A N N E X H

M & I WATER SUPPLY

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H 1 INTRODUCTION

This ANNEX presents a study on the municipal and industrial (M&I) water requirements to be supplied from the three studied river basin's water resources.

These requirements were estimated for the purpose of each basin's water balance analysis and determination of the proposed dam schemes' water supply capacities and benefits.

In making the analysis, necessary data were gathered through the relevant ministries of the Government of Korea and by provincial and municipal offices through field survey. Some foreign statistics were also referred to for the study such as Japanese industrial statistics. Major references and data sources are listed in the last page of the text of this ANNEX.

H 2 PRESENT CONDITIONS OF M&I WATER SUPPLY

H 2.1 M&I Water Supply in Korea

H 2.1.1 Municipal water supply

Municipal water (M-water) supply in Korea has been rapidly improved in these several years. In 1976, 3.9 x 10^6 m^3/d of water was served through municipal water supply system to 17.9 x 10^6 people. That means a half of the total national population was served by municipal water supply system with 220 litre per capita per day (lpcd) (Table H 1). Comparing with 1971, water supply has increased by 15.0 % annually. Pipe-served population has increased by 6.3 million during those five-year period.

The pipe-water supply is concentrated in urban area. In 1976, 87 % of the pipe-served population is gathered in cities with the population of more than 100,000. In terms of supply volume, more than a half of the total supply is concentrated in Seoul in 1976.

H 2.1.2 Industrial water supply

In parallel with the rapid expansion of economy of Korea, industrial water (I-water) supply has increased rapidly in these several years. At the end of 1974, supply capacity of industrial water amounted to 747,200 m^3/d in total in 15 industrial estates (Table H 2) (Ref. H 1). The major of these are (in order): Ulsan (with capacity of 170,000 m^3/d), Seoul (110,000 m^3/d), Suweon/Anyang (100,000 m^3/d), Pohang (100,000 m^3/d) and Masan/Jinhae (85,000 m^3/d).

At present, there exists dual administration of industrial water supply in Korea. Of the above 15 industrial water supply systems, those of Pohang, Ulsan, Masan/Jinhae, Yeocheon and Suweon/Anyang are under the direct control by MOC. While the others are administrated by local municipalities. In the Fourth Five-Year Plan, the unification under the government control is considered to increase the effective utilization of existing facilities.

The supply capacity in 1975 is reported to be 844,000 m^3/d (Ref. H 2). According to the above Plan, it is expected to increase to 1.9×10^6 m^3/d by the end of 1981.

H 2.2 M&I Water Supply in the Three Basins

H 2.2.1 Municipal water supply

Details of municipal water supply in the three basins in 1971 and 1976 are shown in Tables H 3 to H 8. As of August 1978, statistics are available up to 1976. Adding some existing expansion plans, current municipal water supply in each basin in described hereunder.

(1) The Han basin

Within the basin in 1976, 26 municipalities including Seoul and Incheon were supplied with pipe-water by pumping the Han river water, while outside the basin one urban city, Suweon, received its supply partly from the Han. Population served by pipe-water supply from the Han has increased from 6.1×10^6 in 1971 to 8.7×10^6 in 1976 while the total population of the corresponding area has increased from 10.4×10^6 to 12.0×10^6 in the same period.

Municipal water supply volume for the Han depending area has been doubled during the five years of 1971-1976 from 1.2×10^6 m^3/d to 2.4×10^6 m^3/d, which corresponded to 61 % of the total municipal water supply in the whole nation in 1976. The annual increase was 14 % for the same period. In 1976, Seoul occupied 86 % of the total supply of the area followed by 9 % of Incheon. Adding Suweon and Anyang, these four cities located downstream reaches occupied 96 % of the total municipal water supply volume of the area.

Per capita daily use has increased from 200 lpcd to 277 lpcd as an average in the area during the period of 1971-1976. In Seoul, per capita daily use amounted to 304 lpcd in 1976. Rural pipe water supply occupies less than 1 % of the total supply of the area.

