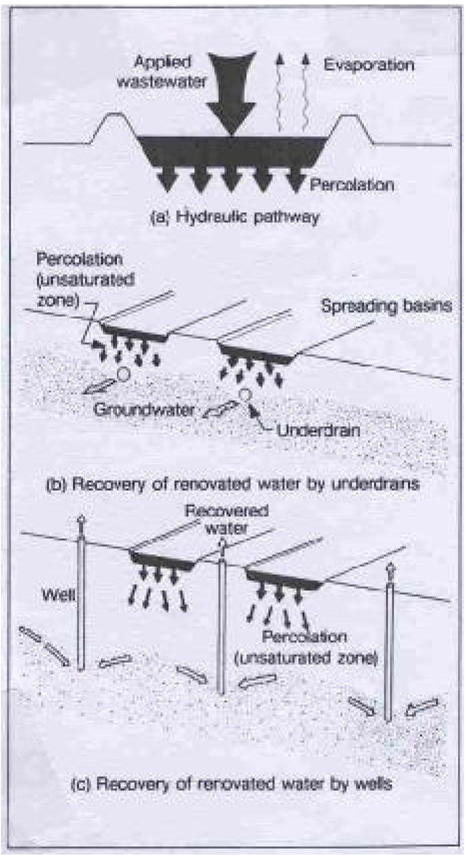


Fig.-18 Example of Artificial Groundwater Recharge

(5) 5th November – Introduction of Technology(2):

1) Pumps and Volume Control

2) Control and Monitoring System

1) Pumps and Volume Control

1. Type of pumps and Features

Table 1-1 Classification of Pumps by Characteristics and Structues

Classification				Range of application		Figure
				Bore mm	Head m	
Volute pump (including volute pump having mixed flow type impeller)	Horizontal	Single suction	Single stage	40-800	5-50	1-1
			Multistage	40-500	20-3000	1-2
		Double suction	Single stage	150<	5-120	1-3
			Two stage	300<	60-150	
	Vertical	Single suction	Single stage	40-2000	5-120	1-3
			Multistage	50-500	20-300	
		Double suction	Single stage	300<	5-120	
			Two stage	300<	60-150	
Mixed flow pump		Horizontal	Single stage	300<	3-8	
		Vertical	Single stage	200<	5-50	1-4
			Two stage	200<	30-80	1-6
Axial flow pump		Horizontal	Single stage	300<	4(5)>	1-5
		Vertical	Single stage	200<	5(6)>	1-7

Remark: The lift sometimes changes by the bore and frequency, refer to catalogue of every model

