Since the above-mentioned (a),(b), (d), (e), (f) and (g) have no relation with the objective four rivers, the reserved flow can be set from the viewpoints of maintaining and restoring the water familiarity functions in (c), (h), and (i) above.

No formula has been established to estimate the amount of reserved flow objected restoring and utilizing the water familiarity functions. There were some examples to estimate reserved flow, when recall of the fishes was intended, calculation was made from the flow velocity and water depth, influence the living action of objective fishes, and when the flow restore was intended to satisfy the spectacle, estimation was made from the desirable water width and flow velocity.

The reserved flow was, therefore, calculated based on the width of the river forming a beautiful view. The means of securing the reserved flow was then studied. If this application is technologically and economically inappropriate, a second plan in which only the surface of the areas with demands for high water familiarity functions shall be structured, shall be formulated.

4.3.4 Target of River Space Improvement Plan

In the Seoul Metropolitan area, improvement of parks and green zones was promoted by taking the advantage of the opportunity of the Seoul Olympic in 1988. However, the per capita park area still remains at a level of 8.3 m^2 (as of 1989) and that of city parks provided with facilities is only 2.7 m^2 (1988), with large differences between each zone.

In addition, the budget of Seoul Metropolitan for environment and green zones makes the acquisition of new land for parks difficult in the city area due to the increased demand for roads and parking lots and sudden rises in land price, while the ratio of the budget to the whole budget of the city shows an annually increasing trend. Therefore, it is presumed that the intended target of

Seoul Metropolitan of acquiring park areas to a level of 14.9 m^2/head within 2000's may be difficult.

There is always a possibility that the river space could be flooded. However, the area shall bring about large socio-economical impacts if restructured as a park, because it can be acquired freely as well as the fact that it is rich in trees and greeneries.

Therefore, the per capita area of the city parks in the Seoul Metropolitan area, when the entire planned areas are improved, is calculated on the assumption that improved river spaces will be used as city parks (Table 4.2-1). The results show that only 20% may be increased even in the expected sections. On the contrary, in the some sections, the per capita park area will be decreased due to the rapid population growth when the original city parks are not improved.

Therefore, the river space improvement plan shall cover the entire planned areas in the studied rivers.

Table 4.3-1 Areal Change of Urban Park per Person When the Planned Section Would be Improved

Unit:m^3/per

River/Bank	Section	1988	2002	2010
Anyang Chong				
Right bank	Upper reach of the confluence of Torim Chong	1.12	0.88	1.27
	Lower reach of the confluence of Torim Chong	2.58	2.47	3.10
Left bank	Lower Reach of St.6	0.25	0.35	0.82
Yangjae Chong				
Right bank	Upper reach of St.2	4.1	3.8	3.8
	Lower Reach of St.2	4.5	4.18	4.3
Left bank	Upper reach of St.2	4.1	3.8	3.8
	Lower Reach of St.2	4.5	4.18	4.3
Ui Chong				
Right bank	Upper reach of St.2	5.2	4.7	4.6
	Lower Reach of St.2	2.7	2.3	2.2
Left bank	Upper reach of St.2	5.2	4.7	4.6
	Lower Reach of St.2	3.2	2.9	2.7
Chungroung Chong				
Right Bank		2.92	2.57	2.45
Left bank		2.92	2.57	2.45

* Figures above shown does not contain the water area. When the water quality of the river were improved, the water area should be contained in the urban park area.

4.4 Needs of Residents for River Environment Improvement

The results of the questionnairing distributed during the survey, indicate that most of the residents share the same opinion about the present condition of the 4 rivers studied. They stated that " the rivers are contaminated," "the river beds are devastated," and that "there is little familiarity with the river water". Moreover, about 70% of the residents stated that "the rivers are not suitable places for recreation and relaxation" and as " children's playground."

A few residents think that "the present condition of the rivers is okay", but more than 90% think that "the contaminated rivers should be cleaned" and that to do so, "necessary regulations should be actively stipulated." The common requests stated were " the transformation of the river spaces into parks for recreation and relaxation", "water quality must be must be improved and basic conditions must be provided to create familiarity with the river water," and "river spaces must be improved so that people can commune with nature." As for Ui Chong and Chungroung Chong, however, the demand "to place the rivers in box culverts" was stronger than the demand "to maintain the natural use of the rivers."

The results of the interview conducted to the users of the Han River Park show that 60% of the frequent visitors of the park live within 30 minutes walking distance. 40% of these visitors frequent the park for a stroll. 80% of the users indicate satisfaction with the park facilities, while very few think that the park structure is in harmony with nature.

4.5 Future River Water Quality

4.5.1 Prediction Method of Future River Water Quality

When a water quality improving measure applicable to a river channel is to be established and the effect of the measure is to be evaluated, it is necessary to use the river water quality realized at the time when the measure is implemented as a base. The method for estimating the future river water quality may vary depending upon the kind and accuracy of available data, and, in this plan, the future water quality is calculated in the following manner:

(1) The future river water quality is calculated by the following formula:

(Future generation load) x (Future apparent run-off ratio)

(2) There are a few rivers where the flow rate and pollution load are not well balanced between each reference point due to the effects of sewage directly flowing into the rivers and latent flows. Therefore, the future river water quality is calculated individually at each reference point and no adjustment must be made to the continuity of the balance between them.

(3) The future generation load is calculated from the future frame described in the following paragraph by using the generation load calculating method described in 3.5.2 above. It is assumed that the generation unit load will not change from the present condition.

(4) The future "apparent run-off of ratio" is largely influenced by the improved condition of sewerage and intercepting sewers. Therefore, when the sewerage and intercepting sewers is not improved, the future "apparent run-off ratio" is used present one, and when sufficient repair and improvement are expected to

the facilities, future "apparent run-off ratio" is considered to be improved to 0.02 in BOD and 0.07 in SS on the basis of the values of the smallest "apparent run-off ratio" at present.

(5) Since the present river flow is the mixture of that of its original river water and that of sewage, the future flow naturally decreases when the intercepting rate of sewage is increased. The actual river flow, when its sewerage-related facility is improved, is obtained by the proportional allotment of the measured discharge to the water quality of the sewage of the Seoul Metropolitan and the original water quality of the river (water quality at the water source section of the river).

(6) The self-purification of the rivers is not taken into account, because the estimation is rough in accuracy.

4.5.2 Future Framework of the Basin

While the future river water quality is calculated by multiplying the future generation load and "apparent run-off ratio" in the basin, the framework in the future, being the basement factors of the mentioned loads and factors, such as future population, land use, and the quantity of industrial waste water are set in the following manner:

the future population of each basin is calculated by distributing the estimated populations by administrative divisions of 2001 and 2010 (shown in Annex A-4) are allocated to the basins in the same manner as used calculating method to the present populations by basins. Populations of intermediate years are decided by linear interpolation from the values of 1988 and 2001 or 2010. Details of the future population of each basin thus estimated and generated domestic population load of each basin calculated on the basis of the estimated future population are given in SUPPORTING REPORT III.

The future area of land use is considered to be unchanged, because, according to the Annex A-4, the policy of the Seoul Metropolitan government is to promote the future demand for land by high-density redevelopment in the developed areas rather than new areal development.

The future quantity of industrial waste water is decided in the same manner as that used for calculating the present quantity of waste water on the assumption that the amount of shipment of all kinds of industries may increase annually 5%. Details of the future quantity of industrial waste water thus estimated and industrial generated pollution load calculated on the basis of the estimated quantity are given on SUPPORTING REPORT III.

Since no drastic change may occur in the number of domestic animals, the present value is used for the future (see Annex H-3).

Calculated results of the ratios of the future generation loads thus calculated to the present generation loads of the planning sections in each river area are shown in Table 4.5-1.

Table 4.5-1 Ratio of Generation Load in Future to Current Generation Load in the Planned Section

Anyang Chong

Source	St.1-2	St.2-4	St.4-5	St.5-6	St.3-
2002/1990(BOD)	1.724	1.679	1.609	1.738	1.497
(SS)	1.423	1.215	1.112	1.422	1.070
2010/1990(BOD)	2.437	2.222	2.090	2.513	1.896
(SS)	2.087	1.732	1.618	2.004	1.592

Yangjae Chong

Source	St.1-2	St.2-4	St.3-
2002/1990(BOD)	2.598	2.624	2.602
(SS)	2.336	2.061	2.131
2010/1990(BOD)	3.238	2.939	3.118
(SS)	2.784	2.196	2.462

Ui Chong

Source	St.1-2	St.2-
2002/1990(BOD)	1.570	1.602
(SS)	1.617	1.659
2010/1990(BOD)	2.032	2.105
(SS)	1.734	1.816

Chungroung Chong

Source	St.1-2	St.2-3	St.3-
2002/1990(BOD)	1.878	1.858	1.793
(SS)	1.720	1.698	1.595
2010/1990(BOD)	2.218	2.207	2.345
(SS)	1.930	1.925	1.888

4.5.3 Predicted Results of River Water Quality

The future water quality at each observation point will be estimated in the manner described in Section 4.5.1 by using the future framework set in Section 4.5.2, and the estimation will be performed on the following cases classified in accordance with the improved and maintained conditions of sewerage facilities.

Anyang Chong

Case - 1: If the present maintenance methods of the sewerage facilities shall not be changed in the future.

Case - 2: The sewage treatment plan in the upstream area of Station 6 shall be executed as scheduled, and the BOD concentration at the (St. 6) upstream end of the planned section shall be improved to 23.7 mg/l (see Annex D-17 for future target). This plan shall only proceed, however, if case I is implemented.

Case - 3: While changes shall be made in the sewage treatment located upstream of Station 6, the sewerage facilities in the Seoul Metropolitan area shall be sufficiently improved and rehabilitated, and the "apparent run-off ratio" shall be improved to 0.02 in BOD and 0.07 in SS.

Case - 4: The sewerage treatment plan in the upstream area of Station 6 shall be executed as scheduled, and the BOD concentration at the (St. 6) upstream end of the planned section shall be improved to 23.7 mg/l. At the same time, the sewerage facilities in the Seoul Metropolitan area shall be sufficiently improved and rehabilitated, and the "apparent run-off ratio" of pollution load" shall be improved to 0.02 in BOD and 0.07 in SS.

Yangjae Chong and Chungroung Chong

Case - 1: Future change shall not be made in the present maintenance methods of the sewerage facilities.

Case - 2: The improvement and rehabilitation of the sewerage facilities shall be sufficiently implemented, and

the "apparent run-off ratio" shall be improved to 0.02 in BOD and 0.07 in SS.

The water quality and sewerage facilities in Ui Chong are considered as favorable, it shall be kept in the same condition in future, too.

The BOD estimates are shown in Table 4.5-2.

Table 4.5-2 Predicted Result of the River Water Quality in Future (BOD)

Unit:mg/l

Anyang Chong

	St. 1	St. 2	St. 4	St. 5	St. 6	St. 3	
	1990	55.5	59.5	52.5	55.7	48.6	22.9
Case-1	2002	148.1	158.9	148.6	164.9	84.5	38.2
	2010	211.3	226.7	213.6	238.4	122.1	48.4
Case-1	2002	110.2	118.2	106.9	115.9	23.7	38.2
	2010	150.0	160.9	146.0	159.0	23.7	48.4
Case-3	2002	86.7	90.0	83.2	92.0	84.5	38.2
	2010	124.5	129.3	119.7	133.0	122.1	48.4
Case-4	2002	39.0	37.7	33.7	35.3	23.7	38.2
	2010	47.3	44.7	39.8	41.2	23.7	48.4

Yangjae Chong

	St. 1	St. 2	St. 4	St. 3
1990	13.5	5.5	5.1	11.2
Case-1 2002	45.3	13.4	5.1	29.0
2010	55.6	15.3	5.1	34.7
Case-1 2002	8.8	7.7	5.1	10.7
2010	10.2	8.5	5.1	12.9

Ui Chong

	St. 1	St. 2
1990	3.5	3.3
2002	5.7	5.4
2010	7.3	7.1

Chungroung Chong

	St. 1	St. 2	St. 3
1990	14.0	11.2	19.0
Case-1 2002	25.5	20.2	34.0
2010	32.4	26.3	44.5
Case-1 2002	6.4	5.5	1.3
2010	7.6	6.7	1.6

4.6 The Existing Water Quality and Flow Regime Improvement Techniques

4.6.1 Applicable Water Quality Improvement Techniques

The water quality improvement techniques considered at present are broadly classified into (a) those applicable to pollution sources, (b) those applicable to the area between the pollution sources and rivers, and (c) those applicable to river channels. Table 4.6-1 further classifies these three techniques, and the necessary precautions to be taken of each are described below:

(1) Applicable techniques to pollution sources

1a Restriction of installation

Locations of factories are large in emitted pollution load and those which may discharge harmful matters are regulated by legislation, etc. The development limitation being applied by the Seoul Metropolitan government is a kind of location regulation. However, it is difficult to apply this kind of regulation to the industrial area like Kuro Industrial Area, already established, because a large amount of expenses may be required for shifting many large-scale factories and compensating factories to be shifted for business suspension. In general, such regulation is applied to an area where its good environment must be maintained from now on by keeping the developed form of its urban zone.

1b Restriction of discharge

When the restriction of installation is impractical, the pollutant content and discharged quantity of waste water from a factory, etc. is to be regulated. In the case of ROK, the waste water emission standards settled by the Natural Environmental Preservation Act correspond to this regulation. No effective results can be expected from such regulation unless the regulation is supported by an executable monitoring system and fair monetary penalty system. Location regulation

1c Installation of waste water treatment plant

In order to control emission concentration of the waste water for the regulation, the treatment plant can be installed in each factory or district. Generally, installation and operation cost must be spent by the private company, its' competitive power will be down in comparison with other competitors who don't need to do so, because production cost must cover

those treatment cost. In the result, there can be a case that factories shift its location to the unregulated area and pollutant sources spread. Therefore, this kind of regulation shall be dutied accompanied with a administrative support like a subsidy for its practical management.

Table 4.6-1 List of Water Quality Improvement Techniques

(1) Countermeasure at the source	1a	Restriction of installation
	1b	Restriction of discharge
	1c	Install waste water treatment plant
(2) Countermeasure between the river and source	2a	Sewerage improvement
	2b	Repair of existing sewer pipes
	2c	Removal of sludge in sewer pipes and retarding basin
(3) Countermeasure at the river channel	3a	Removal of bed sediment in rivers
	3b	Sedimentation pond
	3c	Contact oxidation with cobble plant
	3d	Ground still
	3e	Sheet flow channel
	3f	Aeration facility
	3g	Dilution with clean water

(2) Applicable techniques to the part between pollution source and river channel

2a Sewerage improvement

Sewerage improvement is the most popular means for preventing rivers from being contaminated by domestic waste water, human waste, industrial waste water, etc. However, this may not be economical when pollution sources lie scattered, because the

initial cost for installing sewers may become much higher than the construction cost of treatment plants. The sewage discharging systems can be divided into the combined system which discharges sewage with rain water and the separated system which discharges sewage separately from rain water. In the case of the former, the sewage may flow into rivers when the discharging quantity exceeds the capacity of the sewers and discharge may decrease in during a dry season. In the case of the latter, on the contrary, installation of the sewers may require a lot of time and money, but the river flow does not decline, because rain water is made to flow to rivers, and quantities of pollutants flowing into the rivers are small in compared with the combined system. While a high sewerage diffusion rate has been attained in a short period in the Seoul Metropolitan area due to intercepting sewers installed along rivers, the sewerage system thus installed causes water pollution and declines in flow to the rivers, because the main part of the system is combined system.

2b Repair of existing sewer pipes

When the sewer pipes are installed along a river channel as in the Study Area, rehabilitation work of the damaged sewer pipes are very important because the damaged sewer pipes directly cause water pollution to the river. Leakage of sewage from aged sewer pipe was not observed in this investigation, but at some places it was found that sewage was flowing into rivers due to the design problem of intercepting portion(insufficient intercepting quantities) in the combined sewerage system and due to wrong connection of sewer pipes to storm sewers in the separated system. Therefore, it is necessary to replace the wrongly connected sewer pipes and to review and modify of the design of defective intercepting ports.

2c Removal of sludge in sewer pipes and retarding basin

According to the investigations carried out by Public Works Research Institute, Ministry of Construction, Japan, the pollution load by the sludge deposited in sewers in an area equipped with the combined sewerage system corresponds to 56 - 66% of the emitted pollution load of river basin. And, also in the Study Area, a great volume of deposited sludge is estimated in the sewers. In the Study Area, many retarding basins and pumping stations are installed in the Seoul Metropolitan area to prevent inland water flooding, and the pollution load by the sludge deposited on the bottom of the basins is estimated to be equivalent to or more than the pollution load by the sludge deposited in the sewers. Therefore, removal of the sludge from such sewers and retarding basins may have a considerable effect on the reduction of pollution load flowing into rivers.