(2) The Nagdong basin

Within the basin in 1976, 35 municipalities including Daegu, Gumi, and Jinju were supplied with pipe-water by pumping the Nagdong water, while outside the basin, three urban cities, i.e. Busan, Masan and Jinhae received their supply either wholly or partly from the Nagdong. Population served by pipe-water supply from the Nagdong has increased from 2.9×10^6 in 1971 to 4.9×10^6 in 1976, while the total population of the area including outside the basin has increased from 7.9×10^6 to 9.1×10^6 in the corresponding years.

Municipal water supply volume for the area has increased during the five years of 1971-1976 from 0.5×10^6 m^3/d to 0.9×10^6 m^3/d which corresponds to 26 % of the total municipal water supply in the whole nation in 1976. The annual increase was 12 % for the same period.

Per capita daily use has increased from 162 lpcd in 1971 to 193 lpcd in 1976 in the average of the area. In Busan, per capita daily use amounted to 233 lpcd and 195 lpcd in Daegu in 1976. Rural municipal water supply occupied 5 % of the total supply of the area in 1976.

(3) The Seomjin basin

Within the basin in 1976, only four municipalities, three eubs and one myeon were supplied with pipe-water by pumping the Seomjin water.

Population served by pipe-water supply from the Seomjin counted only 32,000 in 1976 inside the basin. About 780,000 people depended on self-supply by themselves through either wells, water-vendors or self-transportation of river water. This comes from the rural characteristics of the basin.

While outside the basin, Gwangju received its supply though limited to the amount of 100,000 m^3/d from the Dongbog reservoir

(see H 2.2.3). Since January 1977, Yeocheon industrial estate has been also pumping the surface water at the downstream Seomjin near at Hadong (see H 2.2.3).

H 2.2.2 Industrial water supply

Based on the field survey, the up-to-date data as of August, 1978 on industrial water supply in the three basins were collected as described hereunder.

(1) The Han basin

Industrial water supply facilities separated from municipal water supply are installed in three industrial districts; Seoul (Yeongdeungpo), Suweon/Anyang and Weonju. Each supply capacity is shown below.

Unit: m^3/d

Seoul (Yeongdeungpo)	Suweon/Anyang	Seongnam	Weonju
130,000	100,000	5,000	10,000

As for the other areas than the above, Incheon, Chuncheon, Seongnam and Seoul excluding Yeongdeungpo industrial district are supplied with their industrial water through municipal water pipelines.

(2) The Nagdong basin

Within the basin, two industrial cities, Daegu and Gumi, have industrial water supply facilities separated from municipal water supply. In Daegu, however, most of the industrial water is supplied through municipal water pipeline because of the small capacity of industrial water supply. In Jinju, since no industrial water pipeline is installed, industries supply their water individually by either pumping from the Nam river or using groundwater through wells.

Outside the basin, Masan has its own industrial water supply line which is branched to Jinhae and Changweon as well. Water is

taken at the Bongpori pumping station in the Nagdong lower stretch. In Busan, most of the industrial water is supplied through municipal water pipeline because of the small capacity of industrial water supply line. To Ulsan industrial district, a new industrial water supply line with the maximum supply capacity of 450,000 m^3/d has been installed in November, 1977 (see H 2.2.3). The pipeline to Pohang will be completed by March, 1979 from the Yeongcheon reservoir (see H 2.2.3).

Current (1978) industrial water supply capacity in the area is as shown below.

Unit: m^3/d

Inside basin		Outside basin			
Gumi	Daegu	Masan	Ulsan	Pohang	Busan
50,000	35,000	285,000	450,000	(220,000)	5,000

(3) The Seomjin basin

Within the basin, there is no industry that needs industrial water supply. Outside the basin, however, in the southern coastal area, a chemical industrial complex has been established in Yeocheon district and is supplied from the surface water of the downstream Seomjin (see H 2.2.3).

H 2.2.3 New large scale development projects

In these few years, a number of large scale M&I water supply projects have been completed in the three basins. Furthermore, there are some other Projects that are now under construction or under planning. These projects are indicated in Fig. H 1 by pipeline routes.

(1) The Metropolitan Water Intake Project

At present (1978), a large scale expansion work is being undertaken for the metropolitan zone water supply (Ref. H 4). In the first stage of this plan to be completed by the end of 1978, water supply facilities of 1.2×10^6 m^3/d are to be newly installed.

