(5) History of previous flooding

There are no remarkable inundation damages aside from the inland flood damages at low land area near the Tan Chong confluence which was caused by the backwater of Tan Chong itself. This same area also suffered damages during the flood of September, 1990.

3.2.4 Pollution Characteristics

(1) Diurnal variation of water quality

As a result of 24-hour observations made at every 2 hours, no regular variation of water quality could be found. The diurnal variation of the water quality in this river is small as compared with that of Anyang Chong and, especially, is stable in the Yoi Chong.

(2) Seasonal variation of water quality

The results of the analysis of river samples taken once a month at each observation point along the Yangjae Chong are shown in Fig.3.2-6.

The DO concentration shows a slightly complicated variation, but, on the whole, the variation shows such a trend that the concentration becomes lower (about 3 - 5 mg/l) in summer and higher (5 - 8 mg/l) in winter. Observations made at Station 3 show such a high values as 6 mg/l or higher even in summer and a smaller annual variation as compared with other observation points.

The BOD concentration is 3 - 8 mg/l in the period from summer to fall and 20 - 30 mg/l in the period from winter to spring, but the concentration fluctuates largely between each observation point in the period from winter to spring and such a trend is recognized that the concentration becomes lower during the period

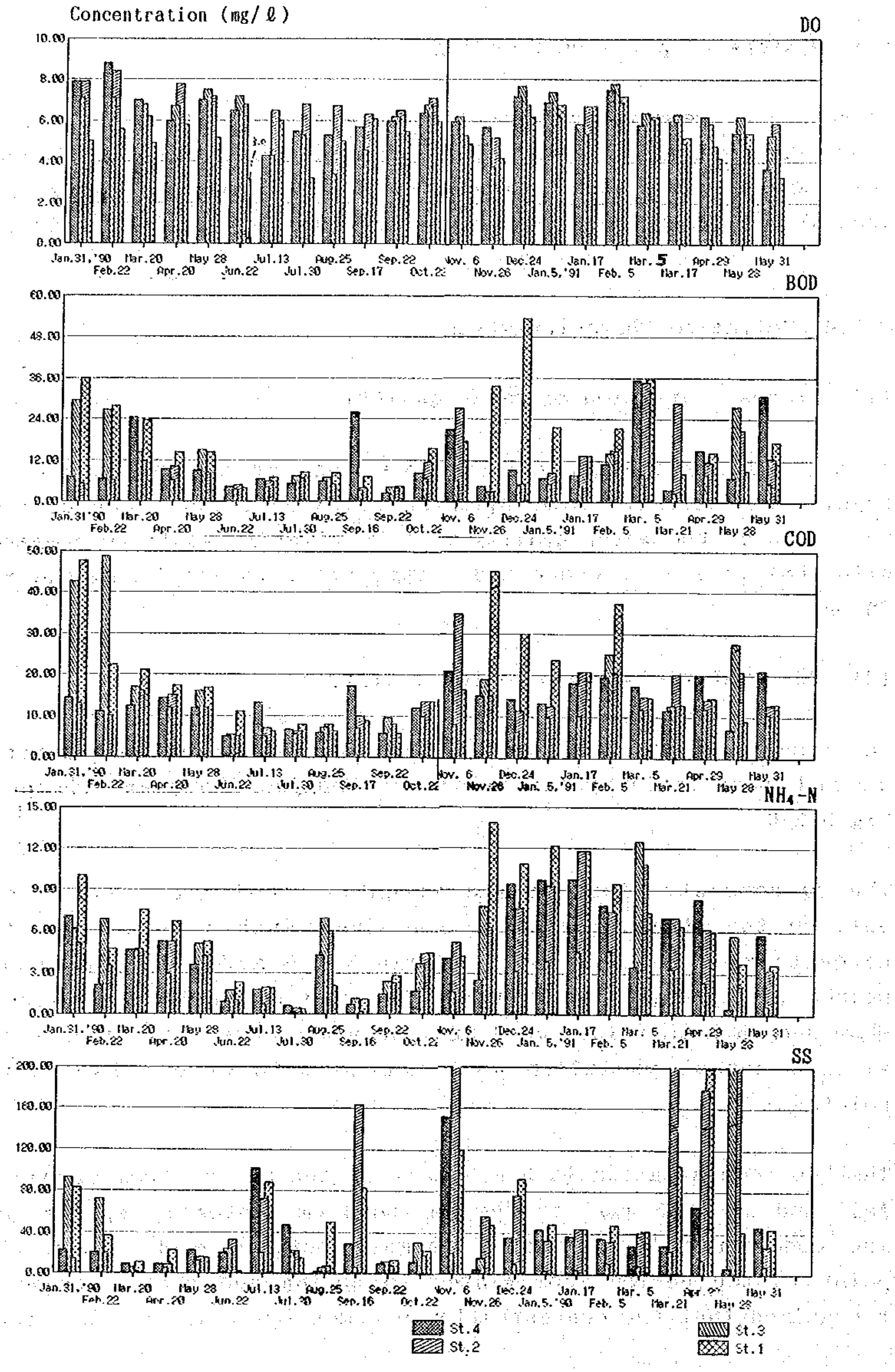


Fig. 3.2-6 Water Quality Fluctuation of Yangjae Chong during the Study Period

when the flow rate increases. The COD (Mn) concentration represents such trend more obviously, with the value being about 5 mg/l in the period from summer to fall and 10 - 25 mg/l in the period from winter to spring. As shown in Fig. 3.2-7, no clear relation can be recognized between the BOD and COD concentration, but this may be attributed to the fact that in many cases where these water samples were taken the flow rate was not in the natural condition due to construction works.

The TN concentration is 4 -15 mg/l all year round and represents the same seasonal variation controlled by the flow rate as both COD and BOD concentrations do. The main constituents of the TN are NH_4-N and NO_3-N and the TON content is 20% or less in many cases. The NH_4-N concentration is 3 mg/l or less in the period from summer to fall and 5 - 10 mg/l in the period from winter to spring, representing a definite pattern of seasonal variation. The TP concentration is 0.14 -1.18 mg/l and 45 - 75% of which is PO_4-P.

No seasonal variation has been recognized in the number of coliform which represents bacilli, but the number abruptly increased in November, 1990. Since then, the number stays at such a high level as 2,000 - 5000 MPN/100 ml with an especially high value at Station 1 at the downstream side end.

CN and Hg were measured as harmful matters. Hg content was not extracted but CN was slightly detected sometimes.

(3) Variation of water quality and pollution load in flowing direction

In order to recognize the polluted condition of the entire Yangjae Chong system, water sample were collected at 3 points along the main course and tributaries on the upstream side of the section to be planned in September, 1990, and analyzed for COD (Cr), TN, and NH_4-N. The analysis results are shown in Fig. 3.2-8.

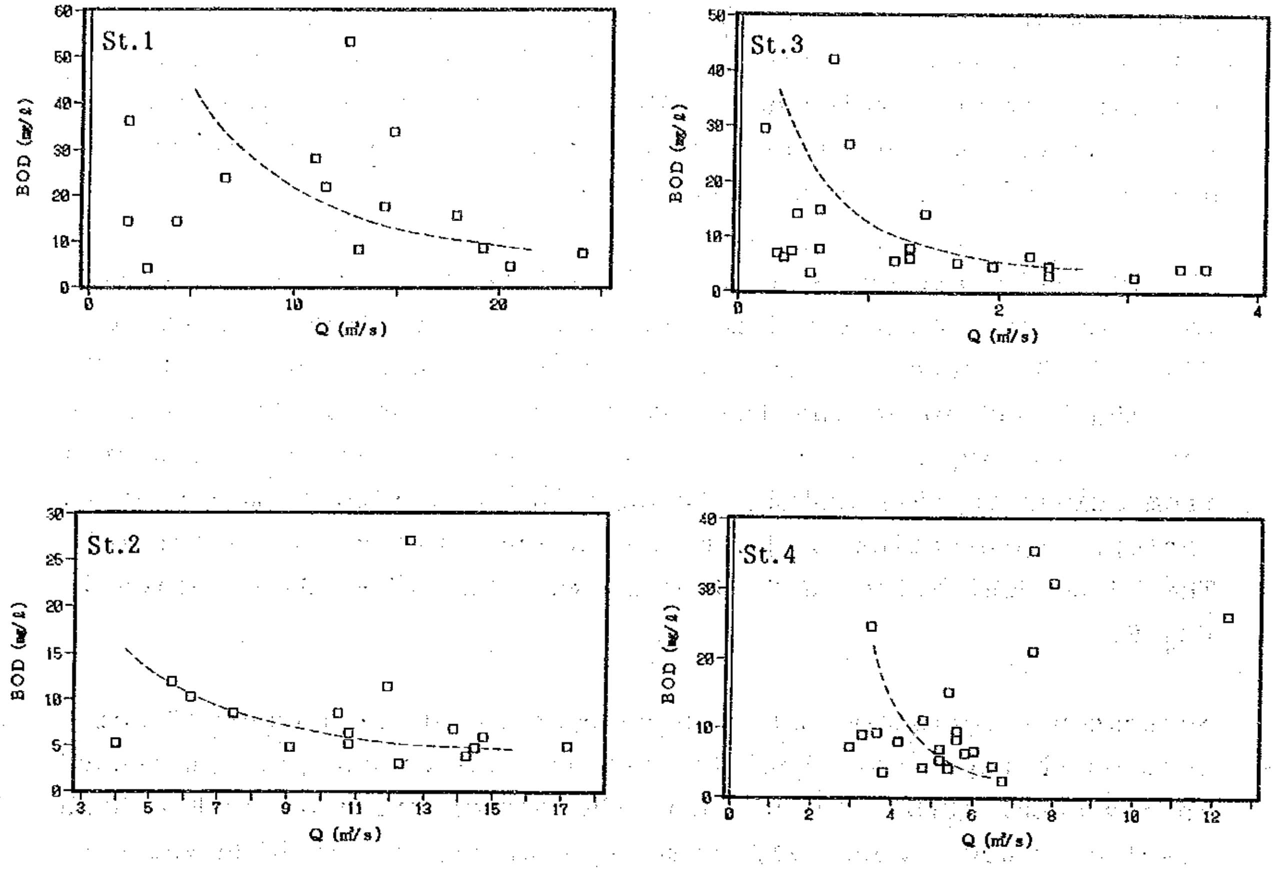


Fig. 3.2-7 Relation between Water Quality and Discharge of Yangjae Chong

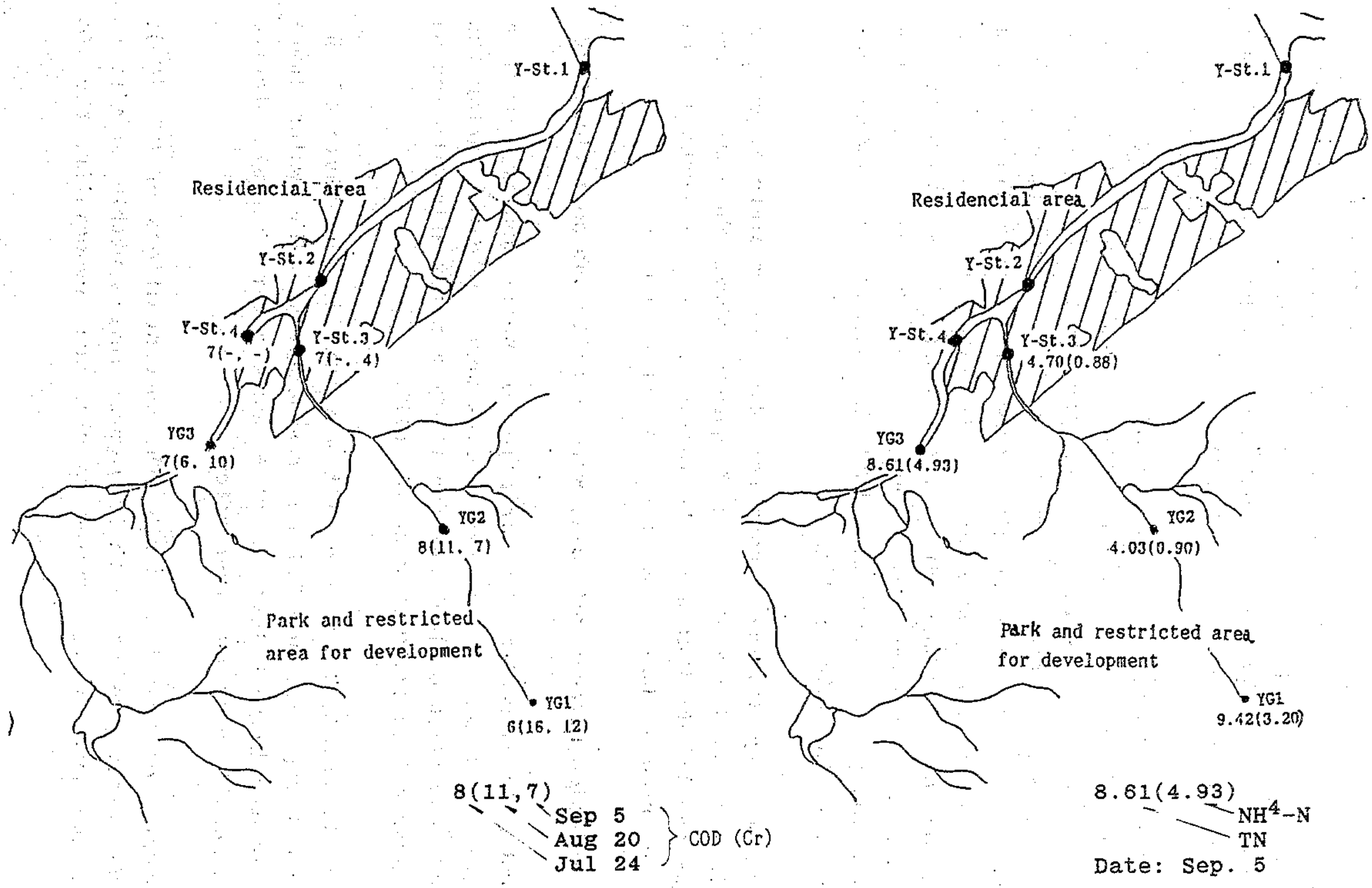


Fig. 3.2-8 Water Quality Condition of Yangjae Chong Drainage System

As easily understood from the figure, both COD and TN (NH_4-N) concentrations of the Yoi Chong water are higher in the upstream section and remarkably decrease toward the downstream side. Therefore, it is considered that the self-purification action considerably takes place while the river water flows.

When Stations 4 and 1 are compared with each other on Fig. 3.2-6, the latter is lower in DO concentration and higher in both BOD and COD concentrations in many cases and, as the whole, the water quality worsens toward the downstream side. This suggests that the sewage flowing into the river from storm sewers between both observation points largely affect the water quality. In many cases, on the other hand, Station 3 is higher in DO concentration and lower in concentrations of BOD, COD, NH_4-H, etc., than other observation points, indicating that, at present, the sewage does not pollute the water quality.

The reason why Station 2 does not show intermediate values of Stations 1 and 4 and Station 1 frequently shows abnormally high values can be attributed to the various possession works in the river carried on during the investigation period.

(4) Relation between rainfall, water quality and pollution load

In order to consider the variation of water quality after a rainfall, a total of 31 water samples were collected during the period from 11:00 o'clock on June 11 (20 minutes after the second rain started) to 11:20 on June 14, 1990.

The daily rainfalls on the 11th and 12th in the basin of the Yangjae Chong 49.5 and 7.7 mm, respectively. The water level rose to the highest level about 6 hours after the rain started and gradually decreased thereafter.

As understood from Fig. 3.2-9, the concentrations of COD (Mn), SS, TN, etc., reached to their highest levels within 10 minutes after the water level started to rise and, especially, the TON concentration rapidly increased. While it is considered that the earth and gravels excavated from and piled up on the riverbed due to construction works might had largely contributed to the increase in the SS concentration, the increases in the COD (Mn) and TN concentrations are considered to be caused by sludges which were accumulated in the sewer pipe misconnected with storm sewers and washed away by the rain water passed through the storm sewers.

(5) Correlation between items related to water quality

A close correlation (r = 0.631 to 0.798) is recognized between the BOD and COD (Mn) concentrations at all observation points and the BOD/COD ratio is 0.7 - 1.1.

While the TN/TP ratio is 6 - 14 which is similar to that of the domestic water in many cases, but Station 3 sometimes showed high ratio of 15 or more, indicating the mixture of drain water from vegetable gardens. As easily understood from Fig. 3.2-10, the water quality at Station 1 along the Yangjae Chong is similar to that of the sewage in the Seoul Metropolitan area.

(6) Self-purification capacity

In Yangjae Chong, the self-purifing capacity of the river was additionally surveyed with TKN, which can be easily measured, because its influence was expected. The self-purification capacity of the area between the Yongdong 2nd Bridge and Yongdong 5th Bridge (flowing time: 74 minutes) was only measured once, and extremely high TKN values (4.20 and 5.21 1/day) were obtained. Since the flow velocity in the measured area was low and 46 -85% of the SS were submerged substances, it is considered that large quantities of pollutants settled during the flow and in the process increased the self-purifying coefficient.

(7) Polluted condition of sediment

Table 3.2-5 shows the analysis results of sediment samples taken on December 5, 1990. The extremely low concentrations of heavy metals other than T-Hg, CN, and AS indicate that no pollution source which discharges harmful materials exists in this basin.

On the other hand, the ignition loss (IL) of the sediment samples is as high as 43 - 63%, indicating that organic matters have deposited in a short period even after the large freshest of September.

Regarding the macro benthos, only Limnodrilus socialis (a kind of earth worm) was detected at Station 2 at a population rate of 132 piece/m^2. Such result might had resulted from the sandy river bed material against such expectation made from the water quality that various kinds of macro benthos lived on the river bottom.

Table 3.2-5 Result of River Sediment Analysis of Yangjae Chong

Unit:mg/kg

Station	CN	AS	THg	Cr(6+)	Cd	Pb	Sulfide	DL(%)	IL(%)
St.1	0.114	0.068	0.009	ND	0.149	1.267	5.54	40.4	43.2
St.2	0.057	0.213	0.028	ND	0.177	1.520	6.01	40.9	63.0
St.3	ND	0.072	0.394	ND	0.152	0.973	5.46	50.5	43.5

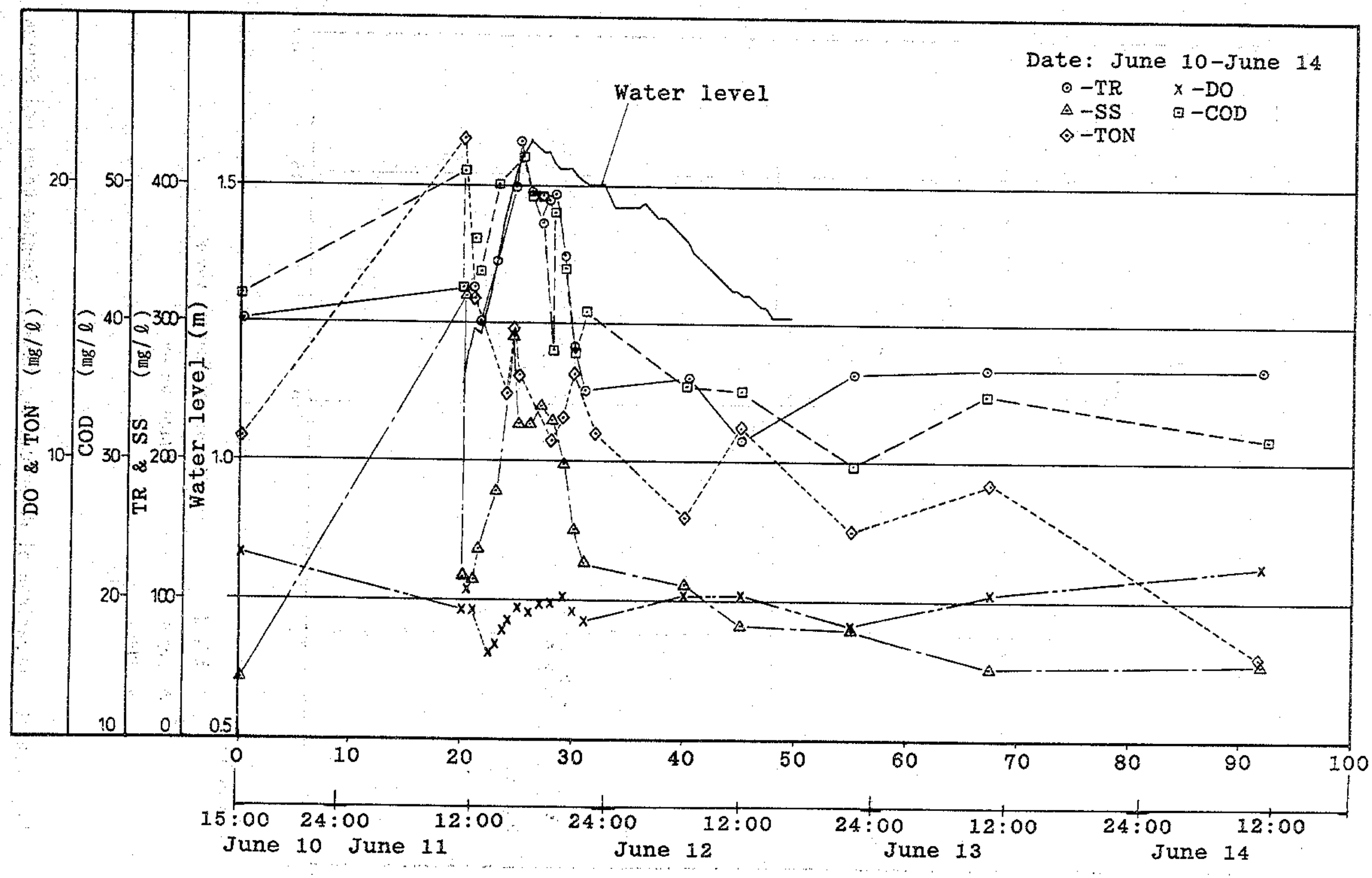


Fig. 3.2-9 Water Quality Change of Yangjae Chong in the Freshet Time

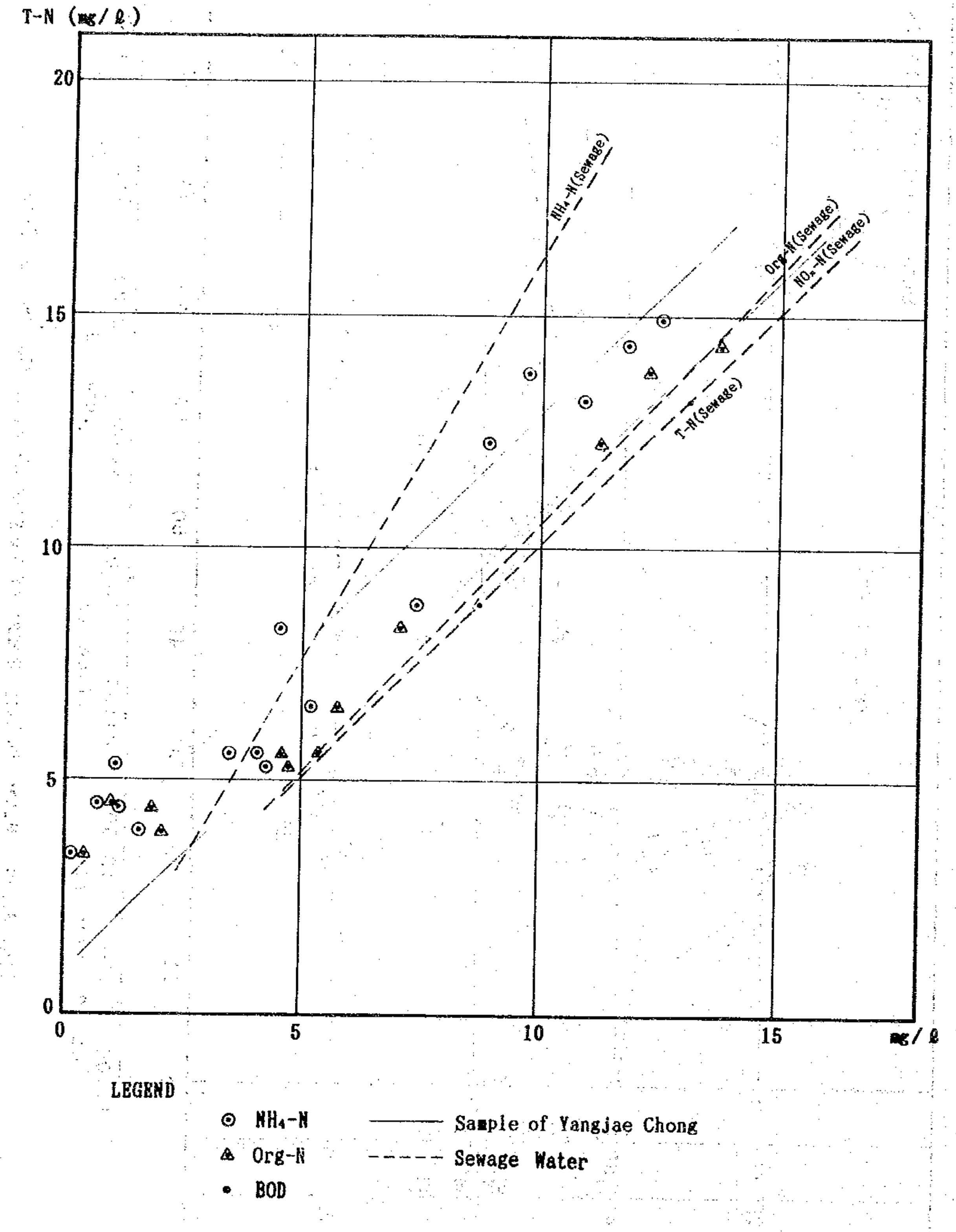


Fig. 3.2-10 Comparison of Water Quality between Yangjae Chong and Sewage

3.2.5 Sediment Run-off Characteristics

(1) Distribution of slope failures

Slope failures scarcely develop in areas composed of gneiss or schists, but develop in areas where granite is distributed. According to the 1987 aerial photographs of the Yangjae Chong, the east mountain side of the dividing ridge of Anyang Chong and Yangjae Chong is rich in slope failures.