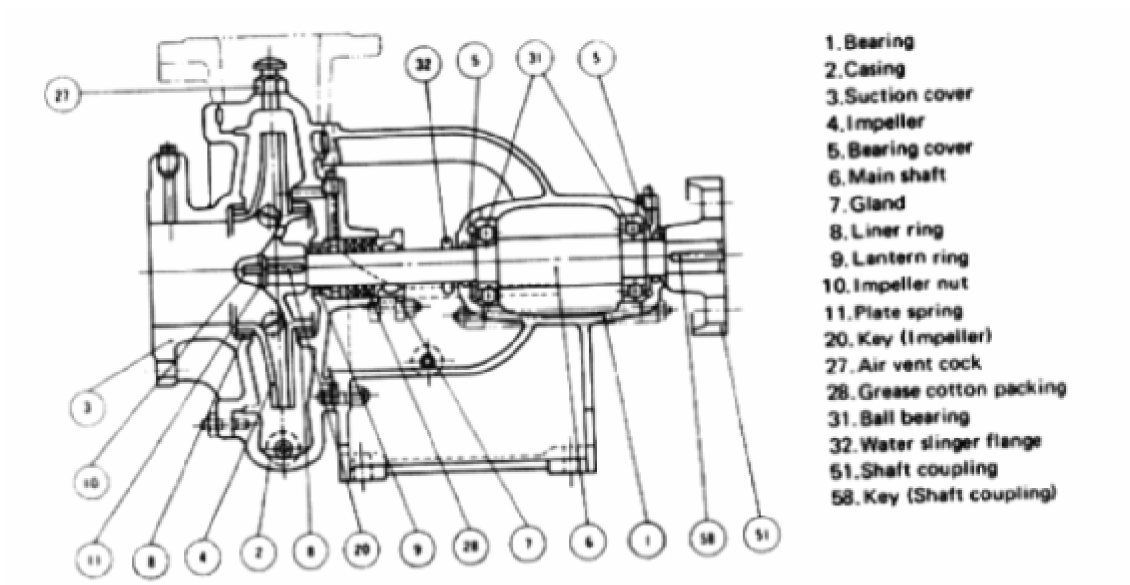


Figure 1.1 Horizontal Single Suction Single StageVolute Pump

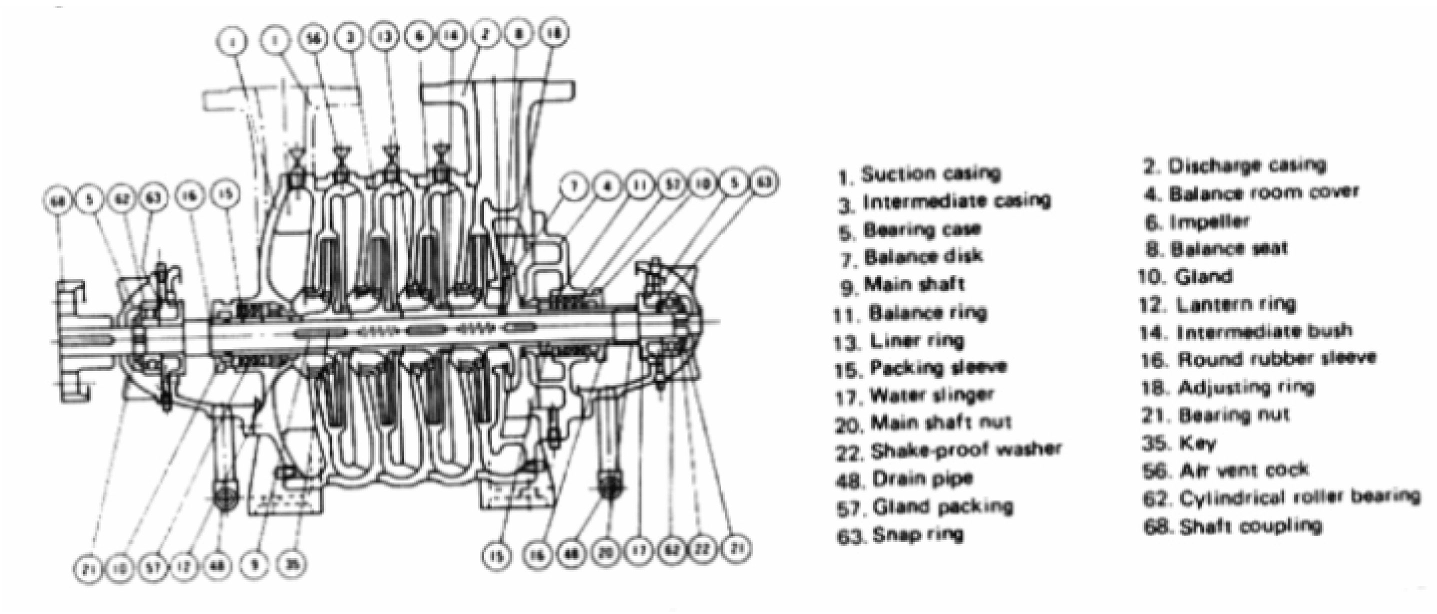


Figure 1-2 Horizontal Single Suction Multistage Volute Pump

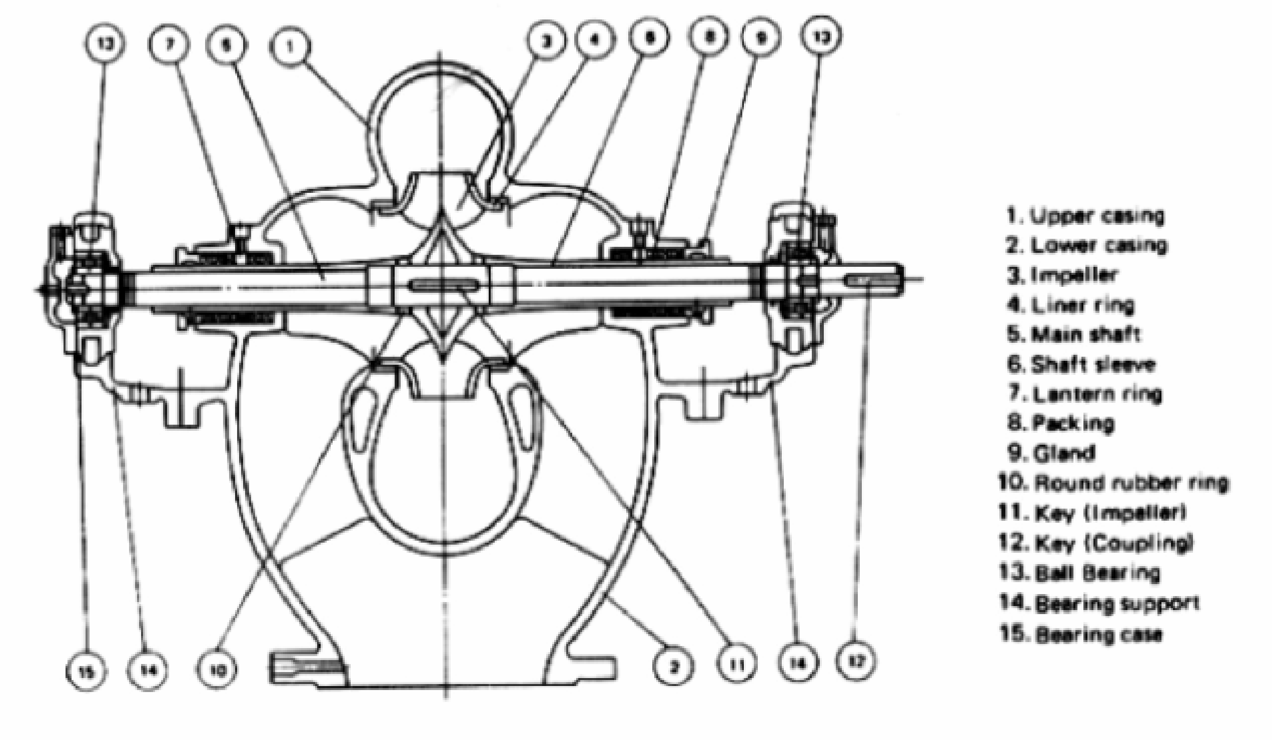


Figure 1-3 Vertical Double Suction Single Stage Volute Pump

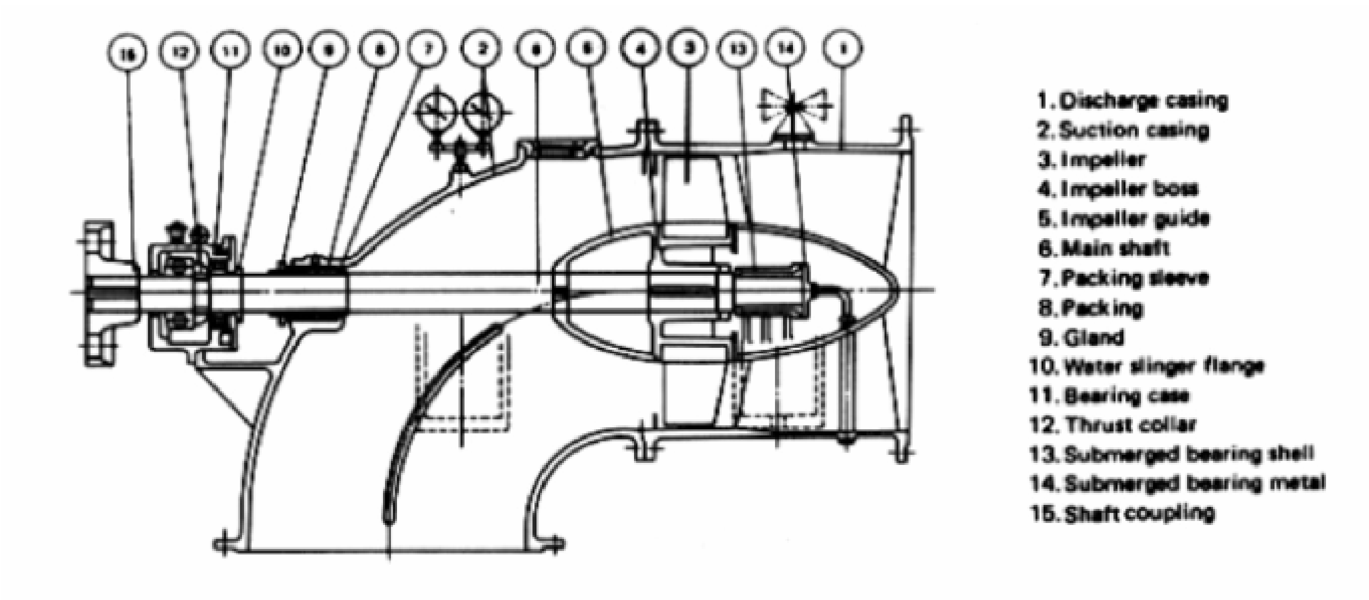


Figure 1-4 Mixed Flow Vertical Single Stage Pump

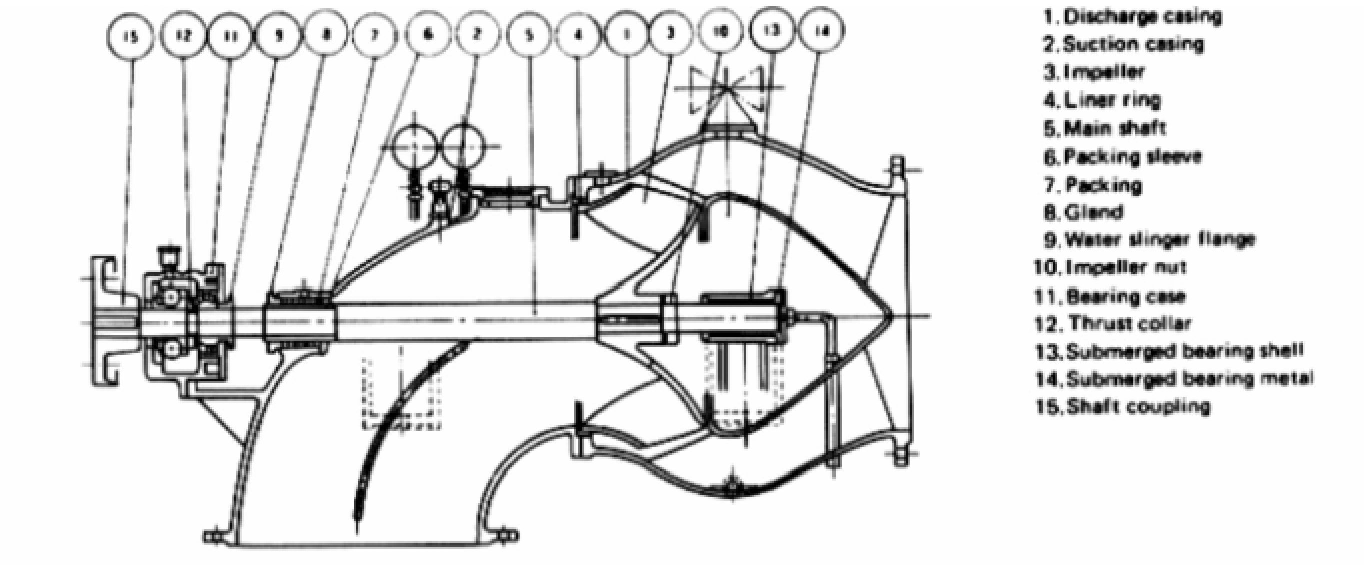


Figure 1-5 Mixed Flow Vertical Double Stage Pump

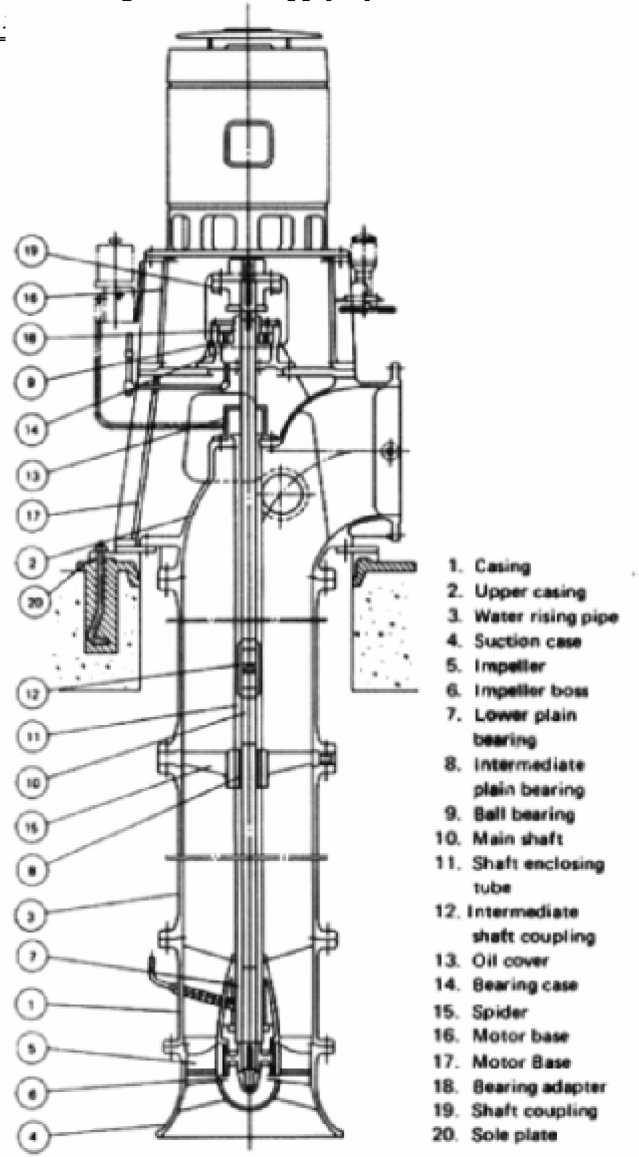


Figure 1-6 Axial Flow Horizontal Single Stage Pump

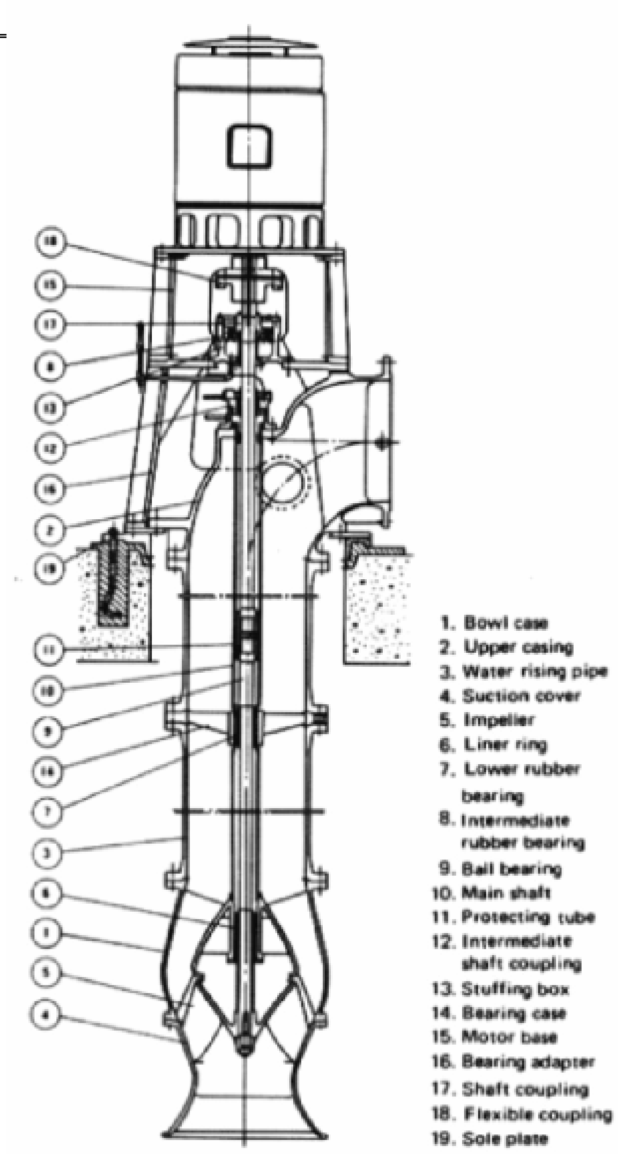


Figure 1-7 Axial Flow Vertical Single Stage Pump

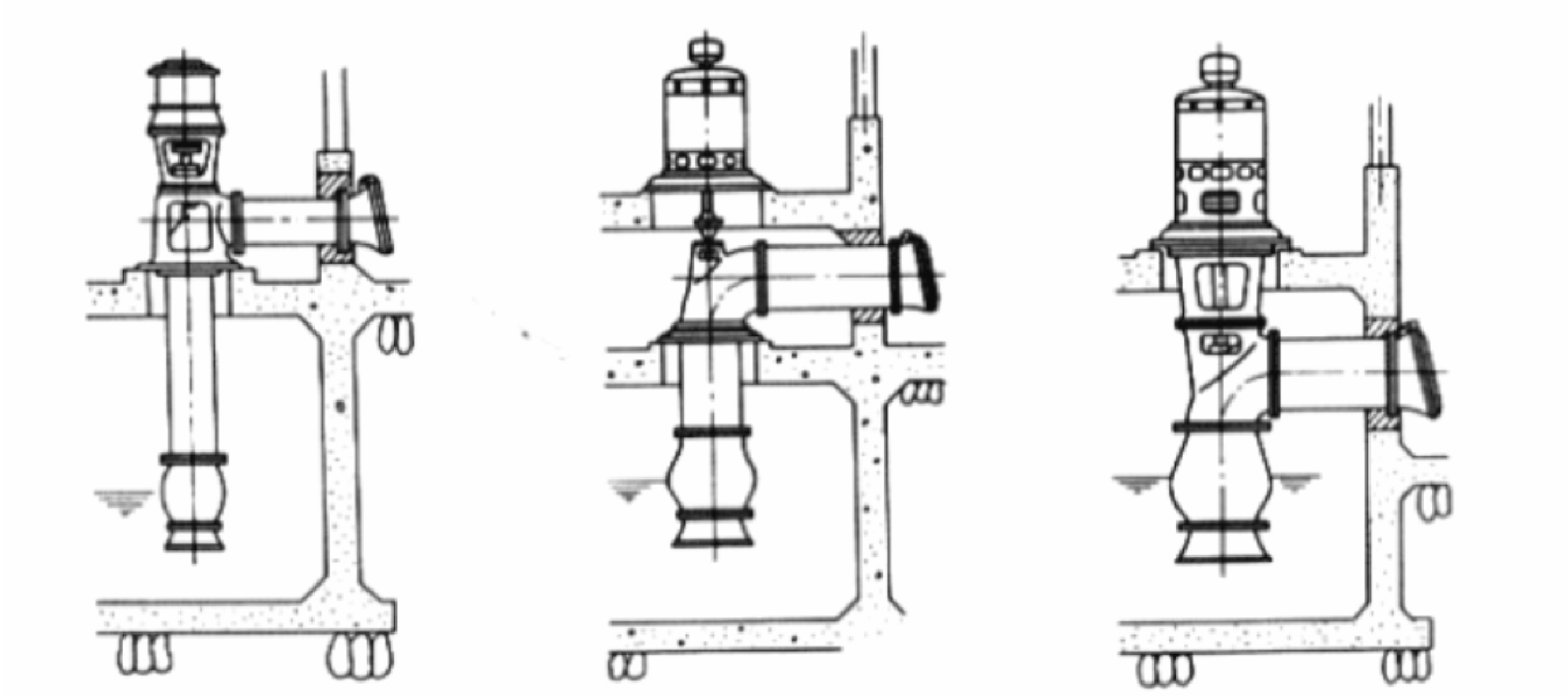


Figure 1-8 Installation Pattern of Axial Flow Pump

2. Flow and Pressure Control for Pumps

The water distribution quantity of the city fluctuates sharply in a day according to water consumption changes of consumers, and Vodokanal should distribute water to consumer with proper quantity and pressure. Therefore distribution flow and pressure need to control for distribution to consumers with sufficient volume and proper pressure.
Distribution pumps are installed as Fig.2-1 and pumps withdraw water from reservoirs. Basically, the influent flow for reservoir should be constant hourly, however the effluent flow must vary hourly with fluctuation of water demand of consumer.
Consequently the reservoir needs to regulate the difference of inflow and outflow volume.

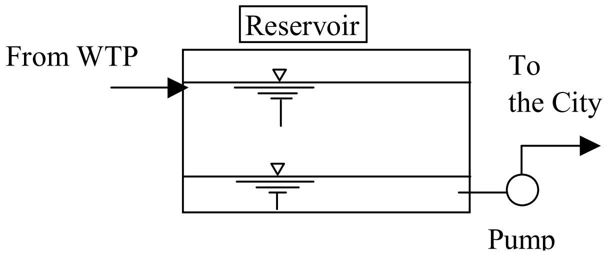


Fig 2-1 Distribution Reservoir and pumps

Methods of volume control are described following:

The methods of flow control are only 3: a) operation number control, a) valve control, and c) revolution speed control.

(a) Operation number control

This control method is the simplest one, and is used in almost all facilities.
The characteristic of the method is shown in Fig 2-2. The efficiency of this method is good, facilities are simple and additionally control is easy, however distribution quantity is changed step by step as shown in fig 2-3. It is the main deficit of this method.

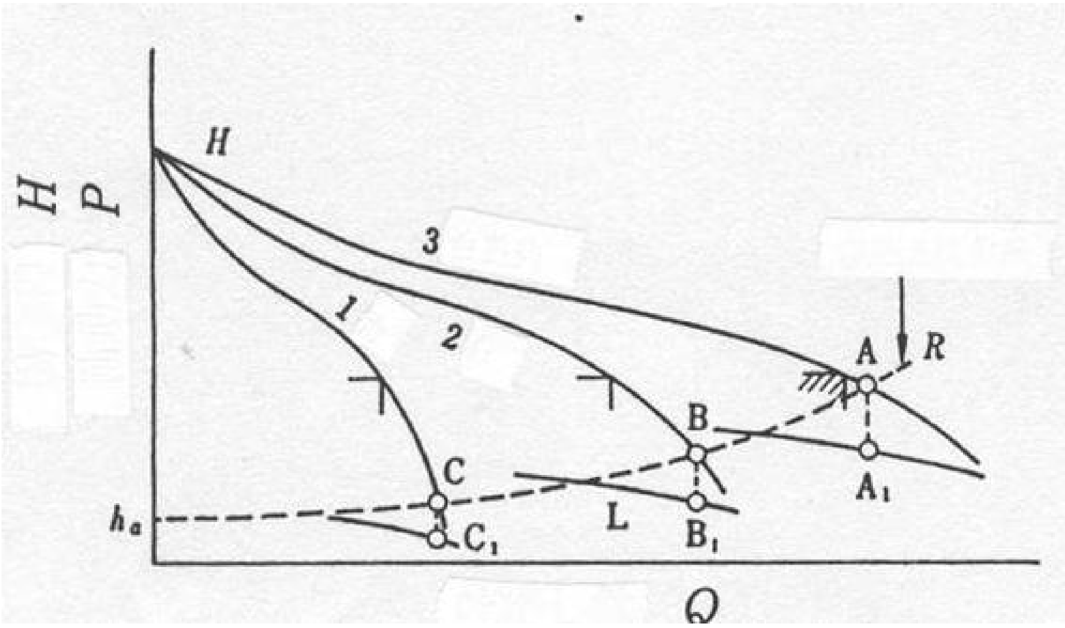


Fig 2-2 characteristic of operation number control

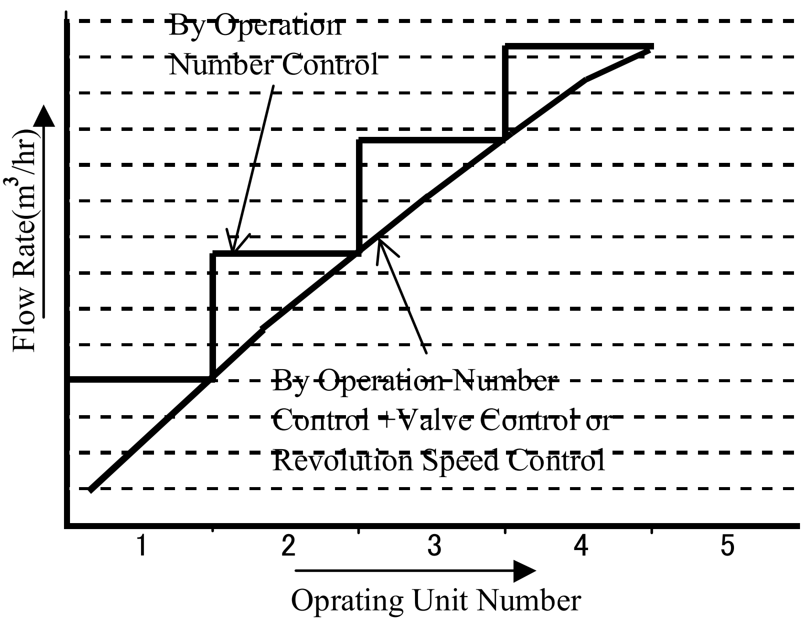


Fig.2-3 Operation Units and Flow Rate

(b) Valve control

Valve control method is also simple to regulate flow rate, however the flow rate is reduced by increasing head loss of squeezing of valve, and electricity consumption for unit discharge volume of water increase sharply. Usually, the operation number control method and the valve control method are combined to improve the deficit of previous method. Fig.2-4 shows operation characteristic of valve control.

