<'84 世界河川博覽會 水資源 심포지움> —發表文—

A Comprehensive Planning for the Lower Han River Development in Korea

Yong-Nam Yoon*

Ⅰ. Introduction

The Korean Peninsula extends southward from the mainland of North-east Asia between 40 and 330 north latitude, and 124 and 131 east longitude. It separates the Yellow Sea from the Eastern Sea, i.e. Sea of Japan. The total area of the Peninsula is 221,000 square kilometers including 3,300 islands. The Republic of Korea consists of about 44% of the total, or 98,430 square kilometers lying south of the DMZ line, which is roughly at the 38th parallel.

As shown in Fig. 1, the Han River Basin lies in the northern part of the Republic and extends across the DMZ into North Korea. It has a length of 469km and a total area of 26,600km² or slightly more than one-fourth of all of the Republic. The total population within the basin amounts to approximately 13 millions, 35 percent of the total population, and gross national products takes 40 percent of the nation.

The Han River runs through the capital city of Seoul near its mouth, which has been grown up as one of the most populous international cities of the world and as the center of political, economic, cultural and social activities of the nation. With the rapid urbanization and industrialization of the city during the past two decades the deterioration of the natural evironment has become a serious problem to be solved.

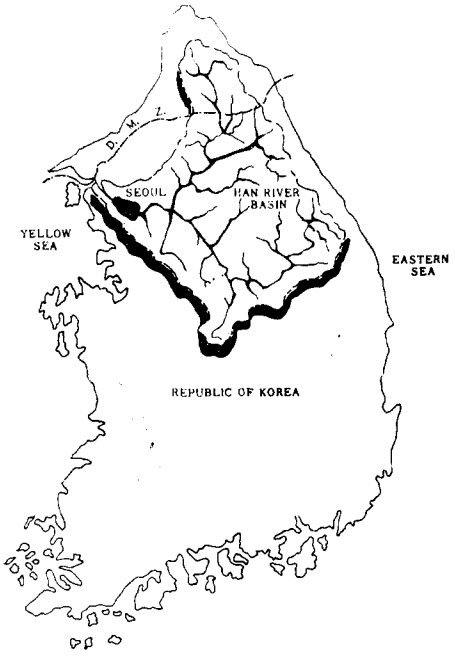

Fig. 1 Location Map of the Project area in the Han River Basin

The polution of Han River reach within the boundary of the City of Seoul was no exception as was faced in most big cities during their industrialization process. The water quality has already been beyond the acceptable standards for domestic water supply due to the sewages and industrial wastes so that the intakes had to be moved far upstream to the Paldang Dam, the last exsisting dam on the Han. The unregulated excavation of construction materials, mostly concrete aggregates, from the river bed to cope with the fast development of the City accelerated the local aggravation and degradation due to frequent floods during the Summer rainy season, which severely destroyed the scenic beauty of the River within the City boundary.

To remedy these problems with the lower reach of the Han the City of Seoul made a plan for action which is being presently under construction. The main objective of "the Comprehensive Planning for the Lower Han River Development" is to restore the clear and beautiful Old Han River at the City of Seoul as it has been along with the long history of the City. The plan

* Ph.D. Department of Civil Engineering College of Engineering Korea University

also has an extra meaning to the City of Seoul which hosts the '86 Asian Game and '88 Seoul Olympic.

The total project consists of four subprojects which are eventually to be coordinated in one; namely, the realignment and stabilization of low flow channels; the orderly formation of flood plains and its maximum utilization as public spaces for parks, sports and recreation; the expansion of existing river-side highway from four to eight lanes for the betterment of East-West heavy traffic along the River; and finally, the construction of sewage treatment facilities including the interceptors for sewerage diversion which will greatly improve the water quality of the River.

In this paper, the basic development plans for the river improvement project, i.e. the reformation of low flow channels and flood plains, will be introduced in detail with the basic concept of development schemes in the hydrological and hydraulic point of view. The presentation will be very brief on the subprojects of flood-plain land use, highway expansion, and the sewage disposal system. The environmental and ecological effects upon implementation of the present project will also be evaluated, and the measures to remedy the probable impacts will be proposal.