These slope failures can be found in 148 places, and the slope failure area totals 0.45 km^2. The average ratio of the slope failure area to the whole catchment area is about 1.3%, but the ratio becomes nearly 4% in a single unit basin where the slope failures are most abundant.

(2) Quantities of sediment yield and run-off sediments

Assuming that the quantity of sediments produced by one time of flood from new slope failures and enlargement of already existing slope failures is 1.6×10^6 m^3 and 10% of the quantity is kept on the river channels, i.e., the quantity of run-off sediments becomes 1.4×10^6 m^3.

(3) River bed material and sedimentation characteristics

While the form of the river bed is not clear, since many sections of the Yangjae Chong are narrow in low-water channel width and low water channels are filled up with water even in low-water level periods, sand sedimentation was observed at part of the downstream section.

The particle size distributions of the river bed material samples collected at 4 points in the section to be planned are shown in Fig. 3.2-11. All of those materials are classified into sands, but, due to bad sorting, all samples contain coarse sands to fine sands.

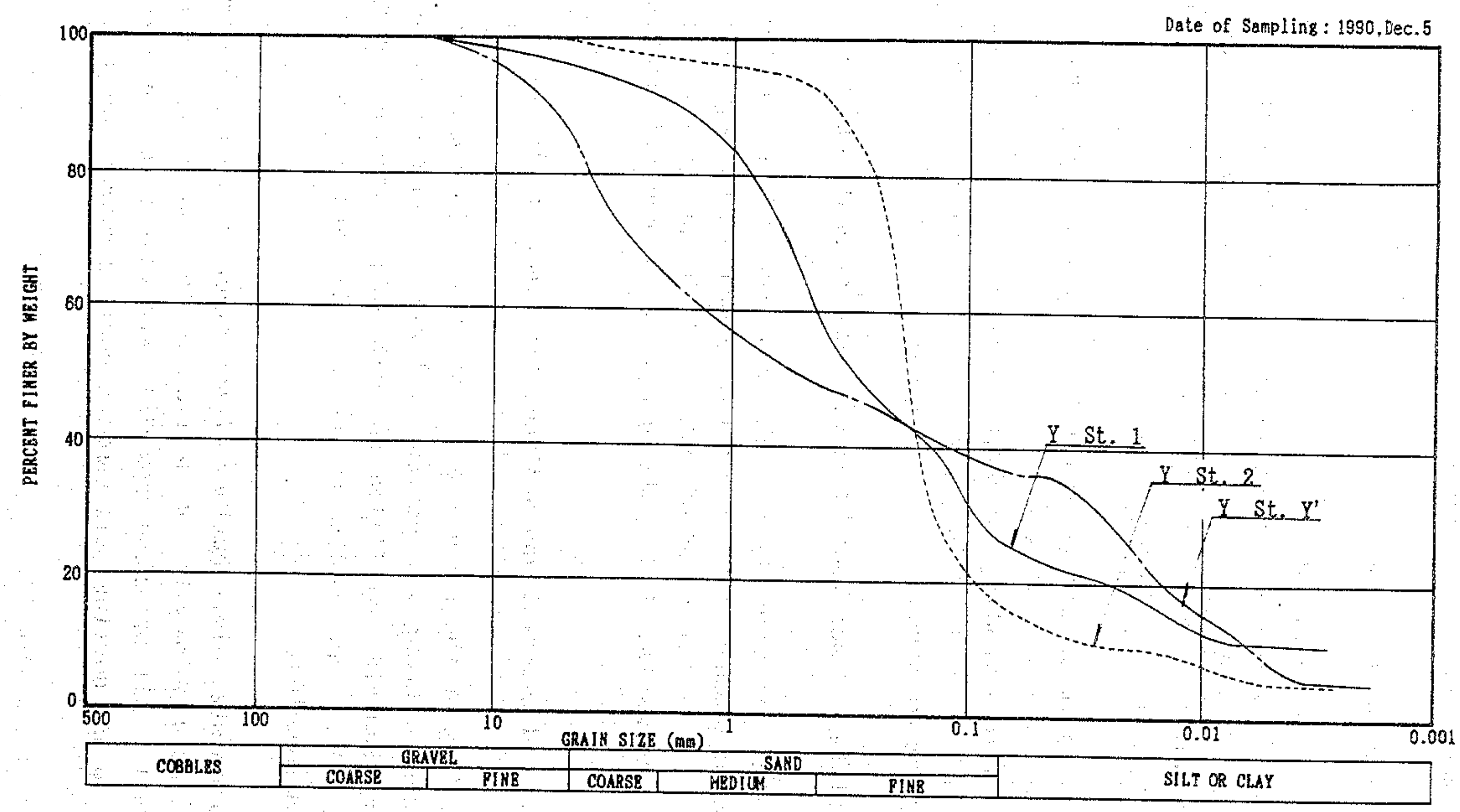


Fig. 3.2-11 Particle Size Distribution of River Sediment of Yangjae Chong

Immediately right after the flood of September 1990, sediments flowed into the river systems rich in slope failures, and natural banks were destroyed in several places. However, public facilities immediately downstream of already existing sediment control dams or falling works were not suffered from the flood due to effect of such structures.

3.3 Ui Chong

3.3.1 Present Condition of the Basin

(1) Topography, geology, and river system

The total length of the main course of Ui Chong is 11.85 km. 8.3 km belongs to Seoul Metropolitan, and was, therefore, the only Ui Chong area included in the study. The Ui Chong basin extends in the NW-SE direction and narrows downstream. Since the main course deviates to the northeast side of the basin, all major tributaries join the main course from the southwest side. The total catchment area of this river is 27.29 km^2 (Fig. 3.3-1).

The entire basin consists of granite and the narrow valley plain is thinly covered with alluvium.

(2) Administrative division and population

The entire Ui Chong basin is included in the Seoul Metropolitan area. The basin has a population of approximately 320 thousand. Population growth is especially remarkable in the central area of the basin, while the downstream population tend to decreases. The average population density in the basin is approximately 120 persons/ha. The population density in residential areas, however, is extremely high indicating about 550 persons/ha.

(3) Land use and industrialization

The water source of Ui Chong above 100 m in altitude is included in Pukansan National Park. The areas below 100 m in elevation are mainly used for residential and commercial purposes. However, an industrial area has been discovered to exist for quite some time on the left bank of the middle reaches. Detached houses and low-storied house complexes are mainly predominant in the residential and commercial areas. Recently, however, large

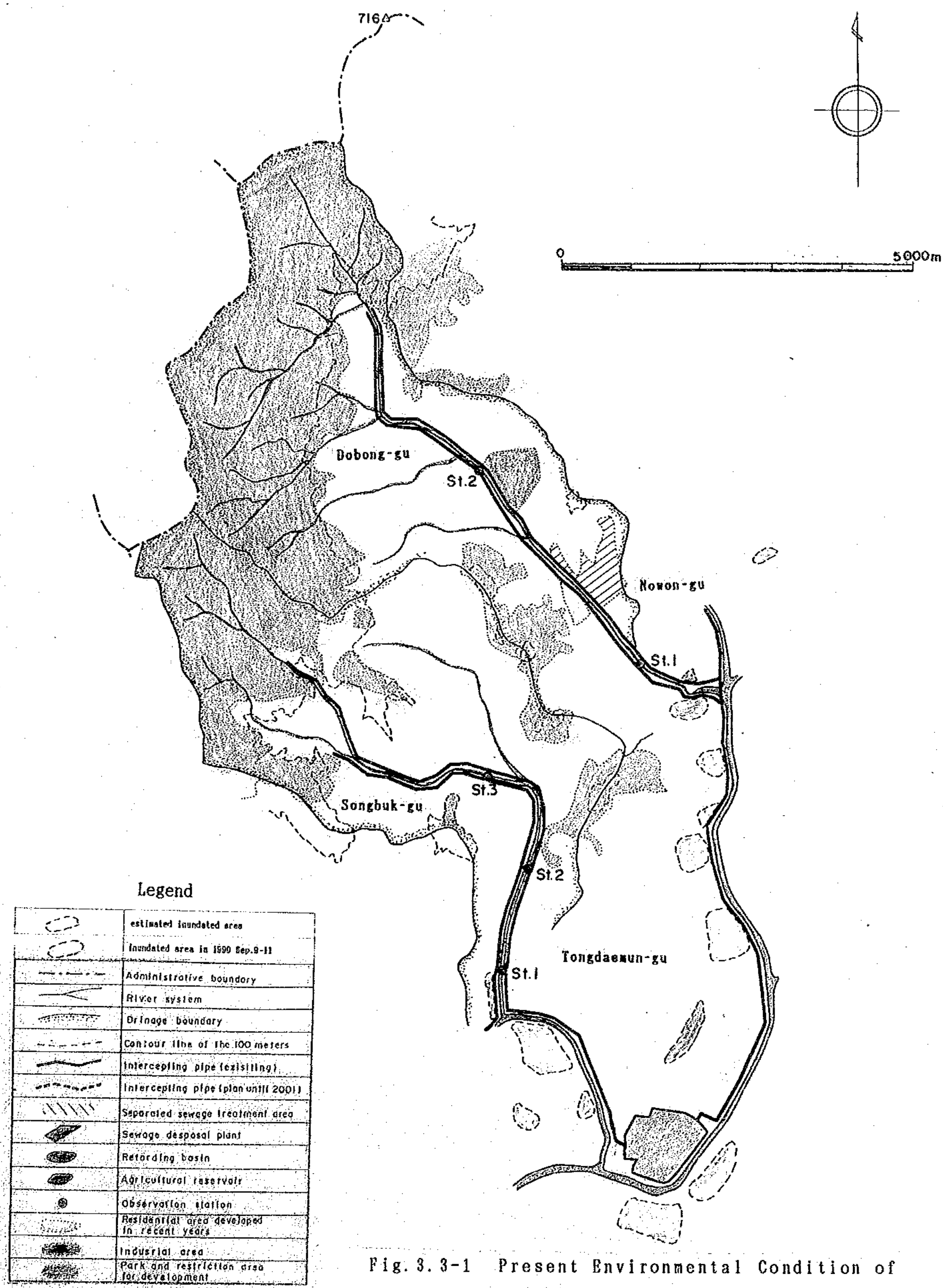


Fig. 3.3-1 Present Environmental Condition of Ui Chong Basin

housing developments can be found on the right bank of the middle reaches. Food and printing factories make up the industrial area.

The area of the urban district of this basin calculated on the basis of the city planning map of Seoul Metropolitan is 4.30 km^2, with the ratio of urbanization being 15.8%

(4) Park and green zone

The park area and green zone ratio upstream are 5.2 m^2/head and 63.8 m^2/head, respectively, values which are much higher than the average values of the entire Seoul Metropolitan due to the Pukan-san National Park. On the other hand, the park area and green zone ratio downstream where a highly densened urban district can be found, are only 2.3 m^2/head and 3.3 m^2/head, respectively.

(5) Pollution source and sewage discharging and processing condition

The population in the basin which closed the base for estimating the domestic waste water discharging source is already shown in the above. Collected Data D - 9 indicates that the generation unit load of domestic waster of Dobong-ku in 1989 was 200 l/head/day.

No industrial nor public pollution source which discharges waste water at a rate of 1,000 m^3/day of more is found on "List of Companies Discharging Waste Water in ROK, 1986" published by Environment Bureau (1987). A total of 66 pollution sources exist in Kangnam-gu and Socho-gu, but almost all of them discharge waste water at rates of 100 m^3/day or less. However, it is not clear that how many of them are included in the basin of Hi Chong.

The diffusion rate of the Ui Chong Sewage System is almost 100%. A separate sewerage system is adopted in the developed area of the middle reaches, while a combined sewerage system is adopted in other areas. Sewage is sent to the Chungryang Sewage Treatment Plant through the intercepting sewers installed in both banks of the main course. It is then discharged into Chungryang Chong after secondary treatment. The average of BOD concentration of the treated water is 15 mg/l.

3.3.2 River Improvement and Utilization

(1) Physical feature of river section

The average gradient of the Ui Chong river bed is 1/240 from the Chungryang Chong confluence up to 6 km upstream, and it is more than 1/70 further upstream (Fig. 3.3-2).

The width of the river channel is 40 - 60 m, and excluding the 1.2 km upstream and 1.8 km downstream planned areas, the cross section forms a compound section. The width of the low water channel which is about 10 m at the upstream side end of the section to be planned becomes in 20 - 30 m in the section between Ui Bridge and Shinchang Bridge in the middle course, but again narrows on the downstream side of Wolgye-ni Bridge.

(2) River structures and underground works in river channel

The construction of the embankment (one part of which is a special embankment of parapet wall) on both sides of the bank of the planned area is almost completed. The height difference between the river bed and the embankment crest is 3.5 - 4.0 m upstream, and not more than 5.5 m downstream.

Falling works (falling height: 1 - 3 m) are installed to 8 sites, but no sluice way nor water gate is installed.

Intercepting sewers are only installed within 0.7 km on the upstream right bank area. From this area to the lower reaches,

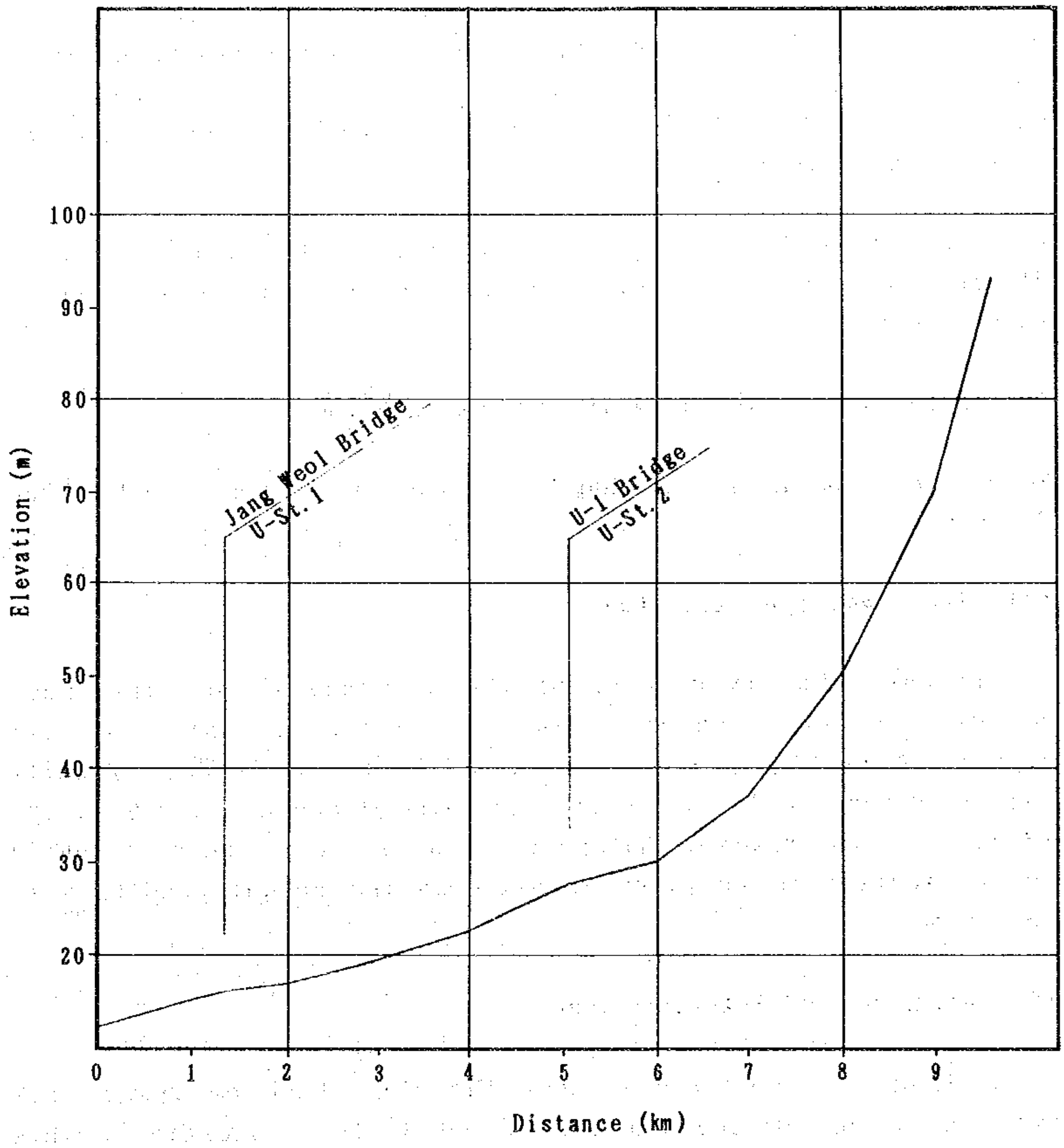


Fig. 3.3-2 Longitudinal Porfile of the Project Setion along Ui Chong

however, they are installed on both banks.

Of the section to be planned, a section of 275.5 m in length is covered. In addition, the downstream area of Daedong Chong, Kwao Chong and Hwakohu Chong, the main tributaries of Ui Chong, are used as sewage rivers and are covered. Roads are constructed on these covered areas.

A total of 23 bridges are constructed in the section to be planned, with 1 bridge being railway bridge and the rest being road bridges.

(3) Retarding basin and drainage pump station

No retarding basin nor drainage pump station are installed to the Ui Chong.

(4) River water utilization

At present, the river water of the Ui Chong is not utilized. However, underflow water is used as industrial water in some places. According to Collected Data C - 29, the number of wells sunk in Dobong-ku is 17 and average pump discharge is 3.99 x 102 m^3/day. It is presumed that part of the wells may be distributed in the section to be planned, although the actual condition is not known.

(5) Exterior and interior land

There is a road constructed near the right bank embankment between Shinchang Bridge and Wolgye 2nd Bridge. Traffic in this road produces noisy sounds as it is heavy. The majority of the neighboring areas of the planned area are residential and commercial areas, and the old closely built small-sized houses were successively replaced with large residential houses. With the exclusion of the housing developments between Shinchang Bridge and Wolgye-ni Bridge, most of the residential and commercial buildings are 2 storied buildings. The renovated area shows streets lined with neat rows of stores and houses.

Most of the major bed is not utilized, except the section between Ui Chong Bridge and Shinchang Bridge where it is utilized by inhabitants as vegetable gardens. It is considered that the vertical revetment works installed to many sections prevent the major bed from being utilized by inhabitants.

(6) Sewage inflow to the river

The site where sewage was flowing into the section to be planned from the flank at the time of investigation was only one. The location of the site and water quality and discharge are respectively shown in Fig. 3.3-3 and Table 3.3-1.

The other sewage which is discharged into the river from the flank is introduced to intercepting sewers in fine days, but flows into the river beyond weirs in rainy days. In order to recognize the average conditions of the water quality and discharge, it is necessary to continue investigations for a long period, because they vary in time and by days.

Table 3.3-1 Waste Water Quality Directly Flowing to Ui Chong

Station	Wt (°C)	pH	DO (mg/l)	EC (mS/l)	Turbid. (mg/l)	COD (mg/l)	SS (mg/l)	Discharge (m^3/sec)
Ui-9	23.6	7.1	---	0.8	20	100	---	0.035

Sampling Date June 14 - 15, 1990
* : Sewer pipe was under construction
**: Water was discharged from retarding basin

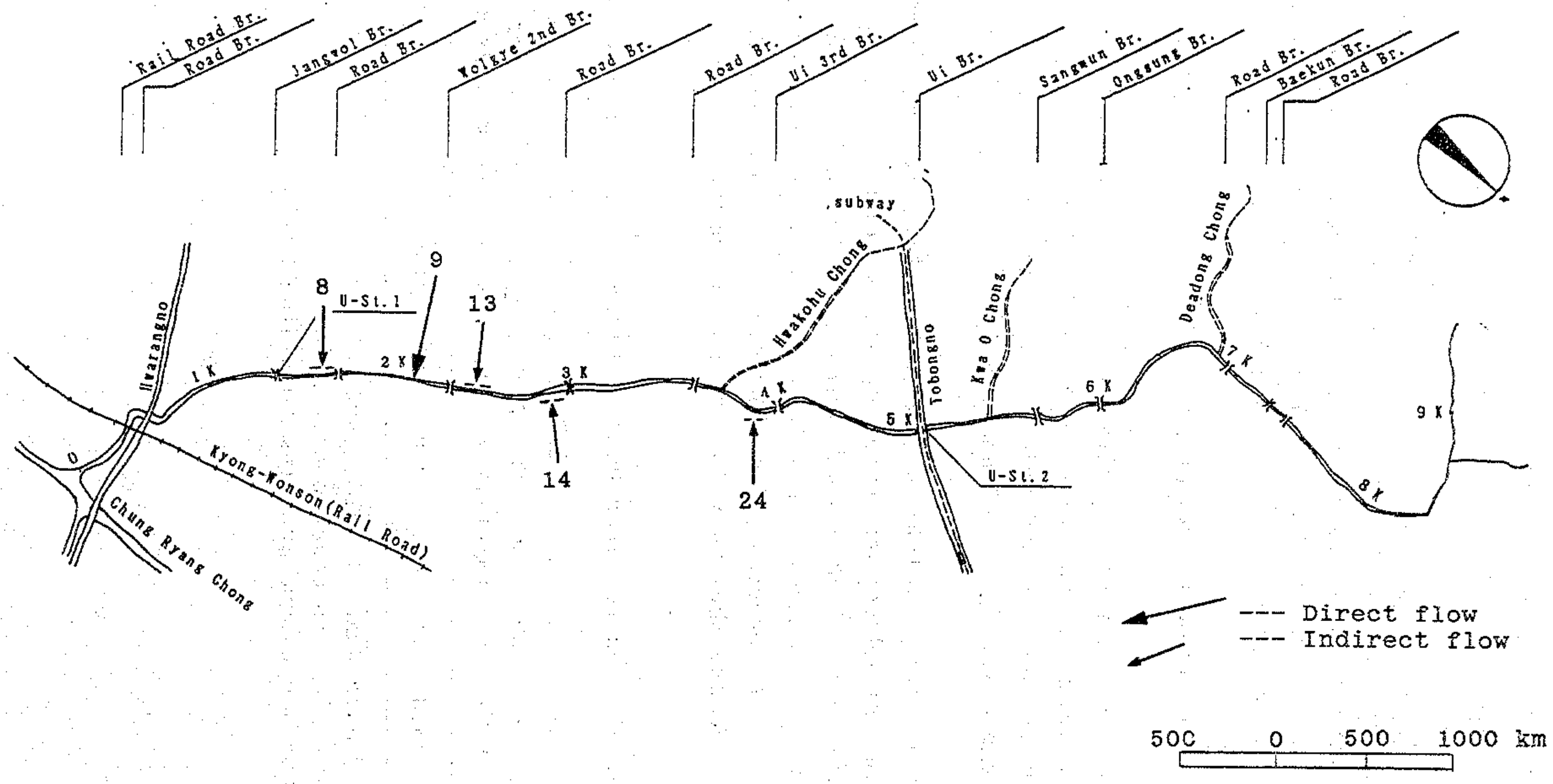


Fig. 3.3-3 Overflow Point of the Sewage along Ui Chong

3.3.3 Flow Regime Characteristics

(1) Relation between water level and discharge

H-Q curve prepared by the field measurements is shown in Fig. 3.3-4. The relations between the water level (H) and discharge (Q) of each observation point are expressed by the following regression curves.

St. 1 : $Q = 65.741396 \times (H - 16.18003)^2$
St. 2 : $Q = 45.513701 \times (H - 27.40016)^2$

(2) Daily variation of flow rate

While such irregular variations of water level as those caused by rainfalls and freezing are seen in the continuous records of automatic water level recorders, no water level variation that indicates the sewage inflow and appears at a fixed time zone every day is found.

(3) Seasonal flow variation and characteristic discharge

Daily discharge estimated from H-Q curve and rearranged in the order as duration curve are shown in Fig.3.3-5. 95, 185, 275, and 355-day discharges and specific discharges calculated from the same data are respectively shown in Tables 3.3-2 and 3.3-3. Since these values are abnormally large as compared with the values of the other 3 rivers and Yoju and it is considered that the method or instruments used for the measurements were defective. Therefore, design values adopt the results of discharge measurement at draught days shown in Table 3.3-4.