In the second stage to be completed in 1981, further 1.4 x 10^6 m^3/d capacity will be available.

According to the plan, the Paldang reservoir water will be conveyed through pipelines (54.5 km in total) to the cities of Seoul, Incheon, Bucheon, Suweon, Anyang and Seongnam (Fig. H 1). Banweol, a newly planned industrial town, will be also supplied with water through this pipeline.

The main purposes of the Project lie in substituting the polluted water at existing intakes, ensuring the water supply for industrial use in Suweon/Anyang district and for municipal and industrial use in the newly planned Banweol industrial town.

After completion of the Project in 1981, the water supply through this Project was estimated to amount to 1.9 x 10^6 m^3/d.

(2) Pohang Industrial Water Supply Project

The pipeline to Pohang with the capacity of 220,000 m^3/d will be completed by March, 1979 from the Yeongcheon reservoir located in upper reaches of the Geumho river, one of the major tributaries of the Nagdong (Ref. H 14).

The Project includes the constructions of the Yeongcheon dam (40 m of dam height), reservoir (81.4 x 10^6 m^3 of effective storage), pipeline (30 km in total) and tunnels (6.5 km in total). The Yeongcheon reservoir water will be diverted through the pipeline to the existing Angye reservoir in the Hyeongsan river outside the Nagdong and further conveyed to Pohang district.

The main purpose of the Project is to supply water for industrial use of the Pohang Steel Mill and its associated industries.

(3) Ulsan/Onsan Industrial Water Supply Project

An industrial water supply pipeline to Ulsan/Onsan district has been installed in December, 1979. The maximum supply capacity of the pipeline is 450,000 m^3/d. The Nagdong water is pumped at

the Weondongmyeon intake near Mulgeum and lifted by 84.5 m to the existing Daeam reservoir and further conveyed to Ulsan district. The total length of pipeline and tunnels is 15.2 km and 15.1 km, respectively.

This water supply system aims at meeting the increasing demand of industrial water in Ulsan and its vicinity districts. After the completion of Onsan industrial estate that is now under construction, the pipeline is planned to be extended further to Onsan district. A part of water supplied through this pipeline is purified and used for municipal purpose of Ulsan district.

(4) Masan Water Supply Project

At present (1978), Masan, Jinhae and Changweon are supplied with Nagdong water by pumping at the Bonpori pumping station located on the right bank of the Nagdong main stream. The Bonpori pumping station, after reinforced by 200,000 m^3/d in 1975, has the maximum capacity of 285,000 m^3/d of which 50,000 m^3/d is conveyed to Masan for domestic use, 60,000 m^3/d to a textile factory in Masan, 15,000 m^3/d to the Masan Free Export Zone for industrial use, 40,000 m^3/d to Jinhae and 35,000 m^3/d to Changweon districts for M&I purposes.

A new water supply project is now planned to convey the Nagdong water to Masan (Source K-27) by pumping at the Namji intake on the Nagdong main stream. The supply capacity is planned to be 200,000 m^3/d. The construction is planned to start in 1979 to be completed in 1981. After the completion of this Project, M&I water for Masan including industrial water for a textile factory and for the Free Export Zone will be supplied from the new Namji intake and the Bonpori intake will supply exclusively to Jinhae and Changweon districts.

(5) Namgang Dam Water Supply Project

The southern coastal area outside the Nagdong including cities of Samcheonpo and Chungmu are now supplied with water

from local sources such as surface water of small local rivers and ground water. However, these local sources are found to be insufficient to meet the increasing water demand of this area.

A water supply project to convey water from the existing Namgang reservoir located in the Nam river, one of the main tributaries of the Nagdong, to the above area is now under planning (Ref. H 5). The Namgang reservoir water will be diverted to Sacheon-eub and Samcheonpo city through pipeline which will be branched to Goseong-eub, Georyu-eub, Gwando-eub and further to Chungmu city. The Project aims mainly at domestic water supply, but the industrial purposes of Samcheompo industrial district is also included.

Though the plan is not matured yet, the construction completion is expected by 1981 (Ref. H 5).