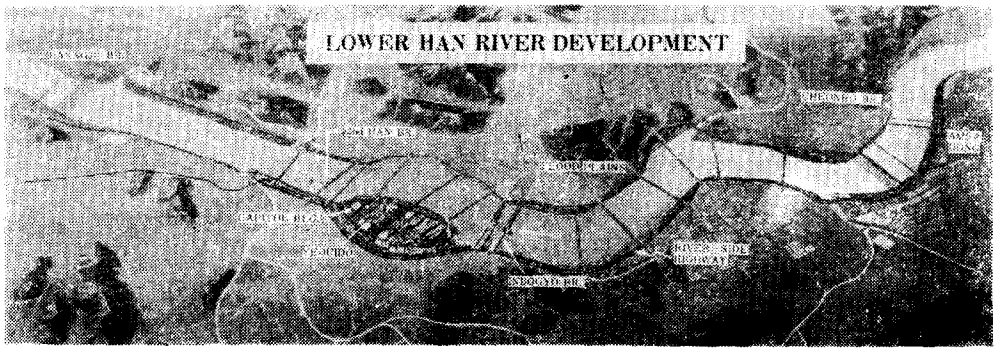

Fig. 2 Project Reach for Lower Han River Development

II. Project Plan and Design

The project reach extends approximately 36 kilometers starting from Amsa-Dong to Haengju Grand Bridge as shown in Fig. 2, which is within the City limit. For the reformation of low flow channel the existing river channel will be so arranged to have the widths of 600-1,175m and the average depths of 2.75m. The plan for the formation of flood plains is to utilize the total area of approximately 694 ha within the river banks for public spaces such as 89 approach roads, 7 athletic parks, recreation spaces of 83 ha, green spaces of 386 ha, parking facilities of 13 ha, and walk-roads of 74km. The expansion plan of existing river-side highway includes new construction and expansion of highways running 26km from the Cheonho Grand Bridge near the upper end of the project reach to the 2nd Han River Bridge near the Capitol building, as well as 11 interchanges and bycicle roads of approximately 100km.

Ⅱ-1 Reformation of Low Flow Channels and Flood Plains

In planning the low flow channel reformation both engineering and economic aspects of the project were thoroughly taken into account. Based on the hydrologic and hydraulic studies the general layout and dimensions of the low flow channels were determined in such as way that it could guarantee not only the stability but also the safety of the channel under the condition of low or high flows. In addition, considerations were also given to the maximum utilization of withinbank spaces and aggregates resources made available with the project implemented.

Based on the hydrologic analysis of the river flows at the key station, Indogyo, within the project reach the design discharges for the low flow and the flood were estimated assuming three different conditions;

Table 1. Design Discharges at Indogyo Station

Frequency	Without Dams (Natural Cond.)	With 6 Dams	With 6 Dams +Chungju Dam
Normal* Discharge	24.5	125.0	200.0
Floods**			
T=0.6	5,400	5,300	5,000
T=1.5	12,500	11,600	10,500
T=50	32,500	31,300	25,000
T=100	36,000	34,500	28,000
T=200	39,200	37,000	30,000

*; Discharge for river maintenance (95% Probability of Exceedance)
**; T=Return period of flood in years

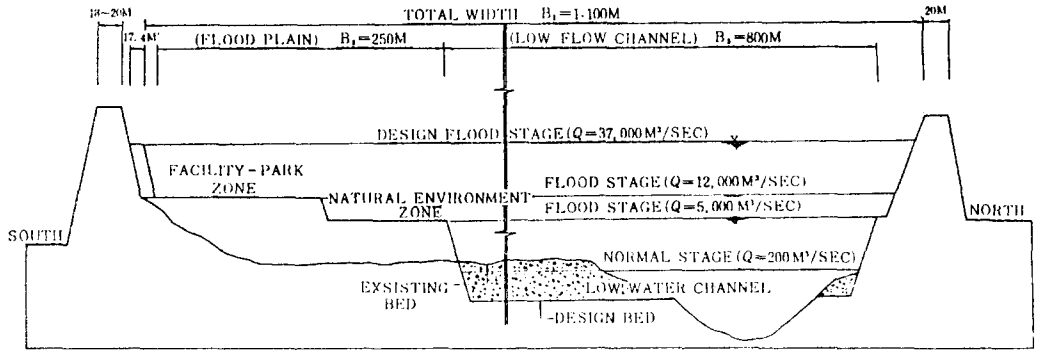

Fig. 3 Typical Shape of Design Cross Sections

i.e. without storage dams, with existing six dams (Hwacheon, Soyang, Chuncheon, Uiam, Cheongpyung, Paldang), and with six dams plus Chungju dam on south Han River which is expected to be completed in '85. The design discharges so determined are listed in Table-1, from which the effect of dams on the river maintenance flow and flood flows is evident.

1. Cross Section Shape

Due to the unbalanced rainfalls throughout a year the river flow of the Han greatly varies in its magnitude from season to season which enforces the river channel to have a composite cross-section shape. Hence, composite cross sections were designed for low flows and the flood flows as shown in Fig. 3. Since the existing river channel is of composite cross-section shape throughout the reach such design can assure a minimum earth work and a maximum utilization of the existing flood plain areas. The river bed variation can also be confined within the low flow channel, which would help the channel stabilization. Moreover, since the design discharge is so determined to flow full in the low flow channel the scenic beauty as well as the navigation and water-related recreation will be greatly improved.

2. Design Discharges for Flood Plains

As mentioned previously the establishment of flood plain area is aimed at fully utilizing the open river space during low flow periods. As was shown in Fig. 3 the areas are divided in two zones, i.e. facility-

park zone and natural environment zone. The design elevation of these two zones of flood plains was determined with due consideration to the present elevation of flood plains, the flood stages of varying magnitudes and the character of flood plain development. The design flood discharges for the facility-park zone and the natural environment zone were estimated as 12,000 and 5,000 m^3/sec, respectively. At these discharges under the present condition the facility-park zone is expected to be inundated once in two years and the natural environment zone six times in a year. However, upon the completion of Chungju multip-urpose dam on South Han River in 1985, the frequency of flood plain inundation will surely decrease and hence public utilization will be greatly improved.