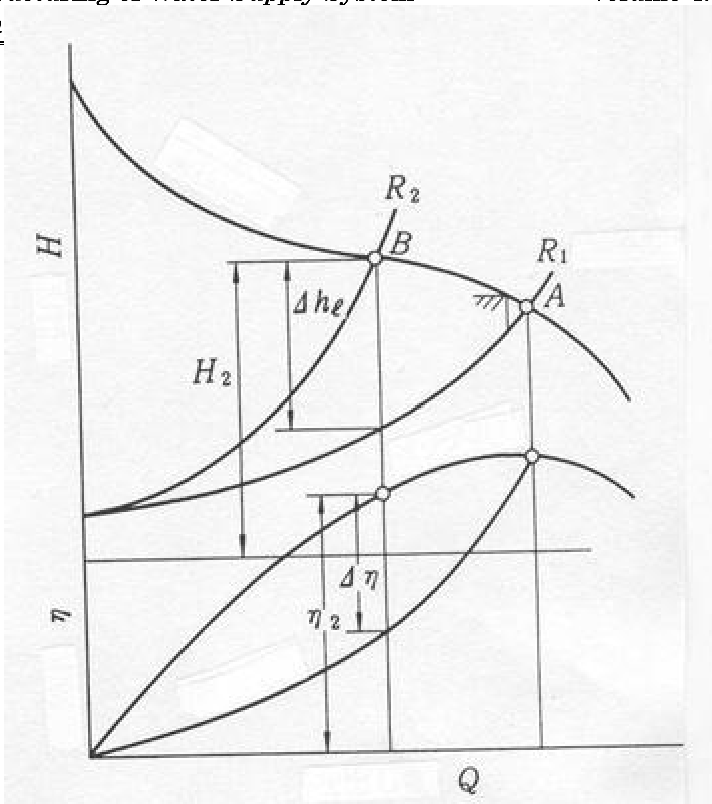


Fig.2-4 Operation Characteristic of Valve Control

If auto-valve and flow meter are combined and controlled by controller as Fig. 2-5, the flow rate can adjust automatically and the flow rate can be controlled linearly as Fig 2-4.

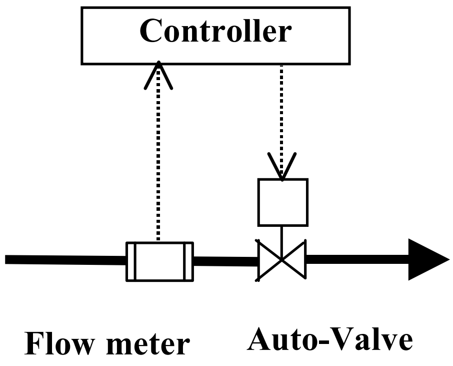


Fig.2-5 Auto-Control for flow rate by Auto-Valve

(c) Revolution speed control

Regulation of Revolution speed can be conducted by mechanical or electrical method, and currently the electrical method is used for almost all revolution speed control.

The electrical method is to regulate the cycle frequency and the voltage in order to change the revolution speed. This method can regulate the flow rate easily and systematically, and when the flow rate is reduced, the electrical consumption is also reduced nearly in proportion to the flow rate.

Therefore this system is excellent for energy saving of water distribution.

However it is relatively high cost to install, especially for large power motors, and regulation range is limited (around 100 to 50%).

When the method is combined with the operation number control, the flow rate can be regulated linearly as shown in Fig. 2-4. Fig.2-6 shows a comparison of the revolution control and the valve control

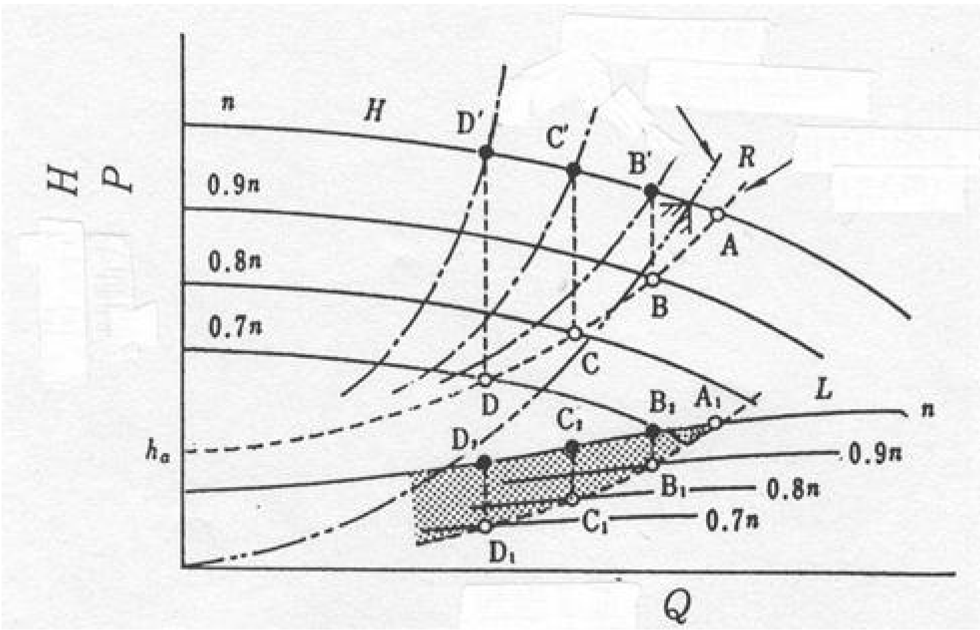


Fig.2-6 Relation of Discharge Quantity and Head for Revolution Speed Control

2) Control and Monitoring for System

Supervisory and Control System for Water Treatment Plant

1.General

I would like to introduce a typical current supervisory and control system for a water treatment plant in Japan here in the occasion of this seminar. A highly automated operation system for the water treatment plant has been established in Japan in conjunction with development and application of instrumentation equipment, computers and communication equipment to achieve a stable water supply system.

The attached drawing is a sample of a monitoring and control system for a water treatment plant.

2.Component of Supervisory and Control System

Two personal computers (PCs) and one server are arranged in the administration building monitoring room, while PLCs (Programmable Logic Controllers) and instrumentation panels are arranged in each local control station to build up the supervisory and control equipment, which is based on the hierarchy and horizontally distributed process control system. The hierarchy system means that the supervisory control level is classified into the field level, local control station level and central supervisory station level to achieve the reliability for the supervisory and control system. These equipment are linked over an open network such as Ethernet to collect the plant loads information and to send command of start/stop to each plant load and set value to each loop control such as flow control of coagulant feeding.

The unified supervisory and control system enables efficient operation an maintenance work of the water treatment plant, because any information about the whole plant is monitored from the central supervisory station.

Operations such as unit test or adjustment test for maintenance or troubleshooting of loads will be carried out at the field level. Accordingly, for execution it is necessary to assemble with a hard relay in auxiliary relay panels for the control circuit of the site single operation even in the case that abnormal conditions happen to the PLC control unit of the upper class system.

(1) Field Level

A local operation panel, comprising “LOCAL-REMOTE” change over switch, “START-STOP” or “OPEN-STOP-CLOSE” and “EMERGENCY STOP” push button is arranged at each plant load to carry out the operation of each load at the field level as follows:

- Inflow valve
- Raw pump

- screen
- sump drainage pump
- sludge collector
- settled water sampling pump
- sump drainage pumps
- de-sludge valve
- vacuum pump
- flow control valve
- backwash recovery pump
- sludge pump
- sludge thickener
- sludge feed pump
- waste water discharge pump
- coagulant transfer pump
- coagulant feed pump
- distribution pump

(2) Local control room level

At the local control room, the automatic and linked operations are provided in each PLC. One PLC is arranged in each local control station so that the PLC failure does not affect the other plant loads controlled by the other PLCs.

As a sample of automatic operation, distribution pumps are controlled directly by the PLC instead of a one-loop controller.

In this case, constant pressure control at the header pipe of the distribution pipes is applied to the distribution pumps.

The local instrumentation panel that stores the converter for the instrumentation detector, indication meter, alarm setting device, one-loop controller etc. is installed in each local control room. From the local instrumentation panel, the signal that is needed for the operation of the field level is outputted to the auxiliary relay panel and in addition the signal that is needed for automatic and linked operation is outputted to the PLC.

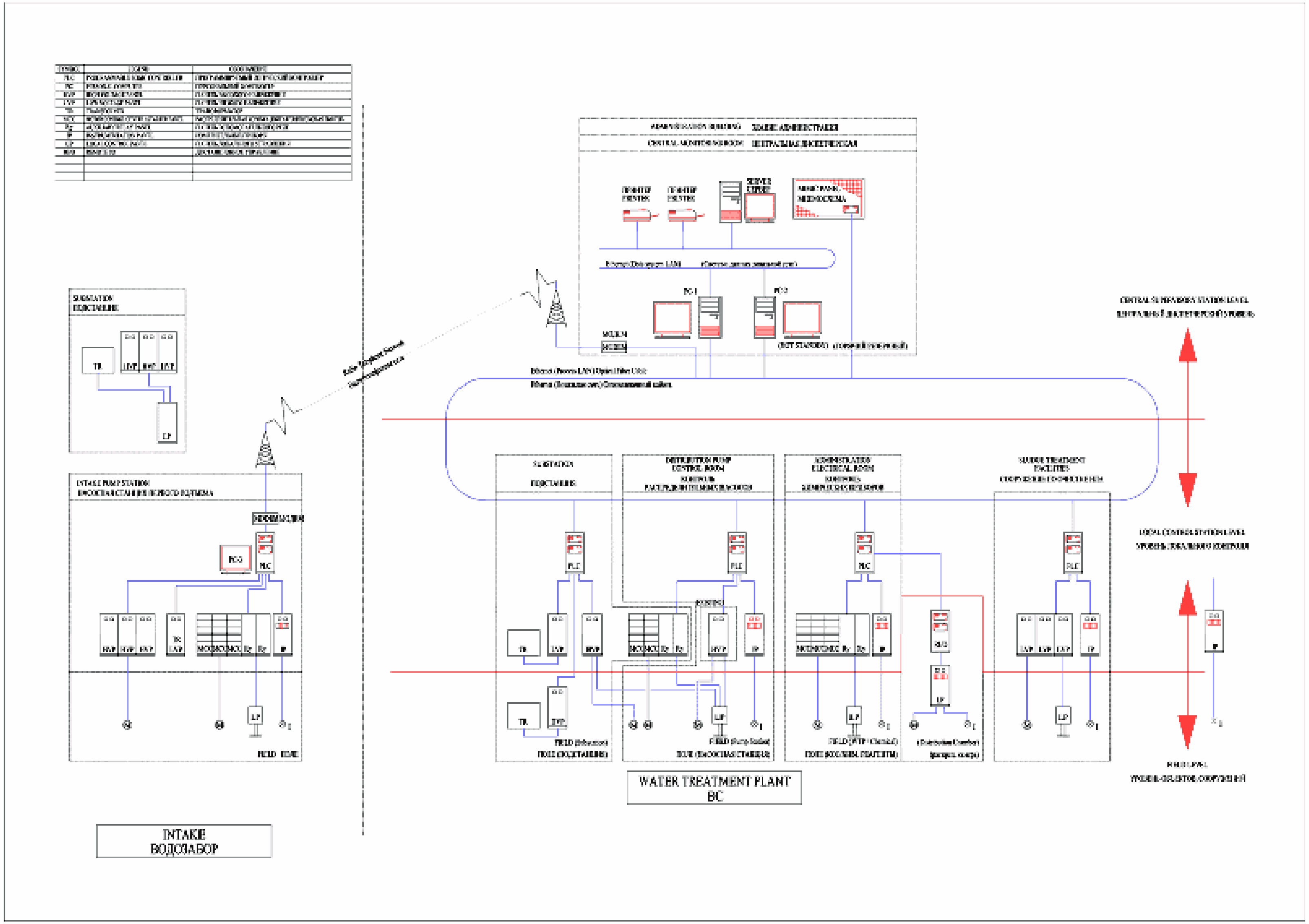
(3) Central supervisory level

Two personal computers (PCs) and one server, one mimic graphic panel and two printers are installed in the administration building monitoring room for the main function of the supervisory and control system. The PCs are the human-machine interface to monitor the plant loads status, failure and process values through a

graphical interface at the central supervisory room level. Furthermore, set values such as intake water flow, chemical dosing rate can be set on the screen of them. Furthermore PCs collect the data from local control level over the LAN, such as plant loads status, failure, process values and the water quality.
All the PLCs are connected to optic fibre cable and communicate each other.

The server plays a role of data processing so that it can generate reports, such as daily monthly and yearly report, historical trends graph, historical process running and historical alarm.

The mimic graphic panel plays a role of demonstration tool to visitors, so it enables to show the water treatment plant in front of many visitors simultaneously.