(3) Applicable techniques to river channel

3a Removal of bed sediment in rivers

In the Anyang Chong, water quality is very close to that of sewage, it is considered that one reason of the water pollution may be attributed to the sludge deposited on the river channel in addition to the sludge deposited in sewers (The sludge described here means soft organic silts and clays). Consequently, removal of the sludge deposited on the river channel by dredging may be considered to be one means for improving the quality of river water, but, since deposition of the sludge will be repeated unless the pollutants are prevented from flowing into the river, the dredging timing must be decided by taking the repeated deposition into account.

3b Sedimentation pond

Sedimentation ponds are installed so as to remove precipitable pollutants by keeping waste water containing a large amount of pollutants in a stationary condition. The sedimentation ponds can be divided into ordinal sedimentation pond where pollutants are precipitated by gravity only and chemical sedimentation pond where chemicals are added so that pollutants may settle by flocculate sedimentation.

3c Contact oxidation with cobble plant

This plant purifies river water by passing the water through a tank charged with cobbles after a sufficient quantity of dissolved oxygen is added to the water and decomposing organic pollutants by means of microorganisms adhering to the surface of the cobbles in an oxidizing atmosphere. This plant contrived after paying attention to the strong self-purifying action in mountainous streams where numerous cobbles are deposited and sufficient quantities of oxygen are supplied. Among the facilities which directly purify river water, this facility is the only facility which utilizes the technique, the treatment effect of which has been quantitatively evaluated, and many plants have been installed.

The advantage of this plant includes (a) cobbles to be used for adhering microorganisms are abundant on river beds and can be obtained at low costs, (b) possibilities of producing secondary troubles is low, since the purifying process of this plant is the same as the self-purifying process of rivers, (c) the plant may not be damaged easily even when a flood, etc., takes place, since the filler is cobbles having strong mechanical strengths, (d) no much costs will be required for the maintenance and management of the plant, because cleaning of the cobbles and removal of the sludge may be made once for about (e) years except the case where the river water to be treated is especially high in SS concentra-

tion, and so on.

On the other hand, this plant has such disadvantages as (a) a large quantity of sludge deposits in a short period and the cobble cleaning and sludge removing works must be made frequently when the SS content of the water to be treated is high, (b) the activity of the microorganisms decline and the treatment capacity is lowered when the treated water is 80 mg/l or higher in BOD content, (c) the activity also declines and the capacity is lowered when the water temperature becomes lower. These advantages, however, can be eliminated to some extent by adding appropriate pre-treatment facilities and controlling the water quality and water temperature. Refer to (3) of Section 4.4.3 about the pollution removing effect of this plant.

3d Ground sill

This facility forms a fall in a river channel and removes organic pollutants from the river water by utilizing the oxygen dissolving into the water when the water drops along the fall. Therefore, this work cannot be installed unless the river bed has a certain gradient in the longitudinal profile. The purifying capacity of this facility varies depending upon the fall, river width, oxygen demand of the river water, etc., and, therefore, quantitative evaluation of this facility is difficult.

For such a highly polluted river as Anyang Chong, it may be possible that installation of a drop work may increase the offensive odor instead of reducing the odor. In addition, when this facility is installed to a river channel having an insufficient flow rate, algae may grow and organic matters may deposit on the upstream side of the drop work and an offensive odor may be produced, because the river water tends to stay on the upstream side of the work.

3e Sheet flow channel

This facility not only supplies oxygen to the river water to which this facility is installed by spreading cobbles all over the river bed which is increased in width and reduced in depth, but also promotes decomposition of organic matters by means of microorganisms adhering to the surface of the cobbles. Since the oxygen supplying method and water staying time are limited, this facility can only be applied to rivers, the water of which is not much contaminated. Moreover, since the flow passing through this channel becomes an eddy current, reduction of the SS contamination cannot be expected. At present, it is difficult to make quantitative evaluation on this facility, because test data are insufficient.

3f Aeration facility

This facility forcibly supplies oxygen to river water by using machinery, such as blowers, etc., so as to promote decomposition of organic pollutants in an oxidizing atmosphere. Since the river water must be aerated for about 35 hours to reduce the BOD content by about 50%, a wide facility area will be required when this facility is installed to a river with a large flow. (For example, when the quantity of the water to be treated is 1.0 m^3/sec, the aeration tank to be installed must have a capacity of about 140,000 m^3, and, when the depth of the tank is 3 m, the required area becomes about 50,000 m^2.)

3g Diluting with clean water

This method is used for lowering the pollutant content of contaminated river water by adding river water or underground water having a good quality and, at the same time, for improving the self-purifying capacity of the river. This is an excellent method when a water source having a good water quality and a large water quantity is available, since the

maintenance and management costs are inexpensive, but it must be noticed that at least the same amount of dilution water is required for reducing the pollutant content of the present river water quality to a half even when the dilution water is significantly clean.

4.6.2 Applicable Water Quality Improvement Techniques to the Riverbed and their Evaluation

(1) Evaluation on applicable water quality improvement techniques in the river channel

This study evaluated the techniques applicable to the river channel (countermeasures that are feasible as river work) and the results are shown in Table 4.6-2. The applicability of each countermeasure and techniques to each river to be planned is discussed in Chapters 6 to 9.

Table 4.6-2 Evaluation of Water Quality Improvement Techniques Applicable to the River Channel

	Type of Investment	Possibility of Enlargement	Equivalent Evaluation	Experience
Removal of bed sediment in rivers	I	o	△	o
Sedimentation pond	I+R	o	o	△
Contact oxidation with cobble plant	I+R	o	o	o
Ground sill	I	o	x	△
Sheet flow channel	I	o	x	△
Aeration facility	I+R	△	△	△
Dilution with clean water	I+R	o	o	o

* The I and R of the "Type of investment" column mean "Initial

cost type" and "Running cost type", respectively.
** Experience are those obtained in Japan.

Among the water quality improvement techniques applicable to the interior of the river channel, sedimentation treatment and contact oxidation with cobble plant can evaluate quantitatively effect of improvement are discussed below.

(2) Quantitatively evaluation on water quality improving effect of sedimentation pond

The sedimentation ponds used for water treatment can be divided into gravity and chemical treatment types as mentioned above and the selection of the pond must be made on the basis of the pollutant contamination of the water to be treated and the required water quality.

In the case of the sedimentation pond, it is generally said that about 30% of the BOD content and 35% of the SS content can be removed at retention time of 3.0 hours and a water area load of 25 $m^3/m^2/day$ (Japan Sewage Institute: Design Handbook for Sewerage Facilities), but the removal ratios vary depending upon the nature of the water to be treated. Especially, when the river to be treated is high in inorganic SS (sediments, etc.,) content like Yangjae Chong, it is expected that the SS removal ratio may reach 35% or more.

Since the pollutant removal ratio with the chemical settling pond varies depending upon the nature of the water to be treated and the chemical used for the treatment, it is desirable to decide the ratio by carrying out jar tests every time.

The jar tests carried out on the water sample (COD (Cr): 23 mg/l) collected from Anyang Chong (at St. 6) in September 1990, by varying the injecting concentration of chemicals, $FeCl_3$ and $Al_2(SO_4)_3$, from 50 mg/l to 1,000 mg/l give good results at injecting concentrations of 300 mg/l for both $FeCl_3$ and $Al_2(SO_4)_3$, with the COD (Cr) removal ratio being about 60%. However, the

water treated with $FeCl_3$ was slightly colored in reddish black.

From the above-mentioned results, $Al_2(SO_4)_3$ and 300 mg/l will be selected as the chemical to be used and injecting concentration to be set when the chemical settling pond is used in this plan. Under such condition, the removal ratios of both BOD and SS can be set at 50%. The detention time and water area load are set to the same values as those used for the sedimentation pond.

(3) Quantitative evaluation on water quality improving effect of contact oxidation treatment with cobble plant

The contact oxidation treatment with cobble plants can be divided into the pre-aerated contact oxidation treatment with cobble plants (a sufficient amount of dissolved oxygen is added to the water to be treated before the water is made to flow to the treatment tank) and the contact oxidation treatment with aerated cobble plants (the water to be treated is directly aerated in the treatment tank), The Ministry of Construction, Japan, recommends the latter when the BOD content of the water to be treated exceeds 25 mg/l on the basis of investigation results.

Since the contact oxidation treatment with cobble plants is a kind of biological treatment, the activity of the microorganisms and, accordingly, the BOD removal ratio decline when the water temperature becomes lower. In order to study the effect of the water temperature on the treatment function of this treatment method, the probability that the water temperature of the objective rivers becomes 1.5 - 22.0 °C was calculated by using the water temperatures measured at the time of periodic water quality observations in 1990 (see Table 4.6-3) and, at the same time, the relation among the water temperature, BOD removal ratio and detention time was calculated by using Howland's equation to be used for the fixed type biological treatment (see Table 4.6-4).

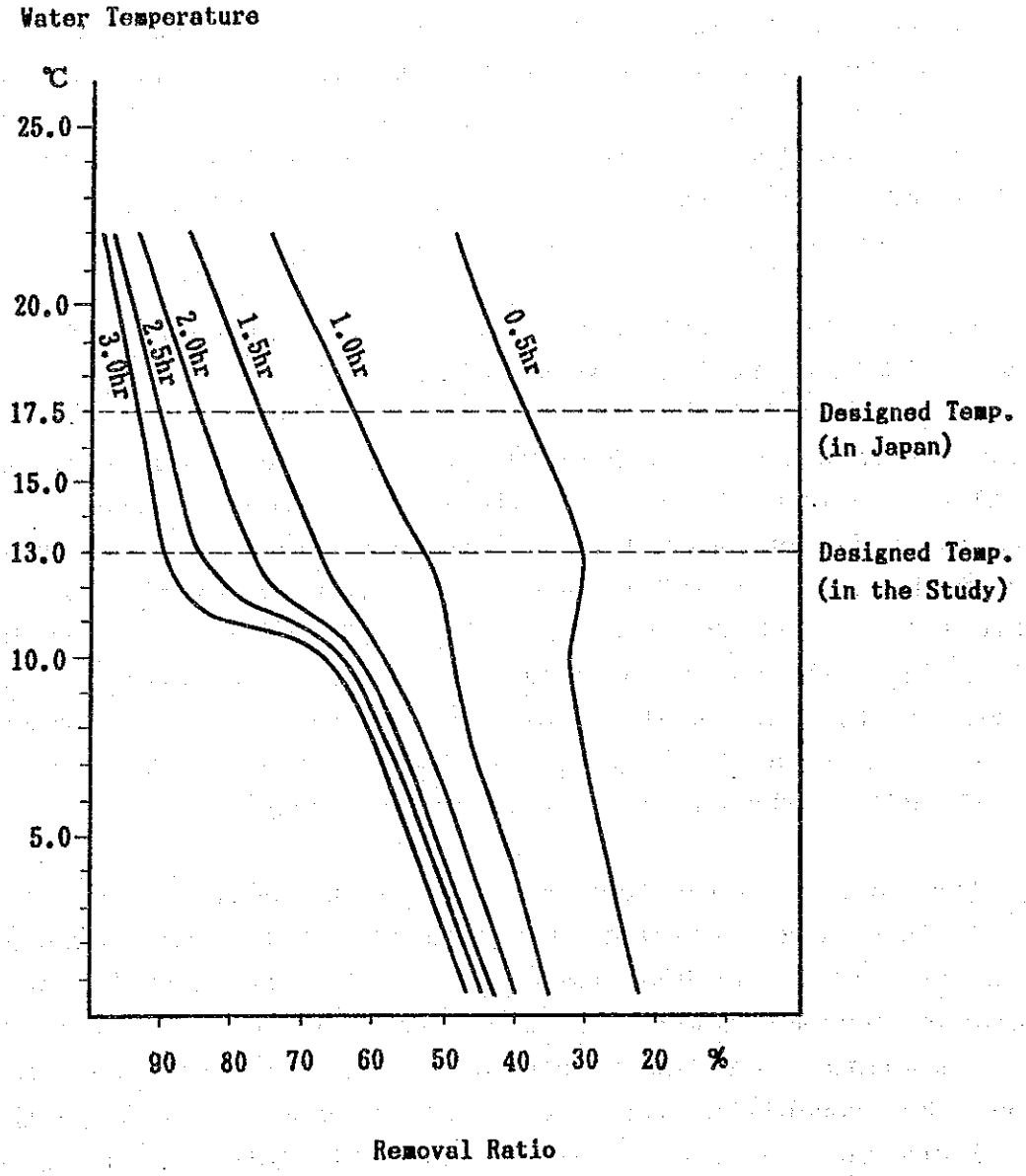


Fig.4.6-1 Relationship between Removal Ratio and Detention Time in Contact Oxidation with Cobble Treatment

Table 4.6-3 Non-Exceed probability of Water Temperature of Objective Rivers

Water Temp. (°C)	22.0	17.5	13.0	10.0	5.0	1.5
Non-exceed Probability(%)	83	58	35	25	10	5
Day	303	212	128	92	37	18

Table 4.6-4 Relation among Water Temperature, BOD Removal Ratio and Detention Time in the Contact Oxidation with Cobble Plant

Unit:removal ratio %

Time (hr)	Water Temperature(°C) 22.0	17.5	13.0	10.0	5.0	1.5
0.5	49.0	40.0	31.0	32.5	27.3	24.2
1.0	75.0	64.0	53.0	49.6	41.8	37.0
1.5	87.0	77.5	68.0	57.6	48.5	43.0
2.0	94.0	86.0	78.0	62.3	52.4	46.5
2.5	97.0	91.0	85.0	64.1	54.0	47.9
3.0	98.4	94.2	90.0	65.2	54.9	48.6
Ratio 1	1.1	1.0	0.91	0.72	0.61	0.54
RAtio 2	1.2	1.1	1.0	0.80	0.67	0.60

As far as the BOD removal ratio at detention time of 2.0 - 2.5 hours which are standards for the pre-aerated contact oxidation treatment with cobble plants, the ratio can be lowered at temperatures which are being used as design standards in Japan in such a way that the ratio can be lowered to about 90% at 13 °C, about 70% at 10 °C, about 60% at 5 °C, and about 54% at 1.5 °C. When it is tried to secure the same removal ratios even when the design standard water temperatures are lowered, the required facility becomes excessively larger in size, because the detention time must be prolonged.

In this plan, therefore, the facility is designed so that the removal ratio at 17.5 ˚C can be secured 100% against the water temperature (13 ˚C) of 75% in annual frequency of occurrence and the removal ratio can be secured about 80% even when the water temperature drops to 10 ˚C. However, it is necessary to carry out pilot tests to validate these figures and confirm the removal ratio before starting actual contact oxidation treatment with cobble plants.

(4) Quantitative evaluation on water quality improving effect of composite treatment

When composite treatment is considered by adding treatment with a sand basin, sediment basin, chemical settling basin, aeration, etc., to the upstream or downstream side of the contact oxidation treatment with cobble plants, the pollutant removal effect of the composite treatment can be calculated from the sum of pollutant removal ratio of each unit treatment. When the pollutant removal ratio of each unit treatment is set to the values shown on Table 4.6-5 in accordance with the descriptions of the (2) and (3) above, the pollutant removal ratio of each composite treatment becomes the value shown on Table 4.6-6.

Table 4.6-5 Pollutant Removal Ratio of Unit Treatment

Kind of treatment	Pollutant removal ratio (%)		Treatment conditions	
	BOD	SS	Detention time	Surface loading ($m^3/m^2/day$)
[1]Sand settling	-	--	60 sec	1800
[2]Gravity settling	30	35	3.0 hr	25
[3]Flocculent Settling	50	50	3.0	25
[4]Pre-aeration C.O.C.	75	85	2.0	
[5]Aeration C.O.C.	90	80	3.0	

* In the flocculent settling 300 mg/l of $Al_2(SO_4)_3$ shall be used.
* C.O.C.: Contact oxidation treatment with cobble.

Contact oxidation with cobble plant is one of the treatments used to eliminate organic matters. It was observed that to reduce organic activity water temperature must be kept low. It was also observed that the process reduces the removal ratio of BOD.

Table 4.6-6 Pollution Removal Ratio of Composite Treatment

Type	Treatment flow	Pollutant removal ratio	
		BOD	SS
Type 1	[1] + [3] + [5] + Re-aeration	95 %	90 %
Type 2	[1] + [2] + [5] + Re-aeration	93	87
Type 3	[1] + [2] + [4] + Re-aeration	82.5	90
Type 4	[1] + [5] + Re-aeration	90	80
Type 5	[1] + [4] + Re-aeration	75	85

* [1] + [5] : see Table 4.6-5

4.6.3 Applicable Flow Regime Improvement Techniques

The flow regime improving techniques considered to be useful at present can be divided into (a) countermeasures to improve the water holding capacity of basins, (b) countermeasures to transfer water from another basin, and (c) techniques to make river flow by water works. The feature, applicable condition, and precaution to be taken, etc., of each countermeasure and technique are described below.