3. Design River Bed profile

The present river bed is apparently in an unstable condition due partly to the artificial excavating of aggregates for long time and to the traping of sediment loads by the upstream Paldang dam. Hence, the channel bed profile was designed for the river bed to approach the dynamic equibrium in such a way that local sediment supply balances the sediment deposition. For the step-by-step computation of design bed profiles empirical formulas for average river bed elevation proposed by Aki and Nononobe were used with due consideration to the hydraulic conditons within the reach as well as upstream and downstream. The so-determined equilibrium design bed profile with its thalweg is shown in Fig. 4 and compared with

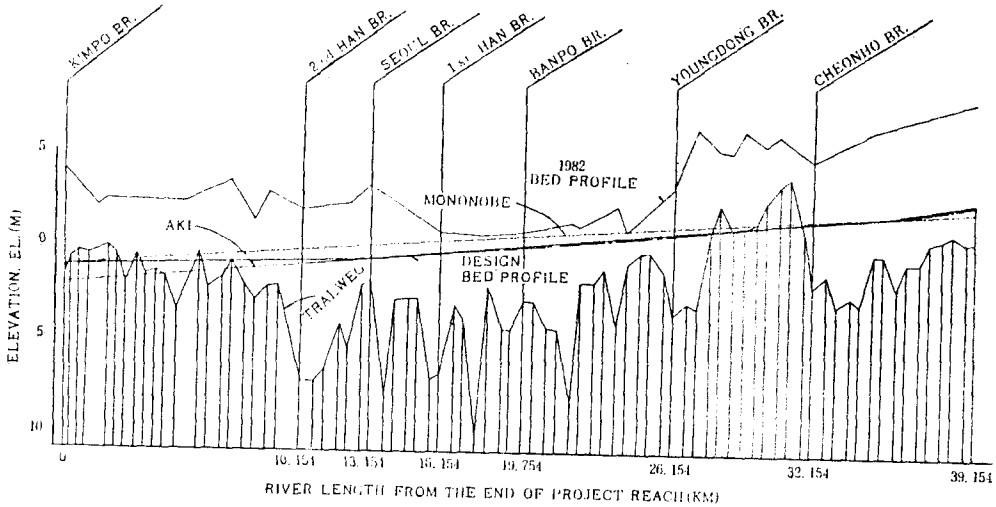

Fig. 4 Comparison of Design River Bed Profile with that for 1982.

Table 2. Design Bed Elevations of Key Stations

Station	Design Bed EL. (m)	1982 Bed EL. (m)	EL. Difference (m)	Design Bed Slope
Kimpo Br.	−1.20	3.81	5.01	1/28,150
2nd Han Br.	−0.85	1.97	2.82	
Seoul Br.	−0.74	3.24	3.98	
1st Han Br.	−0.45	0.81	1.26	1/8,524
Banpo Br.	−0.02	0.86	0.88	
Youngdong Br.	0.77	3.10	2.33	
Cheonho Br.	1.49	4.73	3.24	

the observed 1982 average river bed profile. The channel bed elevations at key sections along the reach are also compared with those observed in 1982 in Table 2. As can be seen in Fig. 4 and Table 2 the design bed elevations are lower than those in 1982 by 0.88~5.01m. The volume of river bed material corresponding to this difference in bed elevations is the very river resources to be removed for concrete aggregates.

4. Design Channel Width

The widths of low flow channel were basically determined by design low flow discharge of 200m³/sec. Considerations were also given to the natural characteristics of the channel, balanced development of flood plains, channel alignments, construction costs, and to the results obtained in the hydraulic model tests of Lower Han during 1970~1977.

Table 3 shows the design width of the low flow channel along with the total river width at selected stations in the project reach.

Table 3. Design Width of Low Flow Channel

Station	Design Width (m)	Total Width (m)
Kimpo Br.	900	1,130
2nd Han Br.	900	1,180
Seoul Br.	1,175	1,370
1st Han Br.	860	1,150
Banpo Br.	800	1,122
Youngdong Br.	600	890
Cheonho Br.	760	960

As can be seen in Table 3 the design Width of low channel ranges 600~1,175m with the average of 930m.