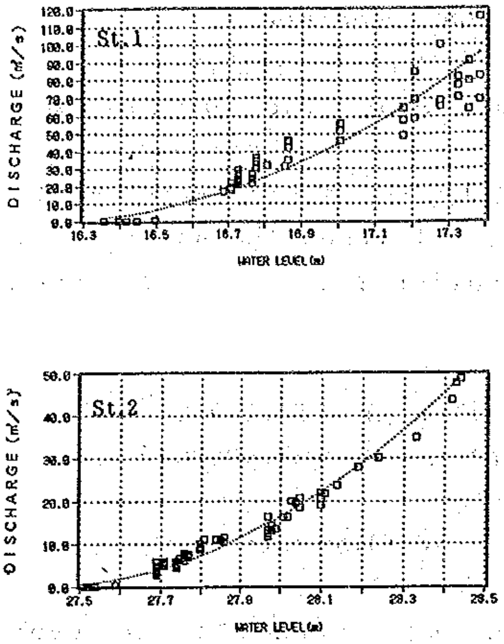


Fig. 3.3-4 H-Q Curve of Ui Chong

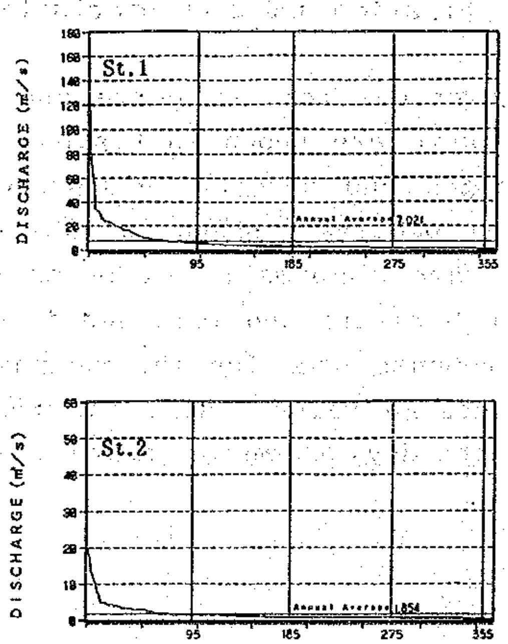


Fig. 3.3-5 Duration Curve of Ui Chong

Table 3.3-2 Discharge in Ui Chong

Unit:m^3/sec

Station	Catchment Area (km^2)	Discharge 95-day	185-day	275-day	355-day	Average
St.1	26.18	5.721	3.328	2.250	1.312	7.021
St.2	16.86	1.572	0.995	0.865	0.436	1.845

* Daily discharge / Jan. 1 - Dec. 31 1990
* As above values are abnormaly large, it is an adequate for the river planning from now on.

Table 3.3-3 Specific Discharge in Ui Chong

Unit:m^3/sec/100km^2

Station	Specific Discharge 95-day	185-day	275-day	355-day	Average
St.1	21.85	12.71	8.59	5.01	26.82
St.2	9.32	5.90	5.13	2.59	10.94
Yoju	2.408	1.119	0.505	0.207	

* Daily discharge / Jan. 1 - Dec. 31 1990

(4) Flow variation in the river profile

Table 3.3-4 shows the results of discharge measurements at each observation point during period free from rains. At both points, the flows are extremely small, but the flow at Station 1 on the downstream side is always slightly larger than that at Station 2.

Table 3.3-4 Discharge measured in Ui Chong in Draught Days

Unit:m^3/sec

Station	Dec. 4	May 28	June 1	June 10	June 13
St.1	0.03	0.35	0.08	0.12	0.08
St.2	0.02	0.28	0.07	0.01	0.04

(5) History of previous flooding

The heavy rains that took place in the central region of ROK, which includes the Seoul Metropolitan area, early in September 1984 flooded Wolgye Dong and damaged 345 buildings in the area. Inundation occurred when the water level of Chungryang Chong increased and its backwater flowed into the Ui Chong.

It can be said that the possibility of this area suffering from floods is very low, because only one record indicating that part of Dobong-ku was flooded at the time of heavy rain visited this area in August, 1979, is kept except the above-mentioned record. Even at the time of the heavy rain of September, 1990, this area was not flooded.

3.3.4 Pollution Characteristics

(1) Diurnal variation of water quality

No regular variation of water quality could be found from the results of 24-hour observations made at every 2 hours.

(2) Seasonal variation of water quality

The results of the analysis of the river water samples taken once a month at each observation point along the Ui Chong are shown in Fig. 3.3-6.

The DO concentration is 4 - 7 mg/l in the period from summer to fall and 5 - 9 mg/l in the period from winter to spring.

Regarding the BOD concentration, such a trend that the concentric is high in spring and low in other seasons is recognized, but the trend is indistinct. The COD (Mn) is high not only in spring, but also in fall. However, no definite seasonal variation is recognized in both SS and NH_4-N concentrations. As Fig.

3.3-7 shows, the relations between the flow and BOD and COD concentrations are not distinct.

While the TN concentration varies within the range of 2 - 6 mg/l, no definite seasonal difference is recognized.

The number of coliform which represents bacilli has somewhat increased since November, 1990, but, even though, the number stays at such a low level as 1,000 MPN/100ml or less.

(3) Variation of water quality and pollution load in flowing direction

The water qualities at 2-km and 3-km points from Station 2 on the upstream side were good as compared with the water qualities confirmed at Station 2 and its downstream side, because the COD (Cr), TN, and NH_4-N concentrations were 2 mg/l or less, 5.2 mg/l or less, and 1.5 mg/l or less, respectively.

When Stations 2 and 1 are compared with each other on Fig. 3.3-6. the former is higher in DO concentration and lower in COD and BOD concentrations in the period from summer to winter in many cases. Especially, the differences in both COD and BOD concentrations are large in the same period.
The reason why the differences are large in the period from summer to winter can be attributed to the fact that Station 1 was located on the upstream side of a falling work and water stayed on the upstream side of the falling work for a while, resulting in the settlement of organic matters. In fact, H_2S bubbles were observed in the vicinity of Station 1 in summer.

(4) Relation between rainfall and water quality and pollution load

In order to consider the variation of water quality after a rainfall, water samples were collected at every one hour from 14:00 o'clock to 23:00 o'clock, August 31, 1990, and a total of

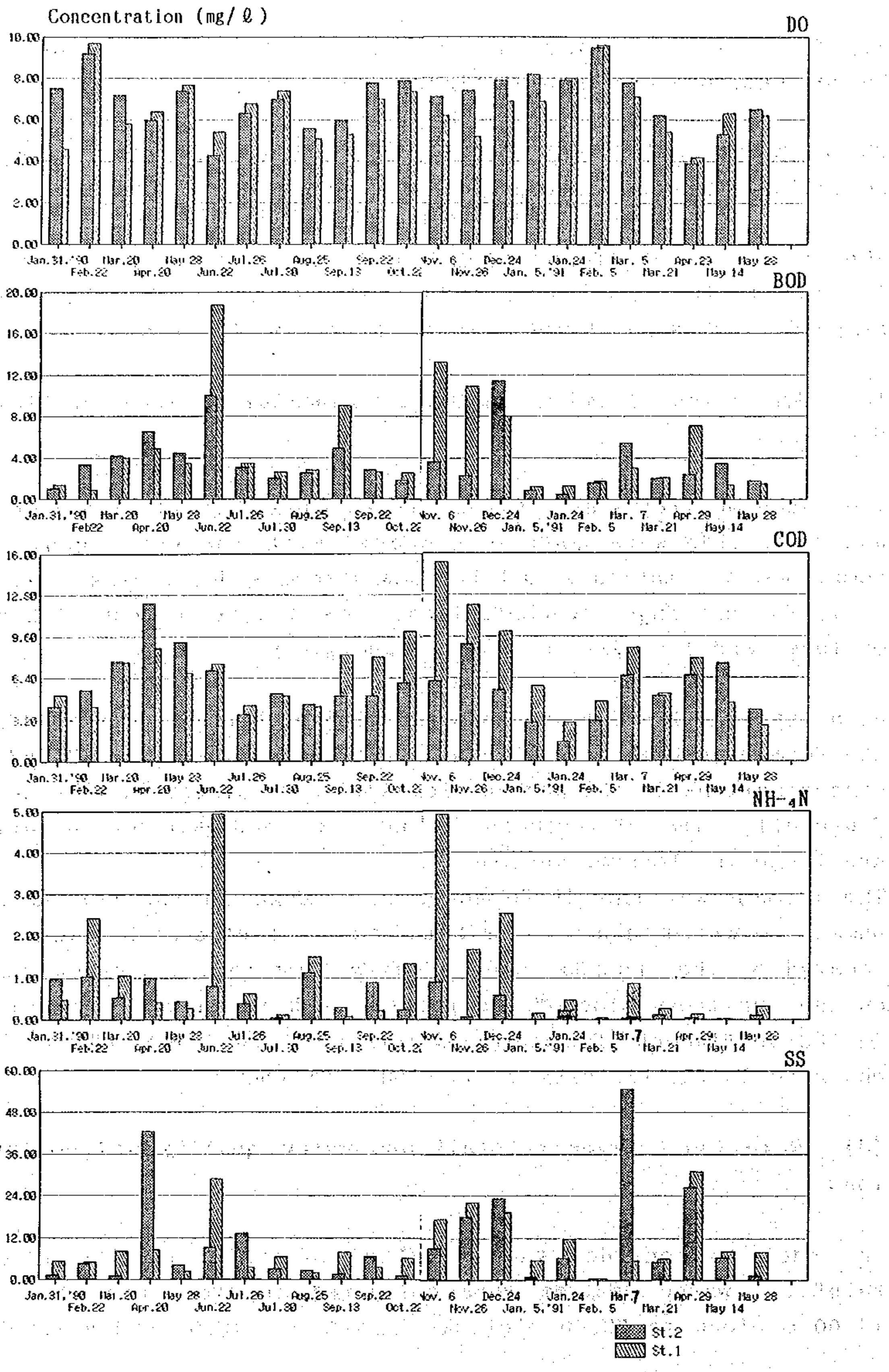
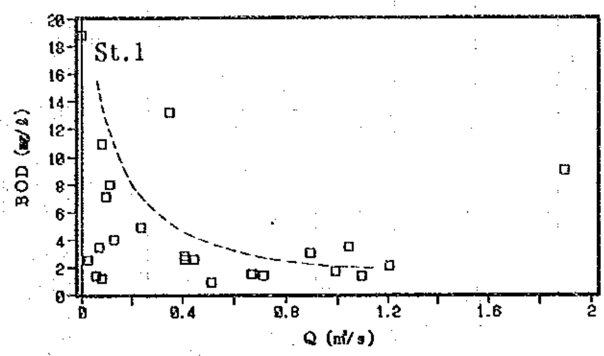


Fig. 3.3-6 Water Quality Fluctuation of Ui Chong during the Study Period



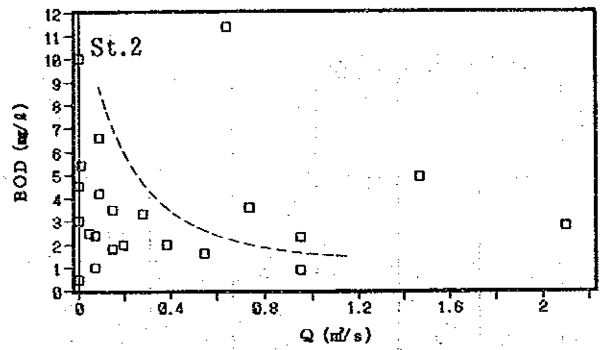
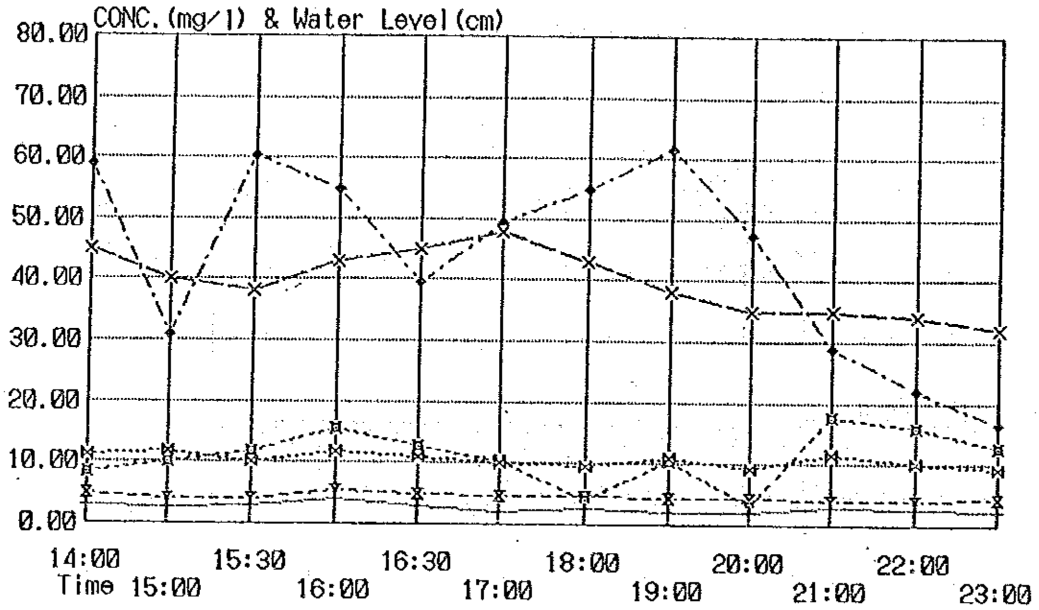


Fig. 3.3-7 Relation between Water Quality and Discharge of Ui Chong

Sampling date: Sep. 1990

St.1



St.2

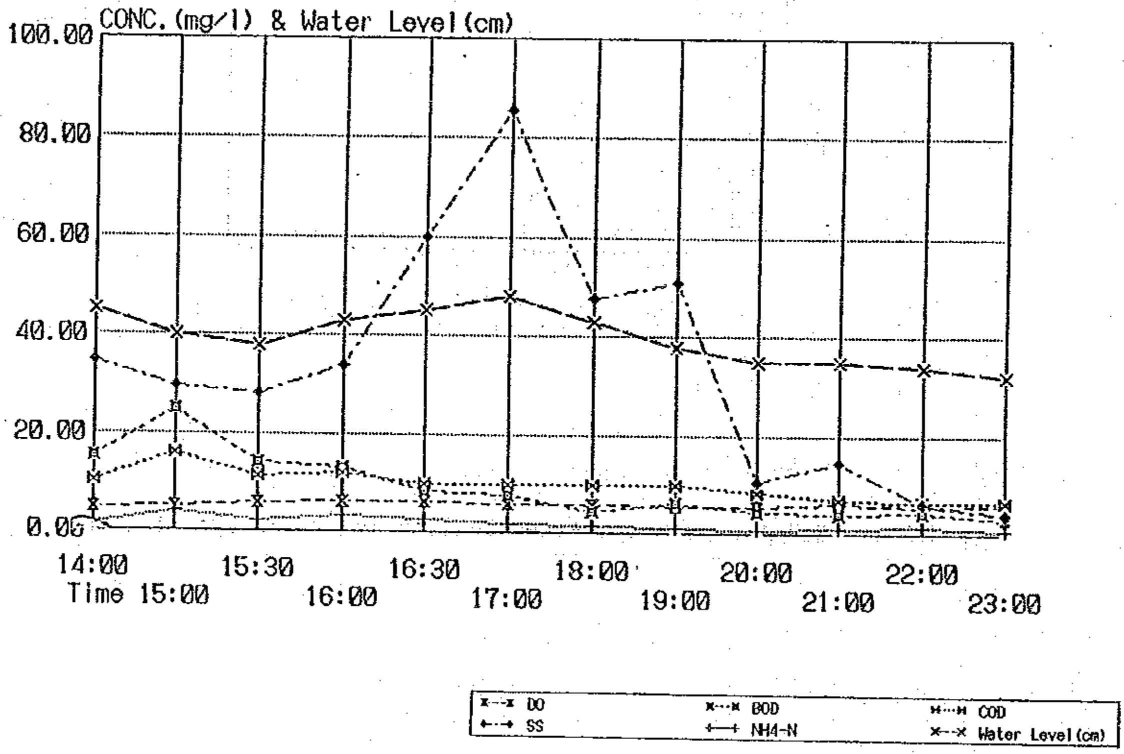


Fig. 3.3-8 Water Quality Change of Ui Chong in the Freshet Time

12 samples were taken.

The rain started from 23:00 o'clock on August 30th and the rainfall had reached 20 mm or more when the sampling was started. The total rainfall for two days of the 30th and 31st was 66.7 mm.

Fig. 3.3-8 shows the then variation of the water quality. While the variation of the water quality in the initial stage of the rain was not observed, the BOD, COD, and NH_4-N concentrations thereafter were several times lower than those obtained under fine weather. However, since the SS concentration was 30 - 35 times higher than that obtained under fine weather, it is understood that the mixing ratio of inorganic matters, such as earth and gravels, etc., significantly increased.

(5) Correlation between items related to water quality

In the Ui Chong, the BOD concentration is always higher than the COD (Mn) concentration and the BOD/COD (Mn) ratio is 0.6 - 0.7 which is very close to that of water. When the correlation between BOD and COD (Mn) contents is taken into account together with the fact that more than 70% of the COD content and more than 60% of the BOD content are contained in dissolved forms, it can be said that the main body of the organic matters contained in the river water of the Ui Chong may be such a substance that is hardly resolved chemically and small in grain diameter (smaller than 1 u).

The TN/TP ratio is usually 7 - 13, indicating a high mixing ratio of domestic waste water, but, sometimes, rises to such a high level as 86 - 104. Regarding the ratios of NH_4-N and TON to TN, the water quality of this river is largely different from that of the sewage in Seoul Metropolitan area, indicating that the mixture of the sewage is very small (Fig. 3.3-9).

The important feature of water quality of this river is that the NO_3-N concentration is high and main constituent of the TDN is

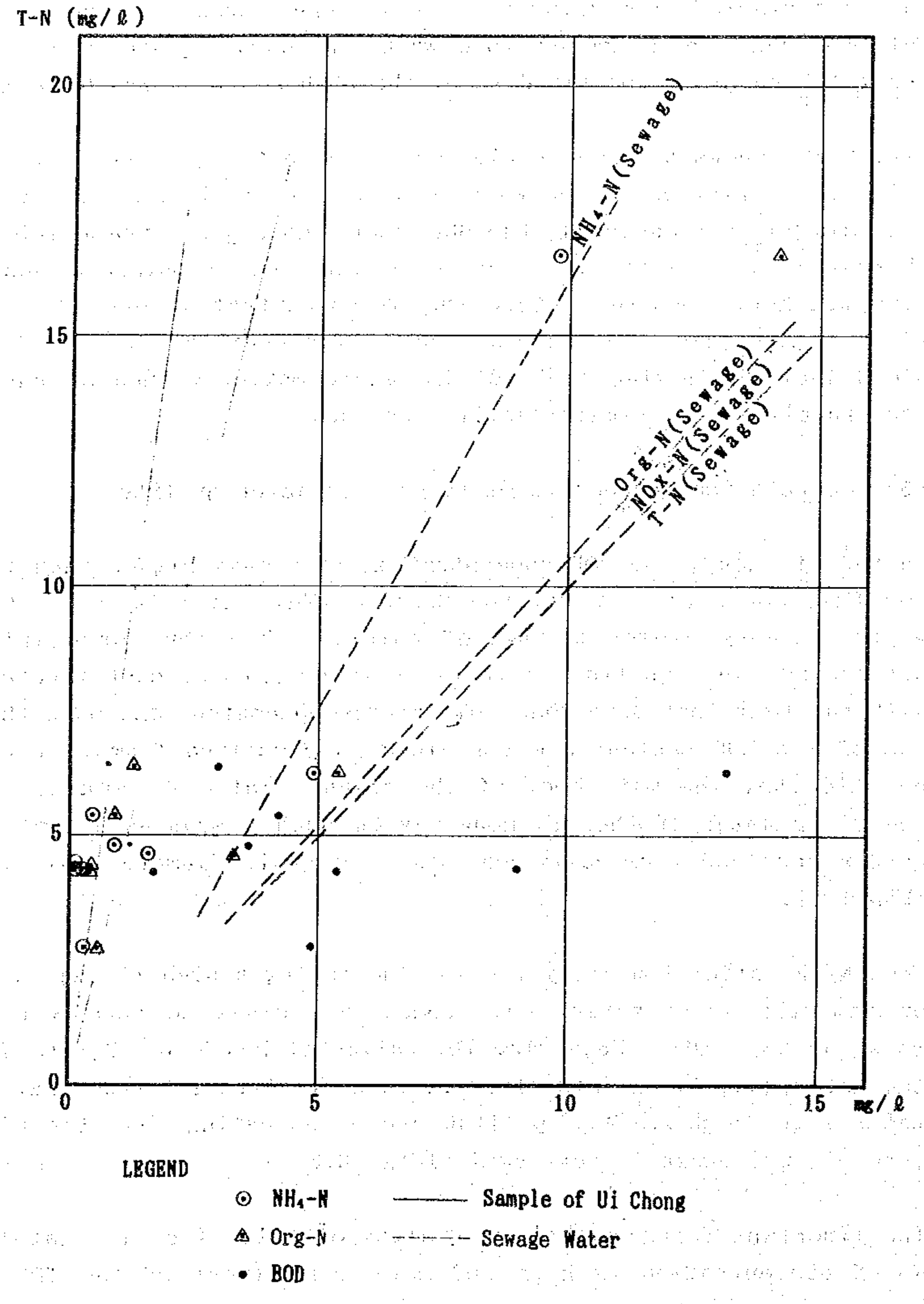


Fig. 3.3-9 Comparison of Water Quality between Ui Chong and Sewage

NH_4-N rather than NO_3-N. Since an experiment carried out for accelerating the nitrification of the bottom deposit taken from the Ui Chong gave a large value, it is considered that abundant nitrification bacterium living in the bottom deposit quickly oxidize NH_4-N by using the oxygen abundantly dissolved in the water.

(6) Self purification capacity of river

The self-purification capacity measurement was made only twice under insufficient conditions (flowing time: about 30 minutes), since no section provided with the conditions which sufficiently meet the requirement of the measurement was not available along the Ui Chong. As a result of the measurements, such high values as 5.27 l/day and 8.15 and 12.48 l/day were obtained for BOD and YKN, respectively. While these measurements must be regarded as reference values due to the above-mentioned reason, it is considered that such high values might have resulted from the river environment where the DO concentration was high and pollutants were easily precipitate due to the slow flow speed.

(7) Polluted condition of sediment

Table 3.3-5 shows the analysis results of sediment samples collected on December 5, 1990. All of the CN, As, T-Hg, Cr (6+), Cd, and Pb contents are extremely low, indicating the absence of any pollution source which discharges such harmful materials in the basin.

The ignition loss of the sediment samples are as high as 38 and 62.5%, indicating that organic pollution took place in a short period even after the large freshest of September.

Regarding the macro benthos, Chironomus yoshimatsu were found at two points, Stations 1 and 2, at population rates of 43 pieces/m^2 and 23 pieces/m^2, respectively. This river was the richest in macro benthos, because a total of 4 species of macro benthos were found at Station 2 in addition to the above-mentioned species.

Table 3.3-5 Result of River Sediment Analysis of Ui Chong

Unit:mg/kg

Station	CN	AS	THg	Cr(6+)	Cd	Pb	Sulfide	DL(%)	IL(%)
St.1	0.409	0.133	0.063	ND	0.100	1.133	6.68	36.4	38.0
St.2	0.250	0.233	0.054	ND	0.183	1.960	6.45	59.0	62.5

3.3.5 Sediment Run-off Characteristics

(1) Distribution of slope failures

According to 1987 aerial photographs, the area in Ui Chong basin which is rich in slope failures is the upstream area of the main river where the elevation is more than 200 m. Granites outcrop from the steep slopes of the area.

There are 148 slope failures in the basin and their area totals 0.3 km^3. The average ratio of the slope failure area to the whole catchment area is about 2.4%, but the ratio becomes 3% in a single unit basin where the slope failures are most abundant.

(2) Quantities of sediment yield and run-off sediments

Assuming that the quantity of sediments produced by one time of flood from new slope failures and enlargement of already existing slope failures is 5.6 x 10^5 m^3 and 10% of the quantity is kept on the river channels, the quantity of run-off sediments becomes 5.1 x 10^5 m^3.