Table 4.6-7 Flow Duration Improvement Technique

(1)Countermeasure to enhance the water retaining capacity	1a	Conservation of Land Use
	1b	Improvement of River Structures
	1c	Improvement of Infiltration Ability of Land Surface
	1d	Reversion of Treated Water to Ground
(2)Countermeasure to supply water from another water source	2a	Utilization of Reservoir Water
	2b	Utilization of Groundwater
	2c	Utilization of Another River Water
	2d	Utilization of Patable or Industrial Water
	2e	Utilization of Treated Water of Sewerage Treatment Plant
(3)Techniques to keep water surface	3a	Improvement of Low Water Channel
	3b	Installation of Weir

(1) Countermeasure to enhance the water retaining capacity

1a Conservation of land-use

In order to maintain the water retaining capacity of the basin, development of forests and farmland, are high potentiality in the water holding capacity, shall be limited by legislation, etc. When these land contain private area, compensation must be made to the owners, because limitation to the exercise of their private rights is required.

1b Improvement of river structures

River bed and embankment shall be made as natural condition by removing concrete lining, and groundwater come to flow increasingly as river base. However, it is necessary to consider decline of flowing capacity and erosion of the embankment on the view-point of flooding. Besides, There is possibility river does not flow during dry season when the ratio of under flow is large.

1c Improvement of infiltration ability of land surface

This method is to promote infiltration of rain water into the ground in urban area by providing infiltration boxes, infiltration basins, infiltration pavement, etc., so as to reduce the percentage of the rain water flowing out. These facilities must be the structure to cause scarcely clogging. When these facilities are installed to an area with low water permeability, good results may not be expected.

1d Reversion of treated water to the ground

This method is to reverse groundwater by allowing the treated water of the sewage in each house or block to percolate. The infiltration facility used for this method must be the structure which hardly cause clogging. In addition, measures must be taken so as to prevent occurrence of ground water contamination.

(2) Countermeasure to supply water from another water source

2a Utilization of reservoir water

This countermeasure is to supply storage water of the reservoir to the river during draught days as maintenance flow. Generally, large amount of investment and long con struction period are required for a big scale of new water reservoir. As mentioned in Chapter 3, agricultural water reservoirs exist on the upstream in Anyang Chong and Yangjae Chong basins and these reservoirs may be used for this purpose, because the using quantity of agricultural water has decreased, but no such water reservoir exists in Ui Chong and Chungroung Chong basins.

2b Utilization of groundwater

This countermeasure is to secure the maintenance flow by

discharging pumped up groundwater to the river. Judging from the geological condition described in Chapter 3, it is considered that little groundwater is available for this purpose in the periphery of the Seoul Metropolitan area except latent flows flowing through reversible. It is necessary to confirm the condition and volume of the aquifers.

2c Utilization of another river water

This is countermeasure to supply maintenance flow by introducing the water from different river basin having an ample quantity and relatively good water quality to the river through a conveyance canal or pipes. When the water source is far, the length of the canal or pipes becomes longer and a larger amount of investment is required. In addition, there is possibility to make troubles on water utilization in source river basin by the flow reduction.

2d Utilization of potable or industrial water

This is a countermeasure to secure the maintenance flow and improve water quality by potable or industrial water having guaranteed water quality. It shall be first condition that a plenty of water is prepared for potable and industrial waters however, since operation and maintenance cost will be very expensive, water recycling use is common system.

2e Utilization of treated water of sewage treatment plant

This countermeasure is to secure the maintenance flow by reverse circulating the treated water of a sewage treatment plant. The pollutant concentration of the treated water must be lower than that of the river water, because, when the quality of the treated water is worse than that of the river water, the river water is contaminated by the treated water at the cost of the recovered flow rate. The treated water from the Anyang Chong Sewage Treatment Plant is very bad,

with the BOD being 80 mg/l, because the plant treats sewage in the primary stage only. While the sewage treatment plants installed to Tan Chong, Chungryang Chong and Kwa Chong treat the sewage to the secondary stage, the treated water from these three is 15 mg/l or higher in BOD. At present, therefore, use of the treated water from these plants cannot be recommended for this purpose from its qualities.

(3) Technique to keep water surface

3a Improvement of low water channel

This technique is to be taken when a sufficient water flow cannot be secured in a river channel, and forms shallow water channel in order to collect and keep water surface. For a river with a large quantity of latent flow, the loss of the flow rate can be prevented when three-side lining is applied to the river, however, landscape is not interesting.

3b Installation of weir

This countermeasure is to taken to a low water channel when a sufficient water surface cannot be formed by the improvement of the channel. Water is dammed up by the weir and forms a water surface with gentle slope allowing the water to stay longer. A gate weir is desirable for this purpose, since a fixed weir may affect the flood controlling function of the river. Rubbish and contaminants tend to gather on the up stream side of the weir and, when such rubbish and pollutants are not removed from time to time, the landscape and water quality of the river channel become worse and, an offensive odor may be produced in certain circumstances.

Of the flow duration improving technology, those which are applicable (executable measures as river improvement works) to the objective river channels of this study is summarized in Table 4.6-8. The applicability of each countermeasures to each river is discussed in Chapters 6 to 9.

Table 4.6-8 Evaluation of Flow Regime Improvement Techniques Applicable to the River Channel

	Type of Investment	Possibility of Enlargement	Equivalent Evaluation	Experience
Improvement of river structures	I	o	x	△
Use of storage water in reservoir	I	o	o	x
Use of groundwater	I+R	△	△	△
Water transfering from another river	I+R	o	x	△
Use of potable water	R	x	△	△
Improvement of low water channel	I	△	△	o
Installation of the weir	I+R	△	o	o

* The I and R of the "Type of investment" column mean "Initial cost type" and "Running cost type", respectively.
** Experience are those obtained in Japan.

4.7 Restrictions in River Space Utilization

4.7.1 Location and Use of River Space

In general, river spaces are roughly divided into land spaces consisting of major bed spaces, which are temporarily covered with water at the time of flooding but can be released to people as much as possible, and embankments and water space the use of which is usually limited due to flowing water.

(1) Land space

The use of the land space various according to the characteristics of the location, the social conditions of the hinterland, the shape of the major bed and the natural conditions in the river space. Therefore, the sections to be planned will be divided into several zones on the basis of the combination of these elements and the utilizing form of each zone is studied by taking the characteristics of the zone into account.

In this plan, the following zones shall be established.

Multipurpose zone
Places with relatively wide spaces for the establishment of playgrounds and health care facilities which shall be open not only to the local residents, but also to the residents of neighboring areas.

Family zone
A zone which shall be constructed near areas to promote daily communicate between the young and old generation and between parents and children.

Nature zone
This zone shall be constructed in a place blessed with good landscape and natural environment. This place shall encourage people to commune with nature, the sketching and viewing of the flora and fauna, and the pursuance of recreational activities such as bicycling.

Nature preservation zone
This zone shall be constructed in a place where the ecological system is still preserved. The protection of the system shall be a priority in this zone, and aside from river improvement works, artificial improvement works shall be restricted in this area.

Landscape improvement zone

The river shall be the principal axis of rows of houses. The creation of a waterside landscape that blends with the rows of houses in this area is desirable.

(2) Water area

Contrary to the above-mentioned land space uses, flood control functions shall take precedence over the water spaces uses. Especially, for rivers as Ui Chong and Chungroung Chong having steep river bed gradients, utilization of their water areas with objectives other than flood control must be avoided from the point of safety, because the water level suddenly rises at freshet time.

4.7.2 Flooded Frequency and Major Bed Utilization

The major bed is usually submerged when floods occur, and the frequency of inundation and its inundated condition largely affect the growth of plants and the maintenance of the various kinds of facilities. Therefore, the utilizing form and maintaining and managing methods of the major bed must be studied by paying attention to the frequency and condition of inundations. The general relations between inundation and plants between the inundation and park facilities are described here.

(1) Inundation and plant growing environment

The distribution of reversible vegetation are controlled by the physical and chemical properties (water content, granular variation, humid content, etc.,) of the soil and the flooded condition of plants.

A flood not only washes away plants and buries plants with earth and sands transported from the upstream side by the flood, but also affects the soil in such way that inundated soil becomes to

contain excessive water and is lowered in air-permeability, resulting in root humus of plants which are not highly water resistive.

It is said that the period until the gravity water drained from the soaked soil and air-permeability of the soil is restored after an inundation is several hours for sandy soil, 24 hours for well-drainable soil, and several days for clayey soil. Planting in the major bed shall be, therefore, conducted in areas which are not directly affected by floods. Moisture resistive plants which are suitable for the soil of the major bed shall be planted such areas.

Of the broadleaf trees widely distributed in the Seoul Metropolitan area and its vicinity, the aspan, poplar, acasia, liriodendron, elm (Ulmas Davidians var. japonica), azalcas can be considered to be higher in moisture resistance and applicable to the sections to be planned.

In addition, water resistive flowering plants include the California poppy, Komachi-sou, red poppy, cosmos, cornflower, Harusha-giku, Ookinkei-giku, babies'-breath, pechunia, scarlet sage, marigold, wild pink, etc.

(2) Inundation and facility improvement

Inundation limit space utilizing extents and states. Generally speaking, as the frequency of inundation increases, natural preserving facilities become more suitable than artificial facilities, linear facilities become more suitable than planar facilities, and static facilities become more suitable than dynamic facilities.

The facilities listed on Table 4.7-1 can be considered as concrete examples of the facilities.

Where the frequency of inundation is high, in addition, facili-

ties which are transferable and can be structurally disassembled shall be chosen, and they shall be water-resistant and sterilized.

Table 4.7-1 Relation between Flooded Frequency and Applicable Facilities

Frequency of inundation	Applicable facilities	
Low ↑	Sporting facilities	: Football ground, tennis court, volleyball court,
	Playing facilities	: Trapezes, slides, seesaws, ladders
	Resting facilities	: Resting places, benches, outdoor tables
	View improving facilities	: Trees, flower gardens
↓ High	Nature protective facilities	: Nature watching parks, aquatic zoos

4.7.3 Coordination with a River Space Utilization Plan Having Objectives Other Than Environmental Improvement

The demands for the use of the river bed space is considerably high in the Seoul Metropolitan area which is notably lacking in space. The Traffic Bureau is pressured with the immediate solution of traffic problems and consequently formulated a plan to cover the rivers and retarding basins and construct parking lots on them. On the other hand, the Construction Bureau plans to widen the highways and build new ones.

The use of the river space as land for road and parking lots, or its preservation as a part of nature has become a controversial issue. The present condition of a city which had the same prob-

lem in the past may be suggestive.

In Tokyo, for instance, many small rivers and canals were filled up with earth, sand, and gravels in 1960's to meet the increased demand for roads, but, at present, a great effort is being spent for restoring and maintaining natural environments of the lost rivers, etc., at a huge cost. It can be said that such effort has resulted from the increased needs of the inhabitants to better environments as their living level rose and the re-evaluation of the rivers as an important element to make Tokyo a charming city. In addition, the important role of the river space as a safe area at the time of natural disasters and noise intercepting zone is also recognized anew.

The demand concerning the improvement of the living environment is presumed to escalate gradually in future in view of the rapid progress in the Seoul Metropolitan' standard of living. It would be wise, therefore, to improve and preserve the river space as a part of nature and not to use it for the construction of the planned roads and parking lots which are only beneficial for a short period of time.

Chapter 5

Chapter 5. Fundamental View for the Basic Concept of the River Environment Improvement Plan

In this chapter, such items to be discussed before making basic plans to individual rivers as [1] water quality improving plans to be adopted when the attainment of the target quality by countermeasures which are only applicable to river channels is difficult, [2] flow duration improving plans to be applied to the rivers which have not been subject to flood control, [3] problems which must be guaranteed upon executing the river space improvement plan, [4] concepts about run-off sediment controlling plans required for protecting water quality and flow duration improving facilities and space utilization facilities from sediment disasters are described.

This chapter describes the basic conception of the river environment improvement plan shall be established in four objected rivers, as below.

(a) Approach of water quality planning when the target of water quality cannot gained by the countermeasure applied in river channel

(b) Approach of the river flow regime planning when water is not utilized for any purpose

(c) Safety to be guaranteed in the river space improvement plan for flooding protection

(d) Approach of the sediment run-off planning in order to protect the water quality and flow regime improvement facilities and river space utilization facility.

5.1 Fundamental View of the Water Quality Improvement Plan

Various water quality improvement techniques were introduced in Section 4.6.1 and the most basic technique is the one that can reduce the discharge of pollution load to the least minimum quantity at each pollution source. However, as the pollution

load moves farther from the source, it becomes more difficult, and the mixture of clean water greatly affects the fluctuations in the water volume and the water quality and worsens the efficiency of the purifying facility.

The locational regulation is based on the concept that no pollution source is allowed in the basin of a river and the development limited area designated by Seoul Metropolitan nearly follows this concept. Most of the Study Area is designated to the development limited area. Therefore, as a first prerequisite to prevent the further deterioration of the river water quality, the designation should not be dissolved. Additionally, it is necessary to install appropriate waste water treatment facilities against direct pollution sources (mostly domestic pollution sources, but many stockbreeding pollution sources also exist in the Anyang Chong basin).

The improvement and preservation of the sewerage facilities are very important measures between the pollutant sources and river. It is already described in 2.2.1 above that the sewerage system diffusion rate in Seoul Metropolitan has reached 95% of the planned drainage area, and other local governments in the basins, their sewage-related facilities are not yet improved sufficiently at present, are actively executing sewerage construction works, like sewers, sewage treatment plants, intercepting sewers, etc. Therefore, when these facilities are completed and used as scheduled, it is expected that the ratios of domestic and industrial loads directly discharged to the rivers will be remarkably reduced and the water quality of the rivers will be improved after 2001, especially in the Anyang Chong basin.

However, as mentioned in Chapter 3, many sewers in the Anyang Chong basin are directly connected to the river without intercepting and this is the largest cause of the increased pollutant load in the Study Area. Even in the Chungroung Chong where the sewerage system diffusion rate is 100%, the water quality is close to that of sewage and tracer investigations clearly show

that sewage is leaking from intercepting sewers to the river in some sections. Moreover, several places where sewage always flows from storm sewers to the river are confirmed along the Yangjae Chong equipped with a separated sewage system.

If the sewerage system will still include structural problems of sewerage and intercepting sewer and waste sludge and sediment in the sewer pipe and retarding basin, the river water quality cannot be improved with upping of the sewerage diffusion ratio.

Accordingly, it is very important to rehabilitate structural problems of the existing sewage and intercepting sewer and to remove sediment waste in the pipe and retarding basins in Seoul Metropolitan, in order to avoid additional water quality problems.

Since a survey on the actual conditions of the pollutant sources and the sewerage was not conducted, the basic concept of river classification stated in Chapter 6-9 shall only study the water quality improvement technique applicable to the river channel. If the desired water quality is difficult to achieve, the pollution source countermeasure and the improvement and rehabilitation of sewerage facilities must be implemented.

5.2 Fundamental View of the Flow Regime Improvement Plan

The various techniques for the improvement of the flow regime of the river were previously discussed in Section 4.6.3, and among these is the technique to strengthen the water holding capacity in the river basin. However, this techniques will require large amount of money and a long period of time before the results can be observed. In addition, only little effect can be expected from the use of this technique, even if it is most applicable, in Ui Chong and Chungroung Chong, if the principal tributaries become sewage rivers where flow is intercepted by the sewers before it reaches the confluence, and where the volume of under-

flow is large in the main stem.

On the other hand, the countermeasures of supplying water from other sources is considered to be very effective in directly increasing the flow of the main river. However, this countermeasure can only be implemented if there is a nearby source with adequate flow and water quality.

Furthermore, even with the availability of such source, large amount of construction expenses and operation and maintenance expenses should not be made to collect and convey water from this source if, like the 4 study rivers, the improvement of the flow regime is only aimed to recover and activate water familiarity functions and not for the attainment of water use benefits. In this regard, the conveyance of water from other rivers and the use of potable water are not considered as practical.

If the constant securement of regular flow is difficult due to restraints in the budget and problems with the water source, the use of the wide water surface of the area with limited but clean flow will have to suffice. The establishment of weirs and the improvement of low canals would be, therefore, effective in this situation.

The flow rate at St. 3 (downstream of Torim Chong) of Anyang Chong and that at St. 3 of Chungroung Chong have become smaller by one figure after intercepting sewers were repaired in the upstream-side sections of the stations. On the other hand, the flow rate of the Ui Chong which was considered to contain little sewage from its water quality has been extremely small at low-water level time right from the beginning of the observation. These facts indicate that, when intercepting sewers already installed along a river are repaired, the flow rate of the river will decrease, but the water quality will be improved.

Therefore, while it is expected that the flow rates of Anyang Chong and Yangjae Chong may decrease in future, no countermeasure

is considered against such decreases in flow rate of both rivers, because the maintained state of sewage-related facilities was not investigated.

5.3 Fundamental View of the River Space Improvement Plan

The use of the river space of each river shall be determined according to the characteristics of the areas classified on the basis of the present natural and social conditions of the catchment area and the river improvement and utilization conditions. In addition, areas with large and suitable demands shall be used as model sites, and facilities in these areas shall be considerably improved.