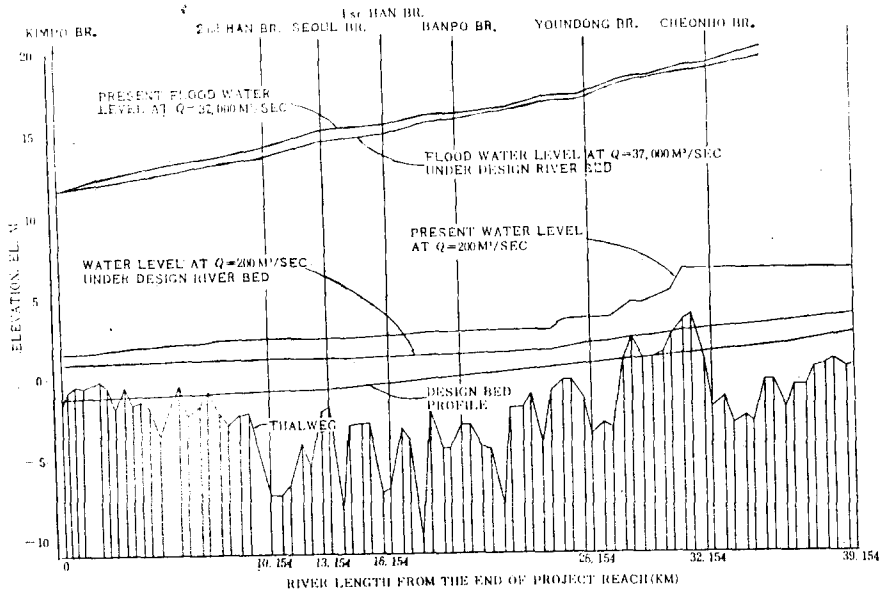

Fig. 5 Comparison of Water Levels Under Present and Design Conditions

5. Water Surface Profiles

With the low flow and flood plain sections determined as described so far complete design cross sections were defined at 81 sections along the reach. The water surface profiles were computed for the various design discharges by the commonly used standard step method, the backwater effect due to 18 bridges within the reach being taken card of by D'Aubuission formula. Fig. 5 shows the computed backwater curves under the design conditions for the normal discharge of 200m³/sec, and the design flood of 37,000 m³/sec at Indogyo station and compared with those under present channel conditions. As can be seen in Fig. 5 the design water surface profile for low flow with project considerably drops compared with that under present condition, whereas the difference in water surface elevation for design flood is insignificant.

If the water surface profile in the low flow channel drops as in Fig. 5 a series of problems will occur. Firstly, 8 public and 24 private water supply intakes with drawing water from the project reach would not function due to the drawdown of river water surface. The salt water intrusion would severely threat the domestic and industrial water supply for the City of Seoul as well as irrigation wate supply for the farmlands along the lower part of the project reach. Moreover, structural damage due to land snbsidence caused by a severe drawdown of ground water table are also adverse effects to be anticipated.

6. Maintenance of Low Flow Stages

The only way to remedy these problems would be to artificially raise the low water level caused by the project up to approximately same level under present condition. Hence, submerged weirs were planned for construction at two locations in the reach; i.e. one at the nearby section downstream of Jamsil Grand Bridge (Jamsil submerged weir) and the other at the section slightly upstream of Kimpo Bridge (Kimpo submerged weir) as shown in Fig. 6.

The crest elevations required for maintaining the present low water levels upstream were determined as EL. 6.20m for Jamsil submerged weir, and EL. 2.20m for for Kimpo weir, respectively. The weirs are of concrete gravity type as shown in Fig.7 with a movable weir consisted of a number of roller gates, a navigation lock and a fishway The general features of the two submerged weirs are listed in Table 3. A series of hydraulic model tests are planned in order to investigate the performance of submerged weirs under the design conditions.

With these two submerged weirs at their proposed locations backwater computations were made for the various design discharges, i.e. 200, 5,000, 12,000, and 37,000 cubic meters per second. The results are

Fig. 6 Location of Submerged Weirs

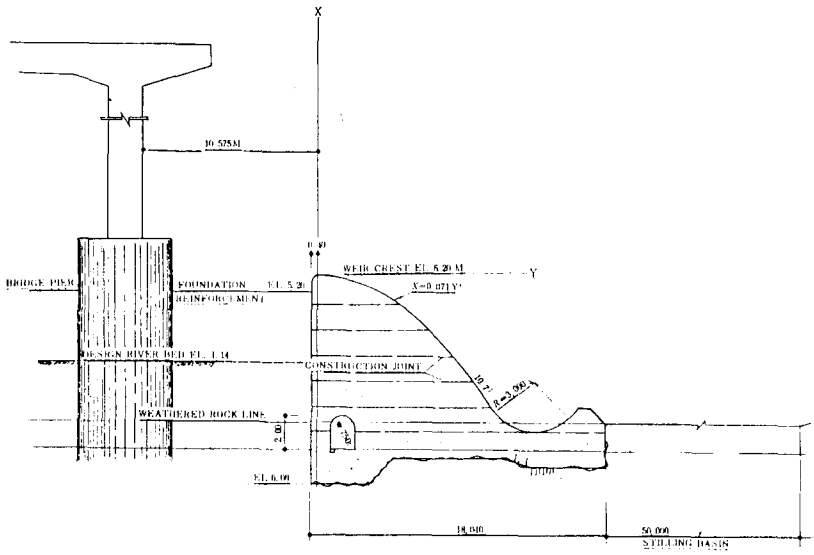

Fig. 7 Typical Cross-Section of Submerged Weirs

Table 4. General Features of Submerged Weirs

Features	Jamsil Weir	Kimpo Weir
Total length (m)	1,185	750
Movable weir (m)	200	200
Navigation lock (m)	18	18
Fishway (m)	20	20
Crest EL. (m)	6.20	2.20
No. of gates	5	5