(3) River bed material and sedimentation characteristics

In the upstream section of the point which is 300 m up the river

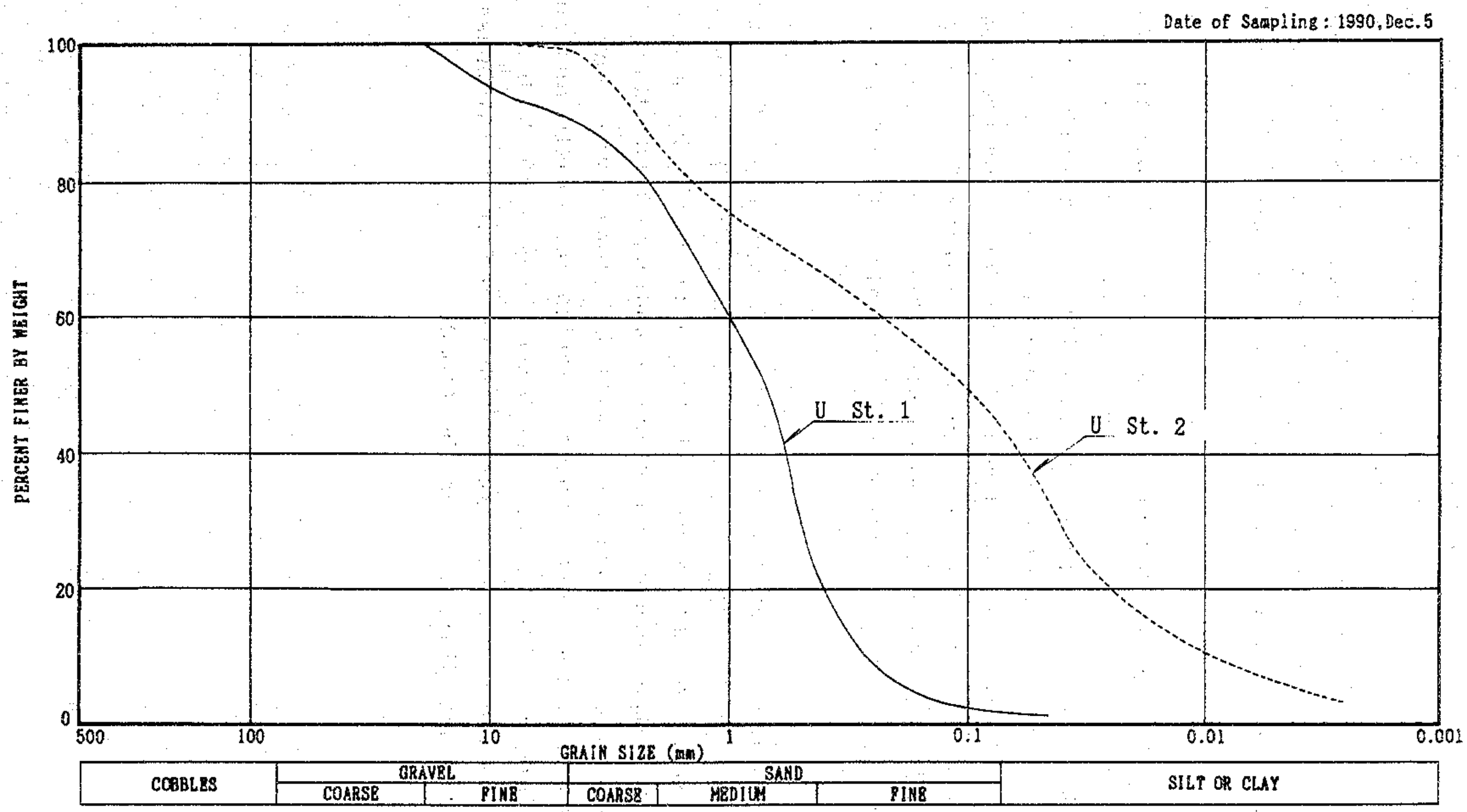


Fig. 3.3-10 Particle Size Distribution of River Sediment of Ui Chong

from Baegun Bridge, granite directly crops out on the river bed, but, in the downstream section of the point, the constituent of the river bed material changes from gravels to sands through sands mixed with gravels. The river bed between Sekimon Bridge and Wolgye-ni Bridge shows a medium-scale river bed form, because alternating bars of about 500 m in length are formed on the river bed.

The particle size distributions of the river bed material sample taken at 2 points in the section to be planned are shown in Fig. 3.3-10. Both of the samples are classified into sands, but the sample taken on the downstream side contains more coarse grains than the sample taken on the upstream side does, because the one taken at Station 2 on the upstream side contains 56.5% of sands and 37.0% of silts and clayey materials, whereas the sample taken at Station 1 on the downstream side contains 98% of sands and 2.0% of silts.

Immediately right after the big flood of September 1990, sediments flowed in the upstream area of the main river and left numerous piles of sediments at the bottom of the mountain streams. With the future occurrence of another flood, there is a possibility that these sediments will be flown downstream. The river channel in the middle course section was single and meandering before the flood, but has been changed to double and meandering and had a sand layer of about 0.5 m in thickness on the river bed immediately after the flood.

3.4 Chungroung Chong

3.4.1 Present Condition of the Basin

(1) Topography, geology, and water system

The main stem of Chungroung Chong has a length of 10.85 km. The 7.6 km area downstream included in the Seoul Metropolitan area was, therefore, included in the study. The Chungroung Chong basin extends in the E-W direction upstream and narrows in width in the N-S direction downstream. The catchment area of Chungroung Chong is 19.66 km^2, about 22% of which is occupied by the basin of the Ryangkohu Chong (Fig. 3.4-1).

The entire basin is composed of granite, and the narrow valley plain is thinly covered with alluvium.

(2) Administrative division and population

The entire basin area is included in the Seoul Metropolitan area and the population is estimated at approximately 380 thousands. The average population density in the basin is 250 - 350 persons/ha, but the population density in the residential area is high at 500 - 600 persons/ha. Recently, however, the population tends to decrease just like the population in central Seoul Metropolitan area.

(3) Land use and industrialization

The water source of Chungroung Chong above 100 m in altitude is one of the Pukansan National Park areas. The areas below 100 m in altitude are mostly densely populated residential and commercial areas. There are not much areas left in the basin for further development.

The area of urban district of this basin calculated on the basis

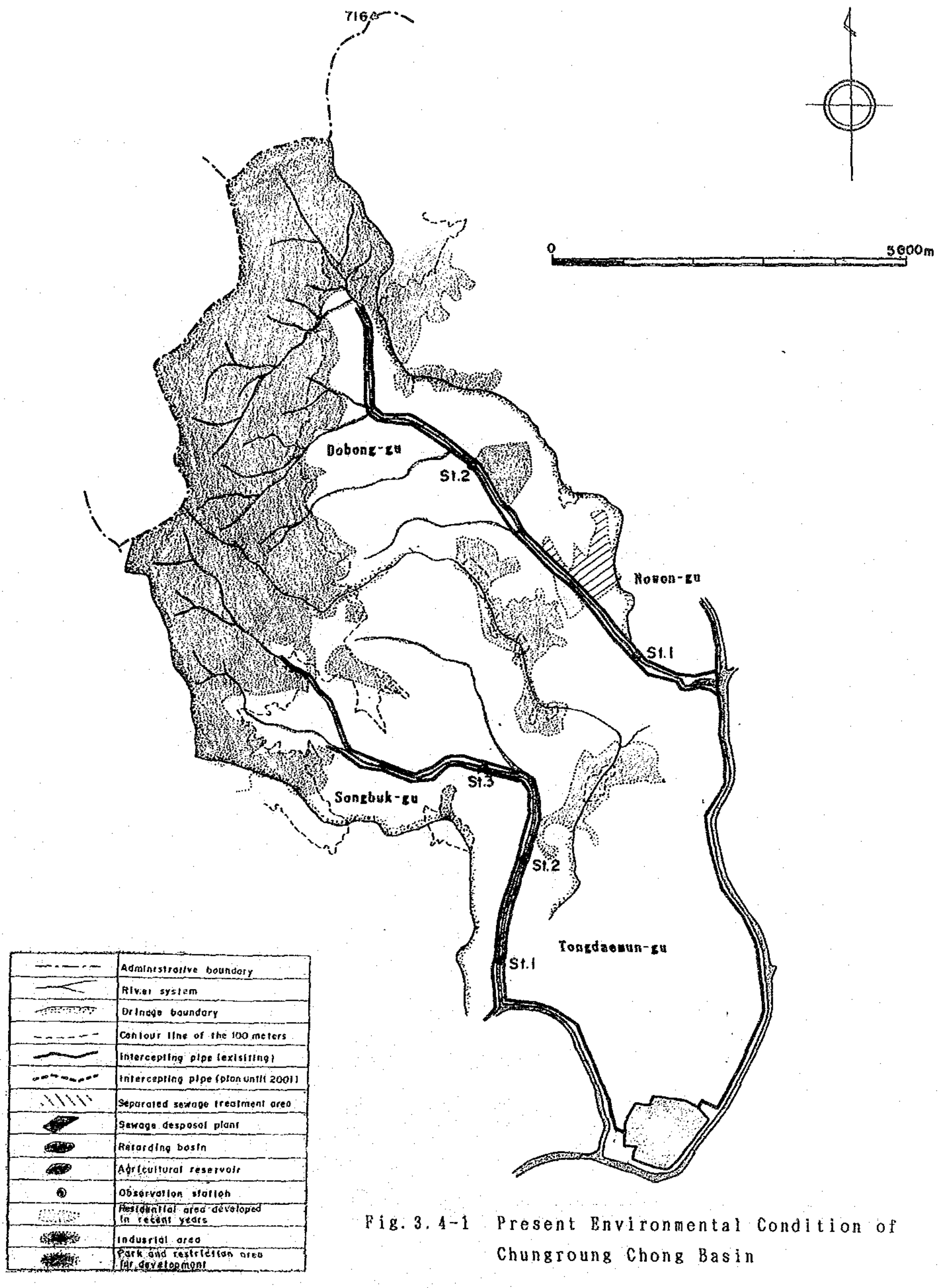


Fig. 3. 4-1 Present Environmental Condition of Chungroung Chong Basin

of the city planning map of Seoul Metropolitan is 9.70 km^2, with the ratio of urbanization being 49.3%.

(4) Park and green zone

Due to Pukansan Park, the park area and the green area ratio in the upstream basin are high at 2.6 m^2/head and 39.4%, respectively. The conditions downstream are considerably poor with only 0.7 m^2/head of park area and 18% green area ratio.

(5) Pollution source and sewage discharging and progressing condition

The population in the basin which used the base for estimating the domestic waste water discharging source is already described. Collected Data D - 9 indicates that the generation unit load of domestic waste water in Songbuk-gu in 1989 is 200 x 10 $1/m^3$/head/day.

Such an industrial nor public pollution source that discharges waste water at a rate of 1,000 m^3/day or more is not listed on Collected Data B -4. A total of 74 pollution sources exist in Songbuk-gu and Tongdaemun-gu, but almost all of them are small in scale and discharge waste water at rates of 100 m^3/day or less. However, it is not known that how many of them exist in this basin.

The sewage diffusion rate in Chungroung Chong is nearly 100% and all areas adopt the combined sewage system. Through the intercepting sewers installed on both banks of the Chungroung Chong main stem, sewage is sent to the Chungryang Treatment Plant and then discharged to the Chungryang Chong after secondary treatment. The average BOD concentration of the treated water is 15 mg/l.

3.4.2 River Improvement and Utilization

(1) Physical feature of river section

The river bed of the Chungroung Chong has an average gradient of 1/180 from the Chonggye Chong confluence up to 2 km upstream. From here up to within 6.7 km, the gradient average is 1/130, and more than 1/30 further upstream (Fig. 3.4-2).

There are no major bed within 0.7 km of the upstream right bank of the planned area, but compound cross sections can be found in other areas.

The width of the river channel is 30 - 50 m and the low water channel width is about 20 m at the upstream side end of the section to be planned and becomes the widest to 46 m near the point 200 m up the river from Chegi Bridge, but again narrows to about 30 m in the downstream section.

(2) River structures and underground works in river channel

The construction of embankment (one part of which is a special embankment of parapet wall) on both banks of the planned area is almost over, and the height from the river bed to the crest embankment is 4 - 5 m.

Falling works (with falling heights of 1 - 3 m) are installed to 4 sites, but no sluice way nor water gate is installed. An intake weir is installed to the most downstream section, but the weir is not used at present.

Intercepting sewers are installed below the major beds of the left and right banks, while open intercepting sewers are installed in areas without major beds parallel to the level of the low water channel.

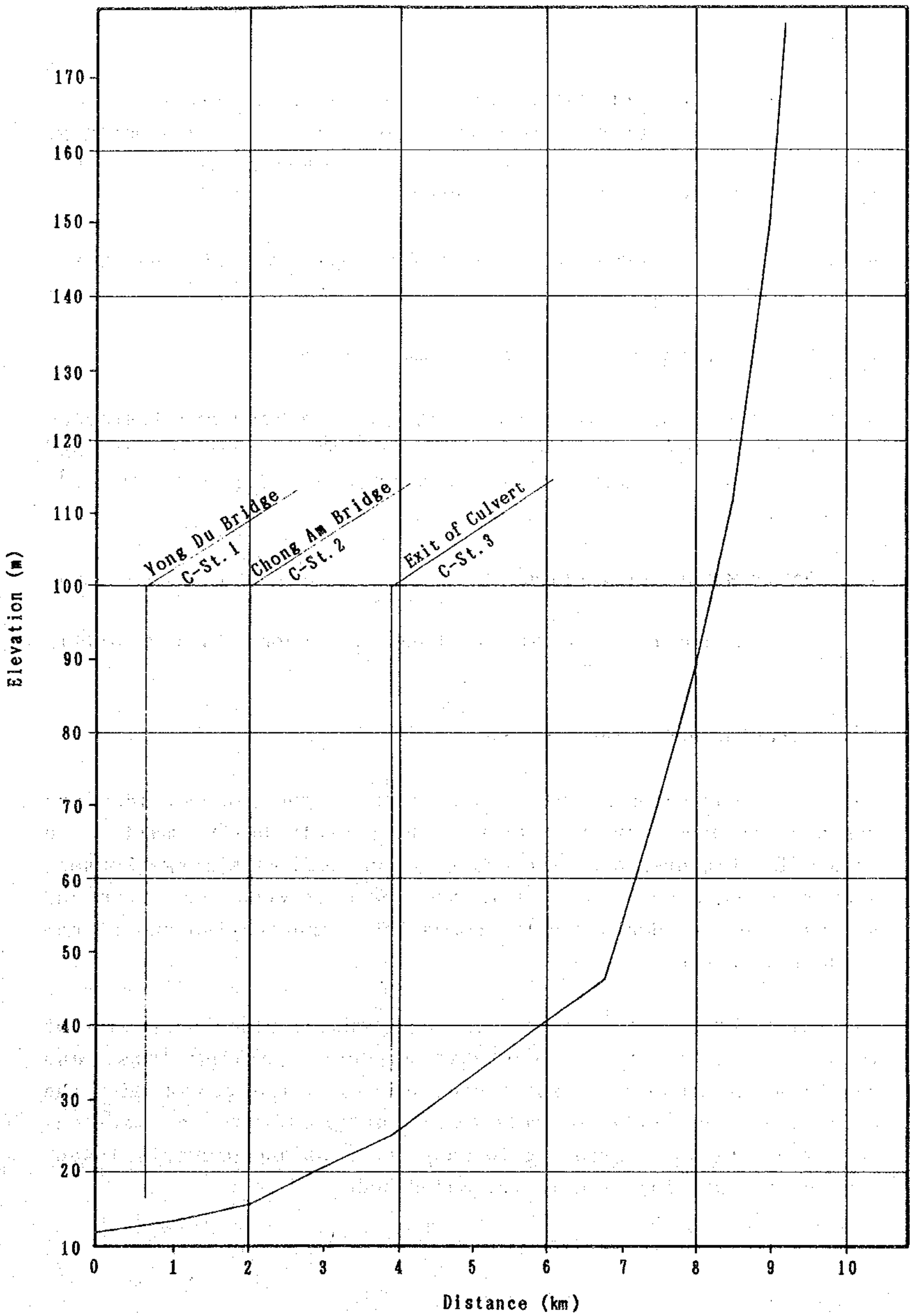


Fig. 3.4-2 Longitudinal Porfile of the Project Setion along Chungroung Chong

A total of 2,766 m or 36% of the planned area is covered. Furthermore, the tributary Walgok Chong and the area upstream from the planned area are covered and used as sewage rivers. The spaces on the cover are used as roads.

A total of 14 bridges are constructed, with all of them being road bridges.

(3) Retarding basin and drainage pump station

Only one retarding basin and drainage pump station are installed to the junction with the Chonggye Chong. The catchment area and water storage capacity of the basin are 43 ha and 11,000 m^3, respectively.

(4) River water utilization

At present, the river water of Chungroung Chong is not utilized.

(5) Exterior and interior land

Most of the areas adjacent to the river of the planned area are residential and commercial areas. Old closely built small-sized houses in this area were successively replaced with large houses. Narrow roads are constructed in the space between the river and houses. The residents use the roads for communication and recreational purposes.

The major bed is not utilized well as a whole, since only part of the bed is utilized as vegetable gardens, parking lots, and public waste material transferring places. The reason why the major bed is not utilized well can be attributed to the vertical revetment which is installed to many sections and prevents inhabitants from getting down to the major bed.

(6) Sewage inflow to the river

The sites where sewage was flowing into the section to be planned from the flank at the time of investigation made in July 1990, are shown in Fig. 3.4-3 and the water quality and discharge of the sewage are given on Table 3.4-1.

The sewage flowing into the river from the flank can be divided into two groups, namely, the sewage directly flowing into the river and the sewage introduced into intercepting sewers in fine days, but flowed into the river beyond weirs in rainy days. The water quality and discharge of the latter type of sewage changed in time and by days. The total amount of the sewage which was directly flowing into the river was about 0.06 m^3/sec.

Table 3.4-1 Waste Water Quality Directly Flowing to Chungrong Chong

Station	WT (°C)	pH	DO (mg/l)	EC (mS/cm)	Turbid (mg/l)	COD (mg/l)	SS (mg/l)	Discharge (m^3/sec)
1	-	-	-	-	-	2	-	-
9	25.6	8.1	6.2	0.9	9	35	-	0.012
10	23.6	7.4	5.9	0.7	0	4	-	0.002
11	24.7	7.5	4.6	0.5	40	172		
16	25.2	8.4	5.9	0.7	93	124	-	0.048
17	22.5	7.6	7.2	0.9	6	11	-	0.001

Sampling Date June 14 - 15, 1990
* : Sewer pipe was under construction
**: Water was discharged from retarding basin

3.4.3 Flow Regime Characteristics

(1) Relation between water level and discharge

H-Q curve prepared by the field measurements is shown in Fig. 3.4-4. The relations between the water level (H) and discharge (Q) of each observation point are expressed by the following regression curve.

St. 1: $Q = 30.012379 \times (H-12.93781)^2$
St. 2: $Q = 36.269257 \times (H-16.01848)^2$
St. 3: $Q = 38.727405 \times (H-25.01978)^2$

(2) Daily variation of water level

Such a pattern that the water level abruptly rises and drops twice a day in time zones 10:00 to 14:00 o'clock and 20:00 to 2:00 o'clock is found from the continuous records of the automatic water level recorders at the 3 observation points along the Chungroung Chong. The difference between the highest and lowest water levels is 2 - 4 cm. It was considered from the time zones that such pattern might had been created by the sewage flowed into the river, but such water variation pattern has disappeared since May 1991, probably due to the repair of intercepting sewers.

(3) Seasonal variation and characteristics flow

Duration curve prepared by the daily flow is shown in Fig. 3.4-5. The 95, 185, 275, 355-day discharges and specific discharges are shown in Tables 3.4-2 and 3.4-3, respectively.

The 275-day discharge and 275-day specific discharge obtained at Station 3 at the upstream side end of the section to be planned are 0.042 m^3/sec and 0.419 m^3/sec/100 km^2, respectively, which are slightly lower than those obtained at Yoju.

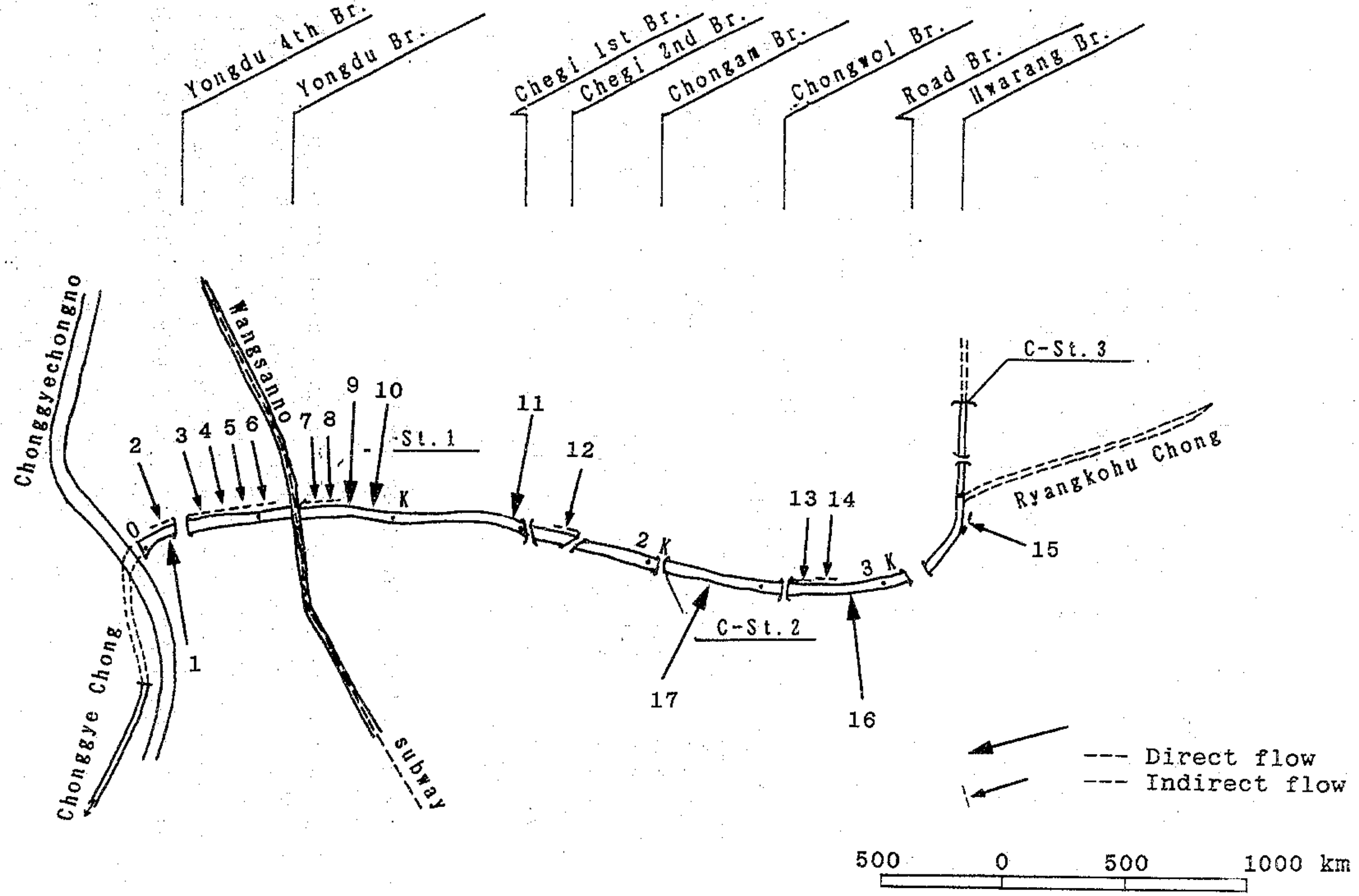


Fig. 3.4-3 Overflow Point of the Sewage along Chungroung Chong

Table 3.4-2 Discharge in Chungrong Chong

Unit:m^3/sec

Station	Catchment Area (km^2)	Discharge 95-day	185-day	275-day	355-day	Average
St.1	19.40	0.434	0.244	0.109	0.012	1.028
St.2	17.92	0.715	0.300	0.075	0.020	0.973
St.3	10.03	1.107	0.168	0.042	0.011	1.105

* Daily discharge / Jan. 1 - Dec. 31 in 1990

Table 3.4-3 Specific Discharge in Chungroung Chong

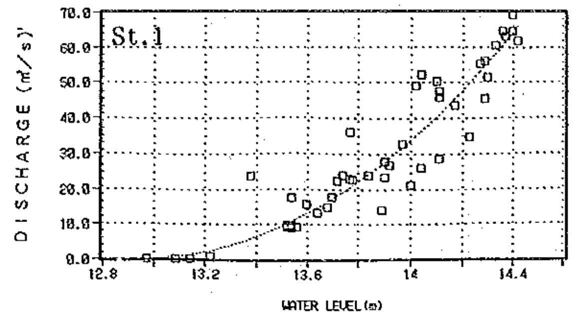
Unit:m^3/sec/100km^2

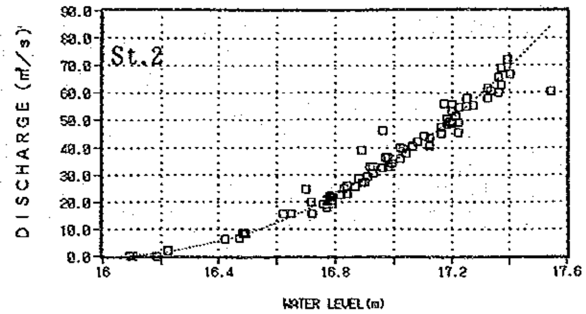
Station	Specific Discharge 95-day	185-day	275-day	355-day	Average
St.1	2.237	1.258	0.562	0.062	5.299
St.2	3.990	1.674	0.419	0.112	5.430
St.3	11.037	1.675	0.419	0.110	11.017
Yoju	2.408	1.119	0.505	0.207	

* Daily discharge / Jan. 1 - Dec. 31 in 1990

(4) Flow characteristics in river profile

Table 3.4-4 is the results of discharge measurement in draught days. The flow is always largest at Section 3, and decreases toward the downstream side. The fact that the river water is taken to an open conduit and the river water itself becomes latent flows between Stations 1 and 2 may contribute to such phenomenon.