As for river space utilization, there is a need to generally inspect the degree of safety of the area against floods. However, the inspection was not conducted and the appropriate cross section data were not kept and changes were conducted everywhere in the embankment of each river. The river space improvement plan shall be formulated, therefore, under the premise that it shall be completely safe from floods. Furthermore, a utilization plan which shall change the features of the major bed and cause further deterioration in flow efficiency, shall not be adopted.

The major bed is assumed to be easily submergible. According to the results stated in Section 4.7.2, the area shall be used, therefore, in a manner that will assure less flood damages, and the facilities to be installed shall be water resistant and sterilized.

5.4 Fundamental View of the Run-off Sediment Control Plan

If the planned are is affected by sediment run-off, it is necessary to formulate countermeasures that can appropriately protect the water quality improvement facilities and the river space

utilization facilities from flood damages.

The distribution of slope failures in the water source area of each river and the quantity of the sediments produced by and running off from the slope failures are already described in Chapter 3. However, it is very hard to study what influences the run-off sediments will give to the river beds in the planning sections, because no data are available about the transition of the longitudinal profiles of the river bed. Moreover, the sediment storing effects of already existing sediment controlling facilities are also difficult to study, since most of them are not controlled by Seoul Metropolitan.

Therefore, the influence of run-off sediments must be estimated from the river bed variation and river bed materials observed immediately after the freshet occurred in September 1990, during the investigation period.

Driftwoods, sands and gravel accumulated in the upstream area of the 4 rivers. However, only Chungroung Chong was directly affected by sediment run-off, and the sediments that accumulated downstream of Station 3 were removed by hand. No influence was observed from the planned sections of the other rivers. The sediments that were accumulated upstream of the planned sections shall gradually move down-stream along with the next flood or freshet and this occurrence shall only affect the planned sections slightly.

In spite of the assumptions made above that the run-off sediments accumulated upstream shall be gradually removed at every freshet, soil saving facilities must still be installed upstream as a basic measure.

The sediment controlling facility shall be basically combination of two types of sediment controlling dam, one is screen type to intercept big rolling rocks flowing trees, and other is high concrete type to store sand sedimentation. By the both effect,

sediment run-off to the project area shall be protected.

Details of the structure and arrangement of these sediment controlling facilities are described on SUPPORTING REPORT IV, but it is desirable to construct such facilities by paying sufficient attention to the preservation of the spectacle of the installed areas.

Chapter 6

Chapter 6 The Basic River Environment Improvement Plan for Anyang Chong

The water quality standard desired for Anyang Chong is Class V, and composite treatment which shall mainly implement contact oxidation with cobble plant shall be the basis of the water quality improvement plan for this river. Treatment facilities shall be installed successively toward the downstream area from St.6 while observing the improvement in the river water quality caused by the progress of the sewerage treatment works upstream. However, if the maintenance and improvement of the sewerage and intercepting sewers in the planned area remain unchanged, except for St.6, it would be difficult to achieve the desired water quality for this river. It is, therefore, necessary to concurrently conduct the repair of the defects in the sewerage and intercepting sewers, the removal of sludge accumulated within the pipes and the retarding basins and the installation of the treatment facilities. Furthermore, the removal of sludge in the river channel might increase the effectivity of the water quality improvement work conducted in the planned section.

There is no need to implement the flow regime improvement plan in Anyang Chong because it has enough flow to propagate water familiarity functions.

Since the demands for the use of the river space in the planned downstream section is high and the major bed is wide enough to accommodate various recreational activities, recreational zones are installed in 3 places in response to the needs of the residents. Of the 3 zones, two were structured into multipurpose utilization zones with health and sports facilities. The zone installed at the Anyang Chong and Kehwa Chong confluence was structured into a nature zone since the area is presumed to be habitually flooded. The facilities to be installed in this area shall be water resistant and sterilized.

6.1 Problem and Future Outlook on River Environment

Prior to establish the basic environment improvement plan in Anyang Chong, present condition and future outlook of the environment, as referred to mainly in Chapters 3 and 4, are summarized below by the field of water quality, flow regime, space utilization and flood control.

6.1.1 Water Quality

(1) The water quality in the planning section is especially poor during winter-spring seasons just like sewage of Seoul Metropolitan when the river has little flow. Even in summer-fall seasons, the water quality is improved a little bit, however, still lower than Class V of the river water quality standard. Self-purifying ability has been almost lost and H_2S gas is seen in a broader range of the area.

(2) The pollutant load emitted at the upstream beyond St. 6 is presumed to be about 15% of the entire basin, however, this section occupies more than 50% of the load of the amount measured at St. 2 or St. 1 flowing down the river because of untreated sewage in this area.

(3) Although the sewage system has already been improved in the Metropolitan, the load was largely increased between St. 5 and St. 6. According to the investigation with tracer, no leakage of sewage was observed from the intercepting sewer on the right bank of the downstream past St. 6. Therefore, the increased load in this section is believed mainly due to the waste water discharged to the river directly.

(4) The downstream section past the confluence of Taolin Chong is affected tidal flow, so the polluted materials are apt to sediment, sludge deposits densely and H_2S is making bad smell. This sludge is believed to enhance the deterioration of the water quality considerably. On the other hand, the pollution concen-

tration is decreased between ST. 5 and St. 4 with decreased river flow, therefore, the water quality is considered to be improving through the filtration-effect accompanying the underground flow.

(5) During the period of observation, the replacement work of the intercepting sewer was executed and the work completed in December 1990. At present, the water quality at St. 3 is much improved and the load run-off ratio in the future shall be maintained at a lower level.

(6) Anyang-shi, Kunpo-shi and Yiwang-shi are planned to construct a sewage treatment plant jointly in Anyang-shi and complete it by 1992. The construction work has been commenced already. According to Annex D-17, these 3 cities have a plan to expand the capacity phase by phase even after 1992, and by 2001, 100% of the waste water in the cities will be treated. Also when this plan was implemented, the water quality of Anyang Chong at St. 6 is expected to be improved to 23.7 mg/l in the annual average of BOD.

6.1.2 Flow Regime

(1) In the planned section, more than 1/3 of the low water channel width is covered by water, even when in the low water level. Therefore, the maintenance flow is sufficiently supplied.

(2) However, there are places with stored waste water at the outlets of sewage to the river directly and front of the overflowing of the intercepting sewer. This is not only spoiling the surrounding scenery but also the source of bad smell. The regime at these location is also to be improved.

(3) In the construction plan of the sewage treatment facility of Anyang-shi as mentioned above, the treated water would be discharged into Anyang Chong. Therefore, the flow of Anyang Chong

would never decrease even after the completion of the sewage treatment facility.

6.1.3 Space Utilization

(1) Since the major part on the right bank of the planned section is distanced by the roads and railroad covered with heavy traffic from the residential area. This makes difficult and endangers that the residents visit to the river. Noise is also staying in the river space.

(2) Also the majority of the planned section is a quasi-industrial zone, so it lacks green and spectacles.

(3) No fish inhabitating the river has been confirmed and no wild bird has ever been sighted in the urban area of the Metropolitan because the river water quality is very poor. Botanical plants in the riverbed are also scarce and monotonous. Accordingly, there is few natures to be protected.

(4) On the left bank in the planned section, a large scale construction of high-storied condominiums are progressing and the rapid increase park and green area is estimated with increase of the population.

(5) In 2 Ynagping retarding basins on the right bank of downstream, parking lots are constructed utilizing the upper space of the basins. Construction plan of the similar parking lot are also progressing in 2 retarding basins of Toksan and Shikong.

6.1.4 Flood Control

(1) In the planned section in Seoul, the river renovation ratio is reaching 100%, including the tributaries, so the damage due to the water from the outer area is considered mostly prevented.

(2) However, the damage due to flood is occurring almost every year because the increase of run-off coefficient in the basin under the rapid urban development and the back water of the Han River are overlapping.

(3) Seoul is striving for to reduce the damage due to flood by adding the capacity of its drainage pump station though, what is longed for is a long-term, comprehensive flood control project which would involve other cities in the basin.

6.2 Water Quality Improvement Plan

6.2.1 Basic Policy

Based on the problems and future outlook as referred in the above paragraphs, following basic policy on the water quality improvement plan shall be set.

(1) To improve the water quality of Anyang Chong fundamentally, it is necessary to improve sewer system in the basin of Kaihoa Chong and Wuryu Chong and intercepting sewage running in the planned section in addition to the improvement of sewer in the upper basin beyond St. 6.

(2) These measures are to be executed as a sewer project, however, the execution of which would takes considerable time while the improvement of the resident' living environment and the effective utilization of the river space could not be expected. Under such circumstances, any feasible measure shall be used, to execute as the river improvement works, so as to improve the water quality as early as possible.

(3) The measures to be applied to the river shall be executed from upstream phase by phase while checking the water quality to

maximize the investment effect.

(4) When failed to attain the target water quality by the application in the river channel, it is necessary to execute countermeasures against pollutant source and the part between source and river channel, however, concrete program is not mentioned here.

6.2.2 Target Water Quality

Environmental Bureau determined that the water quality of this river should be Class V, however, the actual water quality is lowering " the limit that would not give any disconformity to the people's daily life (Class V)" greatly, and terribly stinky.

Therefore, tentative target of water quality on Class V (BOD concentration is below 10 mg/l) shall be set. This water quality is the limit of making no bad smell caused by the decomposition of organisms.

As stated previously, Anyang-shi's sewage treatment facility will be operated fully (100%) in 2001, and the water quality at St. 6 is expected to be improved by then to BOD concentrations of 23.7 mg/l, and the target mentioned above could be attained until 2002 by operating appropriate river purifying facility.

However, judging from the current load measured in the downstream past St. 6 and a possible increment of the load occurred hereafter, it appears to be very difficult to attain the target in the entire planning section by 2002, even if the arrangement of sewer were executed as per plan.

In order to clear the hurdle of Class V in the entire planning section, it is necessary to execute orderly arrangements and repair of sewage-related facilities in the downstream past St. 6 in parallel with the installation of water quality purification facilities.

6.2.3 Selection of Applicable Technology

In the downstream side of the confluence of Torim Chong, which river width is narrow, is belonging to the tidal area, sludge is deposited on the river bed and H_2S gas is generated through the year. According to the survey report of Environmental Bureau prepared in 1987, the thickness of sludge in this section was as much as 30 cm, however, sludge is believed to be more than that at present. Also, sludge would deposit around the outlet of drainage pipe, intercepting sewer, etc. with bad smell.

Therefore, if the technology of "removing of sludge accumulated in the river channel" is applied, this would be very helpful in improving the water quality, especially for the prevention of stink though, it is difficult to evaluate it quantitatively. With the quality of water as present, sludge would deposit again in a short time, therefore, dredging should be done only after the measures reducing the emission load and run-off ratio were applied and the water quality is improved to a certain degree. Besides, the removing of the sludge deposited in the river channel will expand the area of discharge section in the segment, it would definitely improve the safety of flood control.

The installation of "drop works" and "sheet flow channel" are not suitable in the cases that the gradient of river bed is not so sharp in the planned section. These facilities are expected certain effects when the pollution of water quality is not terrible, therefore, the application cannot be considered under the condition as it is, because it would only increase the stink and expedite the deterioration of environment as the sludge would deposit in the upstream.

The application of "installation of direct aeration system" and "introduction of purifying water" are difficult because such facilities would require the land corresponding to the discharge, in the case of Anyang Chong where the discharge is big and the water quality is extremely bad.

Conversely, "sedimentation pond" and "contact oxidation with cobble plant" can be applied to the river channel in the planned section with considerable effect expected.

However, according to the prospect of water quality made in Section 4.5, if the sewage treatment of the upstream remains as it is, the water quality of the planned section in 2002 may have BOD concentration of 84.5 mg/l even at St. 6 and hardly expect of the effect of contact oxidation with cobble plant even if it was applied.

If the sewage treatment of the upstream progressed on schedule and the water quality of St. 6 is improved to 23.7 mg/l as envisaged, the target water quality at St.6 could be attained by 2002 however, the attainment of this target water quality would be failed if the condition of intercepted waste water in the Metropolitan area remained as it is.

As a consequence of the above study, the sedimentation pond and contact oxidation with cobble plant shall be installed and simultaneously apply the measures eliminating the direct run-in of sewage in the planned section in order to gain the target water quality of Anyang Chong, and it is desirous to dredge the sludge deposited in the river channel after applying these measures to improve the water quality completely.

6.2.4 Design Standard of Major Facilities

(1) Design water quality

BOD concentration is adopted as envisaged in Case C of 4 cases set forth in Section 4.4.1 applicable to the water quality improvement facilities in the river channel. Incidentally, SS concentration shall be worked out from BOD concentration using SS/BOD ratio of the period of investigation. The results are indicated in Table 6.2-1 below:

Table 6.2-1 Designed Water Quality of the Water Quality Improvement Facility in Anyang Chong

Anyang Chong Unit:mg/l

Year(Item)	St.1	St.2	St.4	St.5	St.6	St.3
1990(BOD)	55.5	59.5	52.5	55.7	48.6	23.0
(SS)	56.4	53.9	67.0	42.9	41.1	42.0
2002(BOD)	39.0	37.7	33.7	35.3	23.7	38.2
(SS)	58.5	56.6	50.6	53.0	35.6	57.3
2010(BOD)	47.3	44.7	39.8	14.2	23.7	38.2
(SS)	71.0	67.1	59.7	61.8	35.6	57.3

(2) Design discharge

The design water quality described above has been worked out basing on the average value of the water quality measured every month during January 1990 and May 1991. Therefore, they could be considered as 50% value. Accordingly, as regards the design discharge corresponding to them, ordinary discharge (Q185) which is approximate to 50% value, is adopted, however that in Table 3.1-4, the values of St. 1 and St. 4 are made smaller than that of the upstream being affected by the underground flow, so a supplementary correction was made as shown in Table 6.2-2, referring to specific discharge, etc.

Table 6.2-2 Designed Discharge of the Water Quality Improvement Facility in Anyang Chong

Anyang Chong Unit:m^3/l

	St.1	St.2	St.4	St.5	St.6	St.3
Q(185-day)	9.632	8.962	7.494	5.630	3.252	2.268

(3) Treatment method

When the design water quality has values as shown in Table 6.2-1, the load to be removed to clear the target water quality (BOD concentration: 10 mg/l) at each standard point is calculated as shown in Table 6.2-3. And simultaneously, the type of treatment corresponding to the load to be removed is selected from Table 4.4-8 and added it to Table 6.2-3, providing that installing the facilities from the upstream down is a precondition.

Table 6.2-3 Removal Load and Treatment Method for Accomplishing the Target Water Quality

unit:kg/day

	St.1	St.2	St.4	St.5	St.6
2002	---	17,291	9,346	34,751	3,862 (type 4)
2010	---	22,241 (type 5)	12,574 (type 5)	53,554 (type 4)	-

(4) Treatment capacity

Fig.6.2-1 represents the relation between the treatment capacity of the proposed contact oxidation with cobble plant at St.6 and the river flow or the water temperature.

The actual river flow exceeds the design discharge for approximately 170 days per year, however, it is expected that the target water quality can be sutisfied in the mixed condition of the treated water and the river flow, because it is recognized that the BOD concentration tends to decrease if the river flow increases. In winter season, the water quality deteriorates and the removal ratio of the plant decreases. However, it is possible to maintein the equivalent removal ratio at the design water temperature by extending the detention time, because the river flow gets lower than the design discharge.