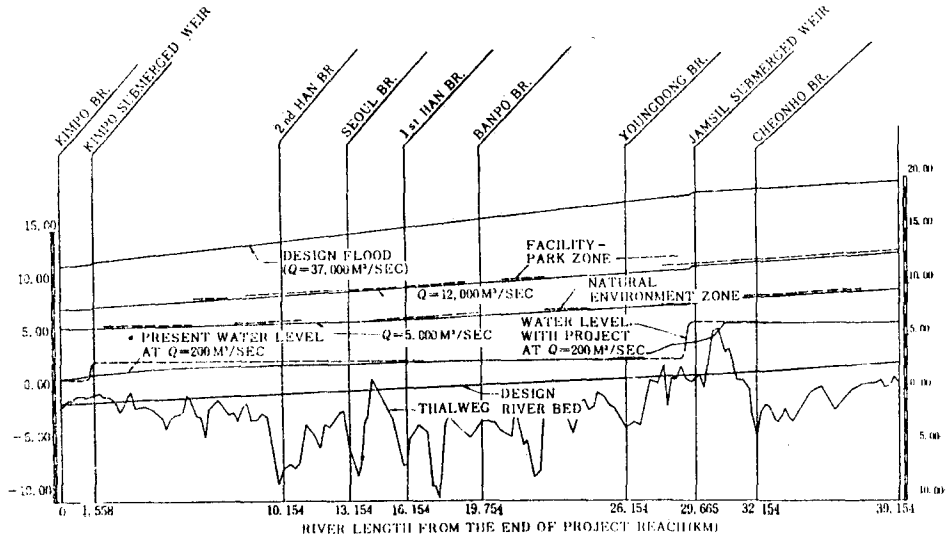

Fig. 8 Backwater Profiles with the Submerged Weirs

shown in Fig. 8. The computed water surface profiles for 5,000 and 12,000 cubic meters per second are in a good agreement with the general site elevations of the natural environment zone and the facility-park zone, respectively. The backwater curve for normal discharge of 200 cubic meters per second also approximates fairly well the present normal water levels along the project reach. This assures no danger for the adverse effects which might occur due to the present project.

7. Related River Works

Besides the reformation of existing river channel, that is, the excavation of low flow channel and the grading of flood plains, other major related river works include placing of revetments on the channel slope, reinforcement of bridge piers, and stabilizing measures for the confluence of tributaries discharging in the project reach in addition to the submerged weirs just mentioned.

Revetments have mostly been used in river improvement projects particularly to protect the river banks against flood water. However, the purpose of placins revetments in the present project is set not only for the channel stabilization but also for environmental and ecological improvement. Therefore, a combination of different types of revetments are designed depending on the elevation of the river bank from the design river bed. Schematic drawings of two typical revetment layouts are shown in Fig. 9.

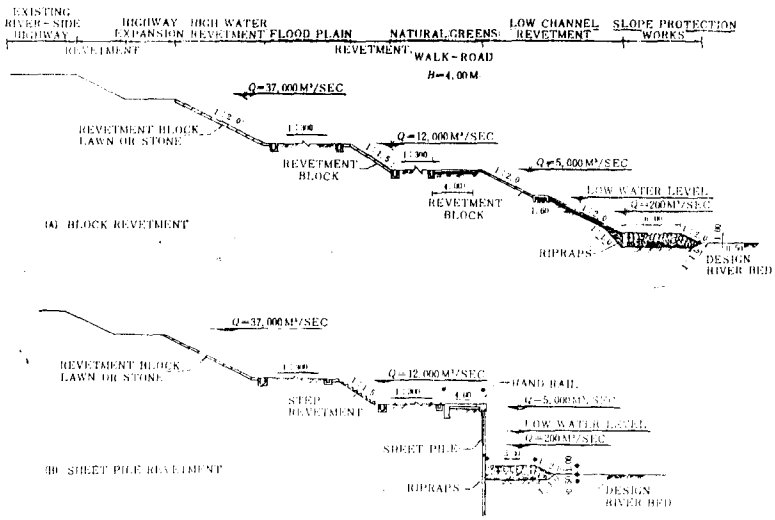

Fig 9. Typical Cross Sections of Revetments

Since the mean elevation of low flow channel bed is to be lowered considerably by excavation, some structural problems might arise at the foundation of bridge piers. Hence, the safety of 18 bridges in the reach has been examined and judgement was made to properly reinforce the foundation of piers of five bridges; namely, 2nd Han, Han River Railway, 3rd Han, Jamsil, and Cheonho bridges.

Due to the substantial lowering of the low flow channel bed, the bed elevation difference of the main channel and tributary confluence becomes 1.30~5.78 meters at the confluences of 8 tributaries coming in the reach. To maintain the stable outlet of the tributaries a drop-structure of concrete gravity type with stilling basin has been proposed at the confluence of each tributaries.