WATER TREATMENT PLANT
BC
INTAKE
ВОДОЗАБОР

(6) 10th Dec. and 17th Dec -Introduction of Preliminary Master Plan

---

Outline of Study for Technical Portion

1. Problems of Present System for Water Supply based on the Investigation by the Study

- There is much leakage from housing (22-23%) and pipelines (30%, including irrigation water) (shown in Table 1-1)
- Much equipment for water supply needs to replace urgently because it is already over its life time and deteriorated
- Insufficient O&M (operation and maintenance) manner: shortage of budget, insufficient training for staff and lack of manuals for O&M
- Water intake capacities of Kibray WTP (water treatment plant) and other underground water WTPs are decreasing: 1) Kibray WTP's deep wells are not suitable for its hydro-geological situation, 2) Intake capacity of Other WTP's deep well is decreasing because of deterioration, and 3) Many pumps for deep well are not match with intake capacity of these wells (for example pump discharge capacity is 600 m^3/hr and well's intake capacity is 200m^3/hr)
- Insufficient control system of water supply network, (shown in Fig.1-2):
  1) Basically major WTPs, such as Kadirya, Kibray and Boz-su WTPare, located at such high elevation that water head/pressure from these WTPs to the city is enough to distribute by gravity,
  2) However water pressure in the city is so low to distribute consumers that many pump stations are constructed in the city because valves of distribution net work are squeezed too much to prevent destruction of facilities
- When volume fluctuation of distribution water will be increased in the future due to saving water based on meter installation (shown in Fig.1-3), volume control facilities (e.g. service reservoir) for water distribution will need to be constructed

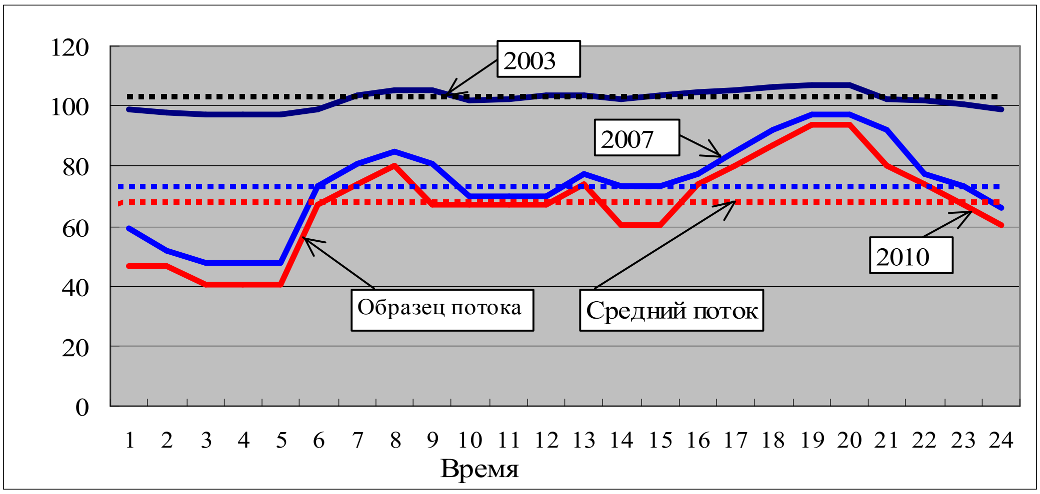


Fig. 1-3 Increasing of Flow Fluctuation

Table 1-1 Calculation for Loss of Distributed Water Quantity

Data	Area	Kind of house	Divisition	Situation In 2002				Evaluation			
				Population	Consumption		Rate	Real consumption		Difference	Rate
					L/cap/d	m^3/d		L/cap/d	m^3/d	m^3/d	
By city government	In City	Apartment	With meter	99.5	110	10.95					
			Without meter	1,527.0	390	595.53					
			Sub-Total	1,612.5		606.48	29.4%	125	201.56		
		Detached house	With meter	223.1	220	49.08					
			Without meter	364.2	330	120.19		155	56.45		
			Sub-Total	537.5		169.27	8.2%				
		Sub-Total		2,150.0		775.74	37.5%		258.01		
Large consumer	Budgetary organization					181.07	8.8%	90%	162.97		
	Hot water plants					420.83	20.4%	90%	378.75		
	Other large consumer					243.20	11.8%	90%	218.88		
	Total					845.10	40.9%		760.59		
Total						1,620.84	78.5%		1,018.61	602.24	29.1%
Leakage from pipes and irrigation water						445.22	21.5%			1,047.45	50.7%
Distribution amount from WTP						2,066.06	100.0%				
by Vodokanal	In City	Apartment	With meter	99.5	160	15.92					
			Without meter	977.0	580	566.66					
			Sub-Total	1,076.5		582.58	28.2%	160	172.24		
		Detached house	With meter	223.1	200	44.62					
			Without meter	377.8	300	113.34		200	75.56		
			Sub-Total	600.9		157.96	7.6%				
		Sub-Total		1,677.4		740.54	35.8%		247.80		
Large consumer	Budgetary organization					181.07	8.8%	90%	162.97		
	Hot water plants					420.83	20.4%	90%	378.75		
	Other large consumer					243.20	11.8%	90%	218.88		
	Total					845.10	40.9%		760.59		
Total						1,585.64	76.7%		1,008.39	577.25	27.9%
Leakage from pipes and irrigation water						480.42	23.3%			1,057.67	51.2%
Distribution amount from WTP						2,066.06	100.0%				

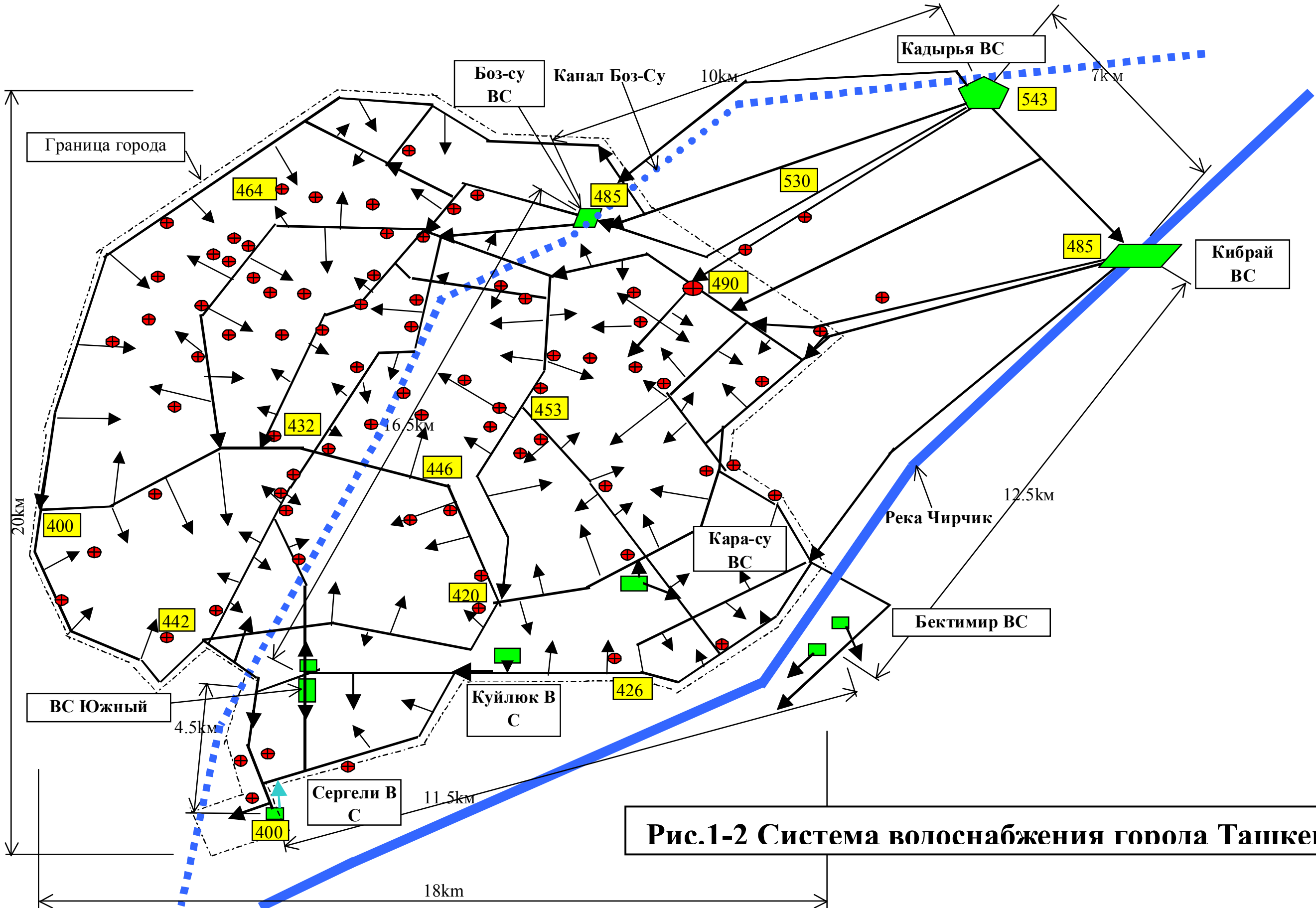
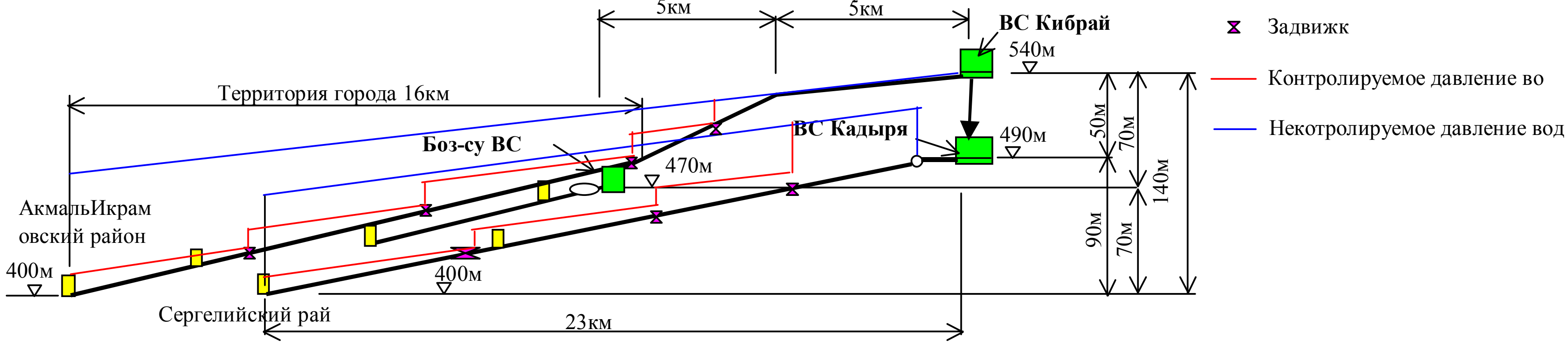


Рис.1-2 Система водоснабжения города Ташкента



2. Outline of Master Plan

2-1 Projection of the Future Water Distribution Quantity for the City: Table 2-1 and Fig 2-1

- To project future service population
- To decide future water demand per capita individuals and large consumer
- To project water distribution amount to the city including estimation of daily fluctuation

2-2 Formulation of Suitable System for projected Distribution Amount: Table2-2 to 2-4

- To plan necessary water treatment capacity
- To plan suitable distribution network including selection of necessary WTPs and construction of service reservoir

Table 2-2 Distribution Amount to the City

Distribution Amount		Unit	Year		Note
			2010	2015	
Daily Average	Min.	$10^3m^3/d$	1,323	1,326	
	Max.	$10^3m^3/d$	1,616	1,636	
Daily Maximum	Min.	$10^3m^3/d$	1,588	1,591	For WTP capacity
	Max.	$10^3m^3/d$	1,939	1,963	
Hourly Maximum	Min.	$10^3m^3/hr$	79.4	79.6	For distribution Capacity
	Max.	$10^3m^3/hr$	97.0	98.2	

Table 2-3 Nominal Capacity of WTPs

Name	Capacity		Elevation of Reservoir
	Each	Sum-total	
	$10^3m^3/d$	$10^3m^3/d$	m
Kadirya	1,375	1,375	543
Kibray	455	1,830	485
Boz-su	235	2,065	485
South	143	2,208	410
Others	100	2,308	420-400

2-3 Formulation of replace Plan for deteriorated Facilities

- To select facilities, such as pipes, valves, pumps electrical facilities, machines and others, to replace urgently based on diagnosis including EBRD project
- To formulate replace plan for facilities of water supply until target year

Table 2-4 Necessary Volumes of Reservoirs

Item	Name	Volume 10^3m^3	Distribution Capacity $10^3m^3/d$	Necessary Volume 10^3m^3	Elevation m
Minimum requirement: 4hr	Min. flow	265.2	---	---	---
	Max. flow	327.2	---	---	---
Existing reservoir	Kadirya WTP	30	1375	199	453
	Kibray WTP	10	455	66	485
	Boz-su WTP	30	235	9	490
	Mirzo-Urgubek P/S	25	720	---	490
	South WTP	10	143	14	510
	Sergeli WTP	2	40	5	400
	Bectimir WTP	1	20	2	420
	Chilanzar P/S	25	72		440
	Sergeli P/S	12	72		400
Total		145		295	

2-4 Review and formulation of proper distribution network system: Fig. 2-2(1), 2-2(2), 2-3

- To review and evaluate for current distribution network and its operation
- To divide distribution area for network to adapt to future distribution flow pattern and to abolish booster pump stations in the city
- To plan arrangement and location for service reservoirs including newly constructed ones, which existing reservoirs located in Kadirya WTP, Kibray WTP, Boz-su WTP and Mirzo-Urgubek P/S (pump station) are new ones will be planed to constructed in these facilities and proper elevation in the city
- To plan necessary new distribution pipes to divide distribution area and to distribute by gravity
- To plan monitoring and control system for whole distribution network in the city and to plan to construct a control room at Kadirya WTP or Vodokanal head office