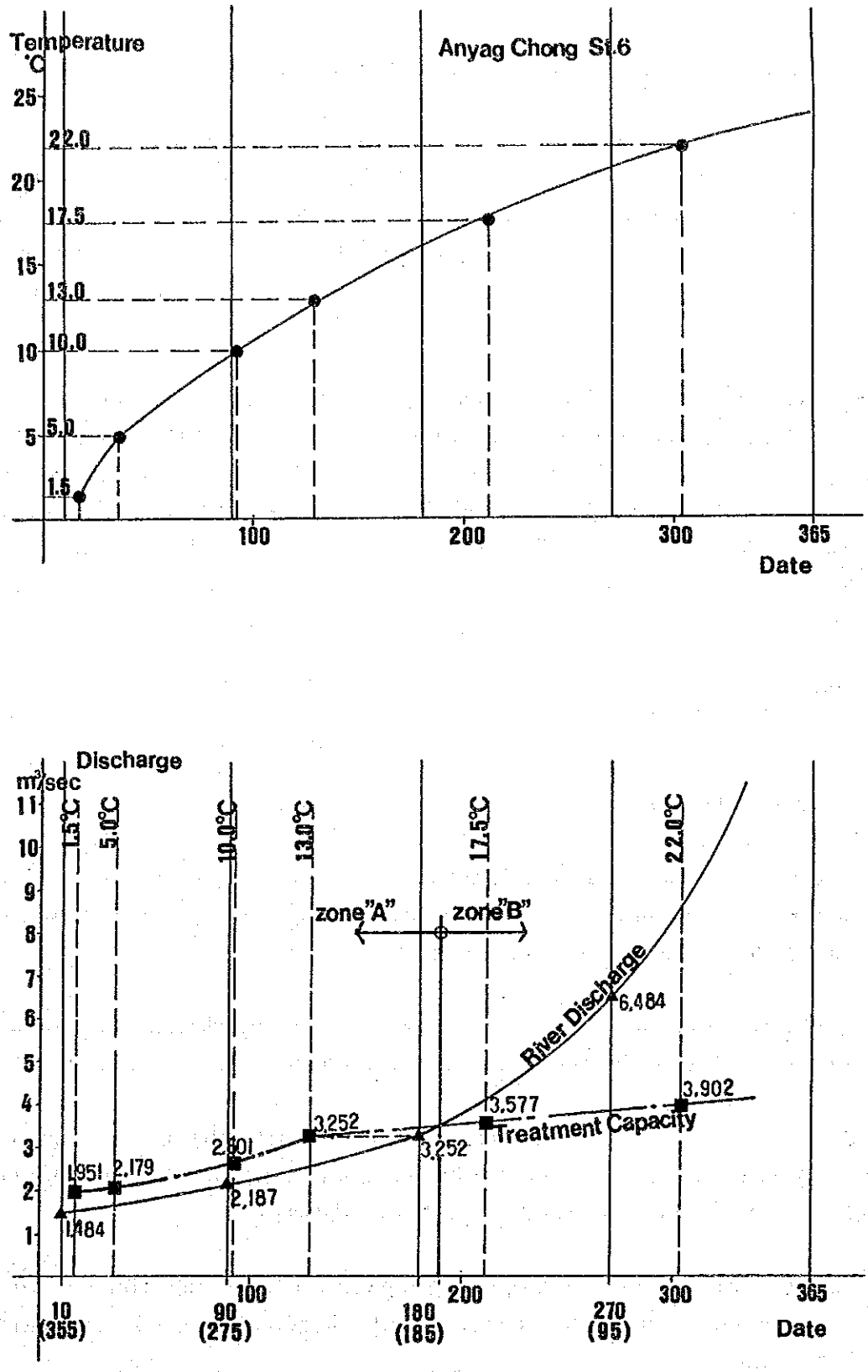


Fig. 6.2-1 Treatment Capacity of Water Quality Improvement Plant St.6

6.2.5 Expected Water Quality Improvement Effect

As there is no effective alternate measure applicable to the water quality of this river, only the effect of the water quality improvement of these case as established in 6.2.4 which would install treatment facilities from the upstream down is expressed by the river water quality and amount of load (Figs. 6.2-2 and 6.2-3).

To attain the target water quality in the entire planning section, it is necessary to install a complex treatment facility comprising of the sediment pond and contact oxidation with cobble plant from St. 6 to St.2 phase by phase though, it is quite obvious that the effect of installing such facilities at St. 5 is great.

6.3 Space Improvement Plan

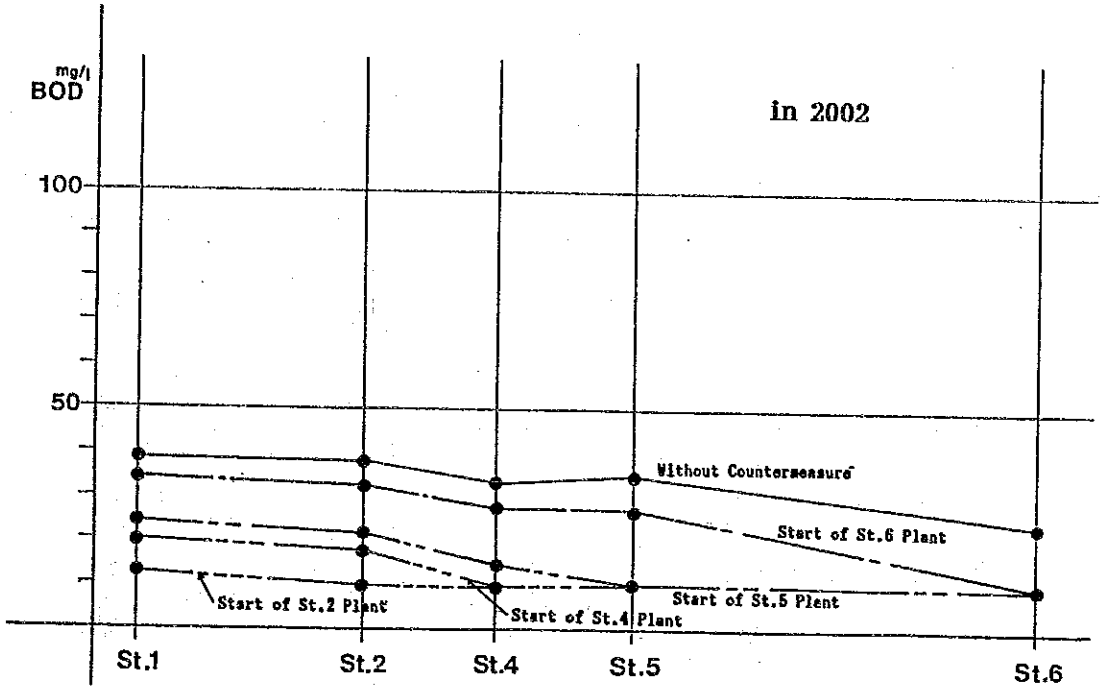
6.3.1 Basic Policy

Based on the problems and future outlook as described in the preceding paragraphs, the basic policy of the space improvement plan of Anyang Chong is determined as follows.

(1) Improvement shall be proceeded with recovering and growing the nature, almost defunct nowadays, surrounding the river.

(2) Since the major bed has the broader width which is enough to harbor sporting facilities therein, sporting and health control facilities will be provided for the residents.

(3) In the area where a higher frequency of inundation is anticipated, arrangement and improvement preconditioned inundation shall be made.



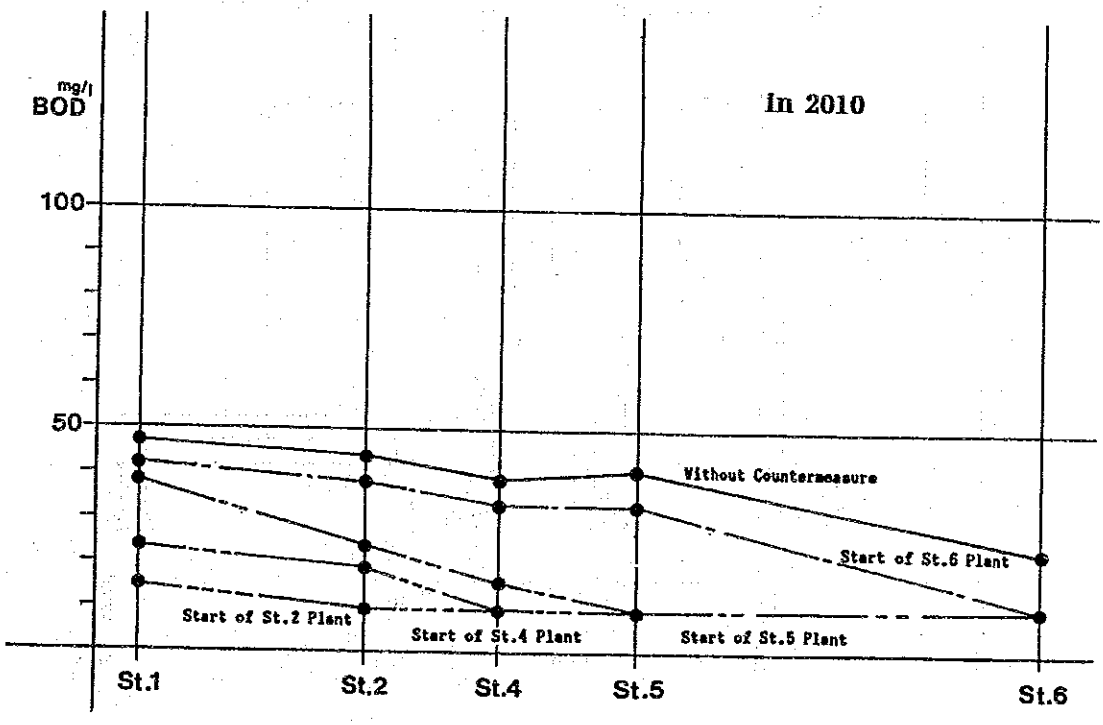
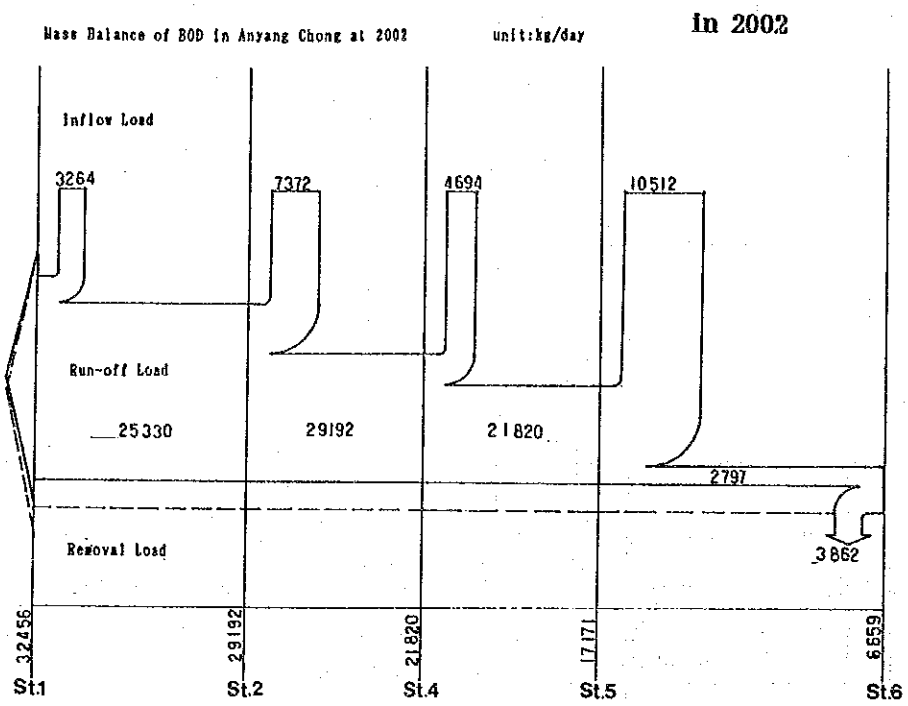


Fig. 6.2-2 Estimation of Water Quality when Water Quality Improvement Plant Installed



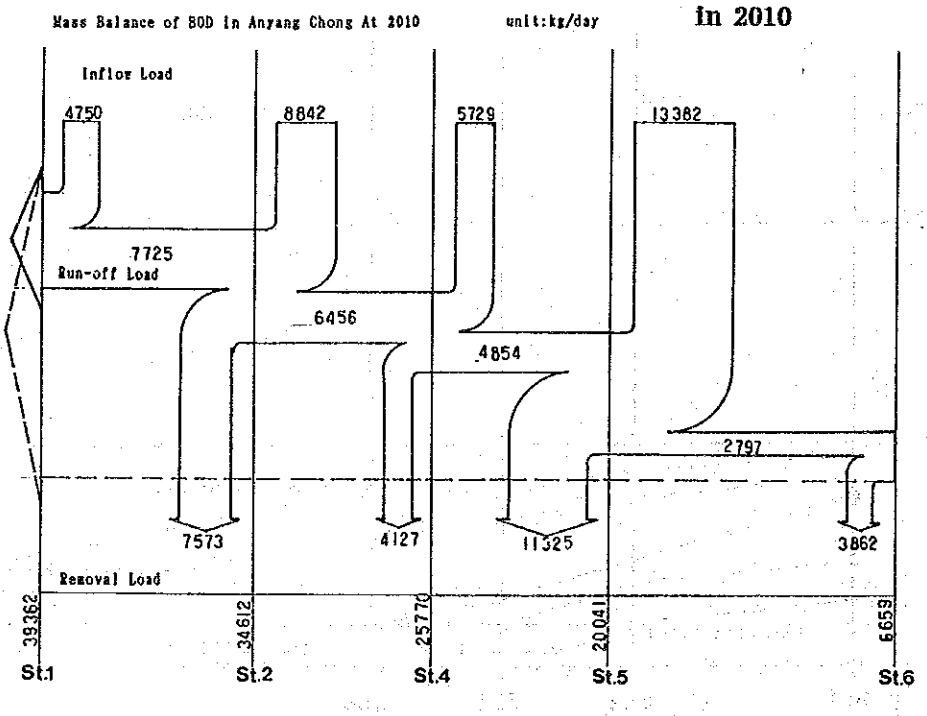


Fig. 6.2-3 Estimation of Pollution Load Balance when Water Quality Improvement Plant Installed

6.3.2 Zoning and Improvement Plan for Each Zone

Zoning in the planned section is provided combining the space classification described in 3.6.1 and the land use mentioned in 4.5.1 (Fig. 6.3-1). The established zone is divided into 3 types, i,e. multipurpose zone, family zone and natural zone. The results of zoning is shown in Fig. 6.3-1 and the layouts of the 3 zones are shown in Fig. 6.3-2.

Multipurpose zone

Area to be improved: Left bank (L = 3.75 km)
Right bank (L = 5.5 km)

Improvement policy:

a. Walking road shall be provided to have the segment under plan keep a link with it.
b. The facilities shall be utilized by factory workers to have them enjoy sports or rest

Major facilities:

Walking road, sport ground, green plaza(provided with health increasing equipment and playthings), esting park (provided with bench and shelter).

Family zone

Area to be improved: Left bank (L = 8.8 km)
Right bank (L = 7.8 km)

Improvement policy:

a. Walking road shall be provided to have the segment under plan keep a link with it
b. Flowers shall be planted to beautify the major bed

Major facilities:

Walking road, sub-area park, flower bed, and green plaza.

Natural zone

Outline is referred to 6.3.3, since it is corresponding to M3 area of model site.