(6) Yeocheon/Gwangyang Industrial Water Supply Project

A new industrial water supply pipeline to convey the Seomjin water to Honam Chemical Industrial Estate in Yeocheon has been completed in January 1977.

The Seomjin water pumped at the intake 6.5 km upstream of Hadong is lifted by 68 m to reach Sueo reservoir (22.5×10^6 m^3 of effective storage) located in the upper reaches of the Sueo river, a small local river outside the Seomjin. From the Sueo reservoir, the water is conveyed through pipeline to Honam Chemical Industrial Estate (Ref. H 33).

The total length of the pipeline is about 55.5 km including tunnels of 3.7 km from the intake. The maximum supply capacity is designed to be 300,000 m^3/d, the supply being expected to reach 250,000 m^3/d in 1979.

The pipeline will be branched to Yeosu city in the near future. After the completion of this branch, the current water supply to Yeosu from the Isa river, a small local river outside the Seomjin, is planned to be shifted to Suncheon city.

In the opposite coastal area of Yeocheon across the Gwangyang bay, located is Gwangyang district that is planned to be a heavy chemical industrial estate in the near future. When this industrial estate is established, the above pipeline system will be branched to Gwangyang district to supply its M&I water.

This Sueo pipeline will also supply to Suncheon in the future. Although Suncheon is at present supplied by the Isa and Dong rivers, local rivers outside the Seomjin, when their supply capacity reached maximum, the Sueo pipeline is planned to be branched to Suncheon to meet M&I water demand in Suncheon.

At the future water demand in Yeocheon/Gwangyan industrial district is estimated so large, an alternative measure will be needed in the near future (after the capacity of the existing Sueo pipeline reached its maximum,) to meet the water demand of these southern coastal area outside the Seomjin.

(7) Dongbog Dam Water Supply Project

The Dongbog dam and reservoir in the Seomjin have been constructed in June, 1971 to divert water to Gwangju city outside the Seomjin. The dam (concrete gravity type with the height of 19.3 m) is located in upper reaches of the Dongbog river, one of the main tributaries of the Seomjin. The catchment area is 187 km^2, the effective storage of the reservoir being 2.6 x 10^6 m^3. The main purpose of the Project is to supply M&I water to Gwangju. The maximum capacity of water supply is 100,000 m^3/d.

As the water demand in Gwangju has increased, the construction of another Dongbog dam has been studied (Ref. H 30 and H 31). The new dam is planned to be of the concrete gravity type with the height of 45.5 m. The existing dam is designed to be consolidated as the coffer dam of the new dam. The effective storage of the reservoir is designed to be 91.7 x 10^6 m^3. The new dam will be equipped with a small-scale power station with the installed capacity of 2,750 kW. The water supply to Gwangju is planned to be 350,000 m^3/d.

H 2.2.4 Other information

(1) Water use by purposes

The statistics of whole country on municipal water consumption by purposes were not available. However, the said satistics were available for Seoul and Incheon, which are indicated in Table H 9.

In the case of Seoul, domestic use occupied predominantly as much as 63 % of the total municipal water consumption followed by 21 % of factory and restaurant uses in which factory use were estimated at 15 %. While in case in Incheon, factory use occupied 31 % of the total municipal water consumption followed by the domestic use of 29 %.

(2) Non-adjusted ratio

The data on leakage loss caused by leakage of pipeline or operation loss are not available. Instead the data on non-adjusted ratio that is defined as the ratios of water consumption with no revenue for the water supply bureau to total water production are available for some cities as shown in Table H 10 (Ref. H 4). Although this can only be one of the handhold to know the leakage loss, a high non-adjusted ratio reflects to some extent a high leakage loss. In case of big cities, the non-adjusted ratio is naturally high, because water consumption for social and public purposes such as road cleaning, fountain in a park, government offices and fire fighting uses are not usually accompanied by revenue to the water supply bureau.

As the table indicates, the non-adjusted ratios in Seoul and Incheon are comparatively high. But from the above reason, the actual ratio of leakage loss is estimated rather low deemed to be around a half of the figures. In case of Seongnam, the deteriorated pipeline is pointed out (Ref. H 4) to be one of the causes of high ratio. As a whole, leakage loss seems from the above data to be lowering in these several years.