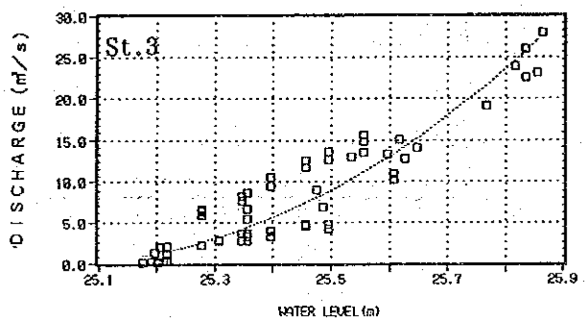


Fig. 3.4-4 H-Q Curve of Chungroung Chong

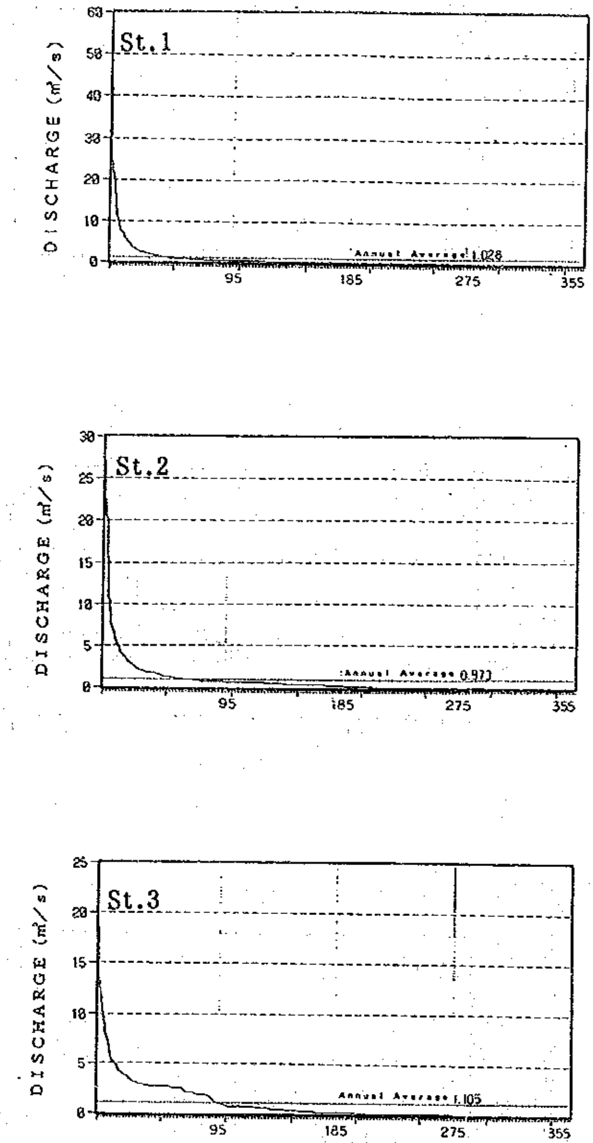


Fig. 3.4-5 Duration Curve of Chungroung Chong

Table 3.4-4 Discharge Measured in Chungroung Chong in Drought Days

Unit: m^3/sec

Station	Dec. 4	May 28	June 1	June 10	June 13
St.1	0.71	0.03	0.005	--	0.012
St.2	0.29	0.08	0.004	0.01	0.04
St.3	0.47	0.23	0.19	0.19	0.10

Table 3.4-5 Result of River Sediment Analysis of Chungrong Chong

Unit:mg/kg

Station	CN	AS	THg	Cr(6+)	Cd	Pb	Sulfide	DL(%)	IL(%)
St.1	0.386	0.187	0.029	ND	0.100	1.200	6.45	33.0	35.0
St.2	0.182	0.160	0.025	ND	0.110	0.793	5.46	49.3	51.5

(5) History of flooding disaster

No record regarding a significant flood is left in this basin.

3.4.4 Pollutant Characteristics

(1) Daily variation of the water quality

Since the water level abruptly rises and drops in specific time zones as mentioned above, a diurnal variation of the water quality may be recognized when water samples are taken at shorter time intervals during the time zones.

(2) Seasonal variation of the water quality

The results of the analysis of the river water samples taken once a month at each observation point along Chungroung Chong are shown in Fig. 3.4-6.

The DO concentration is 4 - 6 mg/l in low season and 6-8 mg/l in high season, but no periodic relation is recognized.

BOD and COD (Mn) concentrations in the high season become several time as high as those (5 - 10mg/l) in the low season. These variations also do not show any seasonal periodic relation, but such a trend that both concentrations become higher as the flow increases is recognized (Fig.3.4-7).

The TN concentration shows such a high value of 3 - 10 mg/l all year round. The main constituents of the TN are NH_4-N and NO_3-N and the ratio of TON to TN is about 6 - 15%. In addition, as easily understood from Fig. 3.4-8, the water quality of the Chungroung Chong is very similar to that of the sewage in the Seoul Metropolitan area.

The number of coliform which represents bacilli has increased since November 1990, but, the number stays at such a low level of 1,000 - 2,000 mpn/100 ml.

The harmful materials, CN and THg, could not be detected at any observation point.

(3) Characteristics of the water quality and pollutant load in river profile section

In comparison with the results of St. 3 and St.1 on Fig. 3.4-6, St. 3 has a higher concentration of COD and NH_4-N. Regarding the DO and BOD concentrations, however, St.1 is higher than St. 3 before November 1990. Therefore, no constant regularity is recognized in the variation of water quality in the flowing

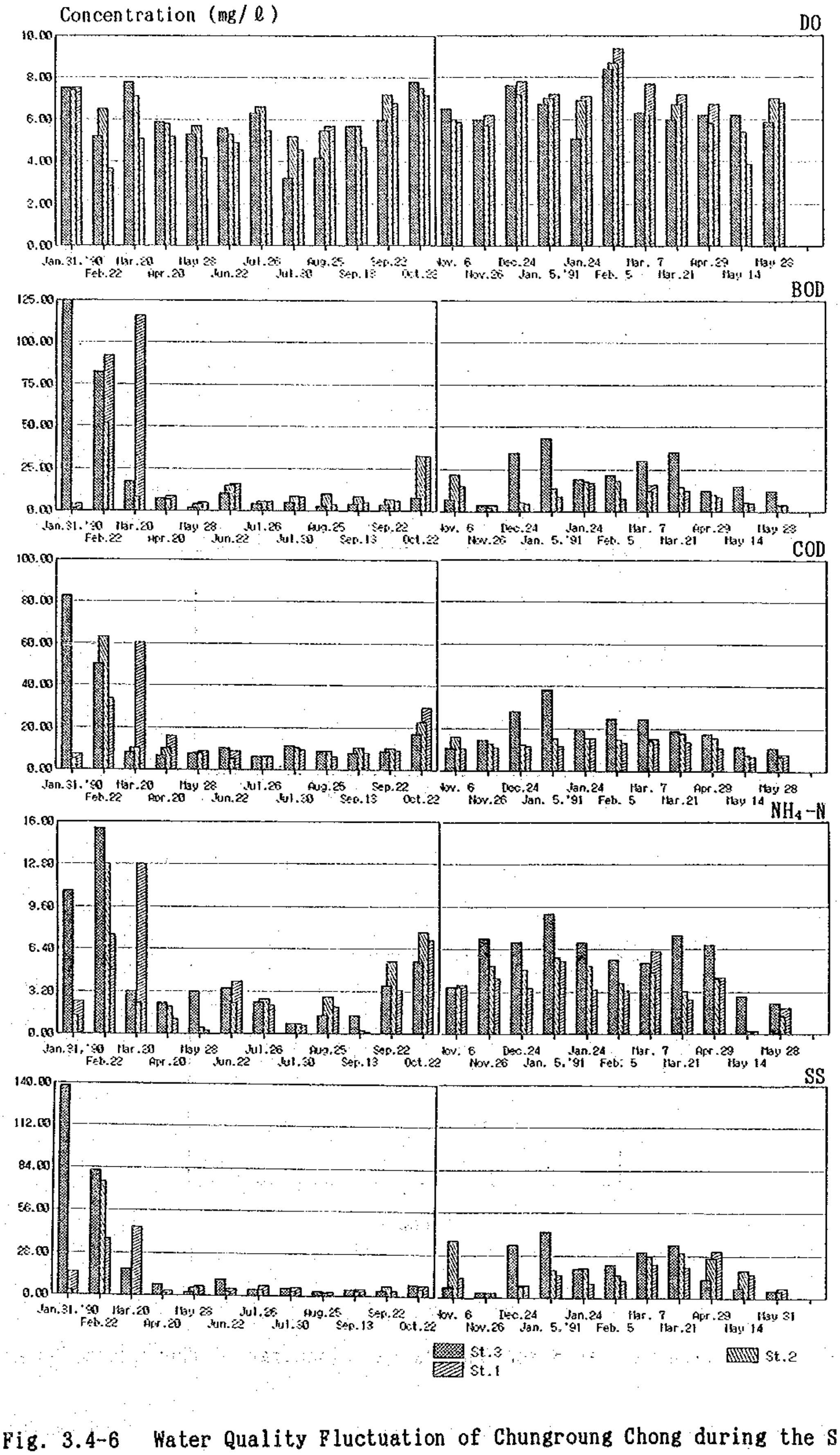


Fig. 3.4-6 Water Quality Fluctuation of Chungroung Chong during the Study Period

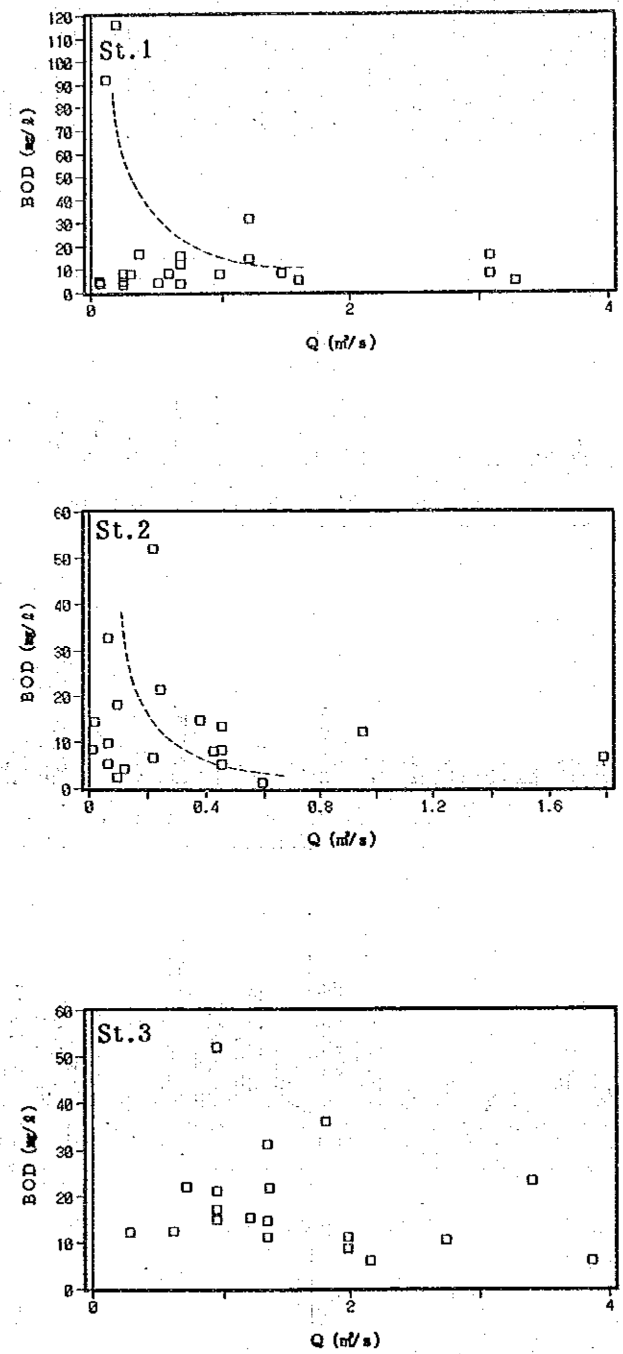


Fig. 3.4-7 Relation between Water Quality and Discharge of Chungroung Chong

direction.

Since the river flow of Chungroung Chong shows an unnatural variation as mentioned above, it is considered that latent flows largely affect not only to the river flow, but also to the variation of water quality in the flowing direction.

(4) Rainfall, water quality and pollutant load

In order to check the variation of water quality corresponding with rainfall, 12 samples were taken from 12:00 to 16:30 in July 1991.

Falling only 2.6 mm of daily rainfall in July 1st, but the rise in water level was significant. As understanding from Fig. 3.4-8, the variation of water quality took place almost parallel to the variation of water level, with the peak of water quality being almost coincident with that of water level.

(5) Relationship of the water quality elements

The COD (Mn), BOD, SS and NH_4-N contents show extremely close relations among them and high positive correlations are recognized among them in any case.

Especially, relativity of BOD and COD(Mn) is high (r = 0.896 to 0.940) and the ratio between them is about 1:1.

(6) Self purification

The self purification survey could not be done to the Chungroung Chong, because no section provided with conditions which sufficiently meet the requirement of the measurement was available.

(7) Pollutant condition of the sediment

Table 3.4-5 is the analyzed results of the samples taken in

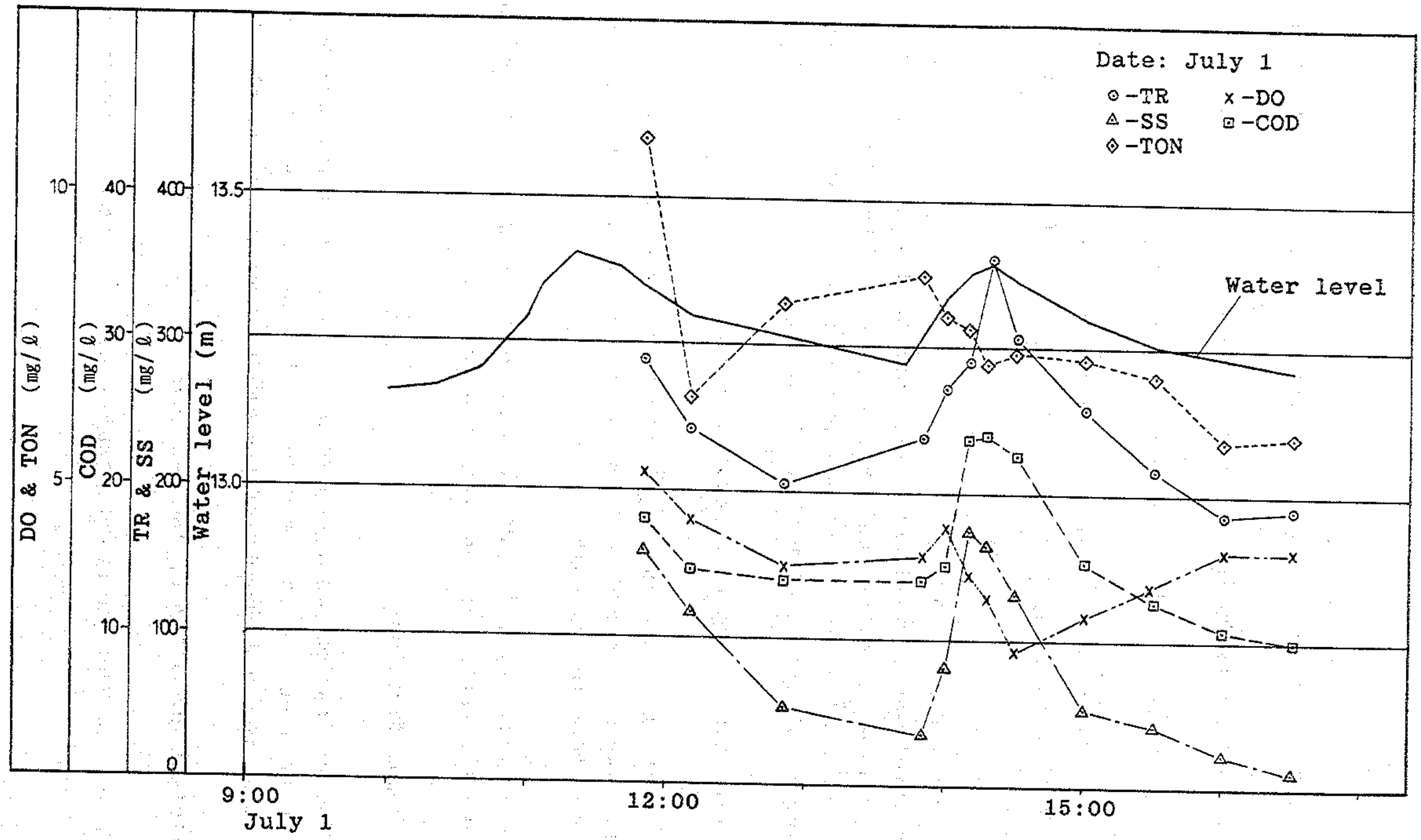


Fig. 3.4-8 Water Quality Change of Chungroung Chong in the Freshet Time

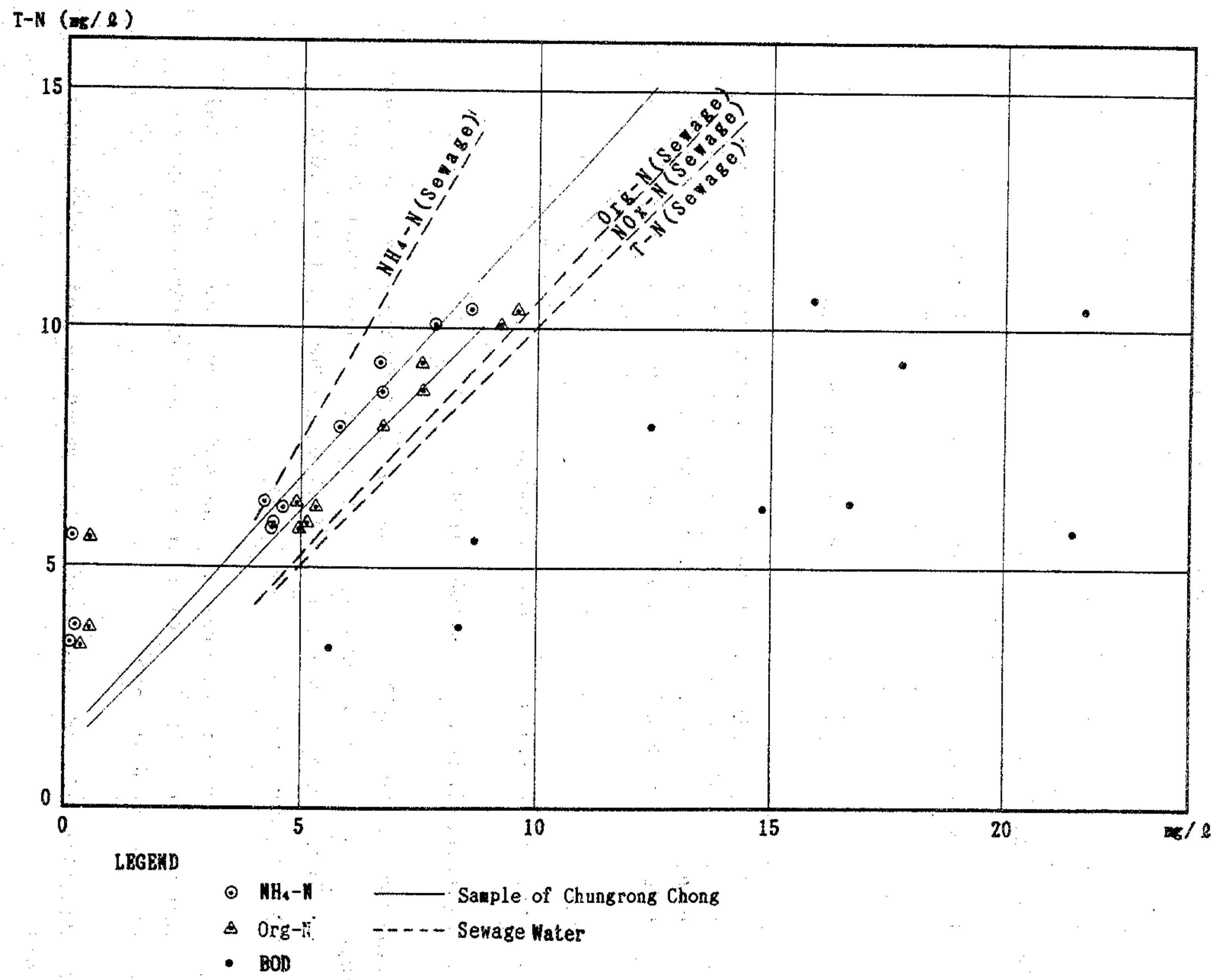


Fig. 3.4-9 Comparison of Water Quality between Chungroung Chong and Sewage

December 5, 1990. CN, As, Cr(6+), Pb are contained lowly, and it is considered that no harmful matters exist in the basin.

On the other hand, a ignition loss (IL) at St. 1 and St.2 are 35% and 51.5%, respectively, therefore, it is presumed that organic materials have been deposited in a short period even after the large freshest in September.

From the sediment, 1 piece/m^2 of Chironomus yoshimatsui at St.1 and 1 piece/m^2 of Physella acuta at St.2 was detected.

Table 3.4-6 Results of the Sediment Analysis

Station	CN	AS	THg	Cr(6+)	Cd	Pb	Sulfide	DL(%)	IL(%)
St.1	0.386	0.187	0.029	ND	0.100	1.200	6.45	33.0	35.0
St.2	0.182	0.160	0.025	ND	0.110	0.793	5.46	49.3	51.5

3.4.5 Sediment Run-off Characteristics

(1) Distribution of the slope failures

According to the 1987 aerial photographs, there are only few slope failures in Chungroung Chong basin. These slope failures can be found on the east mountain side of the dividing ridge of Chungroung Chong and Hongje Chong.

There are 34 slope failures in the basin and their area totals approximately 0.13 km^2. Total area of slope failures is approximately 1.3% to whole area.

(2) Quantity of sediment yield and produced and run-off sediments

The sediment production caused by a flooding is estimated 3.4 x

10^5 m^3 considering new and existing slope failures, and 3.1 x 10^5 m^3 is also estimated on the assumption with almost 10% of diment yield will be stored in river channel.

(3) River bed material and sediment characteristics

The river bed material is course-grain sands mixed with gravels in the upstream section, but the material is composed mainly of medium-grain sands in the downstream section. Only a small stream is observed in the center of the river bed during the low-water level season. The river bed near Chongnam Grand Bridge shows the feature of a small-sized river bed form, since sand piles of about 1 m in wavelength are formed on the river bed.

The results of particle composition sampled at 2 points of the planning section are shown in Fig. 3.4-10. All of these from Station 2 is well-sorted medium-grain sands, whereas the other samples are not much sorted.

Immediately right after the big flood of September 1990, sediment flow occurred. These sediments are presumed to originate not from the slope failures, but from the piles of sediments at the bottom of the mountain streams or from the banks of eroded streams. Most of the sediments are widely accumulated in the downstream area of Station 3 and not at the 3 layered covered area.

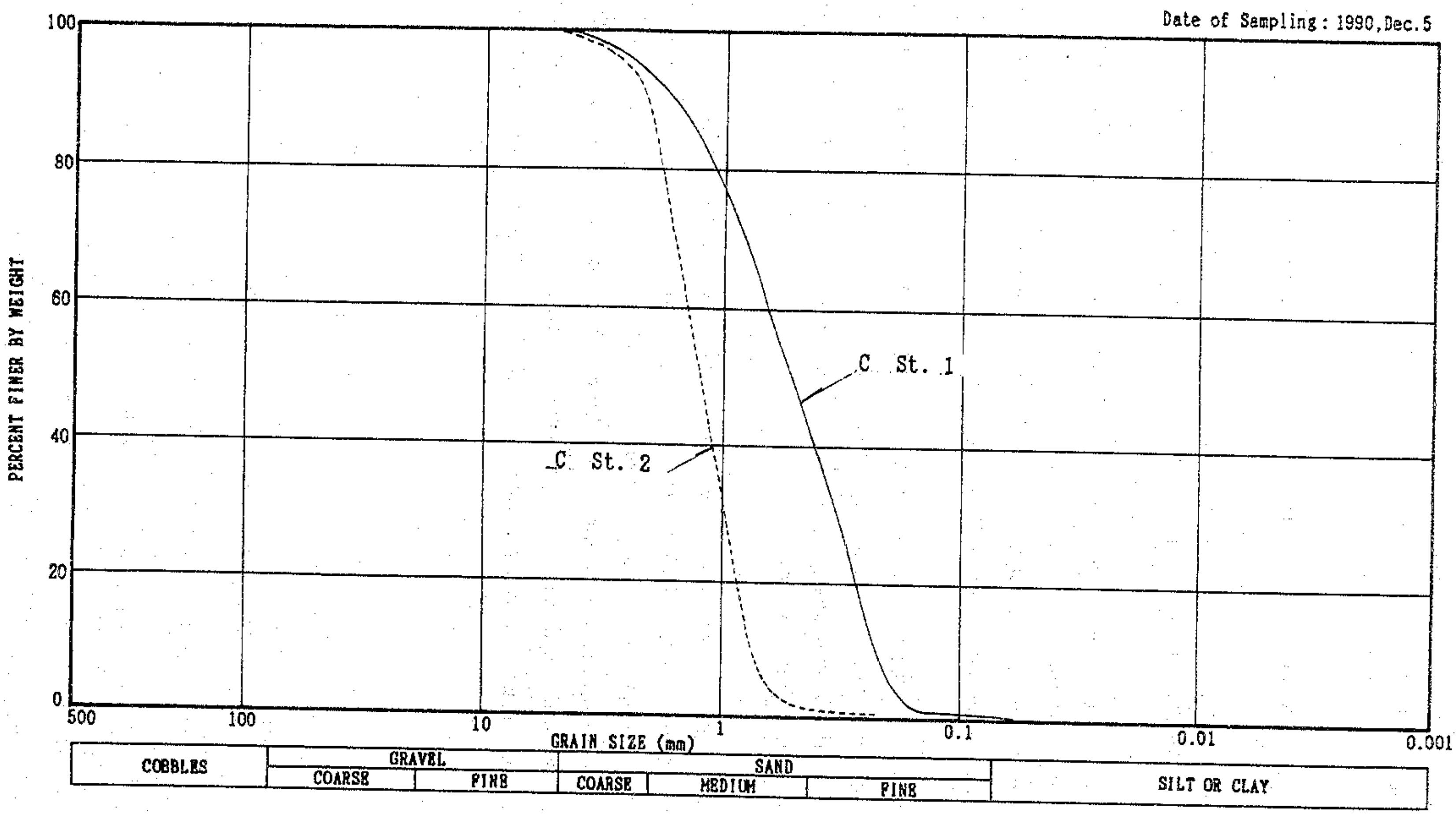


Fig. 3.4-10 Particle Size Distribution of River Sediment of Chungroung Chong

3.5 Examination of River Pollution Mechanism

3.5.1 Flow of Pollutant Load and Emission Load

(1) Flow of pollutant load

Depending on the improved and maintained conditions of the sewerage, sewage removal systems, the flow regime characteristics of the river, etc., pollutants from the basin are discharged outside of the basin in various proportions through various routes. To improve the flow duration and the water quality of a river and maximize the effect, the route and the volume of the pollutant load should be clarified and it is necessary to use techniques which are most appropriate in most suitable positions.