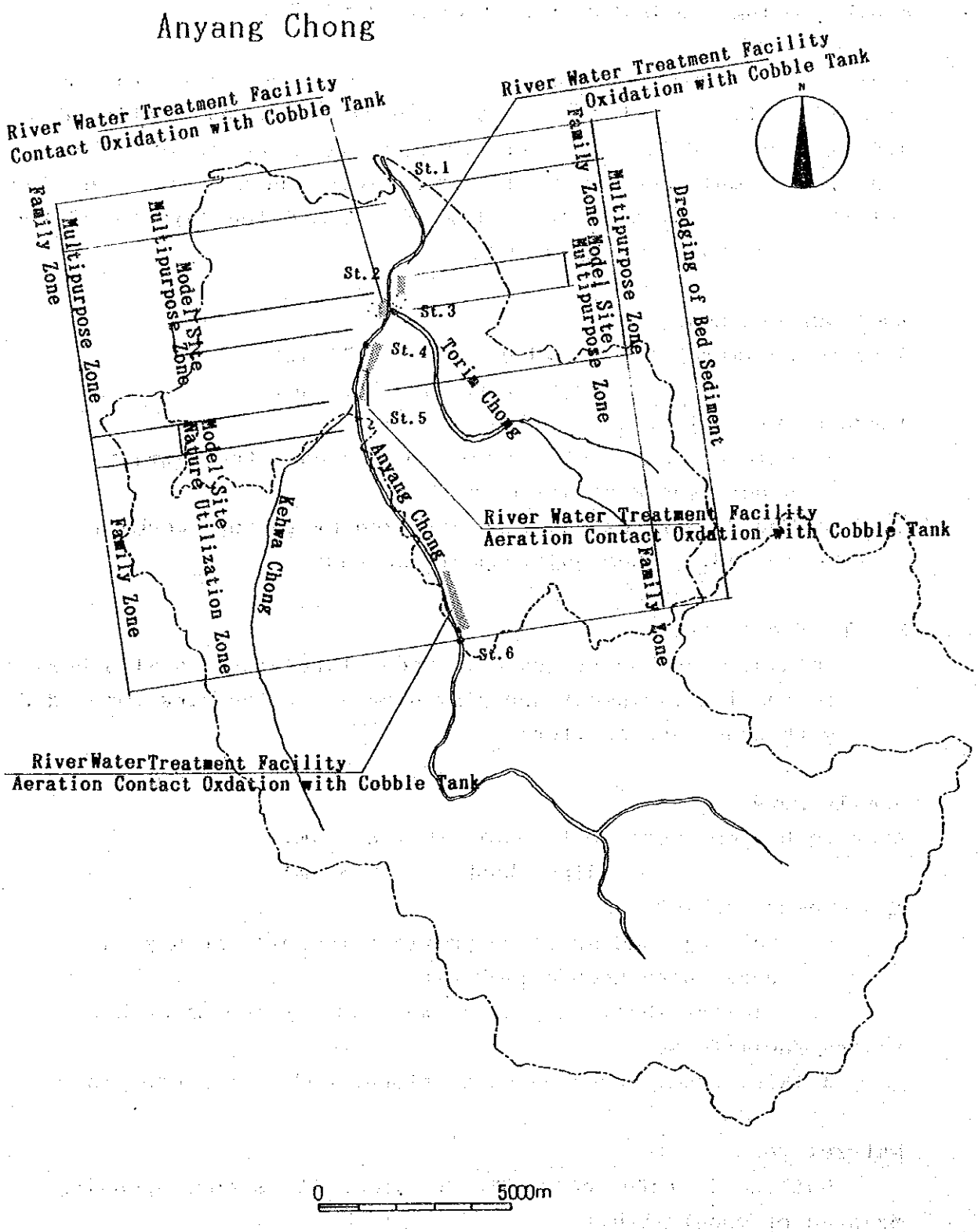
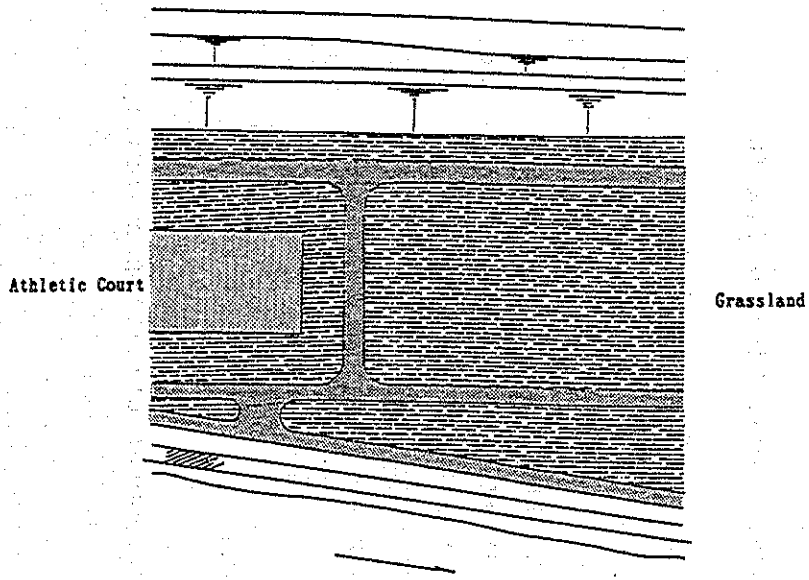
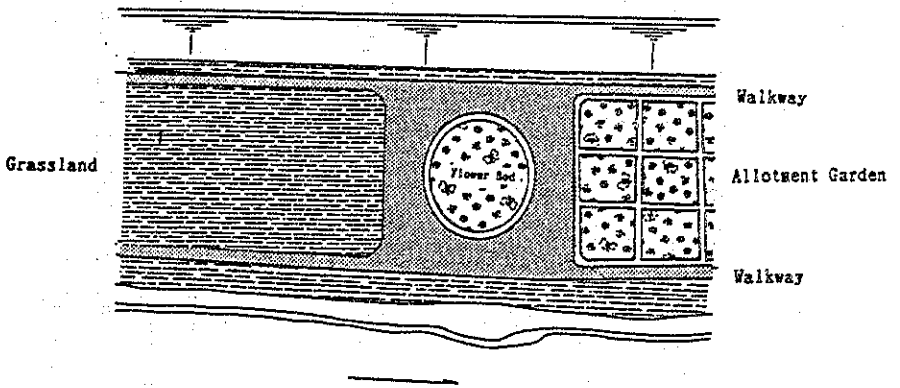
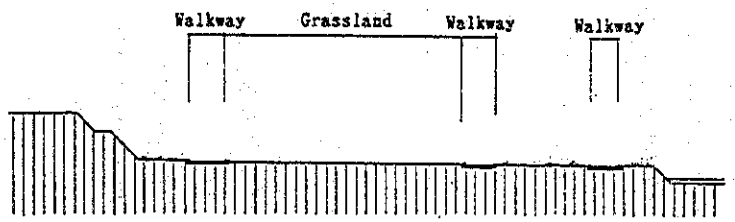


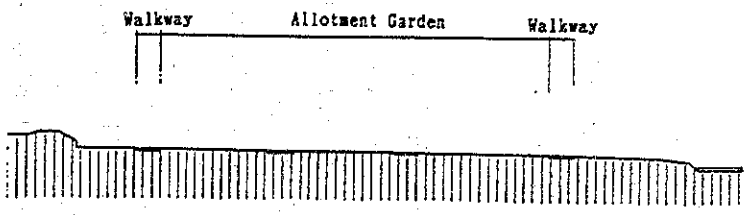
Fig. 6.3-1 River Space Zoning of Anyang Chong







Multipurpose Zone



Family Zone

Fig. 6.3-2 Space Improvement Plan of Anyang Chong on Every Zone

6.3.3. Improvement Plan for the Model Site

Based on the comprehensive evaluation made with regard to the utilization demand and the degree of adaptability of each section as shown in Section 3.6.2, 3 sites of planned section in Anyang Chong shall be improved as the priority sites.

M1 site (Right bank No. 79 - 95)
Area to be improved: 12 ha (L = 800m)
Improvement policy:

a. To provide facilities to have people improve health while playing sports.
b. To provide a plaza to have people hold events

Major facilities:

Plaza (1), tennis court (5), volleyball court (3), green plaza (1), walking road, resting facilities (bench - 30, shelter - 2), lavatory (2 points), control facility (staircases - 3 places, trash bins in 5 points)

M2 site (Left bank No. 84 - 102)
Area to be improved: 12 ha (L = 900m)
Improvement policy:

a. To provide facilities to have people improve health while playing sports
b. To provide a plaza to have people hold events

Major facilities: Plaza (1), soccer coat (1), tennis court (2), volleyball court (1), green plaza (1), flower bed, resting facilities (bench - 30, shelter - 2), lavatory (2 points), control facility (staircases - 3 places, trash bins in 5 points)

M3 site (Left bank No. 146 - 159)
Area to be improved: 5 ha (L = 650m)
Improvement policy:

a. To nurture the natural environment utilizing a variety

of plants comprising trees around the riverside.

b. To arrange and improve the area to enable people to enjoy walking or rest in the natural environment.

Major facilities:

Natural walking road (1,100 m), natural embankment (630 m), resting facilities (bench - 24), lavatory (2 points), control facility (trash bins in 6 points)

6.3.4 Facility and Planting plans

(1) Facility plan

In the facility plan, the following points shall be considered specifically.

(a) Precast concrete and plastics shall compose the major part of facility and material used therefore, to minimize the damage due to inundation.

(b) Lavatory, control structure and sporting facility shall be of portable construction in consideration of the time of inundation

(c) facilities must be easily maintainable and controllable.

(2) Planting plan

In the planting, the following points shall be considered specifically.

(a) When growing flowers on the major bed, flowers inhabiting around the riverbank shall be transplanted for the sake of the maintenance of nature.

(b) For the major bed that would suffer inundation, plant flowers which could easily beatify the surrounding, less expensive, highly anti-hygro prytic, selecting the kinds capable to bloom even under haphazard control.

Chapter 7

Chapter 7 The Basic River Environment Improvement Plan for Yangjae Chong

The water quality standard desired for Yangjae Chong is Class II and composite treatment which shall mainly implement contact oxidation with cobble plant shall be the basis of the water quality improvement plan for this river. Due to the river space restrictions, the installation of treatment facilities at the upstream area of the Yangjae Chong and Yoi Chong confluence is difficult. The water quality in St. 1 is expected to further deteriorate in future, and the installation of treatment facilities in this area will only affect 300 m of the area. The treatment facilities, therefore, shall be installed near St. 2. The desired water quality standard in the St. 2 area can be achieved despite the future increase in the pollution load from the upstream basin covering Yoi Chong. However, it is difficult to reach Class V if the misconnection of the cess pipe and the storm sewer in St. 2 downstream is not repaired.

There is no need to implement the flow regime improvement plan in Yangjae Chong because it has enough flow to propagate water familiarity functions.

In contrast to the other rivers, the Yangjae Chong area is blessed with a rich natural environment. The quality of the water between St. 1 and St. 2 can be actually improved up to the desired level by 2010 if the misconnection of the cess pipe and the storm sewer is repaired. High water familiarity functions which are rarely attained, can be achieved through the implementation of an appropriate river space improvement plan. Plazas that will help propagate water familiarity functions shall be constructed in 2 places, the confluence of Yangjae Chong and Tan Chong shall be made into a nature zone for the consideration of the ecological system, and a zone for the preservation of the natural environment shall be constructed upstream from the confluence of Yangjae Chong and Yoi Chong.

7.1 Problem and Future Outlook on River Environment

Prior to planned the basic concept of environment improvement plan of Yangjae Chong, the problems and future outlook of the present environment condition, referred to mainly in Chapters 3 and 4, are summarized as the fields of water quality, flow regime, space utilization and flood control.

7.1.1 Water Quality

(1) BOD and COD concentrations lower Class V of the river environmental standards. However, summer-fall seasons when discharge is large, the water quality will be improved considerably, i.e., the water quality will clear nearly all items of Class III of the river water quality standard.

(2) The majority of the load discharged from the basin is of the domestic origin; presumably 25% from Kwachon-shi and 75% from the Metropolitan.

(3) In planned section, the water quality is deteriorated from the upstream to down. Water flowing from Yoi Chong and the sewage coming from the rain duct opening its outlet on the right bank at a point between St. 2 and St. 1 are considered to be the main causes.

(4) When the erroneous connection of the sewage pipe to the rain duct was not renovated, BOD concentration of St. 1 would exceed 40 mg/l in 2002 and 50 mg/l in 2010. On the other hand, if such renovation is executed completely, BOD concentration may remain in 10 mg/l or so.

(5) The major part of the basin of Yoi Chong, one of the tributaries, is included in the development restricted area, however, the water quality is averaging worse than that of the main river, especially in the upstream. This is mainly caused by the domes-

tic sewage of the villages discharged into the river directly since no intercepting sewer is provided in the upstream.

7.1.2 Flow Regime

(1) Since the separated sewerage system is applied in the urban area and treated water of the sewage treatment plant in Kwachon-shi is discharged into Yangjae Chong, reduction of river flow has never occurred due to the orderly arrangement of sewage treatment system. Also the fact that the natural environment is well maintained in the upstream area is believed to contribute to the flow maintenance.

(2) In the Yangjae Chong basin, non-urban area is occupying a great part, and the majority of which are designated as the development restricted zones. To maintain the present level of river flow, keeping of this development restricted zones and maintaining of the natural environment would be essential.

7.1.3 Space Utilization

(1) In the downstream, the vicinity of river is reclaimed so the difference in height between the embankment and the major bed becomes 10 m or more where the depth is great and the gradient of slope becomes 1 : 0.5 or so. Up-and-down approach to the major bed via embankment would be danger.

(2) On the left bank between Yongdong 2 Bridge and Yongdong 6 Bridge, a vehicle road is running in parallel with the river. This makes the approach by the people living nearby to the river difficult.

(3) Since the exterior land at the confluence with Tan Chong has good conditions to have wild birds, insects and hygrophytes inhabit there. It is very desirous to keep such natural condi-

tions for ever.

(4) It is not known if there is any plan to occupy the river space.

7.1.4 Flood Control

(1) The flood control of the river in Seoul is relatively good as the renovation ratio of the river channel is reaching 100%.

(2) However, in the lower land in the vicinity of Tan Chong confluence, the damage due to the inside water occurs during the flood season. It is therefore necessary to provide a drainage pump station while raising the ground level of this area.

7.2 Water Quality Improvement Plan

7.2.1 Basic Policy

Basing on the points st issue and future outlook as referred to in the preceding paragraph, a basic policy of the water quality improvement plan shall be established as follows.

(1) Since this river provides a relatively good water in quantity and quality except for some parts, it can be expected to attain high standard recreational zone with water familiarity by water quality improvement work which cannot be executed in other river section.

(2) For such a reason, erroneous connection of the sewage pipe to the rain duct between St. 1 and St. 2 should be renovated. When this renovation was not made, the target water quality of this segment could not be attained by 2002.

(3) The reason why the water quality of upstream beyond St. 2 is

comparatively good is that the proportion of the development restricted area occupied in this basin is great. Therefore to maintain a good water quality, It is necessary to keep this development restricted area and ensure that the sewage treatment of this area be operated properly.

(4) Since the tributary of Yoi Chong has few sources of pollution, it does not affect the river water quality of the river, however, when the development progressed, it may also influence the river. Therefore, the discharge of Yoi Chong shall be included when the measures for the river channel is considered.

7.2.2 Target Water Quality

This river lacks the water quality standards established by Environmental Bureau because of a quasi-river. The Seoul Government has never determined this standard. However, the water quality of Tan Chong joining this river is classified as Class II by Environmental Bureau. Therefore, the target water quality of this river shall be defined as Class II.

This standard defines this river as a model river of the small-medium river environmental improvement project at such a level that is suitable to swimming and playing in the water and this concept is compatible with the basic policy of this scheme intending to create a quality recreation space possessing a great deal of hydrophile properties.

At St. 4, the current annual average water quality has cleared Class III and would not worsen even 2002. However, when the improvement of pipe intercepting sewage did not progress, BOD concentration at St. 2 may exceed 10 mg/l in 2002 under its influence. Therefore, to clear the target water quality of the river channel, we need some water purification facilities.

Also, when the erroneously connected sewage pipe to the rain duct

between St. 1 and St. 2 was not renovated, BOD concentration of St. 1 would exceed 40 mg/l even in 2002. Whereas, this segment is in the downstream of the segments under plan, so providing any purification facility in the river channel makes no sense. It is therefore indispensable to renovate the erroneous connection if intended to attain the target water quality.

7.2.3 Selection of Applicable Techniques

Since the major material of the river bed is sand and there is not much deposited sludge to be removed, "dredging of sludge deposited in the river channel" will not be applied.

As to the installation of "fall works " and "sheet flow channel", the equivalent evaluation is difficult about the application, the effects of water quality improvement by these facilities are expected in this river because the gradient of the river bed is relatively steep and the water quality is not so bad. Installation of a pilot facility to measure the effect, in accordance with water familiarity, can be considered.

"Direct aeration system" and "introduction of water for purification" will require land of the facility corresponding to the size of discharge, so the application is difficult in the case of this river as it has plenty water.

As described above, what is advisable in Yangjae Chong is that sediment pond treatment and contact oxidization with cobbles plant shall be used, and if the results of pilot facilities will be in success, fall works and sheet flow channel will also be applied.

Incidentally, the water quality purification facility is desirous to be installed at a spot where the water quality found to be worst. But when it will be installed at St. 1, the improved section will be only 300 m. Also, the river width in the vicini-

ty of St. 3 is narrow and the intercepting sewer is provided in the small tiers of the bank of the both sides, hence the installation of purification facility is difficult. Therefore, such a purification facility shall be installed in the vicinity of St. 2, and the water quality improvement of the downstream of that shall be done by renovating the erroneous connection.

7.2.4 Design Criteria of Major Facility

(1) Design water quality

The river water quality shall be adopted Case 1 of two cases provided in Section 4.4.1 with assumptions the worst condition, which will be the base on designing facilities. As the index of water quality, BOD and SS concentration shall be adopted, SS concentration shall be worked out from BOD concentration using SS/BOD ratio during the period of investigation.
The result is shown in Table. 7.2-1.

Table 7.2-1 Designed Water Quality for Water Quality Improvement Facility in Yangjae Chong

Unit:mg/l

Year(Item)	St.1	St.2	St.4	St.3
1990(BOD)	13.5	5	5.1	11.2
(SS)	33.9	21.3	24.4	13.2
22002(BOD)	45.3	13.4	5.1	29.0
(SS)	181.2	53.6	20.4	116.0
2010(BOD)	55.6	15.3	5.1	34.7
(SS)	222.4	61.2	20.4	138.8

(2) Design discharge

The design water quality described above has been worked out based on the average of measured values every month during July

1990 and May 1991. Accordingly, this could be taken for approximately 50% value. Therefore, with regard to corresponding to the above, the ordinary discharge (Q185) is used as the design discharge (Table 7.2-2).

Table 7.2-2 Designed Discharge Water Quality Improvement Facility in Yangjae Chong

Unit:m^3/sec

	St.1	St.2	St.4	St.3
Q(185-day)	0.736	0.645	0.397	0.152

(3) Type of treatment

When the purification facility is installed at the St.2, the load to be moved to clear the target water quality (BOD concentration 6 mg/l) is calculated 411 kg/day in 2002 and 520 kg/day in 2010. Accordingly, Type 2 of Table 4.4-8 is considered to be appropriate.

(4) Treatment capacity

Fig.7.2-1 represents the relation between the treatment capacity of the proposed contact oxidation with cobble plant at St.2 and the river flow or the water temperature.

The actual river flow exceeds the design discharge for approximately 170 days per year, however, it is expected that the target water quality can be sutisfied in the mixed condition of the treated water and the river flow, because it is recognized that the BOD concentration tends to decrease if the river flow increases. In winter season, the water quality deteriorates and the removal ratio of the plant decreases. However, it is possible to maintein the equivalent removal ratio at the design water temperature by extending the detention time, because the river flow gets lower than the design discharge.