In Busan, the non-adjusted ratio currently falls in 35 to 45% of which the leakage loss occupies 18 to 22% (Source 23). In Pohang, the leakage loss of 30% was recorded in 1974 (Source 32). In Jinhae, the non-adjusted ratio is currently reported to be 27% of which leakage loss occupies 24% (Source 30).

(3) Water charges

Historical water charges in major cities are tabulated in Table H 11 (Ref. H 3). Water charge varies by municipalities. Since the water charges indicated in the table are those of the average of various kinds of water use comprising domestic use, industrial use and commercial use, etc., they are presented higher than those of domestic use only. Generally, the average water charges can be said centering around 50 ₩/m^3 in 1976. urrent (1977) water charges of treated water in Seoul and Daegu are as shown in Table H 12.

Current (1977) industrial water charges for major industrial water supply are as shown below.

	Suweon/ Anyang	Pohang	Ulsan	Yeocheon	Masan/2	Jinhae/2	Banweol/3
I-water charge (₩/m^3)	12	8	15/1	12	15	15	10

Remarks: /1: raised up to 15 ₩/m^3 from 8 ₩/m^3 in August, 1978

/2: as of August, 1978

/3: under planning stage and 10 ₩/m^3 is for raw water, while 43 ₩/m^3 is expected for treated water.

Source: Ref. H 4 and data collected through field survey.

(4) Sewerage disposal and treatment facilities

Presently sewerage is collected by sewer and/or drained through drainage channels. Efforts has now been made to improve the sewerage disposal and treatment facilities all through the country.

Presently in most cities, newly constructed houses and buildings are obligated under regulations to be equipped with flushing toilets and/or septic tanks. Present conditions and future plan of sewerage and drainage of major cities are described hereunder.

(i) Seoul

Historical development of sewerage and drainage facilities in Seoul is indicated in Table H 13. In 1976, within 62,700 ha of the whole area of Seoul city, 26,240 ha or 42 % of the whole city area is delineated as planning area, of which 12,860 ha or 21 % of the whole city area has been established with sewerage facilities.

Current (1978) capacity of treatment facilities amounts to 250,000 m^3/d. When the expansion works now undertaken has been completed, the capacity will increase to 450,000 m^3/d by the end of 1978.

According to city office (Water Bureau), at present there are 296,800 flushing toilets in Seoul, but still 378,500 toilets are collected by sewer. Improvement from the sewer-collected to flushing toilet is underway at a pace of about 20,000 sites annually. In addition, newly established flushing toilets amount to about 40,000 annually.

Sewerage and treatment facilities expansion plan is now under study for the whole metropolitan area.

(ii) Busan

A long term plan for sewerage and treatment facilities targeted at year of 2000 is already established. According to the plan, treatment plants with total capacity of 1,146,000 m^3/d will be installed by 2000.

(iii) Daegu

Presently an excrement treatment plant is installed with the capacity of 600 m^3/d, which is drained into the Nagdong river through the Geumho river after treated below 40 ppm in

terms of BOD. A basic plan for sewerage and treatment facilities is already established.

Industrial waste water is now primarily treated by each factory. Currently (1978), about 15 % of the total industrial waste water is treated below 140 ppm in terms of BOD as shown below.

Factory	Number of Factories	Factories with Treatm't Plant	Waste Water (m^3/d)	Treated Water (m^3/d)	BOD after treated (ppm)
Inside the Industr'l Estate	294	160	6,100	4,800	140
Outside the Industr'l Estate	1,784	71	36,000	1,400	140
Total	2,078	231	41,100 (100.0)	6,200 (15.1)	

Source: Water Supply Bureau, City of Daegu

(5) Pollution problems

In July 1978, the Pollution Prevention Law has been abrogated and consolidated after strengthening the regulation into the Environment Conservation Law. The new law being provided with the regulations and rules in enforcing the objectives of the law has the provision of penalty against the violation of the law.

Currently in and around large cities such as Seoul, Busan and Daegu, pollution has become a big problem to be tackled with. As for Seoul, the present conditions of pollution including water pollution of the Han river and regulation for pollution prevention are described below.