Ⅱ-2. Paln for Flood Plain Use

Maximum use of flood plains formed within the reach is one of the most important objectives of the

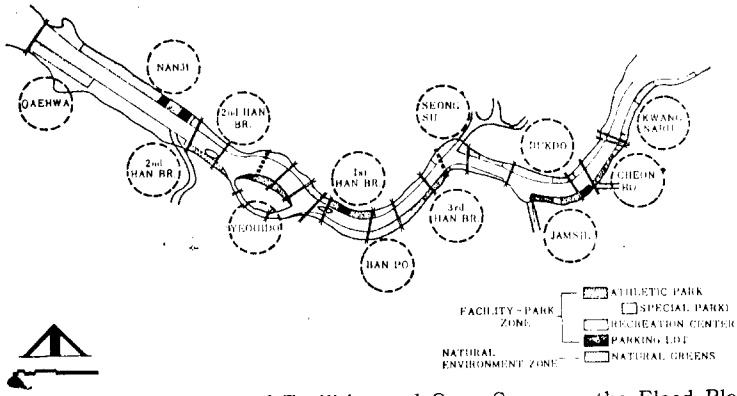

Fig. 10 General Layouts of Facilities and Open Space on the Flood Plains

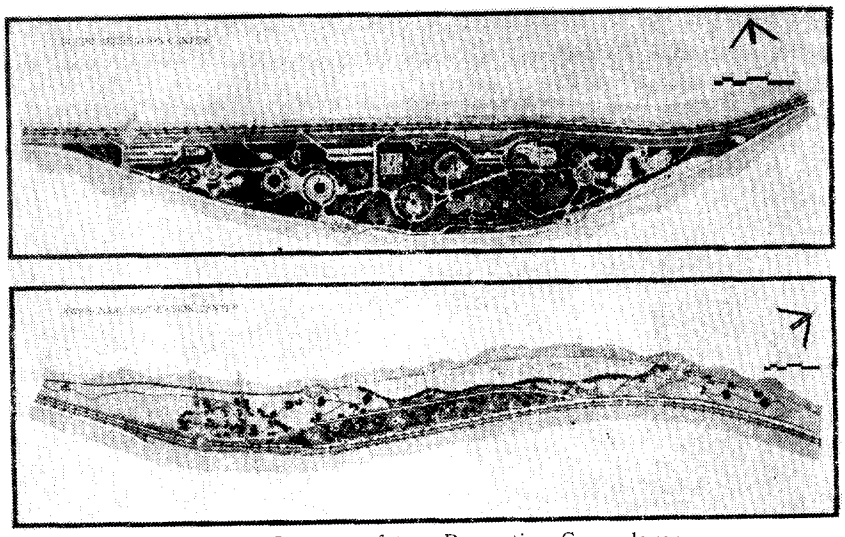

Fig. 11 Layouts of two Recreation Compplexes

project. The flood plains are designed to function as the open spaces for public health, leisure activities, recreation, and as the natural environment for the citizens residing in Seoul. As previously mentioned the open spaces to be built on flood plains are divided into either facility-park zone or natural environment zone, the former corresponding to the general ground elevations subject to the design discharge of 12,000 m^3/sec and the latter to 5,000m^3/sec. The facility-park zone will function as the space where people spend their leisure time enjoying various sports or recreations. Hence, it includes 7 athletic parks, 2 recreation complexes, and one large-scale parking lot. Whereas, the natural environment zone is designed as the space for the conservation of the nature, and hence it will be covered mostly by various pastures with walk-roads. Thirteen of those spaces will be located on both sides of the project reach. Fig.10 shows the location of regional centers and the general layout of the facility-park and natural environment zone along the reach. Artist's view of two recreation complexes are also shown in Fig.11.

Ⅱ-3. Expansion of River-Side Highways

A comprehensive forecast of the traffic flows through the Southern river-side highway up to the target year of 1991 was made by zoning the metropolitan area into 189 zones with due consideration to the pop-

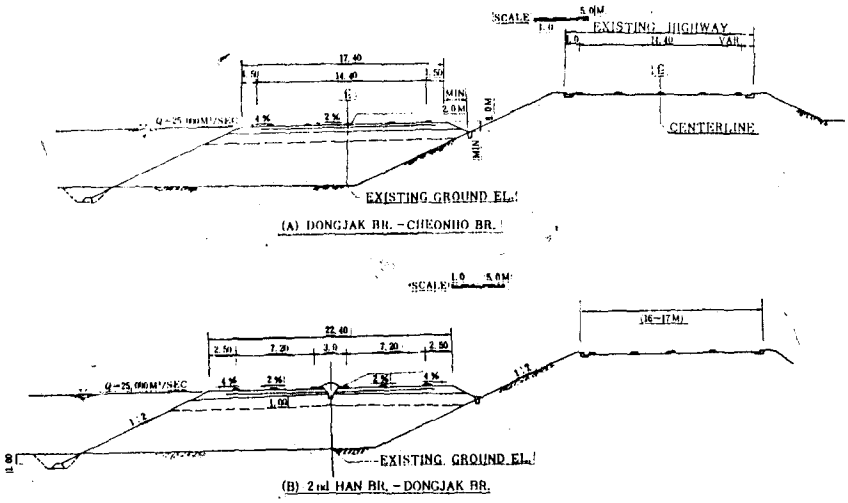

Fig. 12 Stanard Cross sections of Highway Expansions

ulation, economic activity, land-use pattern and so forth. The traffic load of 2,500 vehicles per hour was predicted as the design criteria. To meet this requirement four to three more lanes were judged to be built in order to meet the traffic demand up to 1991. Hence, four more lanes for the 2nd Han Bridge-Dongjak Bridge were decided to be provided and three more for the Dongjak-Cheonho Bridge, for which the standard cross sections are shown in Fig. 12. The general surface elevation of the highway to to built is set to the water surface elevation corresponding to the 50-year flood of 25,000m³/sec. Along the line of highway to be expanded there will be located six complete multi-level interchanges and five partial multi-level interchanges, one of which is shown in Fig. 12.