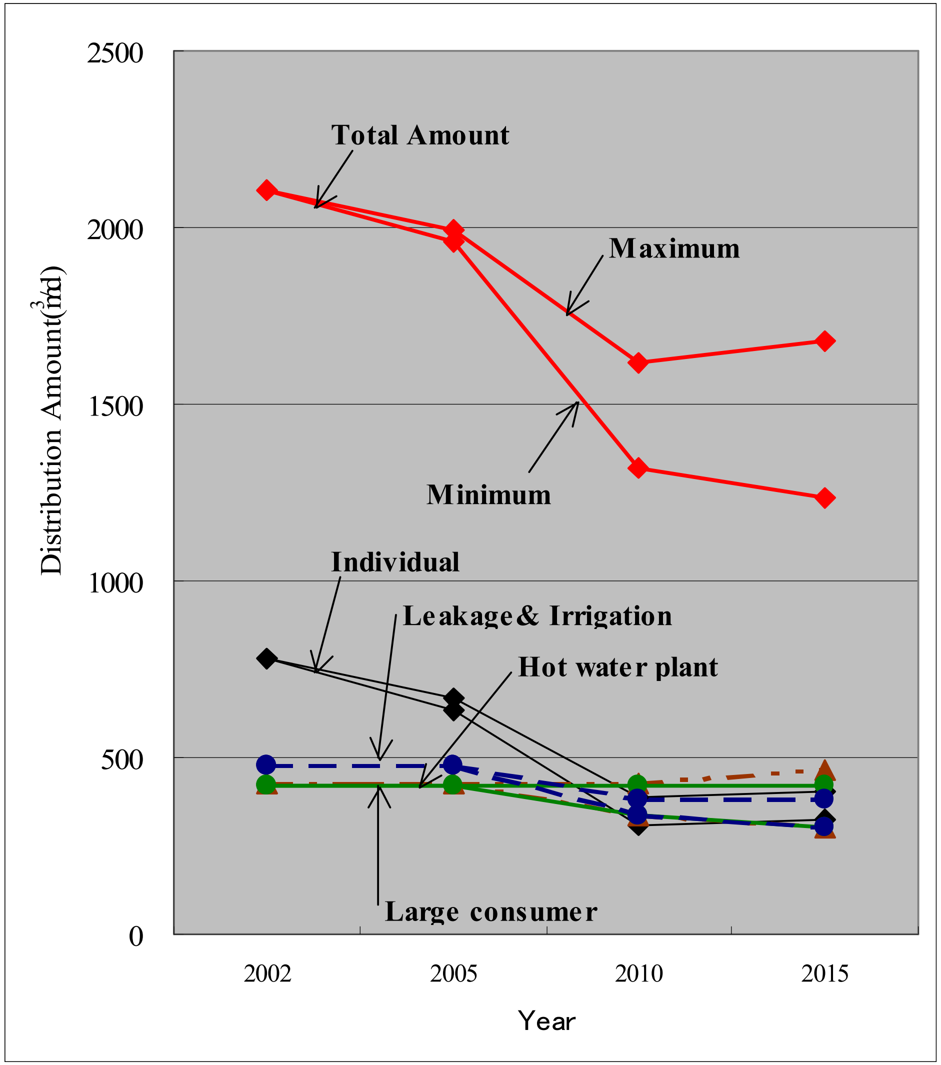
2-5 Reconstruction for System of Kibray WTP: Fig 2-2(2), Fig.2-4

- To reconstruct intake system for Kibray WTP: construction of underground intake infiltration pipes along Chirchik river and intake wells installed pumps
- To construct large capacity of reservoir
- To change distribution system: surrounding area of the WTP is distributed by pumps and the southern area of the city is distributed by gravity

2-6 Formulation of Proper O&M System

- To Evaluate of proper Q&M cost for planned system
- To list up for necessary manual
- To formulate necessary training program for O&M staff

Item		Division		2002	2005	2010	2015
Service population ($x10^3$)		Apart		1,080	1,080	1,080	1,080
		Detached		600	624	689	761
		Total		1,680	1,704	1,769	1,841
Meter Installation Rate (%)	Individual	Apart		10	30	100	100
		Detached		33	70	100	100
	Large			95	99	100	100
Consumption (L/capita/d)	Individual	Apartment	Min	538	454	160	160
			Max	538	466	200	200
		Detached H	Min	334	230	200	200
			Max	334	265	250	250
Consumption ($10^3m^3/d$)	Individual	Apartment	Min	581	490	173	173
			Max	581	503	216	216
		Detached H	Min	200	144	138	152
			Max	200	165	172	190
		Total	Min	781	634	311	325
			Max	781	669	388	406
	Large	Badgetary and others	Min	424	424	339	305
			Max	424	424	424	467
		Hot water plant	Min	421	421	337	303
			Max	421	421	421	421
		Total	Min	845	845	676	608
			Max	845	845	845	888
Leakage from pipes and irrigation water			Min	480	480	336	302
			Max	480	480	384	384
Distribution Quantity (m^3/d)			Min	2,107	1,959	1,323	1,236
			Max	2,107	1,994	1,618	1,678



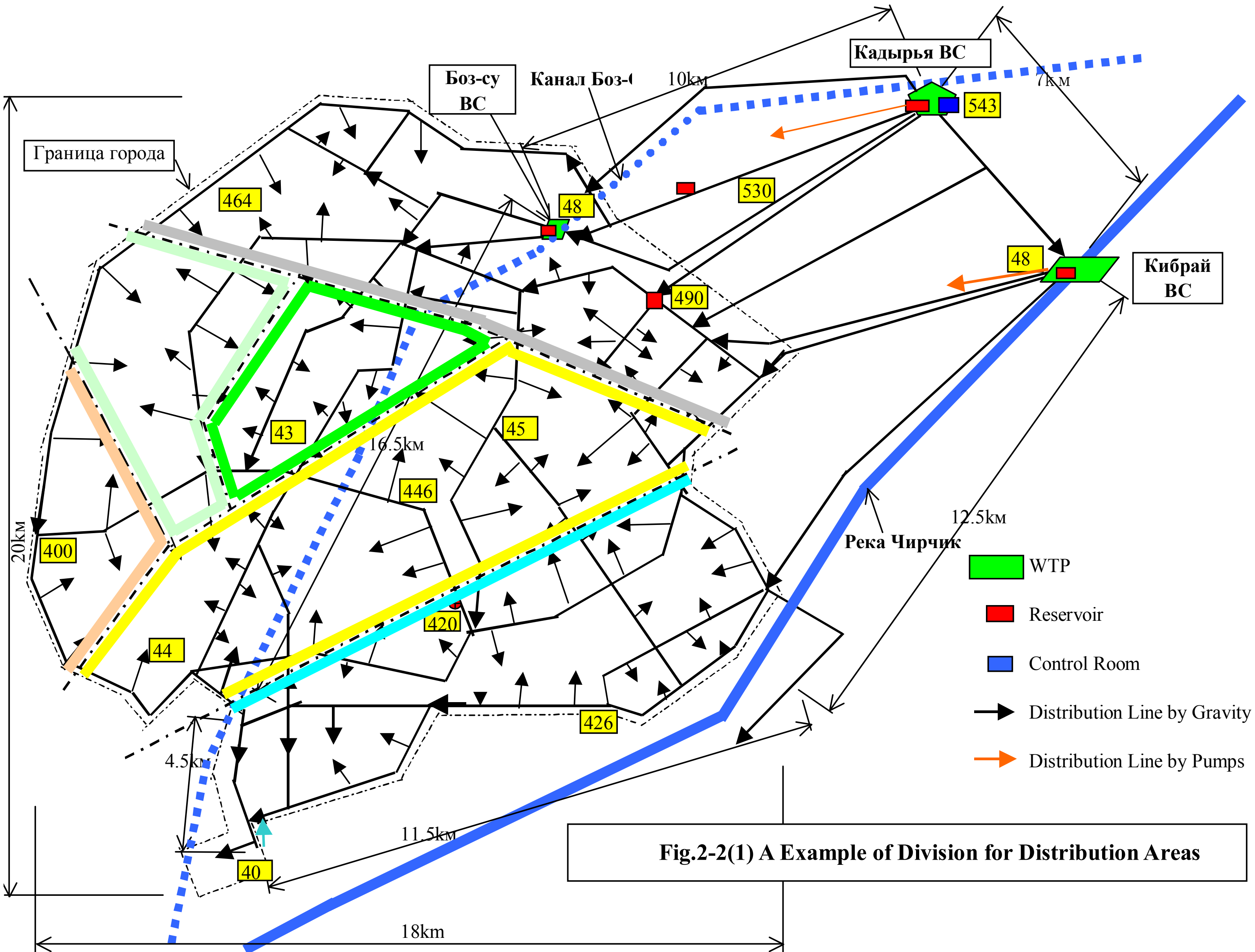
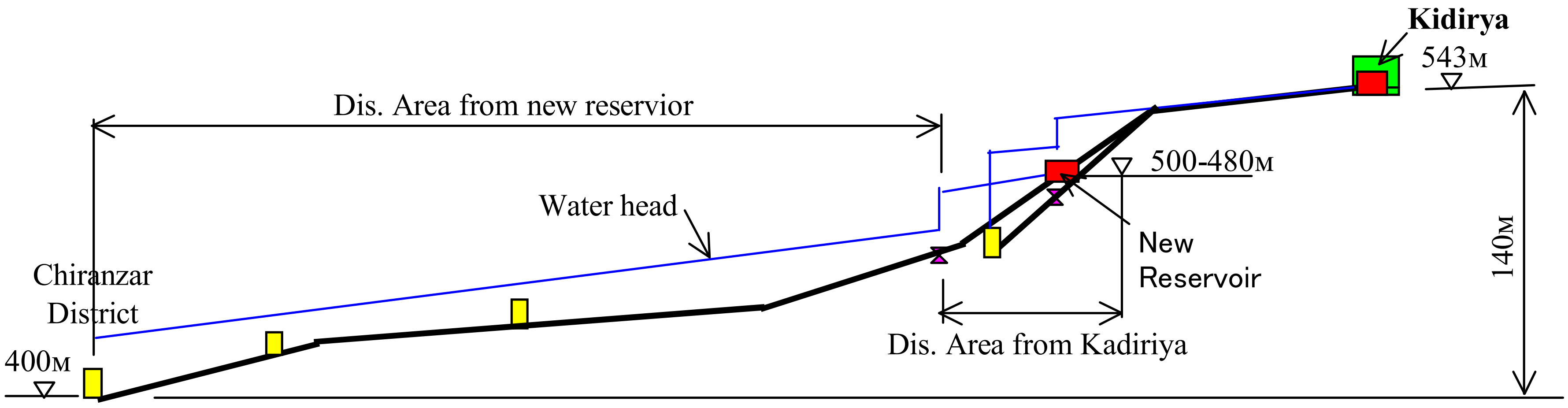
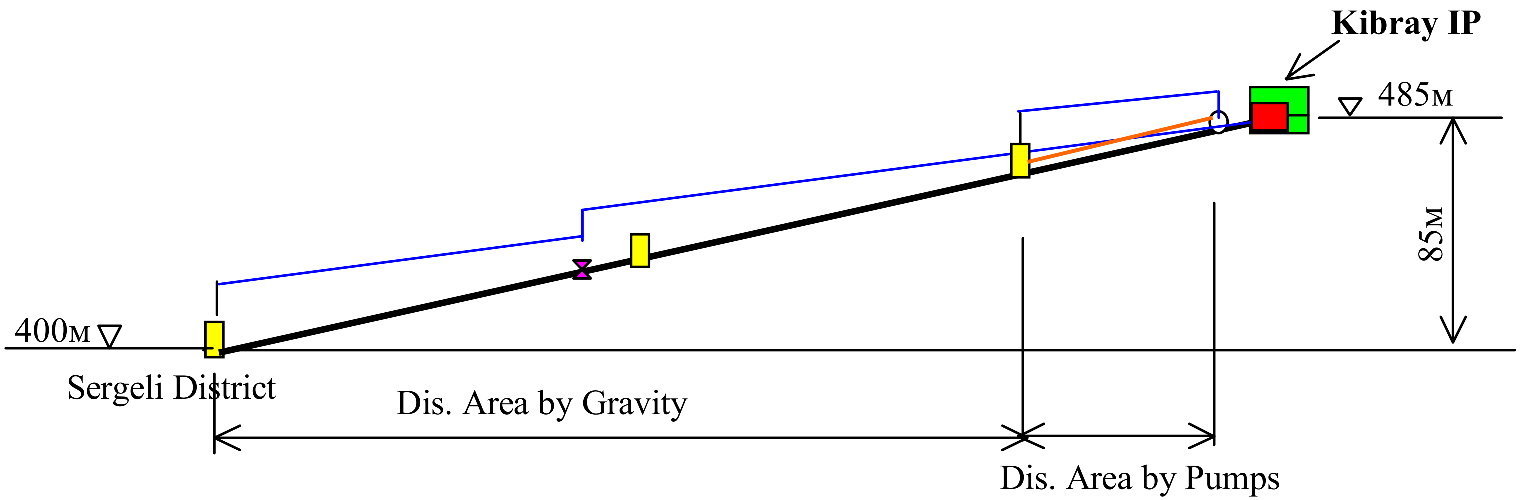