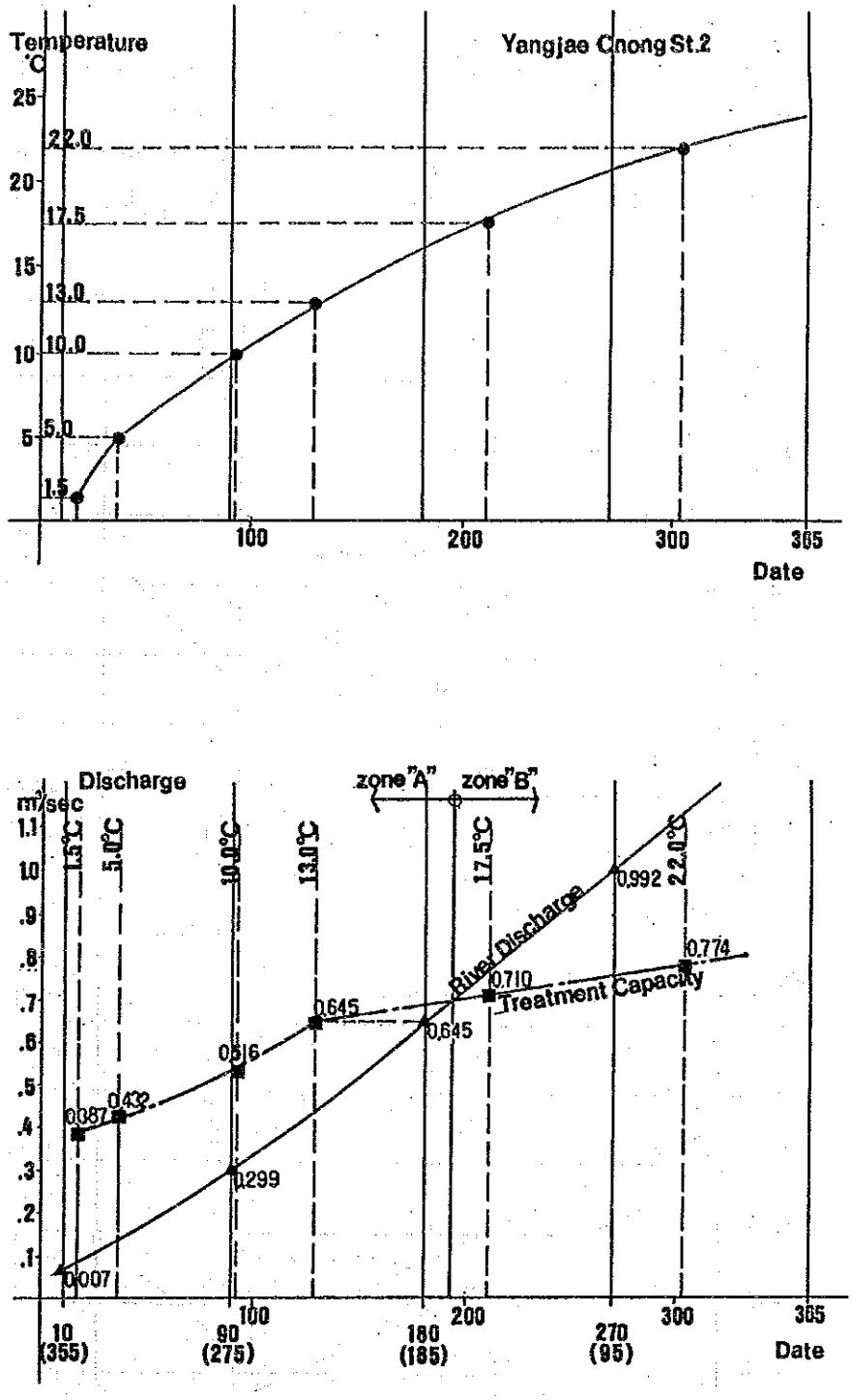


Fig. 7.2-1 Treatment Capacity of Water Quality Improvement Plant at St.2

7.2.5 Expected Effect of Water Quality Improvement

If such a water purification facility as described above was provided, the target water quality will be obtained at St. 2, even if the load flowing will be increased. Also, when the erroneous connection of the sewage pipe to the rain duct between St. 2 and St. 1 was renovated, the quality will be attained Class II.

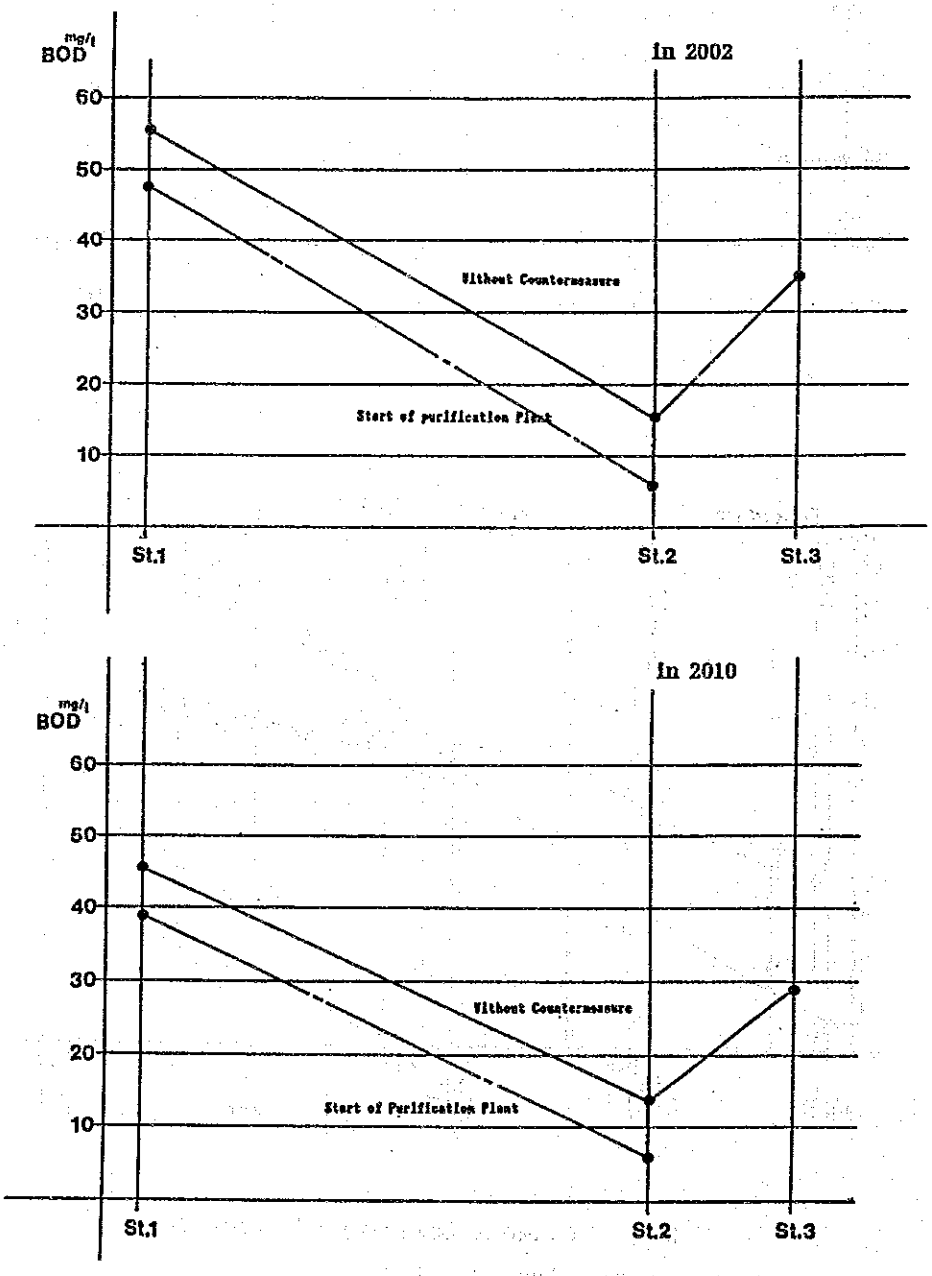
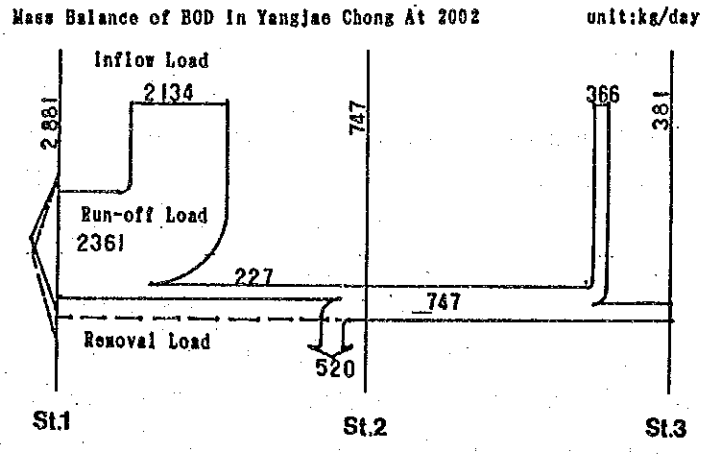


Fig. 7.2-2 Estimation of Water Quality when Water Quality Improvement Plant Installed



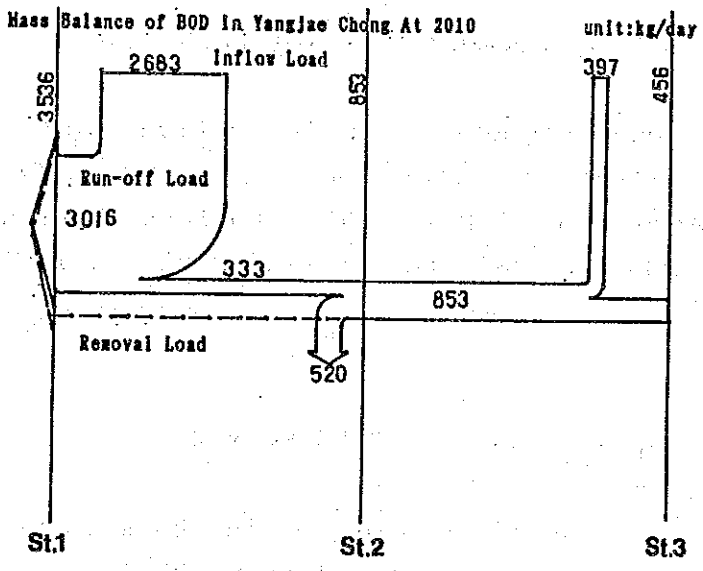


Fig. 7.2-3 Estimation of Pollution Load Balance when Water Quality Improvement Plant Installed

7.3 Space Improvement Plan

7.3.1 Basic Policy

Basing on the problems and future outlook as enumerated in the preceding paragraphs, the basic policy of space improvement plan of Yangjae Chong is defined as follows.

(1) As the rich nature remains in the vicinity of the planned section compared to the other rivers, improvements shall be made with the utmost care of not damaging such a nature. Especially, creatures living around the riverside shall be kept and nurtured carefully so as to enable the inhabitants intimate with them.

(2) Since the river water quality is relatively good, highly water familiarity will be provided.

7.3.2 Zoning and Improvement Plan for Each Zone

Combining the space segment shown in Section 3.3.1 and the mode of utilization shown in Section 4.5.2, zoning between the sections is prepared (Fig. 7.3-1). The provided zones are 3 types , i.e., natural zone natural preservation zone and family zone.

Natural zone

Area to be improved: 2 ha (L = 0.25 km x 2)
Improvement policy:

a. Walking road shall be provided in the segment under plan to have the segment keep a link with it.
b. Breed and nurture the creatures and plants around riverside paying attention to the natural ecosystem so as to make the spectacle of rich nature last long.

Major facilities:

Walking road,resting facilities and control facilities

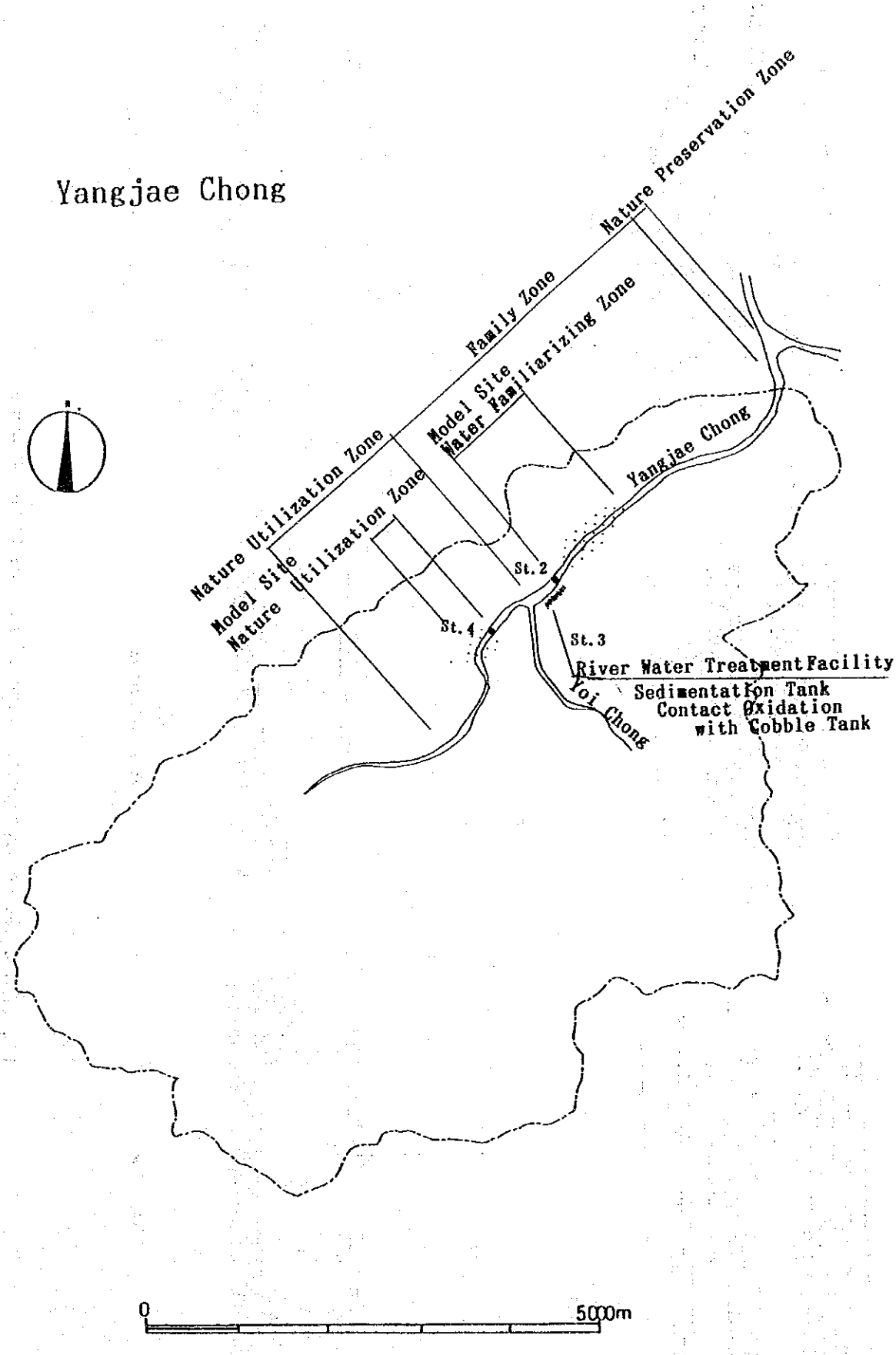
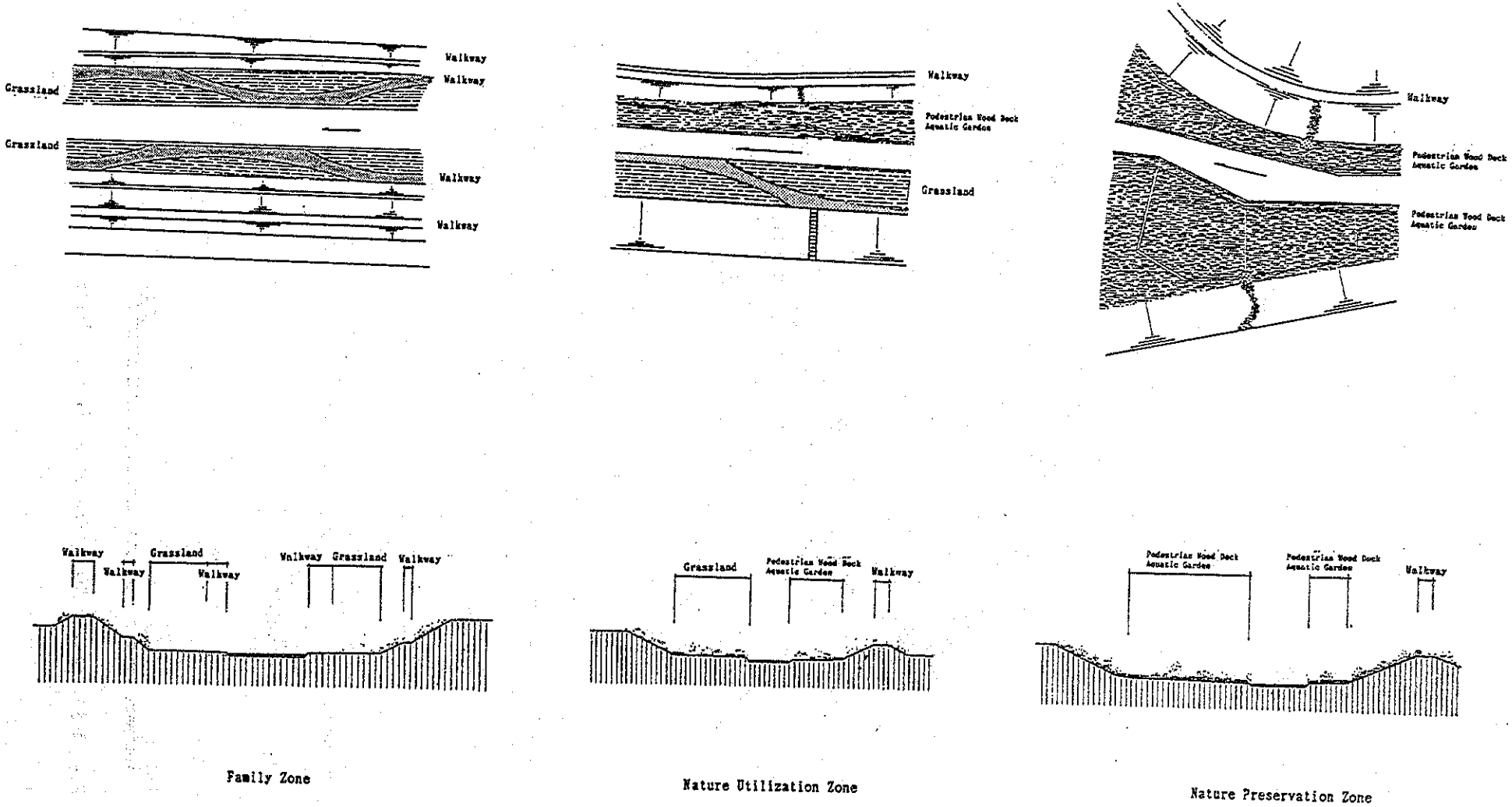