Ⅱ-4. Plan for Sewage Treatment Facilities

Before the comprehensive development plan for the lower Han River was formulated the City of Seoul already had a separate project going for the improvement of river water quality by collecting and treating domestic sewages and industrial wastes at selected stations and discharging back into the main Han River.

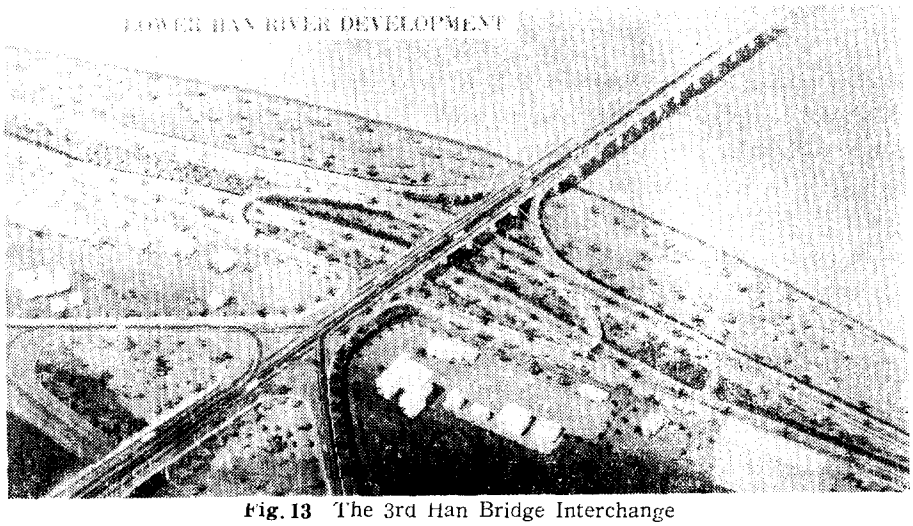

Fig. 13 The 3rd Han Bridge Interchange

This project is simply incorporated into the present project and is being executed in time with other subprojects. The project consists of the construction of five sewage treatment plants with sewage interceptors near the downstream end of major tributaries coming in the main Han, i.e. Jungryang-Cheon, Cheonggye-Cheon, Anyang-Cheon and Nanji-Do. Each plant is designed to take care of the drainage sector for sewages which is formed by dividing the whole City into five zones according to the volume of daily sewages. So-selected five sewage treatment plants with the interceptors collecting sewages from each zone are shown in Fig. 13 with their respective capacities. The sewage disposal from the facilies to be located on the flood plain areas is also incorporated into the sewage interceptor lines which are under construction below the newly-built flood plains.

Ⅲ. Evaluation of Environmental Effects

The possible environmental effects upon implementation of the present project are on the hydraulic characteristics of the river channel, water quality, ecology of water-born living-things, noise level, and scenic views. Each of these effects is briefly reviewed in the followings.

Ⅲ-1. Hydraulic Characteristics

Due to the extensive excavation of river bed materials the water levels at normal discharge of 200m³/sec were shown to drop considerably, which will certainly cause various adverse effects as mentioned previously. Hence, submerged weirs are planned at two locations to raise up the water levels approximately as the present stages. The hydraulic characteristics of river channel with or without submergedweirs are compared with those under present conditions in Table 5.

Table 5. Hydraulic Characteristics of River Channels (at 200m³/sec)

Characteristics	Present Condition	Without Submerged weirs	With Submerged weirs
Average width (m)	619	845	883
Average depth (m)	2.8	2.1	3.2
Average velocity (cm/sec)	10.9	11.1	7.0
Water surface area (ha)	2,108	2,875	3,005

As can be seen in Table 5, the average velocity at the low flow of 200m³/sec decreases from 10.9cm/sec to 7.0cm/sec due to the channel improvement works. This might increase the deposition of sediments and colloidal materials which impair the quality of water. However, since the present project is supported by a separate project for improving the water quality as mentioned previously the effect of velocity decrease in the reach would not be a serious problem. On the other hand the increase of water surface area from 2,108ha to 3,005ha will improve the reaeration capability of river water and this will contribute to improving the water quality in the project reach.