Fig.2-2(1) A Example of Division for Distribution Areas



Water Distribution System from Kadirya WTP



Water Distribution System from Kibray WTP

Figure 2.2 (2) Distribution System from Kadriya and Kibray

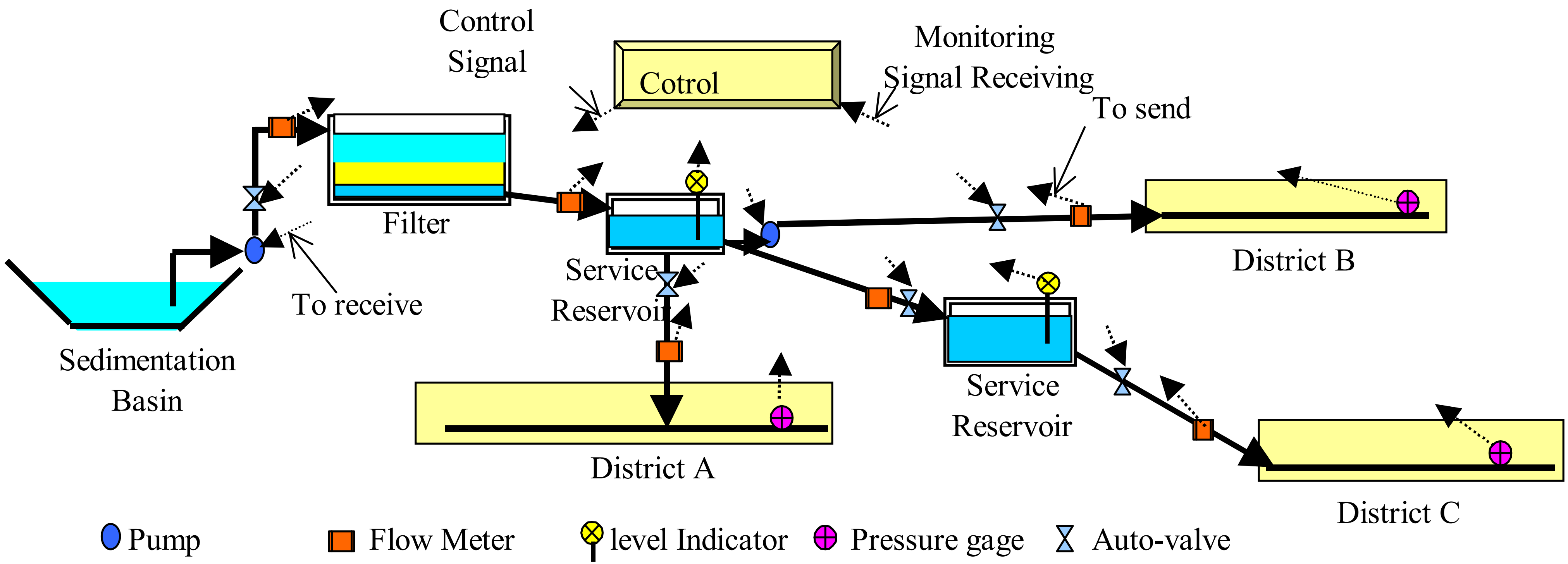
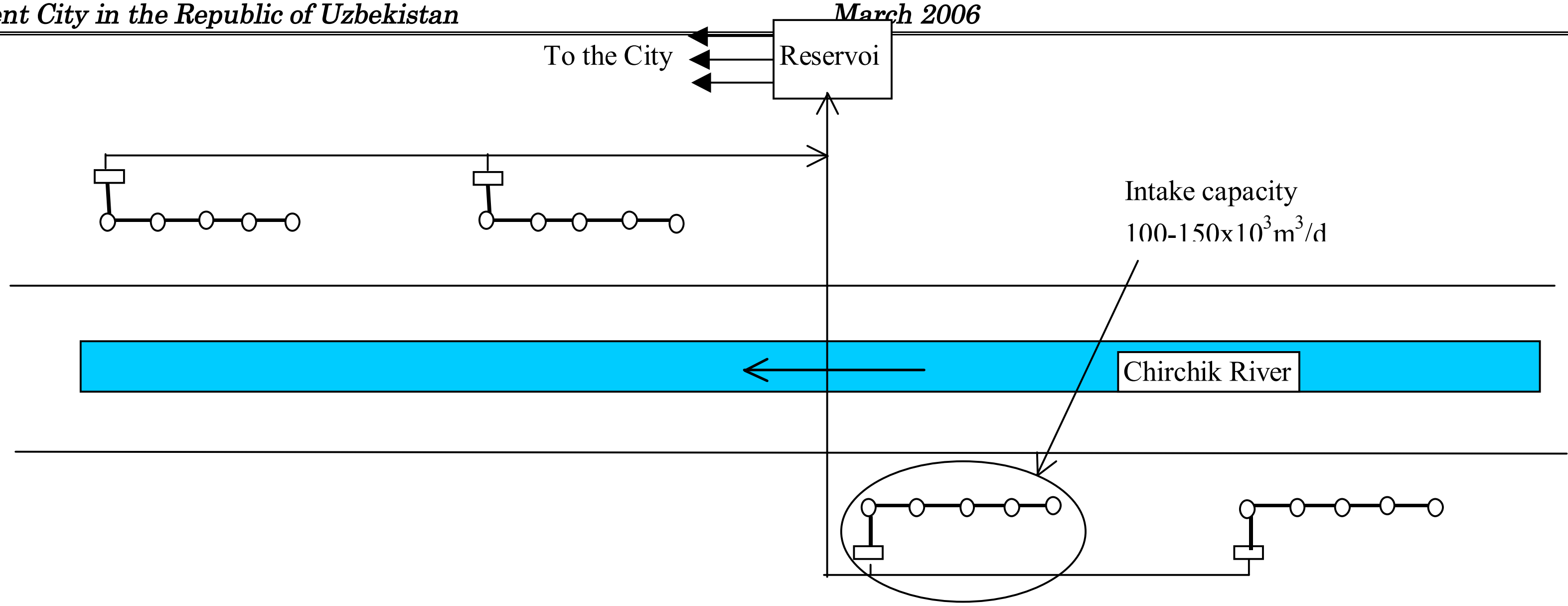
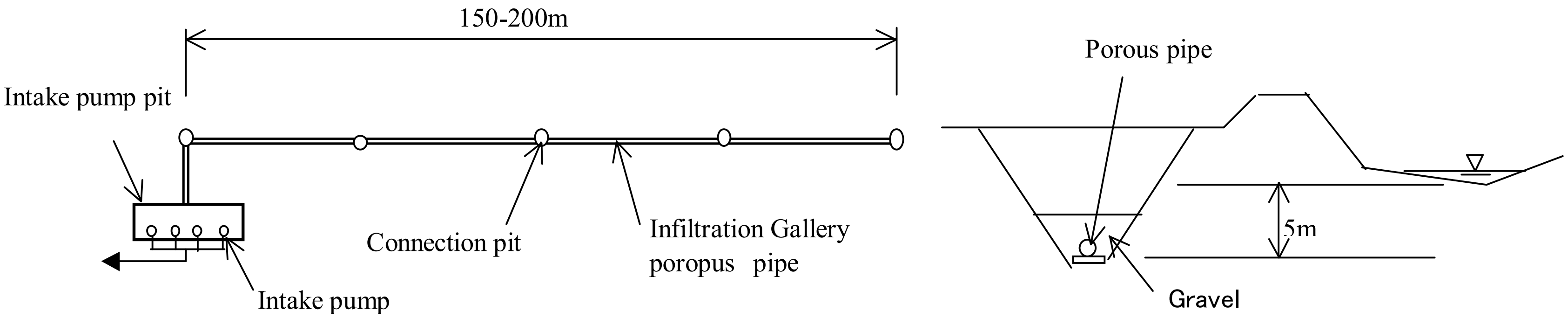


Fig.2-3 Control and Monitoring System



Layout Plan of Infilteration Intake Facilities



Plan

Section

A Example for Structure of Infiltration Facilities

Fig.2-４ Infiltration Facilities for Kibray WTP

Note: Reduction of Electricity consumption

Table 2-2 shows the unit electricity consumption of each facility.

Shown as the table, the unit consumption of Kadirya WTP is the smallest as WTP because of gravity distribution to the city and additionally that of Kadirya will be reduced thanks to replacement of pumps.

Table 2-2 Unit Electricity Consumption

Name	Capacity $10^3m^3/d$	Year	Daily average: Dis. amount $10^3m^3/d$	Daily average: Electricity $10^3kwh/d$	Unit consumption m^3/kwh
Kadirya	1,375	2000	1,360	220	0.162
		2001	1,342	222	0.166
		2002	1,260	220	0.175
Kibray	455	2000	407	179	0.439
		2001	381	167	0.438
		2002	364	149	0.411
Boz-su	235	2000	255	71	0.277
		2001	250	69	0.276
		2002	233	69	0.295
South	143	2000	168	62	0.372
		2001	143	66	0.463
		2002	143	51	0.359
Others	100	2000	95	20	0.208
		2001	72	19	0.260
		2002	70	19	0.275
Booster P/Ss	For all dis. water	2000	2,285	207	0.090
		2001	2,187	213	0.097
		2002	2,066	243	0.118

If the intake system of Kibray WTP is reconstructed and the distribution system is also improved, as before mentioned, the unit electricity consumption will be reduced sharply as shown in Table 2-3.

Table 2-3 Reduction of Electricity Cost

Year		Water dis. amount $106m^3/y$	Electricity consumption $10^6kwh/y$	Unit consumption: Total kwH/m3	Unit consumption: Booster P/S kwH/m^3	Electricity cost: Annual 10^6Soum	Electricity cost: Unit $Soum/m^3$	Electricity cost: Unit Soum/ kwh
2000		833.9	276.7	0.332	0.090	1,107	1.3	4.0
2001		798.4	276.3	0.346	0.097	1,540	1.9	5.6
2002		754.1	294.6	0.391	0.118	2,338	3.1	7.9
2010	Improved system	511	81.76	0.160	0.000	1,308	2.6	16.0
	Current system	511	178.85	0.350	0.000	2,862	5.6	16.0
	Difference	----	97.09	0.190	0.000	1,553	3.0	----

(7) 30th January- Introduction of Master Plan

Outline of Master Plan

JICA Study Team

1. Major Point of Technical Issue

(1) Deterioration of Facilities

Many water supply facilities have been deteriorated, because most of them were constructed before 1980 and proper investment for replacement has not been conducted.

Some of the major facilities such as intake pumps and pipelines need to be urgently replaced.

If these replacements are not conducted, serious breakdowns will take place.

(2) Capacity Decline of Wells

There are six IPs in Tashkent City, and the intake capacities of the majority of wells are lowering and well pumps frequently break down. The condition of wells at left bank in Kibray IP is serious, and these deep wells can be judged that their type is not suitable for the location and hydro-geographical condition.

(3) Unreasonable Distribution Network and Operation

Basically, the major WTPs (Kadirya and Boz-su) and IP (Kibray) are located in high place compared with the city, thus the location of water supply system is so ideal in Tashkent City that most of distribution water should be able to supply by gravity. However while the level difference between these facilities and some part of the city are too large, valves of pipelines squeezed so that the high pressure does not breaks down the pipelines and equipment of consumers. As the result, water pressure in the city is so low that booster P/Ss, which exceed s 100, need to be constructed all around the city.

(4) Lack of Regulation Ability for Distribution System

The distribution flow from each WTP and IP is currently almost flat. However in the future, the flow fluctuation will be expanded according to decrease of water consumption in the city through the progress of meter installation and reduction of water leakage by replacing pipes.

Current retention time of reservoir in the city is too small to regulate the flow fluctuation and manual pump operation needs to be changed to automatic operation.

(5) Inappropriate Operation and Maintenance Manner

For appropriate O & M, a sufficient budget, proper manuals, proper trainings for staff and necessary number of staff are necessary. In Tashkent City the staff is working hard to carry out their responsibility, however Tashkent Vodokanal lacks sufficient budget, proper manuals and proper trainings for staff to undertake appropriate O&M.

2.Water Demand Projection

Table 2-1Water Demand and Distribution Projection ($10^3m^3/d$)

Division		2002	2005	2007	2009	2010	2011	2015
Individuals	Max	850.7	677.2	487.1	297.0	297.1	297.3	297.6
	Mid	850.7	720.8	506.3	291.7	318.4	315.1	311.8
	Min	850.7	634.2	529.2	424.1	413.6	400.1	386.5
Large Consumers	Max	896.0	841.8	805.7	769.5	751.4	706.3	661.1
	Mid	896.0	864.8	843.9	823.1	812.7	786.7	760.7
	Min	896.0	883.7	875.6	867.4	863.3	853.1	842.9
Water Loss	Max	1,153	835.5	835.5	723.9	523.4	323	323
	Mid	1,153	886.8	886.8	789.1	613.7	438	438
	Min	1,153	938.0	938.0	808.2	680.9	554	554
Total	Max	2,900	2,354	2,128	1,790	1,572	1,327	1,282
	Mid	2,900	2,472	2,237	1,904	1,745	1,540	1,511
	Min	2,900	2,456	2,343	2,100	1,958	1,807	1,783
Water Loss Rate(%)	Max	40	35	39	40	33	24	25
	Mid	40	36	40	41	35	28	29
	Min	40	38	40	38	35	31	31

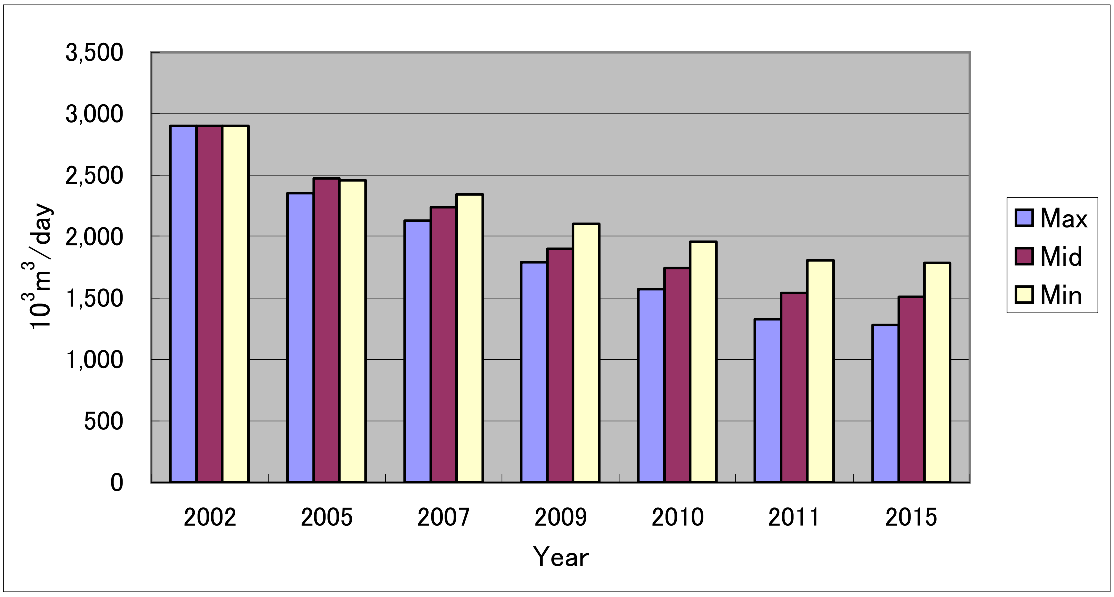


Figure 2-2 Reduction of Total Distribution Quantity

3.Design Water Quantity and Selection of WTP

Table 3-1List of WTPs and IPs in Tashkent City

Division	Name	Supply Capacity				Elevation (m)
		Nominal ($10^3/m^3/d$)	Rate (%)	Real Max ($10^3/m^3/d$)	Rate (%)	
Large scale & high place	Kadirya WTP	1,375.0	58.5	2,200	68.6	540
	Kibray IP	455.2	19.4	470	14.7	495
	Boz-su WTP	235.6	10.0	260	8.1	485
	Sub-total	2,065.8	87.9	2,930.0	91.4	
Small scale & low place	South IP	143.0	6.1	160	5.0	420
	Sergeli IP	40.0	1.7	35	1.1	400
	Kara-su IP	52.2	2.2	35	1.1	420
	Kuiluk IP	25.0	1.1	31	1.0	420
	Bactemir IP	25.0	1.1	15	0.5	400
	Sub-total	285.2	12.1	276	8.6	
	Total	2,351.0	100.0	3,206.0	100.0	