Fig. 7.3-1 River Space Zoning of Yangjae Chong



Family Zone

Nature Utilization Zone

Nature Preservation Zone

Fig. 7.3-2 Space Improvement Plan of Yangjae Chong on Every Zone

Natural preserving zone

Area to be improved: 5 ha (L = 1.1 km x 2)

Improvement policy:

a. Walking shall be provided in the segment under plan to have the segment keep a link with it.

b. Existing natural environment shall be maintained.

c. Improvement having a link with the adjacent public park shall be made.

Major facilities:

Walking road, green plaza,planting, resting facilities and control facilities.

Family zone

Area to be improved: Left bank 14 ha,
right bank 16 ha (L = 3.04 x 2)

Improvement policy:

a. Walking shall be provided in the segment under plan to have the segment keep a link with it.

b. Improve the facilities so as to enable the riverside people to take rest and increase health.

Major facilities:

Walking road, green plaza, resting facilities and control facilities.

7.3.3 Improvement Plan of the Model Site

In accordance with the comprehensive evaluation made with regard to the demand for utilization and aptitude level of each area as shown in 3.6.2, 2 areas shall be given the priorities in the improvement of section under scheme of Yangjae Chong.

M1 site (No. 49 - 73)

Area to be improved: 11 ha (L = 2.4)
Improvement Policy:

Improve the space so as to enable the people to take rest on the river bed comfortably at any time as it is located close to the residence area.

Major facility:
Hydrophile plaza (2),

green plaza (30,500) ha),walking road (total extension 3,600 m), health increasing equipment (30), resting (bench - 30 shelter - 40 control facilities (staircases - 6 places and trash bins in 6

M2 Area (No. 100 - 120)

Area to be improved: 7 ha (L = 2 km)
Improvement Policy:

(a) Improve the park road to enable the riverside people and the frequenters to the adjacent park to enjoy walking and rest.

(b) Improve the facilities to enable the people to enjoy sports readily..

Major facilities:

Hydrophile plaza (2),natural walking road (9 hydrophyte garden (6,000 m^2), health increasing equipment (15), resting facilities (bench - 15, shelter - 4control facilities stair case - 10 and trash bins in 10

7.3.4 Facilities and Planting Plan

(1) Facility plan

(a) Any type of facility and the materials used therefore shall be such that would suffer less damage even under the flood.

(b) Only materials giving natural feeling shall be used to harmonize them with the surrounding natural environment.

(c) Facilities shall be such that are easily maintained and controlled.

(2) Planting plan

(a) In the natural zone and the zone utilizing the nature, transplant the types of trees growing by the riverside.

(b) On the embankment in the family zone, plant taller trees so that a good green belt would be made without interruption and plant the flowers having hydrophile properties in the major bed.

Chapter 8

Chapter 8 The Basic River Environment Improvement Plan for Ui Chong

The water quality in the planned Ui Chong area is presumed to be roughly maintained at Class III the year round, because the apparent run-off ratio of pollution load is low. Consequently, there will be no water quality improvement plan for this river. Only a flow regime improvement plan shall be formulated.

Flow maintenance in this river can be viewed through the recovery and activation of water familiarity functions since the river water is not used for particular purposes. However, it is estimated that about 0.1 m3/s of water supply is required when the water level is low. This water requirement can be supplied through water conveyance from Han River and the construction of a dam upstream. Both means, however, are considered as economically impractical. Therefore, a water surface with a fixed extent shall be formed by constructing a weir at the base where the demands for water familiarity functions are particularly high. As a safety precaution against floods, movable weirs shall be used, and to prevent the water from standing, water collected from the upstream tributaries shall be delivered to the upstream section of the weir.

In addition, the low water channel shall be modified to create a visually satisfying flow and, at the same time, to quickly remove sludge discharged from the sewer pipes during rainy days.
The water quality in St. 2 tends to deteriorate due to standing water. Therefore, the modification of the low water channel is expected to improve the water quality in this station.

A plaza shall be mainly constructed on the water surface aforementioned. The construction of the plaza is aimed to develop the interrelationship between the old and the young generation, or the new and the old residents. Perpendicular revetments can be found downstream from the weir, and since these revetments spoil

the landscape, they shall be modified to improve the landscape.

8.1 Problem and Future Outlook on River Environment

Prior to planning the basic environment improvement plan, the problems and future outlook of the environmental condition described in Chapter 3-4, are summarized.

8.1.1 Water Quality

(1) Seasonal variation of the water quality was not observed in this river, and almost clears the Class III standard.

(2) However, the water quality at St.1 is lowered Class III level frequently. The reason is that this point is located upstream of the fall work and therefore water would stay when the discharge is a little and organisms are accumulated. H_2S is also generated here in summer with bad smell.

(3) The majority of the pollutant load discharged from the basin is of the domestic origin.

(4) Many restaurants and hotels are built up in the upstream beyond Pukansan Bridge and for service to the visitors, and waste water flows to the river directly and trash and junks are scattered everywhere.

8.1.2 Flow Regime

(1) The flow is a little through the year, a considerable part of the river has no water or few during the dry or low water season. This is explained that major tributaries, Daedong Chong, Hwakohu Chong and Kwao Chong, are transformed to sewage rivers and the flow of these rivers is intercepted before reaching the

confluence with the main river, and that the under flow water of the main river is relatively not small.

(2) Because of a scanty flow, a water-staying area is made in the upstream beyond the drop work only to invite junks, trash and organisms which in turn deposit there and cause to generate algae scattering stink and spoils the spectacles.

8.1.3 Space Utilization

(1) While the upstream is favored with relatively rich nature and excellent spectacles, no such natural environment and spectacles worthy to appropriate exist in the downstream. Also, in the downstream, many obstacles such as overhanging of road, parapet wall fence, etc. are preventing the approach to the exterior land.

(2) There is a plan to cover the river over 660 m to construct a parking lot in the vicinity of Wolgye in Nowon-gu.

8.1.4 Flood Control

(1) Since the river improvement ratio has reached 100%, while development of the basin is closer to the point of saturation, the discharge hereafter will be not increased greatly.

(2) However, the 50-year flooding probability is considered to be insufficient as an urban river, it is necessary to expand the planning size hereafter.

(3) Also the damage caused by the inland-water attributable to the back flow of Chungryang Chong occurs occasionally, so a comprehensive flood control plan including Chungryang Chong would be required.

8.2 Flow Regime Improvement Plan

8.2.1 Basic Policy

Environmental Bureau is not establishing the water quality standard of this river though, the water quality standard of the confluence of this river and Chungyrang Chong is made Class III. According to a prospect made with regard to the water quality, the water quality at 2 measuring points could clear Class III in 2002, even no special measures were applied to this river.
Also, even in 2010, BOD concentration would slightly exceed 7 mg/l. Therefore, by applying the flow regime improvement measures as described in the following paragraph, it could contain BOD concentration under 6 mg/l.

Accordingly, with regard to this river, we would not consider the water quality improvement plan particularly but plan the flow regime improvement plan only. The basic policy of flow regime improvement plan shall be established as follows basing on the status as described above and the future outlook.

(1) From the viewpoint of keeping water familiarity function, the supplementary water shall be introduced to cover the shortage of flow under the current condition.

(2) However, when a sufficient supplementary water cannot be gained, or even had, if it is considered to be difficult to execute it technically and economically, a plan ensures certain level of water as the second best policy.

(3) Also, modification of the river flow, by improving the flow regime as far as possible during the dry and low water level seasons, so as to create a certain water-surface as the object of a spectacle while preventing the deposit of sludge during the flood season.

8.2.2 Target Flow Regime

There is no established method defining the flow to be maintained from the viewpoint of recovering and utilizing the hydrophile function, as already described in 4.2.3. Therefore, in the case of this river, the flow to be maintained under such a concept satisfying visually, if at least 1/3 of the low river channel width is covered with water. The result is shown in table 8.2-1.

Table 8.2-1 Trial Calculation of Maintenance Discharge in Ui Chong

Station	Width of Low Flow Channel (m)	Width of Flow Surface (m)	Maintenance Depth (m)	Mean Velocity (m)	Maintenance Flow (m^3/sec)
St.1	13.0	4	0.1 to 0.2	0.1	0.04 to 0.08
St.2	34.0	11	0.1 to 0.2	0.1	0.11 to 0.22

* Mean velocity was calculated from measured values.

When the flow at 2 base points joined together, the flow-to-be-maintained would become 0.1 m^3/s or so. The flow to be lost-through evaporation and/or underground water during the course of flowing-down is called "the lost flow". granting that such lost flow is 0.1 m^3/s or so, the total flow would be 0.2 m^3/s. Since the flow at St.1 and St. 2 during the low water level is 0.05 - 0.1 m^3/s, during such a season the supplementary water to be required would be 0.1 - 0.5 m^3/s.

8.2.3 Selection of Applicable Techniques

(1) Utilization of water of reservoir

Since there is no reservoir in the Ui Chong basin, it is required to construct new reservoir in the upstream to secure the supplementary water. The gradient of this river is sharp and the

development is advancing far up to the upstream. Therefore, the point to secure a certain volume of water is limited to an area of 200 m above the sea level (area of basin: 7.5 km^2).

And, the relation between the dam height and water to be reserved from the topography of this point and discharge the supplementary water can be calculated trial in the preceding paragraph during the low water level season (0.1 - 0.15 m^3/s) from such a reservoir, the number of days capable to discharge the water would become as shown in Table 8.2-2.

Table 8.2-2 Relation between Dam Height and Water Supply Days

Dam Height (m)	Storage (m^3/sec)	Flowing Days (day)
40	453,000	52
30	204,000	24
25	128,000	15
20	70,000	8

Even if such a dam having a height of 40 m was provided, it could supply only half the requirement of low water level season. If taking the expenses such as the compensation for the land purchased, construction of new roads, works called for to prevent the earth and sand flowing out, etc. into consideration, the secured of flow to be maintained by constructing a new reservoir may not be justified as realistic.

(2) Water take-in at the upstream

Daedong Chong, Kwao Chong and Hwakohu Chong, tributaries on the right bank, are sewage rivers. In normal time, the flow of these rivers, together sewage, flows in the pipe intercepting them at the confluence with the main river and never flow in the main river. Therefore, it is conceivable to provide a water take-in station in the upstream of these tributaries, introduce the flow to the main river by pipe or culvert before it would mixed in

with sewage and use it as the supplementary water.

This concept has such merits that the distance conducting water is short and not requiring any large dam and pump station, etc., though, the area of basin of 3 tributaries is not big, and for such a reason, the available water during the low water level season would be less than 0.01 m^3/s in total. Accordingly, it is difficult to secure the quantity to be supplied, under the previously calculated figures.

(3) Utilization of ground water

The ground of the basin of this river is granite and the river drift covering it is almost nil, hence the opportunity of obtaining ground water other than the underground water is considered to be very low. Judging from the geographical map, the point where underground would concentrate is the vicinity of the confluence of Kwao Chong. As stated in 3.3.2, the average volume to be able to suck from a well is 4×10^2 m^3/day or so (if defined the sucking hour is 8 hours; then 0.014 m^3/s). To grasp the supply-potential and the volume available for sucking, a separate investigation of ground water will be necessary, however, it would be not enough to cover the volume to be supplemented.

(4) Regulation of low water channel

Since the low water channel work of this river in the planning section is not regulated at all, the flow during the low water level season tends to discontinue or become stagnant and accelerates evaporation and underground water. By the regulating and eliminating such discontinuation and stagnancy, it would not only affect the spectacle favorably but also improve the water quality and flow.

(5) Installation of the weir (Dam)

In the section to be provided certain water-surface on the spec-

tacle, the necessity of providing a weir should be considered in addition to the regulation of low water channel. Such weir, however, should be removable to ensure the safety in the time of flood.

As stated above, as this river lacks an appropriate means to secure the supplementary water over the entire segments under plan, improvement of spectacle through the regulation of the low water channel should be the base of all planning.
Especially, for the segment required of a higher hydrophile function (the model site for instance), a weir shall be provided to secure a certain area of water-surface. This weir should be removable and the flow shall be supplemented with water taken in the upstream avoiding stagnation there.

8.2.4 Design Criteria of Major Facility

(1) Removable weir

A rubber dam shall be considered because simple in mechanism and easy to maintain and control. The point where rubber weir will be provided in the vicinity of Point No. 59 which then becomes the base point of the space improvement. At this point, a water surface surrounded by a weir of 650 - 700 m (L) x 1.0 m (H) x 8 m (W) will be formed. To prevent local wash-excavation by providing the weir, "water-bashing", protecting-bed work, major bed protection work shall be made over 10 m in the downstream of the weir.

(2) Water conducting work

Intakes work shall be provided in the upstream of Daedong Chong, Kwao Chong and Hwakohu Chong, tributaries on the right bank, and water shall be conducted to the main river by ducts.

The size of water conducting facility shall be defined as shown

in Table 8.2-3, considering the volume of low water at each water take-in point (used the actual specific discharge of 1991 measured at St. 2 i.e. 5.13 $m^3/100\ km^2/s$).

Table 8.2-3 Design Details of Water Conveyance Work

	Planned Discharge (m^3/s)	Slope	Diameter of pipe (mm)	Total length of pipeline (km)
Daedong Chong	0.077	1/50	250	0.85
Kwao Chong	0.041	1/90	250	1.65
Hwakohu Chong	0.067	1/20	200	2.4

(3) Low water channel

The section to be regulated in No. 35 - No. 145 (L = 4,550 m) and the width would be 6 - 10 m. The height of embankment shall be about 50 cm taking the depth of the low water channel into consideration. Natural stones available in the local shall be used to impro spectacle.

8.3 Space Improvement Plan

8.3.1 Basic Policy

Basing on the points at issue and future outlook as referred to in the preceding paragraphs, we would define the basic policy of the space improvement plan of Ui Chong as follows.

(1) Improve the situation under which the residents of old and new communities formed in the upstream and downstream without any strong relation between them so as to make them associate each other through the river.

(2) The downstream basin having dreary look shall be improved modifying the spectacle.

8.3.2 Zoning and Improvement Plan of Each Zone

Zoning is made for the planned section combining the space shown in section 3.6.1 and the mode of utilization shown in Section 4.5.1 (Fig. 8.3-1). The established zones are family zone and landscape improvement zone.

Family zone

Improvement Area: 9 ha (L=4.55 km x 2)
Improvement policy:
Provide a walking road for the embankment and low water channel in the exterior land.
Major facilities:
Hydrophile plaza, low water channel, walking road, control facilities, resting facilities and planting.

Landscape improvement zone

Area to be improved: 4 ha (1.75 km x 2)
Improvement policy:
Cover the perpendicular embankment exposing bare concrete with plants so as to improve the spectacle.
Major facilities:
Improving landscape of the perpendicular embankment.

8.3.3 Improvement Plan of the Model Site

In accordance with the comprehensive evaluation made with regard to the demand for utilization and aptitude level of each segment as shown in 3.6.2, 1 area shall be given the priority and im-