Ⅲ-2. Water Quality

upon the completion of the comprehensive development project for Lower Han River the quality of river water will substantially be improved by virtue of the sewage treatment plants with collecting interceptors. The present sewage treatment capaity of 0.36million tons/day will be increased to 2.96million tons/day

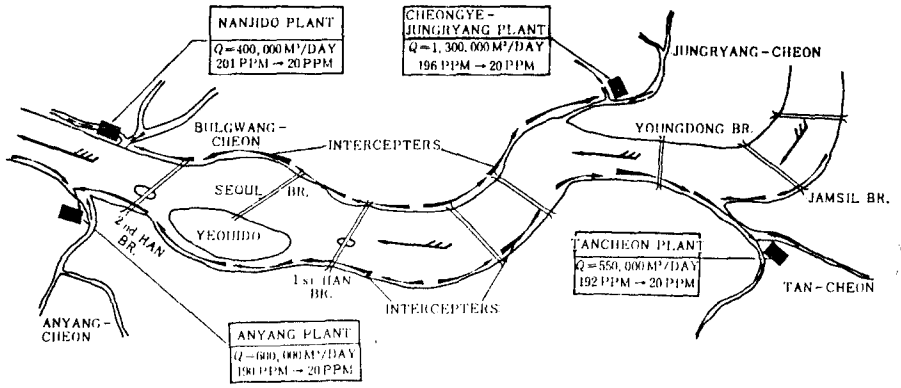

Fig. 14 Location of Sewage Treament Plants with intercepters (Campacity up to the Year 1989)

and the BOD discharges of 268 tons/day will be reduced to 66 tons/day by the diversion interceptors. Fig. 14 shows the BOD levels at the water supply intakes along the project reach after the completion of the project in comparison with the present BOD levels. It is clearly seen that the BOD levels subtantially drop after the implementation of the project.

Ⅲ-3. Ecological Effects

In spite the abundant planktons living within the present river reach the number and type of fish species have been decreased in recent years, the very reason being the pollution of river water. With the improved water quality to be attained through the project it is expected that more fish can live within the project reach. The birds living in the lower Han can be classified as the landbased and the water-based. The land-based birds mainly live on the flood plain, and they will not be affected much due to the present project. Whereas, the water-based birds are likely to be affected due to the removal of sand spits and deltas in the process of channel improvement works. If this is the case some provisions for birds dwellings seem necessary.

Ⅲ-4. Noise Level

It is expected that the increase in traffic volume and speed after the exqansion of river-side highways will certainly increase the noise level in the vicinity of the highway. In the case of river-side apartments the noise level at the first floor is expected to increase from the present 62.3~72.6 db to 65.8~77.1 db and that at fifteenth flood from 69.1~74.0 db to 72.2~79.1db. The present noise level is already beyond the environmental standard and hence some sort of measures for noise level reduction will have to be employed, for instance, barrier walls or plant-belts against the automobile noises.

Ⅲ-5. Scenic Views and Recreation

The small pools and chuter scattered on the present flood plain areas in the reach are the places where river weeds grow and harmful insects inhabit. Through the formation of orderly flood plains these pools and chutes will be replaced by green spaces, facilities, parks, or recreation centers, which will be beloved places to be visited by the citizens of the City of Seoul.

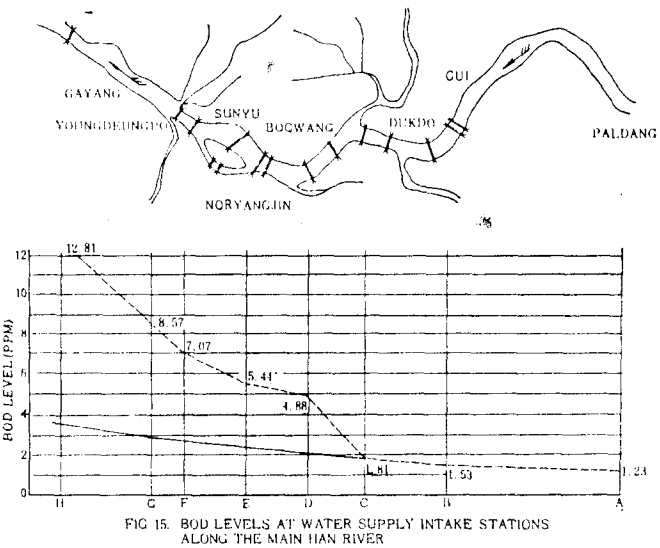

FIG 15. BOD LEVELS AT WATER SUPPLY INTAKE STATIONS ALONG THE MAIN HAN RIVER

Fig. 15 BOD Levels at Water supply Intake Stations Along the Main Han River

Ⅳ. Conclusion

The comprehensive planning for the Lower Han River development is essentially to improve the deserted environments around the river, and to actively develope the open spaces and facilities for the health and welfare of the people living in Soul. Tne subprojects consisting of the comprehensive plan are believed to drastically improve the general environments surrounding the urban river; the channel improvement project will greatly improve the scenic beauty and leisure activities around the river, the improvements in water quality and within-river environments will be a great help for the betterment of river ecology, and the expansion of river-side highways will also provide comforts and safety to travelers. Of course, the adverse effects expected to incur due to the present project remain to be minimized, but the overal advantages and improvements overwhelm the disadvantages.

With this gigantic projected expected to be completed by the end of 1985 future efforts shall have to be continuously given to maintain the essense of the project in good shapes after the implementation of the project.