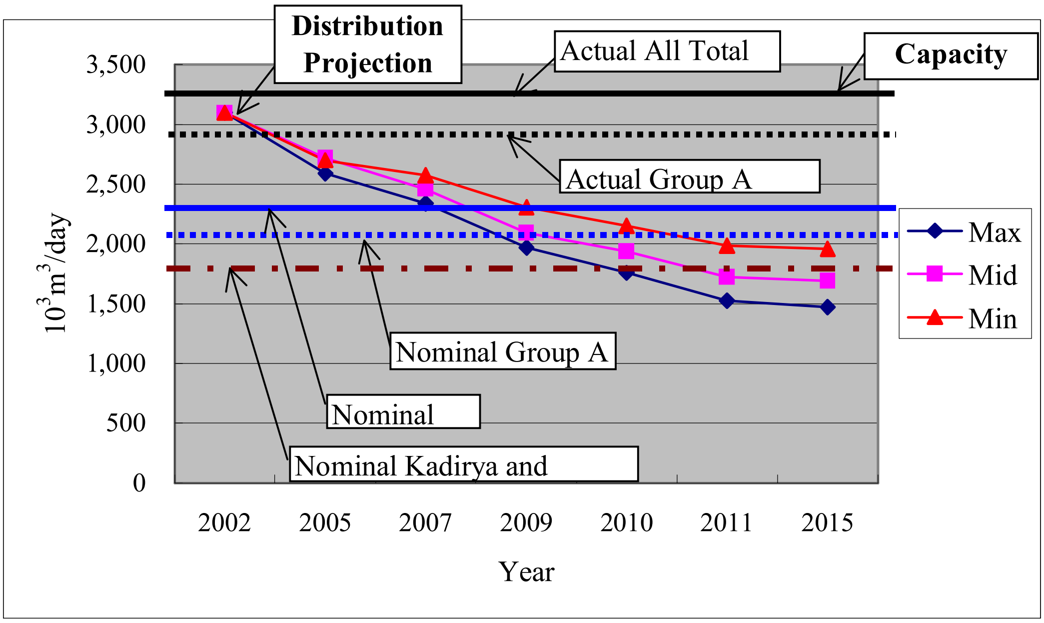


Figure 3-2Comparison of Distribution Quantity and Water Source Capacity

Table3-3 Unit Cost and Staff Number of WTPs and IPs

WTP, IP Name	Unit cost (soum/m^3)	Staff number
Kadirya WTP	1.2	180
Boz-zu WTP	2.6	140
Kibray IP	3.4	193

South IP	2.9	115
Others IPs	1.9	210

4. Replacements and Improvement of Kadirya WTP

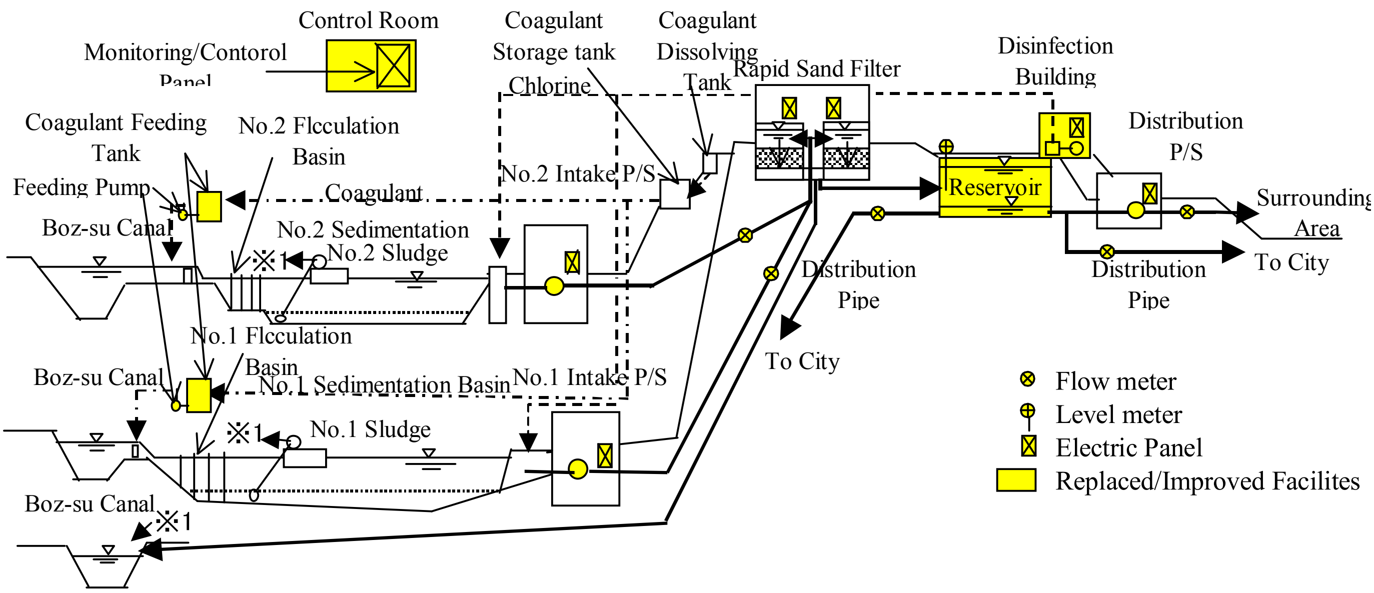


Figure 4-1Improved Flow Sheet of Kadirya WTP

5.Reconstruction of Kibray IP

(1) Problem of Intake method in Left Bank

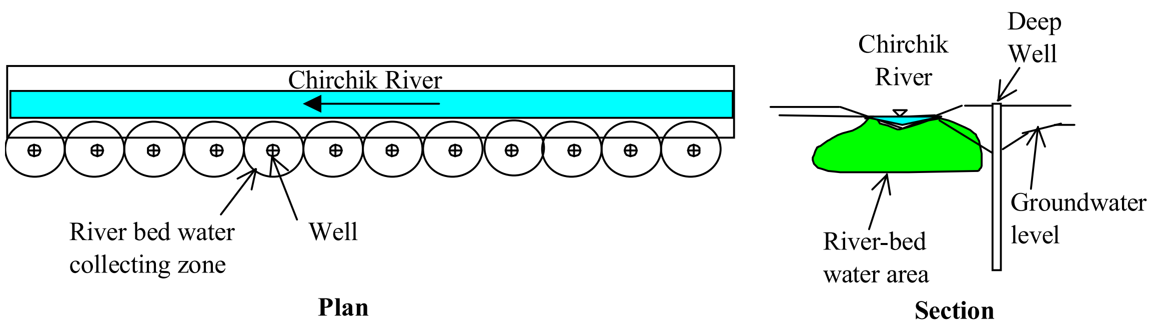


Figure 5-1 Present Intake Method in Left Bank

(2) Water Quality

Water quality is shown in **Table 5-1**.

(3) Reconstruction Plan

Structures of intake facilities are shown **Figure 5-2**, and layout of facilities is shown in **Figure 5-3**.

6. Improvement of Water Distribution Network

Figure 6-1 shows division of proposed distribution network, and pump stations are only Boz-su and Mirzo-Ulbek. **Figure 6-2** shows calculated pressure level of the city by proposed network.

Table 5-1 Water Quality in Kibray IP(2003)

IP Name			Kibray Right			Kibray Left		
Analyzed Well Number			20			32		
Constituent	Unit	Standard Value	Average	Range	Out of standard	Average	Range	Out of standard
Color	degree	20	0	0		0		
Taste	number	2	0	0		0		
Odor	number	2	0	0		0		
Turbidity	mg/l	1.5	0	0		0		
pH value	--	6 - 9	7.2	7.15-7.25		7.4	7.17-7.5	
Total Hardness	meq/l	7	**5.9**	**5.75-6.4**		**4.0**	**3.1-4.5**	
Ammonia (NH4)	mg/l	0	0	0		0	0	
Nitrite (NO2)	mg/l	3	0	0		0	0	
Nitrate (NO3)	mg/l	45	**36.9**	**20-57**	**8**	**8.0**	**5.31-12.55**	
Cloride (Cl)	mg/l	250	9.9	7.5-11		10.4	9.5-14	
Total Iron (T-Fe)	mg/l	0.3	0	0		0	0	
Sulphate (SO4)	mg/l	400	65.0	46-78.5		51.1	41.5-67	
Total Solids (TDS)	mg/l	1000	**411**	**380-432**		**223**	**158-260**	

7. Replacement of Pipeline

Table 7-1Diameter Range and Suitable Pipes Material for Replace

Diameter Range	Current materials			Suitable materials
	Steel	Cast Iron	Total	
25-150	253.4	18.6	272.0	Vinyl chloride pipe
200-600	77.4	47.3	124.7	Ductile iron pipe
700-1400	25.3	0	25.3	Steel pipe
Total	356.1	65.9	422.0	

8. Schedule of Project

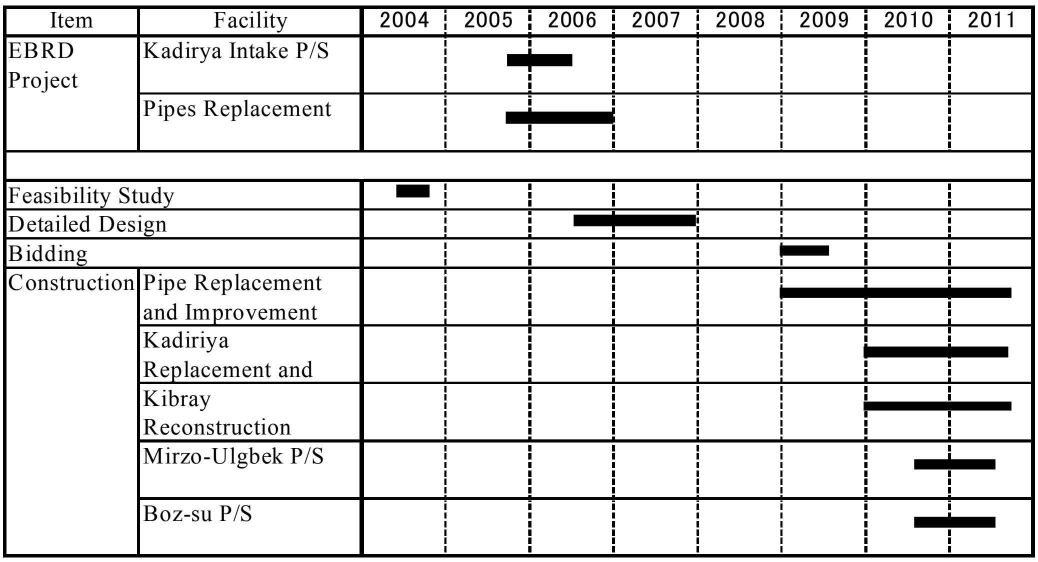


Figure 8-1 Schedule of Project

9. Reduction of Operation Cost

Table 9-1 Electricity Cost

Name	Unit consumption		Water Distribution		Electricity Consumption			Cost	
	kwh/m^3		103m3/d		106kwh/y	103kwh/d	106kwh/y	106Soum/y	
	2002	2015	2002	2015	2002	2015	2015	2002	2015
Kadirya	0.11	0.11	2100.0	1138.0	80.3	125.2	45.7	642.4	365.5
Kibray	0.34	0.11	353.5	373.0	54.6	41.0	15.0	436.8	119.8
Booster P/S	0.12	0.06	2900.0	1511.0	88.2	22.0	8.1	705.6	8.1
Others			446.5	0.0	51.0	0.0	0.0	408.0	0.0
Total			2900.0	1511.0	274.1	188.2	68.8	2192.8	493.4

Table 9-2 Chemical cost

Name	Chemical Name	Unit consumption		Distribution		Consumption		Cost	
		mg/L		103m3/d		t/d	t/year	106Soum/y	
		2002	2015	2002	2015	2015	2015	2002	2015
Kadirya	Coagulant	2.0	10.0	2,100.0	1,138.0	11.4	4,153.7	165.3	447.8
	Liquid Chlorine	0.7	0.7		1,138.0	0.8	282.5	83.7	45.2
Kibray	Chlorine	0.4	0.4	353.5	373.0	0.1	49.0	7.5	7.8
Others	Coagulant			446.5				113.0	0.0
	Liquid Chlorine							14.8	0.0
	Solid Chorine							9.7	0.0