In order to study this conditions, the flow of the pollutant load in the basins of the four rivers were schematically outlined based on the present environmental conditions of the rivers aforementioned in Sections 3.1 - 3.4, and shown in Figs. 3.5-1 to 3.5-4.

The Anyang Chong basin is divided into three areas: the 1st area (Area A) is made up of Anyang-shi, Kunpo-shi, Uiwang-shi and Kwachon-shi all of which are not provided with any sewerage system: the 2nd area (Area K) consists of Kwangmyong-shi, Shihung-shi, and Puchon-shi, each of which is partially provided with a sewerage systems: the last area (Area S) is the Seoul Metropolitan area which is almost entirely provided with sewerage systems. The areas with sewerage systems are again divided into 2: the area using separate sewerage systems, and the area using combined sewerage systems. Sewage exceeding the capacity of the intercepting sewers of the former area flows directly to Anyang Chong in rainy days. It was previously mentioned too, that some of the sewage which are not drawn into the intercepting sewers Area S directly flows into Anyang Chong.

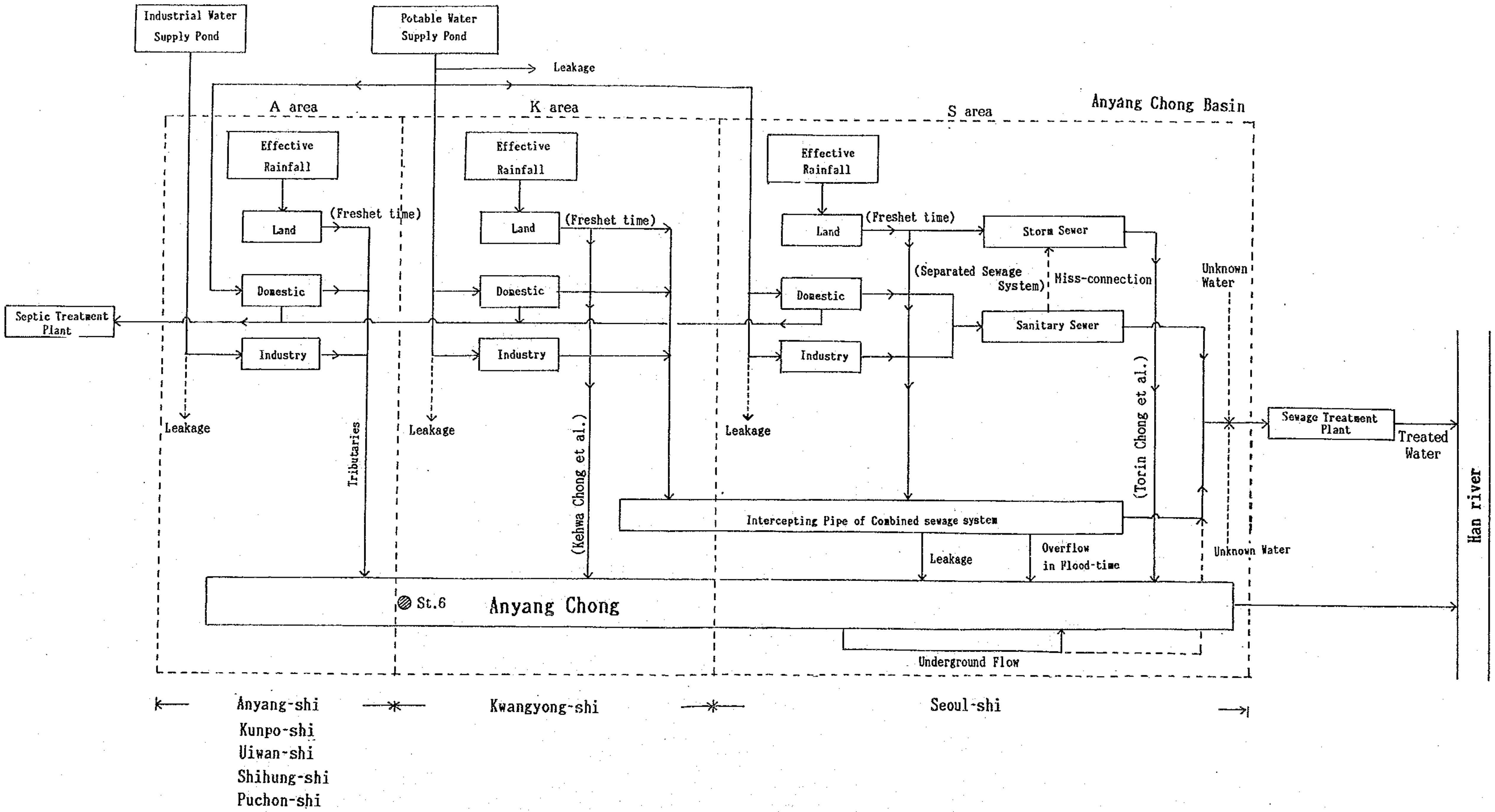


Fig. 3.5-1 Runoff Route of Pollutant in Anyang Chong Basin

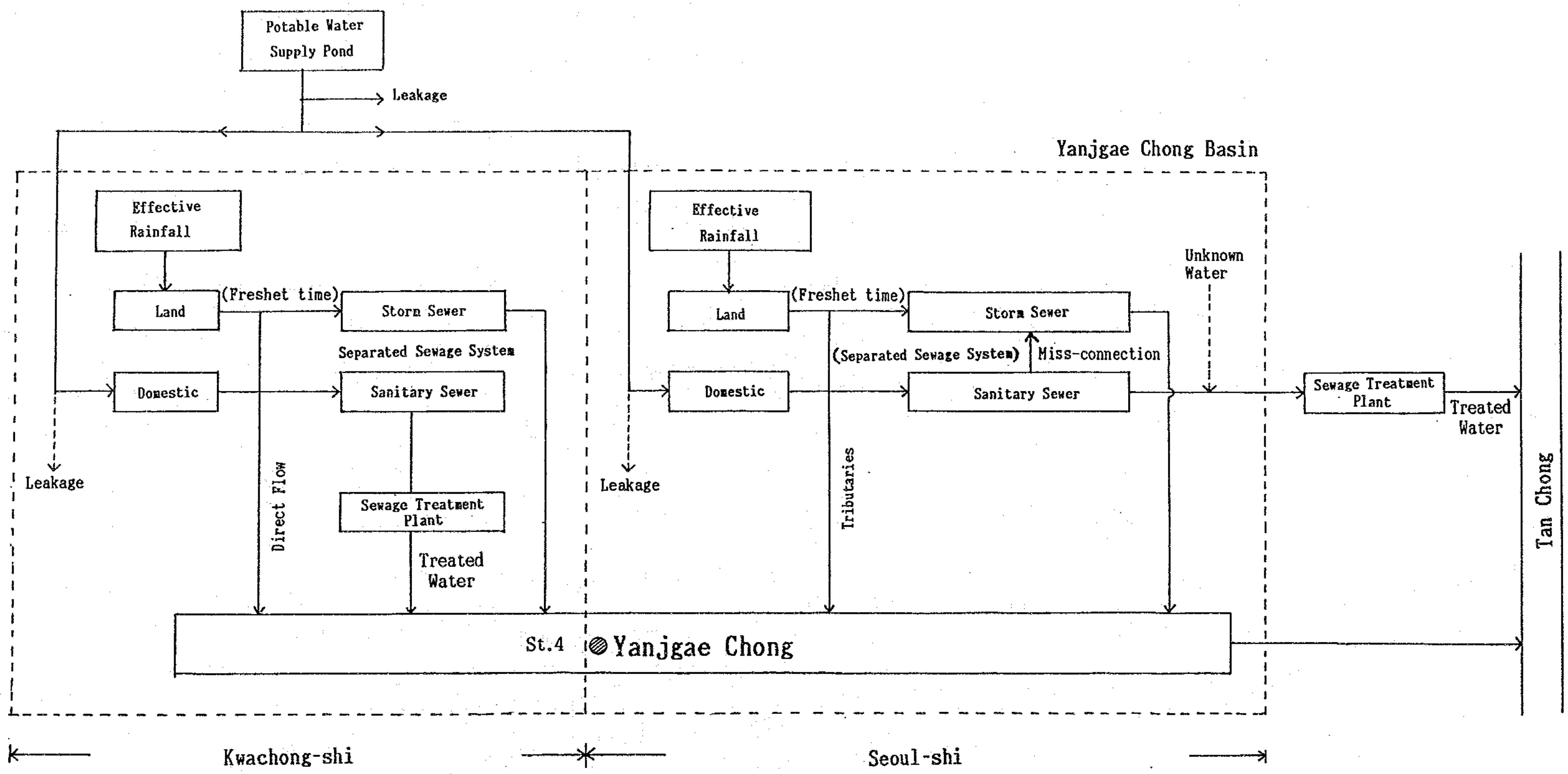


Fig. 3.5-2 Runoff Route of Pollutant in Yangjae Chong Basin

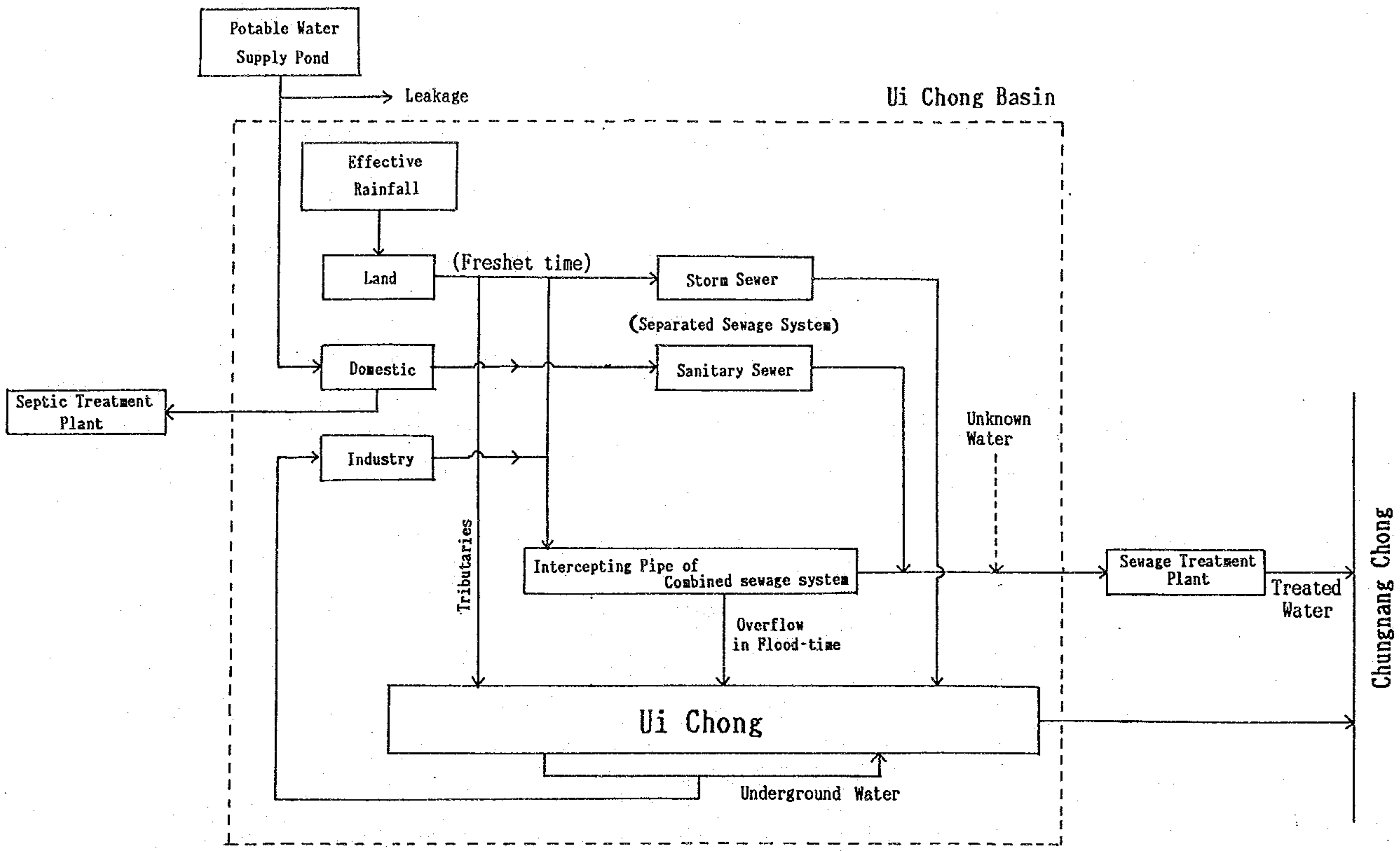


Fig. 3.5-3 Runoff Route of Pollutant in Ui Chong Basin

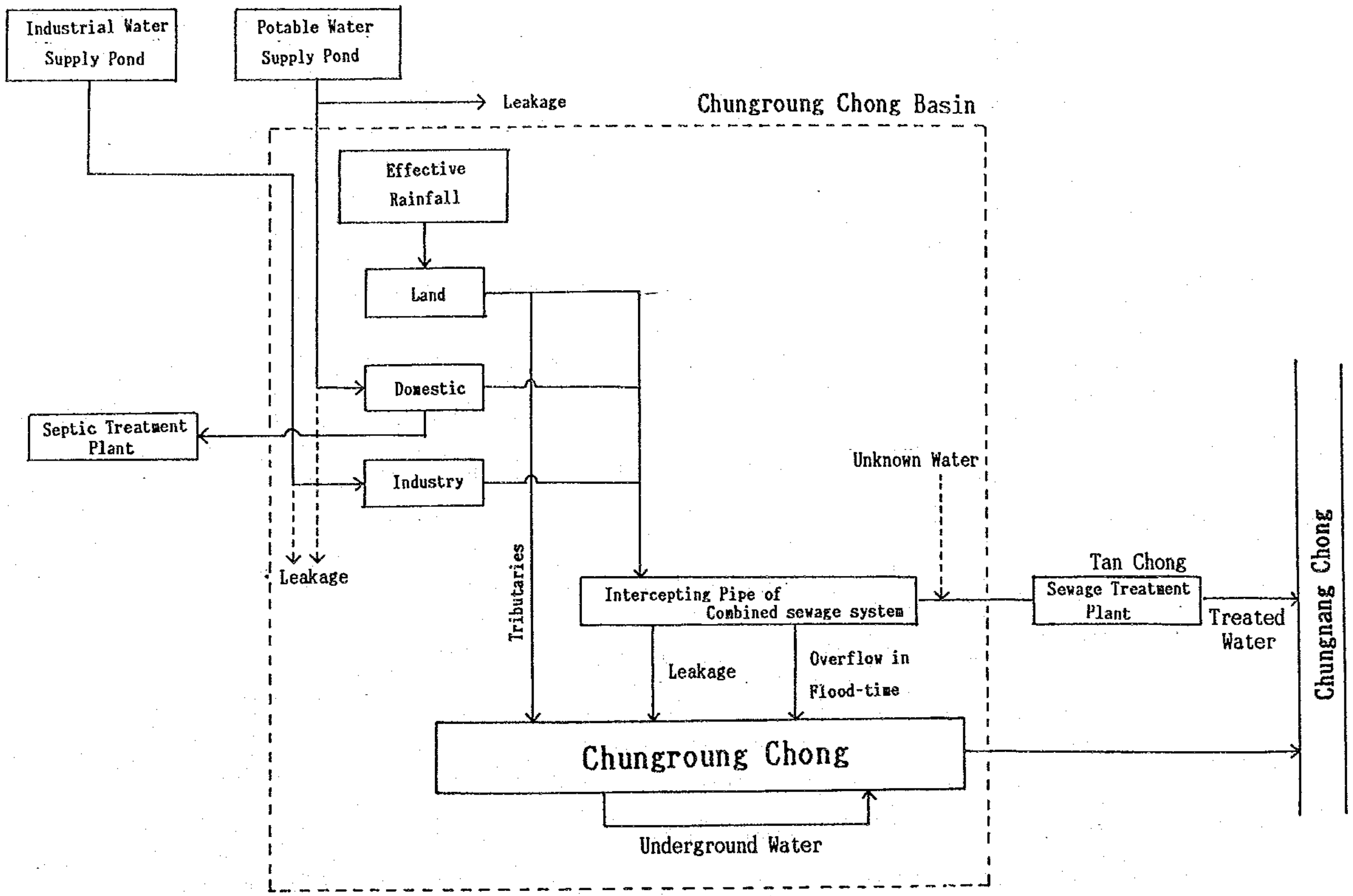


Fig. 3.5-4 Runoff Route of Pollutant in Chungroung Chong Basin

The Yangjae Chong basin is divided into 2: the Kwachon-shi area upstream, and Seoul Metropolitan area downstream, both of which are provided with separate sewerage systems in their urban districts. There are areas within Seoul Metropolitan, however, using combined sewerage systems because the sewer pipes are misconnected to the storm sewers.

One part of the Ui Chong basin uses the separate sewerage system, while most of the area uses the combined sewerage system. Sewage exceeding the capacity of the intercepting sewers of the latter flows directly into Ui Chong in the rainy days. However, little sewage inflow was observed in clear days based on the BOD/COD concentrations and the NH_4-N/TN or TON/TN concentrations of the water quality, indicating that the intercepting sewers are kept in good conditions.

The entire Chungroung Chong basin is provided with a combined sewerage system. However, the visual observations results and water quality analyses indicated that large quantity of sewage flows regularly into Chungroung Chong both during rainy and clear days.

(2) Rough estimate of emission load of pollutant

It is not possible to show the pollution load of each route, since the actual conditions of the sewerage routes is the most important among the flowing routes of pollution loads shown in Figs. 3.5-1 to 3.5-4. could not be investigated. In order to consider the ratio of pollution loads discharged from each basin by areas and pollution sources, emission loads of pollutants are roughly estimated on the following assumption:

(a) The daily emission load of pollutant is calculated by using the BOD as an index.

(b) The emission load of pollutant from the non-point source is calculated based on the divided areas, namely, the urban and non-urban areas by respective emission unit loads. The areas are described in subsections, and values of 90 kg/km2 and 5 kg/km2 are uniformly applied to the urban and non-urban area, respectively, as the unit emission loads of pollutants.

(c) The values of domestic waste water discharging quantity are used from Collected Data D - 9 showing area-wise. The actual conditions of sewage treatment have not been recognized, and the treatment is considered variable by the areas. Therefore, the emission unit load is uniformly adopted 90 mg/l from the actually measured water qualities of domestic waste water shown in Collected Data D-17.

(d) Since the actual treatment conditions of industrial waste water is not clear, the upper limit value, 150 mg/l, of the acceptable range stipulated by the Water Quality Preservation Low is uniformly applied to the emission unit pollution load.

(e) The pollution load discharged by domestic animals is neglected, since the load is very small as compared with that of other pollution sources even in the Anyang Chong basin where the domestic animals are most abundantly bred.

The composition of the pollution load of each basin calculated on the above-mentioned assumptions is shown on Table 3.5-1. The areal ratios of emission loads in Area A, K, and S are 15%, 7.7% and 77.3%, respectively. However, there is possibility that the ratio of Area A can be highly amount.The emission load from Kwachon-shi is 25% of total in Yangjae Chong Basin, and most of them is connected to the treatment plant.

	Anyang Chong			Yangjae Chong			
	Area A	Area K	Area S	Kwachon-shi	Seoul Metro.	Ui-Chong	Chungroung Chong
Basic Data of the Basin							
① Basin Area ($10^6 m^2$)	121	61	104	36	23	27	20
② Urban Area ($10^6 m^2$)	30	10	64	2	8	4	10
③ Non-urban Area ($10^6 m^2$)	91	51	40	34	15	23	10
④ Population (10^4人)	80	23	206	7	17	32	38
⑤ Domestic Waste ($10^{-3} m^3$/人)	140	250	280	250	310	200	200
⑥ Industrial Waste (m^3/day)	60.4	5.80	75.9	0.0	0.0	6.0	7.0
Effluent Load from the Basin (kg/day)							
⑦ Non-point (②×90×10^{-6}+③×5)	3.16×10^3	1.16×10^3	5.96×10^3	3.50×10^2	7.95×10^2	4.75×10^2	9.50×10^2
⑧ Domestic (④×⑤×90)	1.01×10^7	5.17×10^6	5.19×10^7	1.58×10^6	4.74×10^6	5.76×10^6	6.84×10^6
⑨ Industrial (⑥×150)	9.06×10^3	8.70×10^2	1.14×10^4	0.0	0.0	9.00×10^2	1.05×10^3
⑩ Total (⑦+⑧+⑨)	1.01×10^7	5.17×10^6	5.19×10^7	1.58×10^6	4.74×10^6	5.76×10^6	6.84×10^6
	(15%)	(7.7%)	(77.3%)	(25%)	(75%)		

Table 3.5-1 Estimated Effluent Load in the Four River Basins

3.5.2 Generation Load in the Planned Section

Since it is difficult to calculate the emission load itself as mentioned above, the river pollution mechanism in the section to be planned is considered by using the generation load, measured pollutant load, and "apparent run-off ratio of pollution load".

(1) Method for calculating generation load

The generation load largely influences the water quality of the river if the treatment of the pollution sources and the improvement and maintenance of sewerage facilities are insufficient. However, the method of calculation and its accuracy shall largely vary according to the base data. The calculating method adopted is as follows:

(a) Pollution sources are divided into 4 categories, namely, the domestic, non-point, industrial, and livestock sources, and the item to be used as a generator load index is selected to each source. Then the generation load of each source is calculated by multiplying the index by the emission unit load officially announced by an authoritative agency.

(b) The permanent population in each basin in 1990 is used as the generation load index of the domestic source of each basin. The permanent population is found by appropriating the population totalized by administrative units (Annex A-3, A-5) to every survey point (discharge point, water quality). The values shown on Annex D-9 are used as unit generation loads.

(c) The category of land use is adopted as the generation load index for the non-point source. Details of land use condition are determined by land use map and other materials. Values shown on Annex C - 7 are used as unit generated pollutant loads.

(d) The discharged quantity of waste water is used as the generation load index of the industrial source. The discharging quantity is calculated by referring to the shipping amount per employee and unit discharging quantity of each factory per unit shipping amount shown on Annex A-7 on the basis of the number of industrial workers by areas shown on Annex B-9. Values shown on Annex B-10 are used as unit generation load. In addition, industries are divided into four categories, namely, textile, chemical, machinery, and others, following the classification of Kankoku Shoko-bu.

(e) The number of domestic animals is used as the generation load index of the livestock source. The number of domestic animals by basins is obtained from Annex H-3. Values shown on Annex D-9 are used as unit generated pollutant loads.

(2) Calculated results

Calculated results are collectively shown in Table 3.5-2, and the details are given in SUPPORTING REPORT III.

The BOD amount from the industrial source is about twice as high as that from the domestic source in the Anyang Chong. Even in the Ui Chong, the BOD amount from the industrial source exceeds the 30% of the total BOD amount. In Yangjae Chong and Chungroung Chong, on the contrary, the BOD amounts from the domestic sources account for the 90% or more and about 90% of the total amounts, respectively.

Regarding the SS amount, contribution of the domestic source is rather than that of the industrial source in the Anyang Chong. Even in each of the Yangjae Chong, Ui Chong, and Chungroung Chong, the generation load from the domestic source accounts for the 80% or more of the total amount. In addition, the generated pollutant load from the non-point source accounts for the 5 - 7% of the total amount in any basin and the percentage is larger than that of the non-point source in the BOD amount.