Out of 5,900 factories in total currently located in Seoul city area mainly in Yeongdeungpo district, 5,800 factories or 98 % of the total are nominated as sources of pollution hazards in which air pollution and noise hazards occupy most, being followed by water pollution.

Under the long term plan started in 1976, more than 1,000 factories located in the non-industrial district are having been forcedly moved to the delineated industrial district. Within these three years since 1976, more than a half of them have been already moved.

The Banwed new industrial town being constructed aiming at lessenning industrial pollution hazards by relocating densely established factories in and around Seoul is also expected to be considerably effective to the solution of pollution problem.

Water pollution of the Han river has been surveyed comprehensively covering main stem and major tributaries as well for the first time by the City Office of Seoul in October, 1977 (Ref. H 41). The surveyed sites amount to 179 comprising 38 in the main stem, 75 in tributaries, 39 at factory drainages, eight at mining factory drainages, 18 at small municipality drainages and one livestock raiser drainage.

The result of the above survey is depicted in Fig. H 2 in which the water pollution is presented in terms of BOD. According to the survey, as is shown in the above figure, the downstream of the confluence of the North and the South Han is polluted most. BOD rises as going downstream from the confluence. This is caused by the inflow from the tributaries such as the Tan river, in which industrial waste of Seongnam district is drained, and the Anyang river in which sewerage and industrial waste of Anyang district are drained and by the sewerage of Seoul city draining into the Han.

In the south Han, the upstream is more polluted than the downstream due to the industrial waste drained from mining factories. While in the north Han, water pollution is of no significance like the south Han except Gongji in which the sewerage of Chuncheon city is drained.

The historical BOD at the sites of pumping station of Seoul municipal water is shown below (Ref. H 41). As indicated in the table below, water is polluted as it flows downwards from upstream (Gueui) to downstream (Yeongdeungpo).

Unit: ppm

	Yeongdeungpo	Noryangjin	Bogwangdong	Ddugdo	Gueui
1973	7.0	5.9	5.4	2.9	1.8
1974	5.6	3.6	4.0	1.5	1.3
1975	8.5	6.3	7.4	3.0	2.2
1976	8.1	5.6	5.9	2.1	1.7
1977	8.5	5.1	4.7	2.6	2.2

H 3 PROJECTION OF MUNICIPAL WATER REQUIREMENT

H 3.1 General

In this study, "water requirement" is at-the-source quantities inclusive of operational losses. "Municipal water" is defined as the water with the purposes of domestic use, commercial use, public use that includes recreation uses, street cleaning, fountain, fire fighting, government office uses, etc., and other non-industrial uses. "Industrial water" is defined as the water utilized in the production of industrial goods. It is required for manufacturing, processing, cooling, cleaning, etc.

Projection of M&I water requirement was made for the demand centers which depend their water supply upon the studied three rivers. The demand centers were grouped by basin divisions which were delineated for the convenience of water budget analysis.

In projecting the future water requirement, surface water only was taken into account. Groundwater is reported to be pumped in some factories individually for industrial purposes but the statistics were not available. The groundwater use for industrial purposes, however, will possibly be checked by regulation in the future to prevent subsidence of ground caused by excessive pumping of groundwater. While, as urbanization proceeds, the rural population is expected to decrease as is historically recognized as stated in ANNEX A and pipe-served population will increase with time even in rural areas as well. This is expected to bring the reduction of groundwater demand for municipal use in the future. Actually in 1976, municipal water use from groundwater in terms of supply capacity occupied only 0.3 % of the total in the Han, 2.0 % in the Nagdong and nil in the Seomjin.

From the above points of view, the groundwater demand was assumed in this study to maintain the present (1978) level during the study period and not to affect the water budget analysis.

H 3.2 Demand Centers

For the projection of municipal water requirement, 116 municipalities were selected in total of the three basins. Population, service factor and per capita daily water use were projected individually for all of these municipalities. Other municipalities than the above, all of which were those located in rural areas and were not pipe-served as of the end of 1976, were incorporated in this study as "non-water-served" area. Population and per capita daily water use of the non-water-served area were projected collectively for each basin.