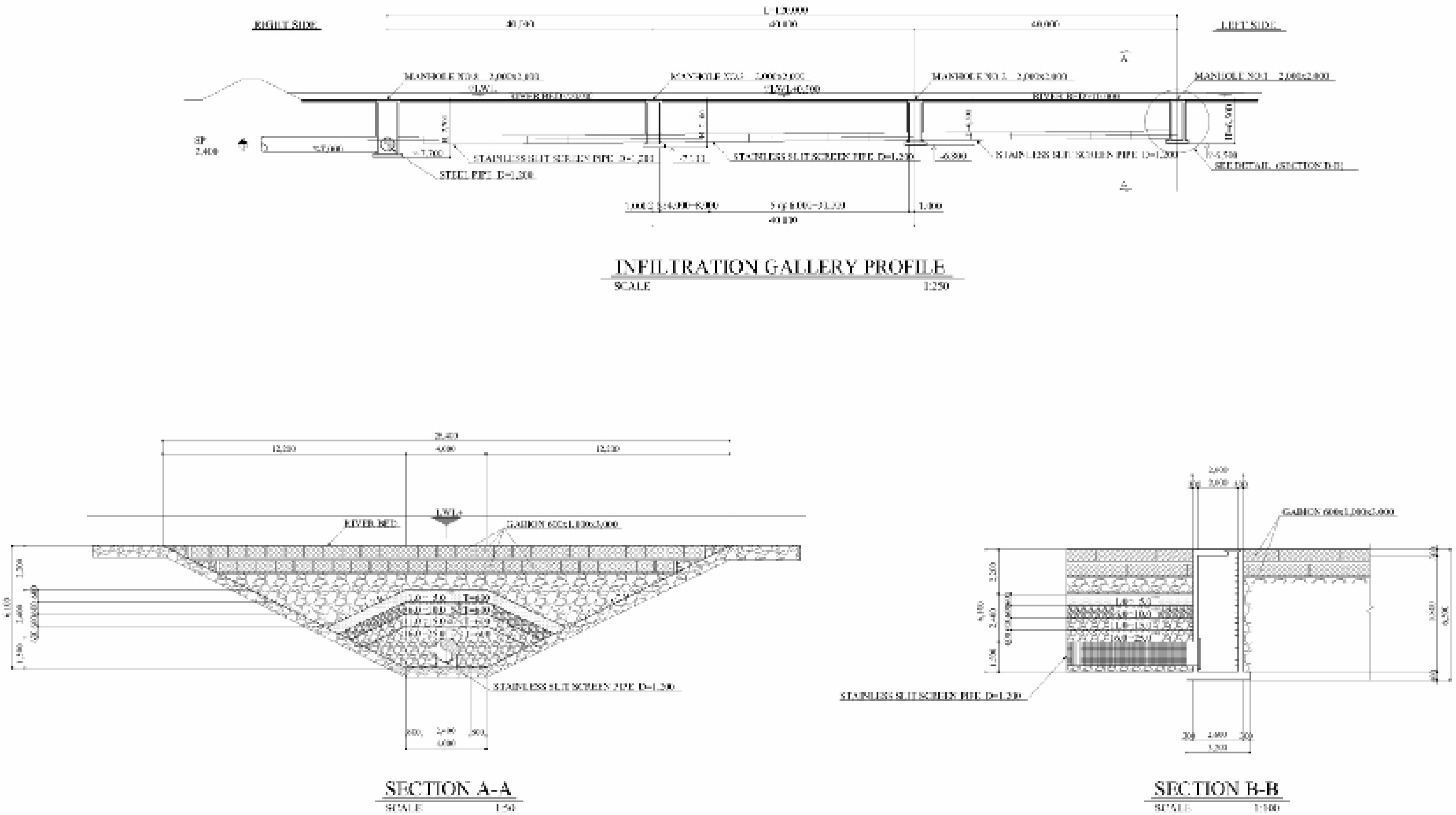
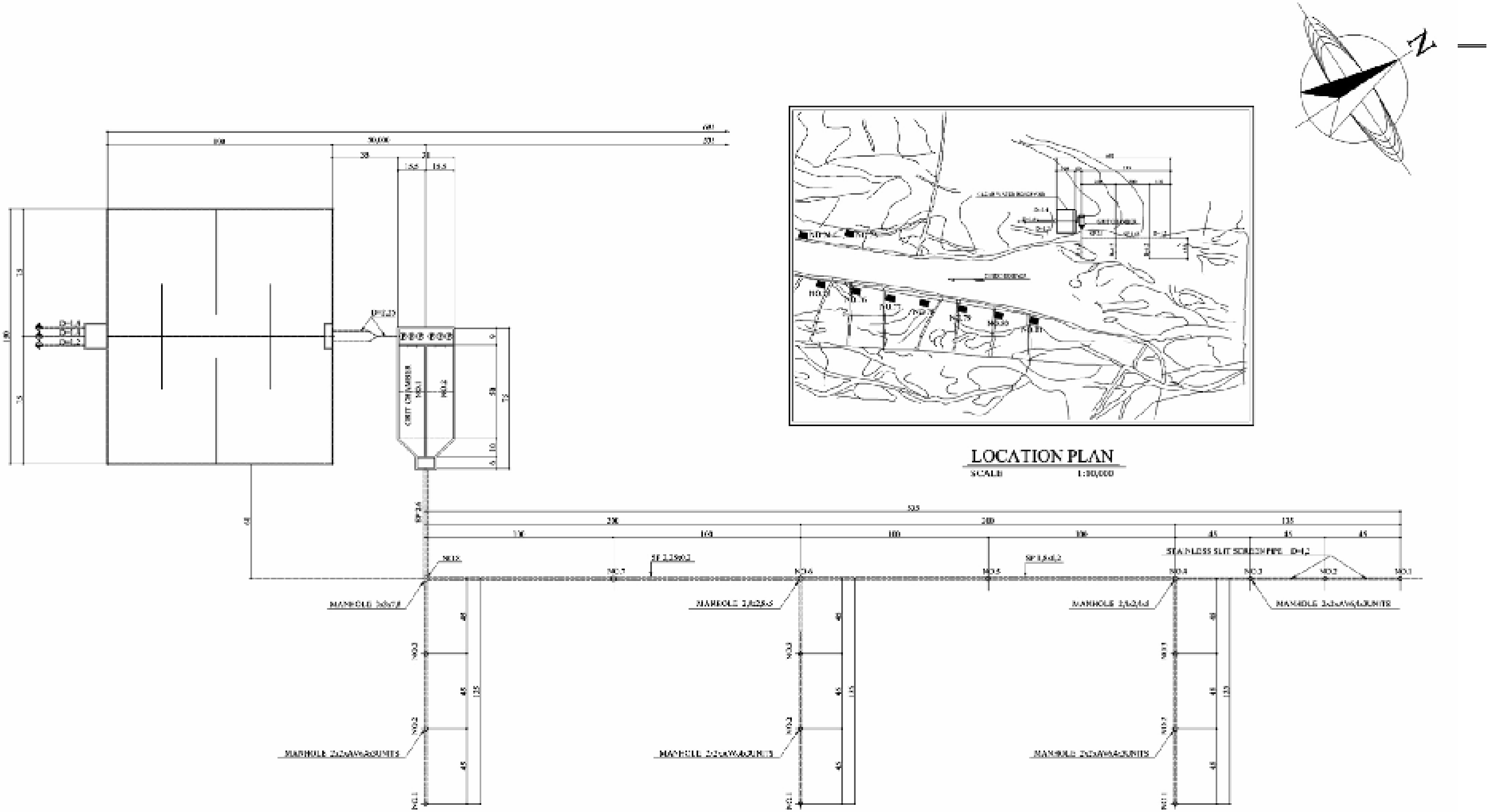


Figure 5-2 Structures of Intake Facilities



LOCATION PLAN
SCALE 1:50,000

LAYOUT OF KIBRAY INFILTRATION GALLERY
SCALE 1:1,500

Figure 5-3 Arrangements of Intake Facilities

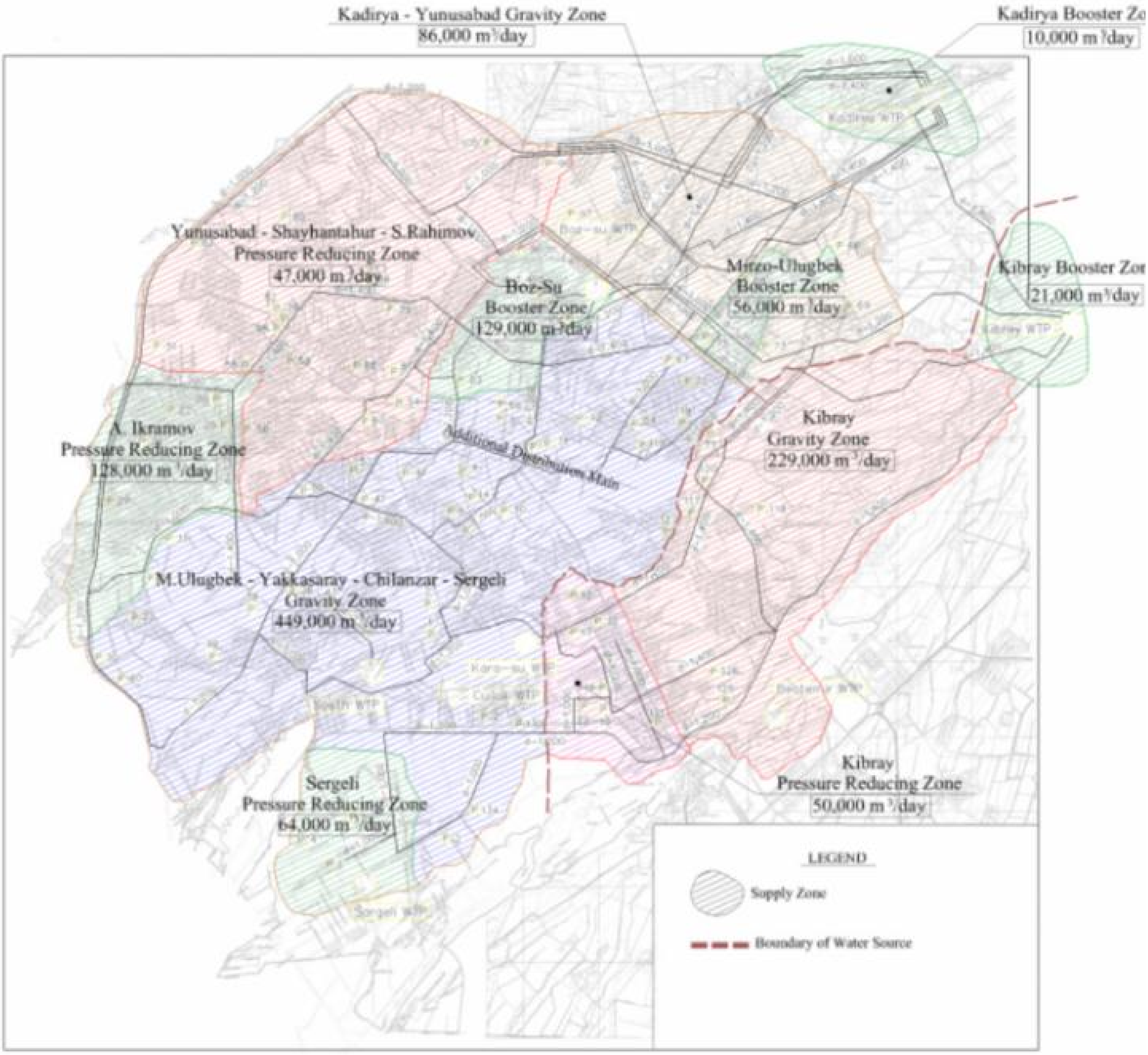


Figure 6-1 Location of Distribution Zones

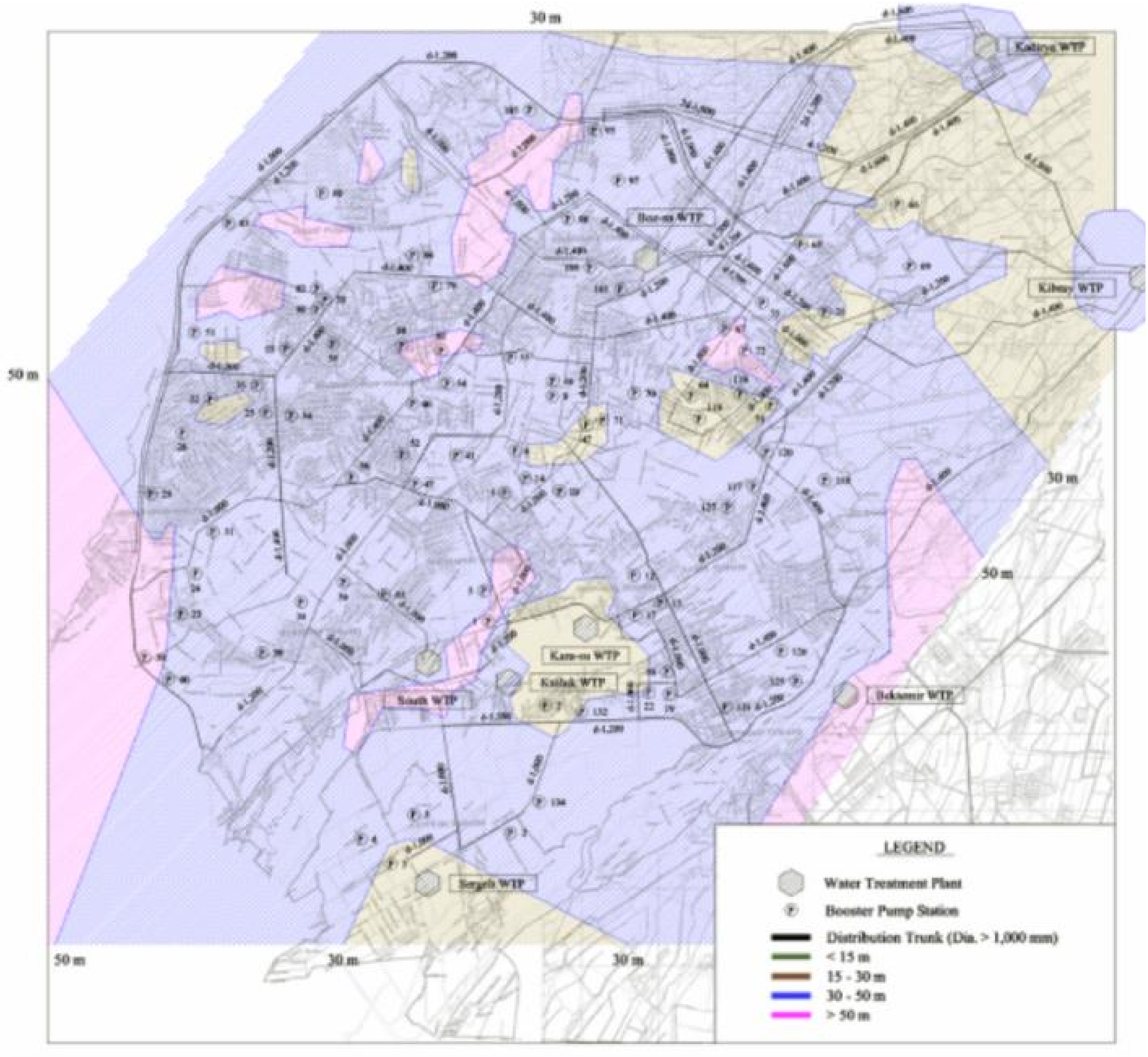


Figure 6-2 Pressure Distribution in Target Year