Table 3.5-2 Current Pollution Load Generation (BOD) in the Planned Section

Anyang Chong

Unit:kg/day

Source	St.1-2	St.2-4	St.4-5	St.5-6	St.3-	Total
Domestic	16,298	10,175	30,898	17,929	66,797	142,097
Industrial	61,631	13,248	17,475	162,246	17,005	271,605
Non-point	1,301	147	1,664	1,188	2,123	6,423
Livestock	7	667	2,835	5,830	27	9,336
Total	79,237	24,237	52,872	187,193	85,952	429,491

Yangjae Chong

Unit:kg/day

Source	St.1-2	St.2-4	St.3-	Total
Domestic	8,529	1,278	4,390	14,197
Industrial	54	31	0	84
Non-point	348	140	54	542
Livestock	0	113	264	377
Total	8,931	1,562	4,708	15,201

Ui Chong

Unit:kg/day

Source	St.1-2	St.2-	Total
Domestic	12,209	9,435	21,644
Industrial	5,561	5,622	11,183
Non-point	377	23	400
Livestock	0	1	1
Total	18,147	15,081	33,228

Chungrong Chong

Unit:kg/day

Source	St.1-2	St.2-3	St.3-	Total
Domestic	4,640	19,922	989	25,551
Industrial	317	831	1,669	2,817
Non-point	107	465	288	860
Livestock	1	0	1	2
Total	5,065	21,218	2,947	29,230

Table 3.5-3 Current Pollution Load Generation (SS) in the Planned Section

Anyang Chong

Unit:kg/day

Source	St.1-2	St.2-4	St.4-5	St.5-6	St.3-	Total
Domestic	17,897	11,173	33,928	19,687	73,348	156,033
Industrial	24,313	5,571	7,204	65,764	7,611	110,463
Non-point	3,367	364	4,144	3,509	5,497	16,431
Livestock	38	3,515	12,186	29,962	123	45,824
Total	45,615	20,623	57,462	118,472	86,579	328,751

Yangjae Chong

Unit:kg/day

Source	St.1-2	St.2-4	St.3-	Total
Domestic	9,384	1,406	4,831	15,621
Industrial	27	16	0	43
Non-point	897	360	114	1,371
Livestock	0	536	1,510	2,046
Total	10,308	2,318	6,455	19,081

Ui Chong

Unit:kg/day

Source	St.1-2	St.2-	Total
Domestic	13,322	10,295	23,617
Industrial	2,264	2,315	4,579
Non-point	974	36	1,010
Livestock	0	1	1
Total	16,560	12,647	29,207

Chungrong Chong

Unit:kg/day

Source	St.1-2	St.2-3	St.3-	Total
Domestic	5,063	21,739	1,079	27,881
Industrial	131	406	759	1,296
Non-point	277	1,205	740	2,222
Livestock	1	0	2	3
Total	5,472	23,350	2,580	31,402

3.5.3 Pollution Load Measured in the Planned Section

(1) Method for calculating measured pollution load

To calculate the pollution load flowing in the river, it is necessary to simultaneously obtain the discharge and water quality of the river. Since this kind of observation was not implemented in the 4 rivers, we made use of the 19 mean values, excluding both maximum and minimum values, of the periodical observations conducted once a month from January 1990 to July 1991.

The annual mean value of measured pollution loads was not use this time because it was not highly reliable. Reliability shall improve though, as the number of measurements increases in future.

(2) Calculated results

The present condition of measured pollution loads (BOD and SS) in the above-mentioned manner is shown in Table 3.5-4.

Table 3.5-4 Current Pollution Load Measured in the Planned Section

Anyang Chong — Unit:kg/day

	St.1	St.2	St.4	St.5	St.6	St.3
BOD	32,119	41,010	18,678	31,807	22,406	154
SS	32,680	37,112	23,827	24,534	18,943	281

Yangjae Chong — Unit:kg/day

	St.1	St.2	St.4	St.3
BOD	1,801	439	281	274
SS	4,540	1,713	323	1,336

Ui Chong Unit:kg/day

	St.1	St.2
BOD	1,327	264
SS	2,359	888

Chungrong Chong Unit:kg/day

	St.1	St.2	St.3
BOD	683	450	1,845
SS	453	226	1,106

3.5.4 Apparent Run-off Ratio in the Planned Section

(1) Calculating method

The run-off ratio of pollution load means the percentage of the pollution load reached to the river to the load discharged from a pollution source, and is originally defined as the ratio of the pollution load actually measured at a survey point to the total amount of pollution load discharged from the basin. In this investigation, however, the pollution load generated from the basin section between each survey point is used instead of the latter and the ratio of the measured pollution load to the pollution load generated from the basin section is called as the "apparent run-off ratio of pollution load".

In other words, the "apparent run-off ratio of pollution load" is the value found by dividing the measured pollution load by the pollution load generated from the basin section between each survey point. Therefore, the calculated results can be negative.

(2) Calculated results

Calculated results are collectively shown in Table 3.5-5 and the details of the calculation is shown in SUPPORTING REPORT III.

The survey points where the "apparent run-off ratio of pollution load" exceeds 10% in both BOD and SS are Station 4 of the Anyang Chong, Station 1 of the Yangjae Chong, and Station 3 of the Chungroung Chong and these calculated results are well agreeable with impressions obtained by the reconnaissance survey. Especially, the "apparent run-off ratio of pollution load" at Station 3 along Chungroung Chong indicates that more than half of the generation load reaches the river because the maintenance of intercepting sewers is extremely bad.

The "apparent run-off ratio of pollution load" at Station 1 along the Ui Chong is a little higher, but, even so, the ratio does not exceed 10%.

Table 3.5-5 Present Apparent Run-off Ratio in the Planned Section

Anyang Chong Unit:%

	St.1	St.2	St.4	St.5	St.6	Total
BOD	0.001	0.231	0.065	0.170	--	0.002
SS	0.101	-0.395	0.229	0.269	--	0.003

Yangjae Chong Unit:%

	St.1	St.2	St.4	Total
BOD	0.215	-0.075	--	0.058
SS	0.435	0.023	--	0.050

Ui Chong Unit:%

	St.1-2	St.2-
BOD	0.059	0.018
SS	0.089	0.070

Chungrong Chong Unit:%

	St.1	St.2	St.3
BOD	0.136	0.005	0.626
SS	0.139	-0.005	0.429

The flow of pollutants in the section to be planned along each river schematized on the basis of generation load, measured flow, and apparent run-off ratio of pollution load obtained by calculation is shown in Figs. 3.5-5 to 3.5-8.

3.5.5 Classification of the Pollution Mechanism and Water Quality Improvement Countermeasures

(1) Classification

The "apparent run-off ratio of pollution load" which controls the pollution of a river largely depends on the extent of the sewage treatment at each pollution source and the improved and maintained conditions of sewerage-related facilities. Since the actual condition of sewer treatment at each pollution source has not been checked, the planned sections of the 4 rivers can be divided into the following 5 types on the basis of the improved and maintained conditions of sewerage-related facilities:

Type A1

The section which is provided with a separated sewage system and sewage is surely separated from rain water and, at the same time, interceptive collection of sewage is perfect. Therefore, significant pollution of the river water does not take place in this section except tentative pollution caused by the first flush at the time of a freshet. The section between Stations 4 and 2 along Yangjae Chong belongs to this type.

Type A2

The section which is provided with a separated sewage system and where the river water is polluted by sewage which always flows into the river due to sewer pipes misconnected to storm sewers. The section between Stations 2 and 1 along Yangjae Chong belongs to this type.

Type B

The section where sewage is collected nearly completely through intercepting sewers, but the sewage overflows weirs and tentatively pollutes the river water at the time of a freshet, because the section is provided with a combined sewerage system. In addition, it may happen in this type of section that the sludge discharged onto the river bed at the time of a freshet contributes to the pollution of the river water. The upstream section of Station 2 along Ui Chong belongs to this type.

Type C

The Section where intercepting sewers are installed, but the river water is polluted by the sewage which always leaks out to the river from deteriorated or unfaithfully installed sewers. In this type of section, pollution loads are added by overflowing sewage at the time of a freshet. While the leaking mechanism is not clear, the upstream section of Station 3 along Chungroung Chong belongs to this type.

Type D

The section where no intercepting sewer is installed and sewage always flow into river directly, causing the pollution of the river water. The upstream section of Station 6 along Anyang Chong belongs to this type. The upstream section of the Yoi

Chong which is a tributary of Yangjae Chong also belongs to this type, but the water quality is improved during course of the flowing down of water along the river, because the quantity of the generated pollutant load is small, since the basin is discharged to a development restricted area, and the self-purification capacity of the river is high.

Type E

The section which has lost its original function of a river, because the entire length is completely covered to a covered sewer conduit. This type does not exist in the section to be planned, but Hwakohu Chong, Kwao Chong, and Daedong Chong which are tributaries of Ui Chong, Ryangkohu Chong which is a tributary of Chungroung Chong, etc., belong to this type. The mixture of river water and sewage flowing through such a covered conduit does not pollute the water of the main course under fine water, since the mixture is collected into an intercepting sewer immediately before the mixture joins the water of the main course.

(2) Water quality improving measure by types

Type A1

It is necessary to clean the surface of roads and inside of storm sewers when the water discharged from the storm sewers gives significant influences to the river water at the time of a freshet. In addition, when the river bed is gentle in gradient, the river bed must be dredged as occasion demands, because the sludge discharged at the time of a freshet may deposit on the river bed and produces a bad smell and river water pollution.

Type A2

The basic measure is to correct the misconnection between a sewer pipe and storm sewer. Such misconnection can be distinguished when the storm sewer is observed at the time of fine weather, but it is not easy to accurately detect misconnected point. In addition, the capacity of the sewer pipe may become insufficient when misconnection of the sewer pipe is corrected. When the correction of misconnection cannot be done due to such reasons, a water quality improving facility must be installed to the river channel or the sewage from the storm sewer must be discharged to the outside through a water quality preserving channel.

Type B

The measure to be taken against Type B section includes the disposal of overflowing water which is the disadvantage of the combined sewer system. While various methods are proposed to the disposal of the overflowing water, it is necessary to study the necessity of a measure against the overflowing water after making clear the influence of the first flush to the pollution of the relevant river. Table 3.5-6 shows the list of measures which are currently considered as useful for the first flush in general.

Type C

The basic measure is to repair a deteriorated or unfaithfully installed intercepting sewer, but, since the detection of the defective part of such sewer and definition of the leaking quantity of the sewage from the defective part require a large amount of man-hour, a water quality purifying facility can be installed to the river as an emergency measure.

Type D

The basic measure against this type of section depends on the kind and distribution of pollution sources in the basin. Namely, improvement of sewerage is preferential to the urban district and sewage disposal by septic tanks installed to each house or each block composed of several houses is preferential to the agricultural district and development restricted area. When the measure against the pollution source takes time, installation of a water quality purifying facility to the river can be considered.

Type E

In the case of a river, the water quality of which is extremely

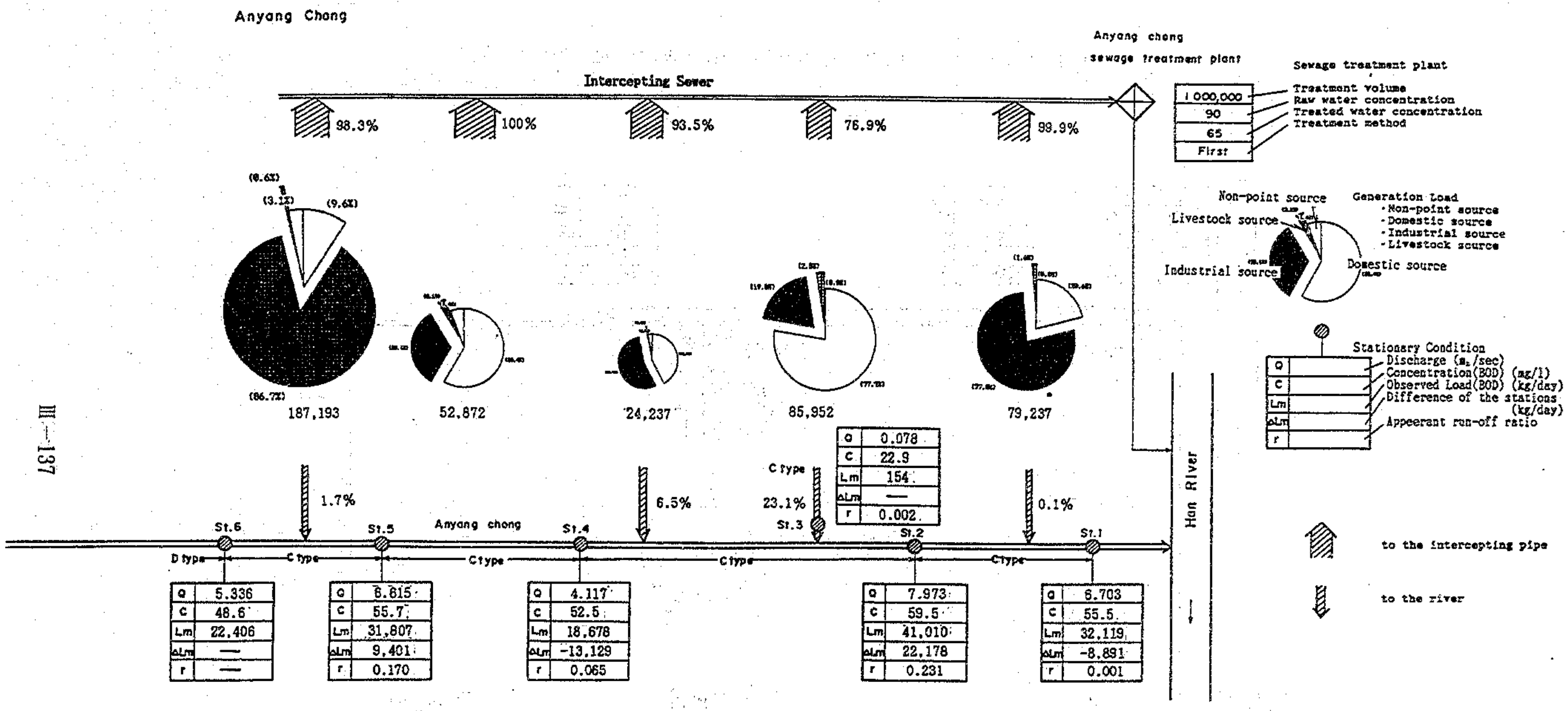


Fig. 3.5-5 Pollutant Migration in the Project Area of Anyang Chong

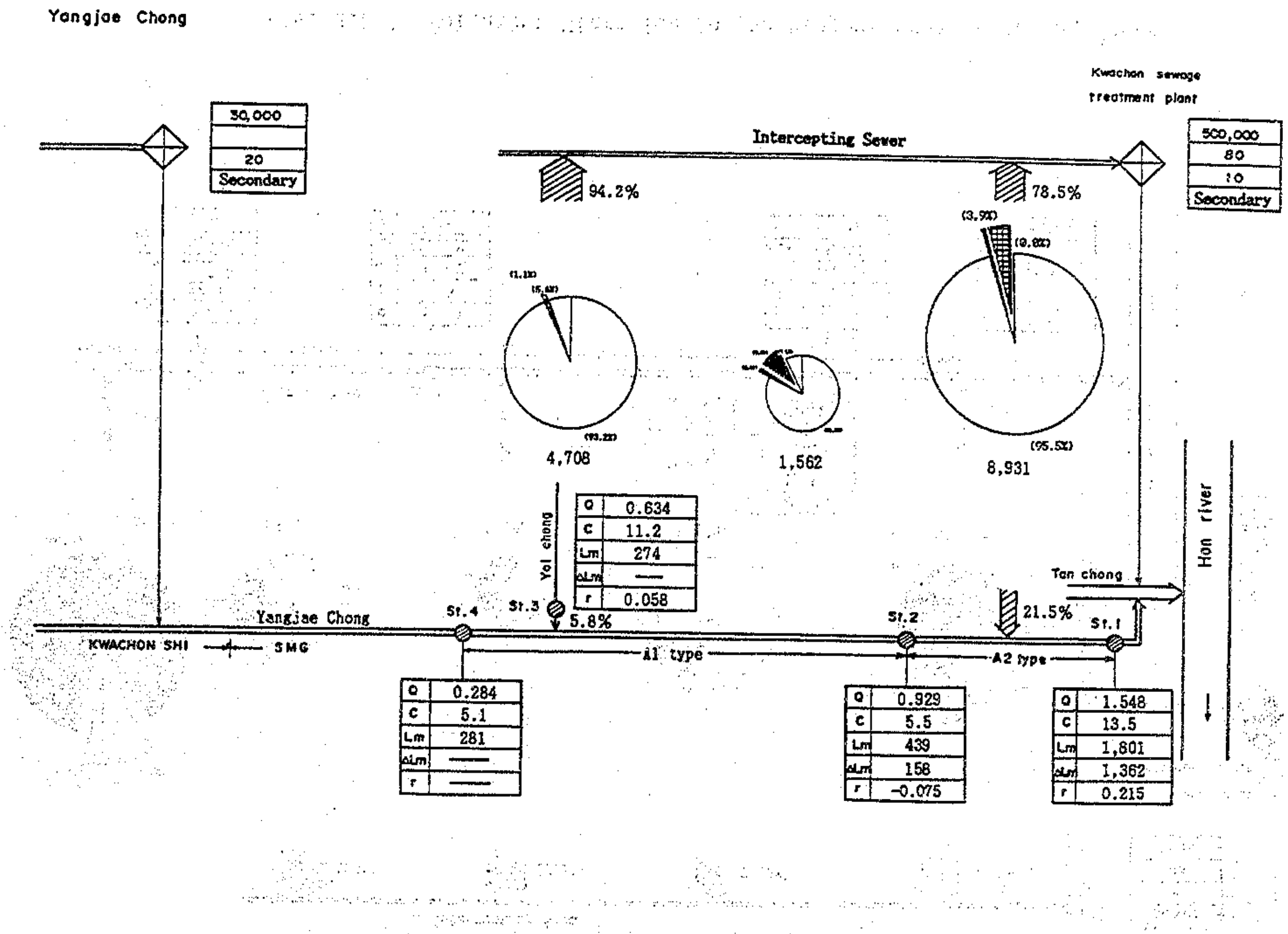


Fig. 3.5-6 Pollutant Migration in the Project Area of Yangjae Chong

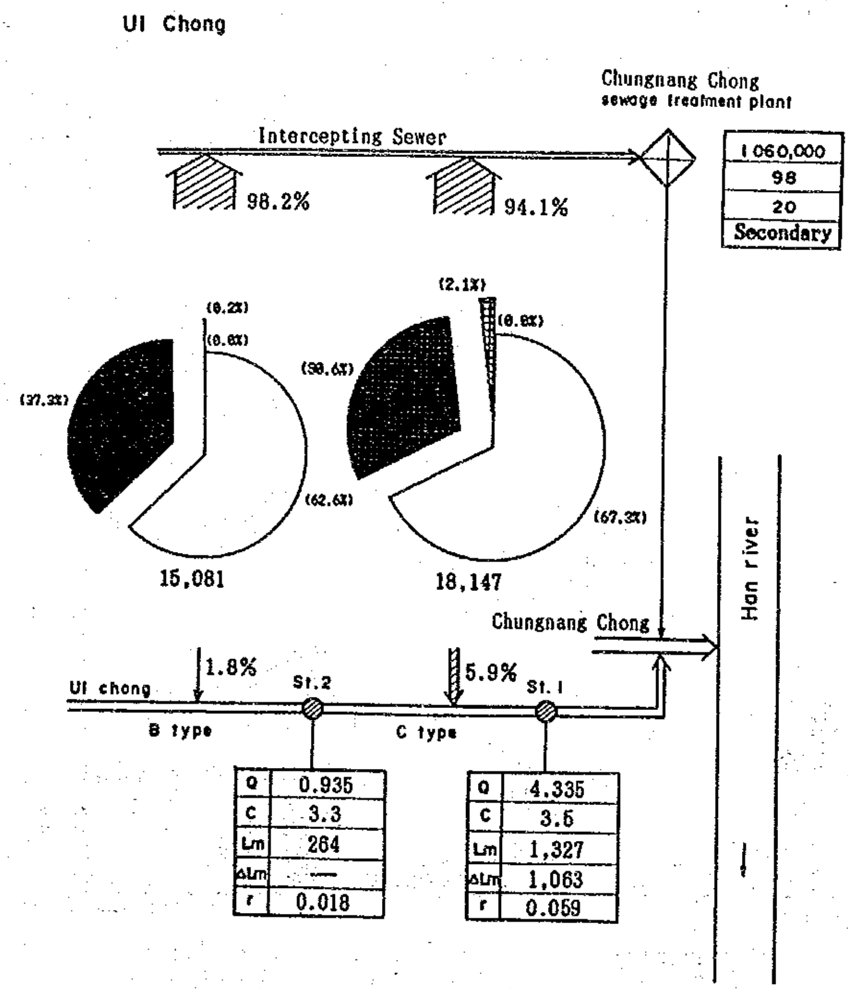


Fig. 3.5-7 Pollutant Migration in the Project Area of Ui Chong

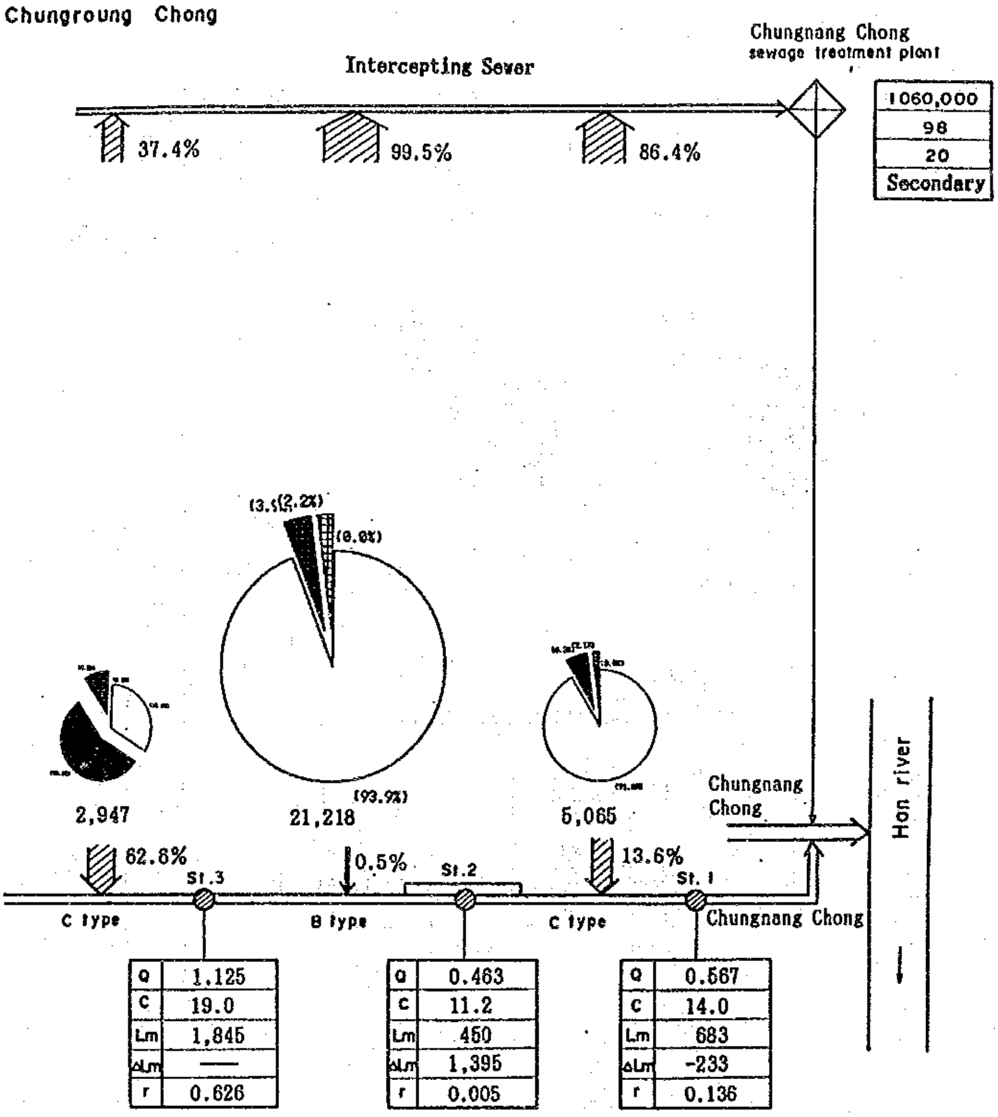


Fig. 3.5-8 Pollutant Migration in the Project Area of Chungroung Chong

polluted, the bad smell caused by the water can be prevented by covering the river, but a riverside space which is important to urban district disappears when the river is covered as possible, so as to make provisions against the demand of inhabitants for a better living environment which may arise among them when their living level rises.
As described above, the pollution mechanisms in the Study Area can be classified by the sewerage system and the condition of interceptive collection.

However, the countermeasures on the water quality improvement in this Study are specified as these matters applying in the river channel zone, therefore, discussion and planning mentioned in Chapters 6 to 9 will not cover the measures to the all of the problems. In near future, when detailed investigations will be performed, the improvement and rehabilitation measures will be discussed on this kind of classification.

Table 3.5-6 Countermeasure to Overflowing Water from the Combined Sewer System

Improvement of existing interceptive sewer	Increase of the capacity
	Raising of overflowing weir
	Covering of open interceptive sewer
Improvement of water leakage	Rehabilitation of old pipeline
	Improvement of connection method
Alternatives of sewerage system	Adopting of a separate sewage system
Restraint of peak	Storage in the pipeline
	Rain water storage pond
	Storage pond on site
	Infiltration box
	Infiltrative pavement material
Reduce of pollution load in overflowing water	Land use regulation
	Cleaning of a pipeline
	Cleaning of man-hole
	Improvement of pipeline installed by wrong sloping

3.6 River Space Characteristics

3.6.1 Classification of River Space

In order to make a river space improvement plan, it is necessary to recognize the characteristics of the planning section .Therefore, each section to be planned is divided into several areas including the hinterland on the basis of the present environmental conditions described in Sections 3.1 to 3.4 above.

The divided results are shown in Figs. 3.6-1 to 3.6-4. The characteristics of each divided area of the 4 rivers are summarized below including the ideal way of improving parks and green zones.

(1) Anyang Chong

Area A

This area is constituted mainly of farmland with scattered cattle sheds, factories, and houses. Since it is expected that high-story apartment-house complexes will be constructed in this area, improvement of parks and green zones will be necessary accordingly.

Area B

Construction of high-story apartment-house complexes is in progress in this area. Since it is expected that the population will grow and the park and green zone improvement rates will drops after the completion of such complexes, space improvement is desirable for the sake of the new inhabitants.

Area C

This area is constituted mainly of mountains and forests with scatters schools and factories. It is desirable to make space improvement in future in connection with the existing neighborhood park adjacent to riverbeds.

Area D

In this area, the construction of Mokudong high-story apartment-house complex is almost completed and the development mode is being changed to a limited scale. The area of park per head reaches the average level of the Seoul Metropolitan area, but green zone must be increased in future, because the area and ratio of green zones are below the average levels of the metropolitan area.

Area E

This area corresponds to Kuro Industrial Zone and the percentage of factory workers to the permanent population is 10% or more, which is the highest in the Seoul Metropolitan area. Improvement of parks and green zones is extremely insufficient, because the area of parks per head is less than the 50% of the average value of the Seoul Metropolitan area and the area and ratio of green zones are about 70 to 80%. It is desirable to improve parks in future by considering the use of parks by factory workers.

Area F

This area is also a factory district adjacent to Kuro Industrial Zone and is lowest in the area of parks and area and ratio of green zones in the Seoul Metropolitan area. It is desirable to improve parks and green zone in future by placing emphasis on the quantitative guarantee.

(2) Yangjae Chong

Area A

This area is included in a development restricted area and the richest in nature in the Seoul Metropolitan area. Such recreation facilities as Seoul Great Park, Horse Riding Park, etc., are provided in the neighborhood. While the population density is the lowest in the Seoul Metropolitan area, the population growth rate of this area shows a high increase. It is desirable to make improvement in future in connection with existing parks and green zones by utilizing the rich nature in the peripheral area.

Area B

This area represents a dense residential district with high-story apartment-house complexes built on both left and right bank sides. The area of parks per head exceeds the average value of the Seoul Metropolitan area, but it is desirable to improve more parks by taking the population growth expected in future into account.

Area C

This area is located at the junction of Yangjae Chong and Tan Chong and the riverside land is suitable for breeding wild birds and insects and growing hygrophytes. Therefore, such an improvement that can preserve and create an environment habitable to plants and animals living on water's edge is desirable.

(3) Ui Chong

Area A

This area is adjacent to Pukansan Park and has become a base for mountain type leisure.

Area B

This area has small houses built at a high density and a population density of 300 persons/ha or higher.

Area C

This area is low in population density and has excellent spectacles of mountains and forests on both left and right bank sides. Since the construction of apartment-house complexes is expected in this area, it is desirable to improve parks by utilizing the excellent spectacles.

Area D

This area correspond to part of the old urban district and has a high population density, but the population is decreasing due to the trend of getting decreased in population seen at the heart of Seoul metropolitan.

(4) Chungroung Chong

Area A

This area corresponds to part of the old urban district and has a high population density, but the population is decreasing due to the trend of getting decreased in population seen at the heart of Seoul Metropolitan. A neighborhood park is provided adjacent to the right bank and the spectacle of this area is mainly obtained from forests.

Area B

This area is the highest in population density in the Seoul Metropolitan area, but the population itself shows a decreasing trend. The spectacle is monotone, because low-story small-sized houses are densely built. Semauru Activity is active in this area and a stable community is formed.

3.6.2 Zoning and Selection of Model Site

In order to utilize the river space for the recreation purposes, it is necessary to grasp the citizen's demand and its applicability by surveying the natural condition, the social condition and the site condition around the river.

In this study, the river space utilization demand was evaluated by [1] the population in hinterland, [2] population flactuation and [3] park improvement condition, and the applicability was evaluated by [1] the accessibility to the river, [2] the natural environmental preservation condition and [3] the width of the major beds. As a result of these, the river space was classified into five zones, referring to Supporting Report V.

The model sites of the river space improvement projects were selected among the sites highly evaluated in the above-said survey, considering the location of the bridge, the land use condition and etc.

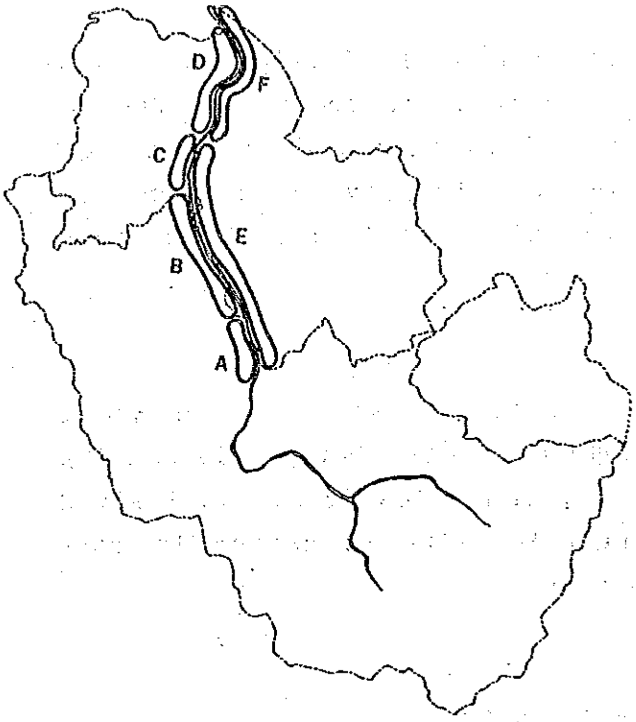


Fig. 3.6-1 River Space Division along Anyang Chong

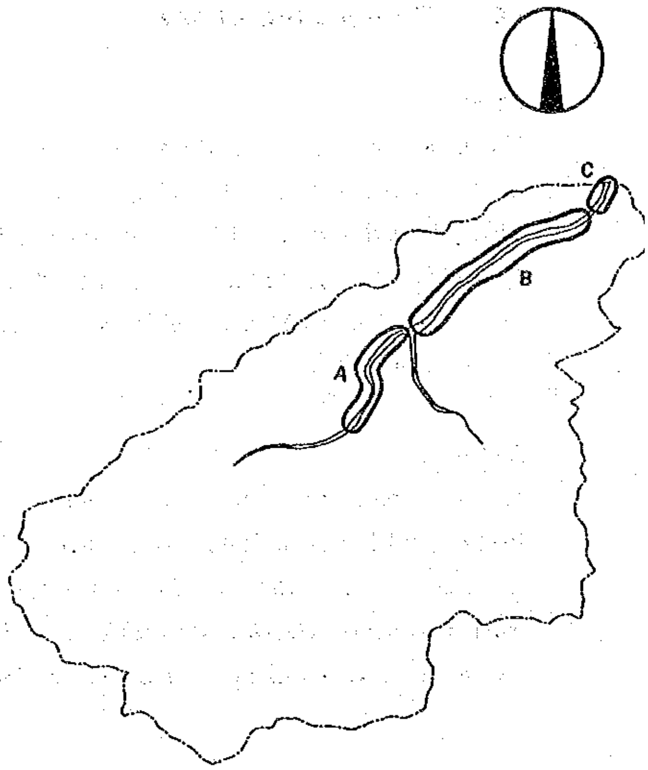


Fig. 3.6-2 River Space Division along Yangjae Chong

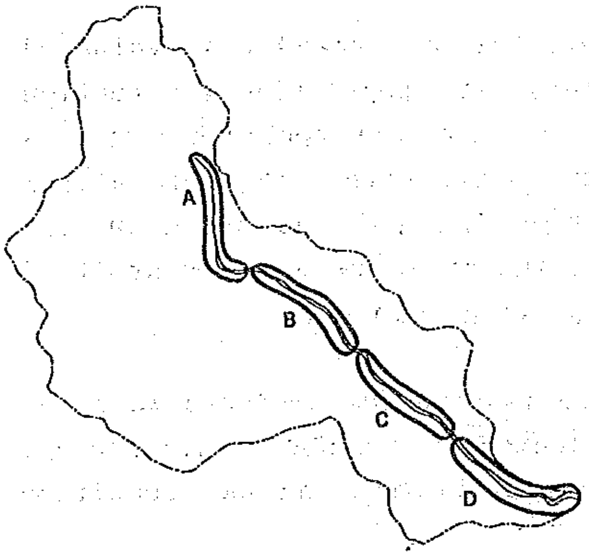


Fig. 3.6-3 River Space Division along Ui Chong

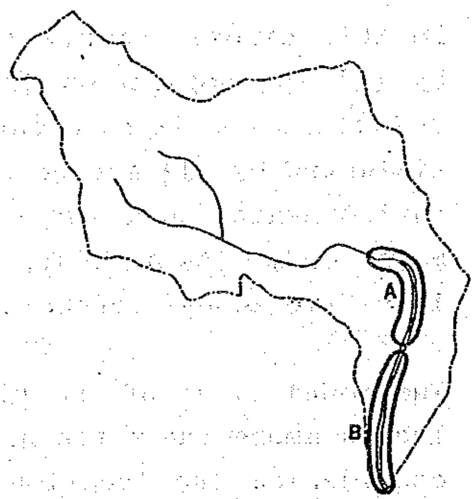


Fig. 3.6-4 River Space Division along Chungroung Chong

Chapter 4

Chapter 4. Approach and Strategy of the River Environment Improvement Plan

A water quality and flow duration improving plan and space improvement plan must be prepared to each river on the basis of the present condition of each river environment described above, but, before making these plans, it is necessary the [1] target years and target levels (environmental target) of these plans, [2] needs of inhabitants to be reflected in the plans, [3] desirable future water quality of each river which becomes the base of each water quality purifying facility, [4] kinds and applicable conditions of environment improving techniques, [5] premises and restricting conditions from other works, etc., which may come into conflict with the proposed river environment improvement works. Since the setting methods of these conditions are common to the four rivers, the methods are collectively described in this chapter.

4.1 Approach of the River Environment Improvement Plan

4.1.1 Approach of the Water Quality and Flow Regime Improvement Plan

On the water quality and flow regime plan, first of all, it is required to study why water quality problems and flow decrease were occurred, then estimate apparent run-off based on the generation load (described in Chapter 3).

On the other hand, the standard of water quality and maintenance flow are determined as administrative targets based on the existing condition and water quality environmental standard committed by the Ministry of Environment. Then, required discharge and pollutant load to be reduced in order to pass the target will be discussed.

After that, the technologies to improve river water quality and flow regime will be reviewed and some of them will be assigned as adaptable one to the project implementation. From this, the water quality in the future will be predicted by future generation load and apparent run-off ratio. Installation points, functions and scales of the required facilities will be planned in order to satisfy target.

Above mentioned procedure is shown in Fig. 4.1-1.

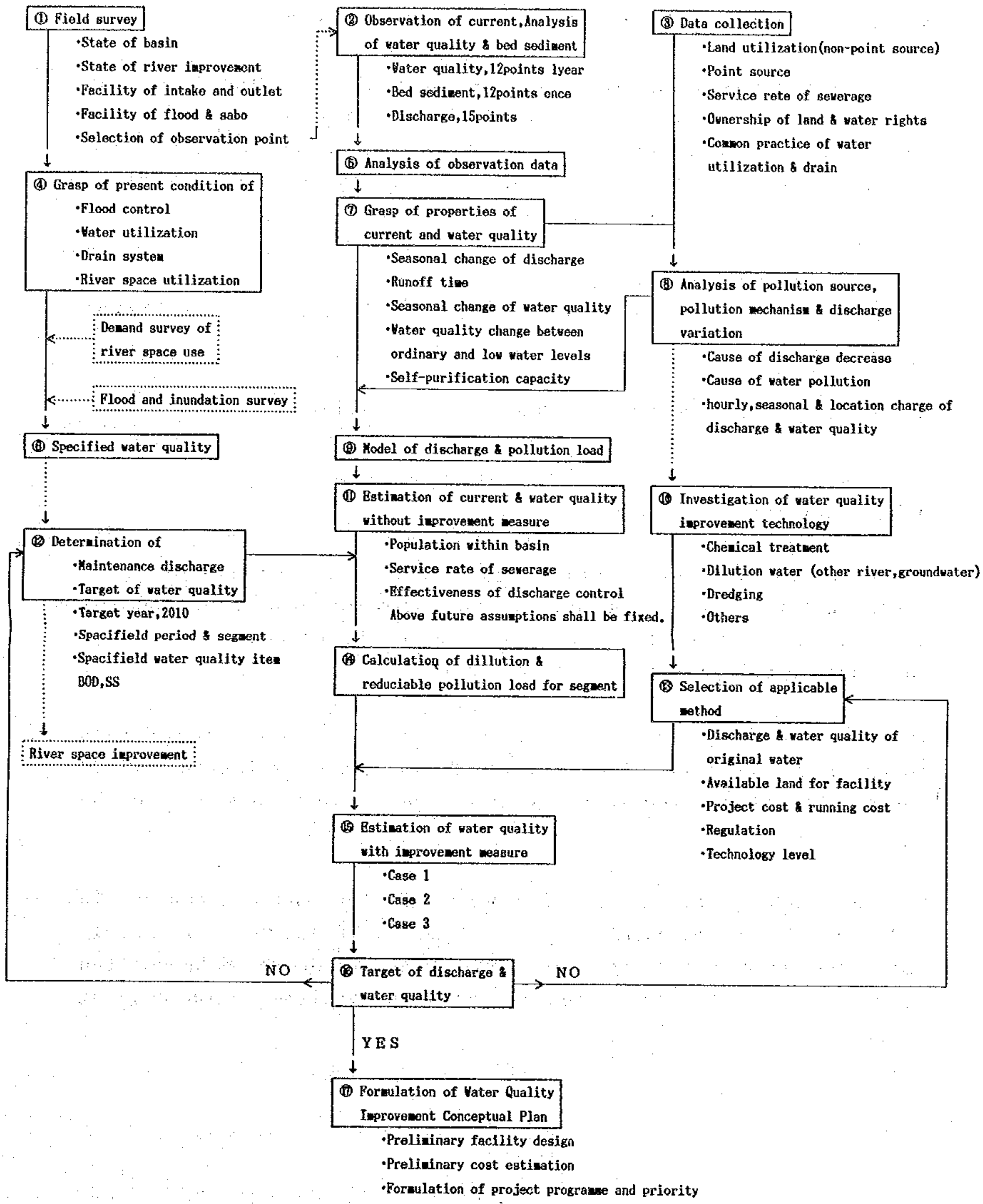


Fig. 4.1-1 Planning Order for Water Quality and Flow Regime Improvement

4.1.2 Approach of the River Space Improvement Plan

In the river space improvement plan, present condition like land use, social accommodation, etc. of the planned sections will be investigated (described in Chapter 3), and interview survey and questionnairing will be performed to recognize needs of the citizens and the basic policy will be determined.

In next, zoning and selection of the model site will be performed in the planned section, and concrete utilization style will be discussed.

Above mentioned procedure is shown in Fig. 4.1-2.

4.2 Target Year

The proposed river environment improvement plan consists of (a) a basic concept which formulates a long term over-all plan and (b) a concrete working plan, based on the basic concept, for works that should be immediately implemented.

The period of time required to accomplish the various improvement works in a wide area with relative accuracy is estimated at 20 years. Therefore, the target year of the basic plan shall be the year 2010.

On the other hand, the 10-year working plan shall commence in 1992 and its target year shall be 2002. This target year nearly coincided with the Long Term Basic Plan of Seoul Metropolitan formulated in 1981, since the latter sets its completion year at in 2001.

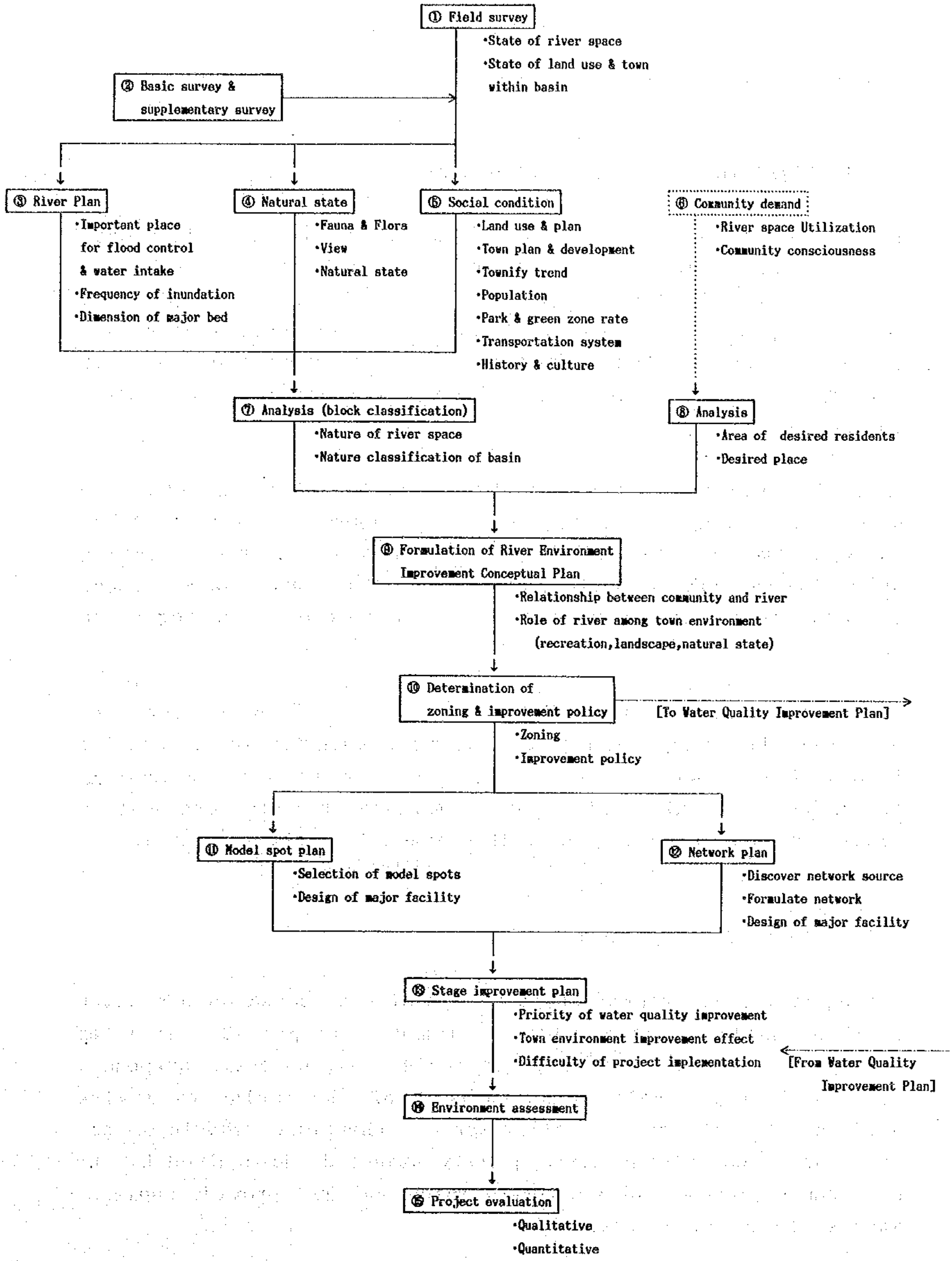


Fig. 4.1-2 Planning Order for River Space Improvement

4.3 Environmental Target

4.3.1 Significance of the Environmental Target

In order to promote an environment improvement work, it is necessary to set a target and to investigate and execute target is usually called environmental standard, the standard are not necessarily set on the basis of scientific information only, but on administrative judgment also after studying the level of pollution preventive techniques, economical feasibility, social influences, etc.

While ROK government has set environmental criterion levels to water areas in ROK as described in 2.5.1 above, the set levels do not mean that the health of residents will be injured or living of residents will be suffered when the levels are not attained, but are set as "the maximum desirable levels for securing sound environments."

Since environmental standard which have been set with such purpose will be changed after a sufficient quantity of scientific information is accumulated or a pollution preventive technology or the living level of citizens is improved, the standard must be updated always in accordance with changes in various conditions.

4.3.2 Water Quality Target

The water quality target shall be established based on how water shall be used. As previously mentioned in Chapter 3, the water of the 4 rivers is not used for irrigation, domestic purposes, etc., and they merely exist as part of the residents living environment. The water quality target, therefore, should be set in Class V, one of the water quality standards determined by the Environment Bureau and a category which does not provide unpleasantness to the environment.

However, a higher water quality level will be required to restore the function of the rivers which makes the residents to become intimate with the river water and to actively utilize the functions of the river as aimed by this plan.

Such functions include (a) water and a green space which give people peace of mind, (b) a recreational place which provides people with fishing, dabbling in water, riverside walking, etc., (c) a place which protects a rich ecosystem including underwater and waterside livings, and (d) a spectacle which adds an accent to the urbanized view of inorganic structures. When protection of fishes is to be taken into account, therefore, it is desirable to set the water quality target at Class III which is the water quality standard for fishery Class 2. When dabbling in water is to be taken into account, the water quality target must be set at Class II which is the criterion for swimming areas.

The water quality standard of Anyang Chong was categorized by the Environment Bureau under Class V. The water quality standard of the other 3 rivers was not determined because they are Class C rivers. However, the water quality standard of Tan Chong which is joined by Yangjae Chong belongs to Class II, and that of Chungryang Chong which is joined by Ui Chong and Chungroung Chong belongs to Class III. Consequently, the water quality targets for Yangjae Chong, Ui Chong and Chungroung Chong shall be class II, III and III, respectively. These water quality targets, however, shall be reviewed if they prove to be technologically and economically difficult to achieve.

Fig. 4.3-1 shows a relation between water quality (BOD) and livings or water area utilization for a reference.

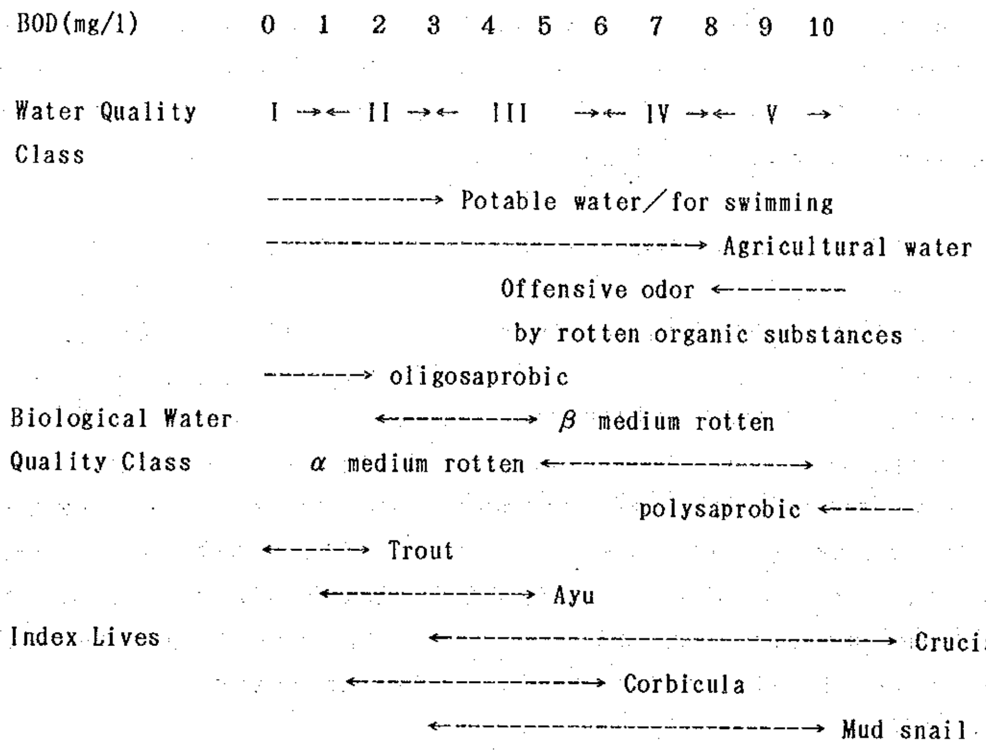


Fig. 4.3-1 Relation between Water Quality (BOD) and Livings or Water Area Utilization

4.3.3 River Flow Target

There are 2 flows which are necessary in order to maintain the normal functions of the river. These are the reserved flow and utilized flow. There is no need to conduct a study on utilized flow since the water of the 4 rivers are rarely used. Instead, it is necessary to discuss the reserved flow. The reserved flow is the one which is decided to be confirmed even in the dry season by collectively considering (a) transportation by ships, (b) fishery, (c) spectacles, (d) prevention of salinity problems, (e) river-mouth closing, (f) protection of river maintenance facilities, (g) maintenance of ground water, (h) protection of animals and plants, (i) keeping flowing water clean, etc.