The selected 116 municipalities include 42 in the Han, 62 in the Nagdong and 12 in the Seomjin basins respectively. In the above 116 municipalities included were those located outside the basins but supplied from the river water of the studied rivers; they amounted to five in the Han, 11 in the Nagdong, three in the Seomjin.

The above 116 demand centers comprise the municipalities:

(i) being pipe-served presently (as of the end of 1976) and planned to be pipe-served in the future as well from the studied rivers

(ii) being pipe-served presently from the others than the studied rivers but planned to be pipe-served in the future from the studied rivers

(iii) being pipe-served presently from groundwater but planned to be pipe-served in the future from the studied rivers and

(iv) presently not served with pipe-water but planned to be pipe-served in the future from the studied rivers.

The determination of the municipalities planned to be pipe-served from the studied rivers was made based on such information as indicated in the Nationwide Water Supply Plan (Ref. H 5), the Metropolitan Zone Water Supply Plan (Ref. H 4) and data collected through field survey.

H 3.3 Projection of Municipal Water Requrement

H 3.3.1 Population projection

The population of the selected 116 municipalities was projected first based on the ratio method and the result was examined further by the annual increase ratio to determine the adopted projection. The forecast made by the municipality office was referred to as well. For the small municipalities with less than 100,000 population, however, the simple eye-extrapolation method was applied based on the historical trend.

To obtain the historical trend, previous population censuses executed in 1955, 1960, 1966, 1970 and 1975 were analyzed for 116 municipalities. Projection of nation population indicated in ANNEX A was utilized in applying the ratio method.

The historical and projected population of 116 selected municipalities is shown in Table H 15. For 25 cities out of 116 municipalities, the percentages to the national population and annual average increase ratios are indicated in Table H 14 and Fig. H 3 for both historical and projected population. Their historical and projected populations are depicted in Fig. H 4.

H 3.3.2 Service factor and per capita daily use

The future service factor and the per capita daily use were determined by reviewing the municipal water supply standard made by MOC (Ref. H 4). Based on the 1971 and 1976 historical figures of service factor and per capita daily use, the above mentioned standard was adjusted and extended through 2001. In obtaining the historical per capita daily use, the water supplied for industrial purpose through municipal water pipeline was estimated and deducted, because M&I water requirement was projected separately in this study.

Service factor and per capita daily use were assumed to vary by the size of municipality population, which is deemed reasonable when referred to the historical data. In projecting the service factor and

per capita daily use, municipalities were classified into four groups and five groups respectively in this study. The above groupings were made based on the estimated 1986 population.

The employed service factor and per capita daily use are shown in Tables H 16 and H 17. In applying these for each municipality to obtain its requirement in 1981, an adjustment was made for some municipalities in such a way that both service factor and per capita daily use should be larger in 1981 than the historical ones in 1976. As for these municipalities, their service factor and per capita daily use differ from those shown in Tables H 16 and H 17. The difference, however, diminishes by the lapse of time to be nil by 2001. After adjusted as stated above, future service factor and per capita daily use of each municipality were projected as shown in Table H 18. For the municipalities with population of less than 100,000, as shown in the above table, the service factor and per capita daily use which are common to each basin were applied.

For the non-pipe-served population living in the pipe-served municipalities in the urban area, per capita daily use of 30 lpcd was applied. For the non-water-served area in the rural districts, the same 30 lpcd was applied to estimate their municipal water requirement. The non-water-served population was derived by subtracting the pipe-served population from the total basin population which were projected in ANNEX A.

The total population who depends water supply upon the studied three rivers inclusive of outside basins' pipe-served population is estimated for each basin as shown in Table H 19.

Based on the data presented before, future municipal water requirements were derived for each municipality for the pipe-served requirement (Table H 20) and for the total requirement including that of non-pipe-served and non-water-served population (Table H 21). Aggregating the requirement of municipalities, the future municipal water requirements for each river basin were derived as shown in Table H 22.

As indicated in Table H 22, municipal water requirement is estimated to increase by annual average growth of 4.3 % in the Han, 6.0 % in the

Nagdong and 6.6% in the Seomjin respectively for the period of 1976-2001. Comparing to the projected annual population increase, the municipal water requirement is projected to grow at as high rate as three times in the Han, four times in the Nagdong and five times in the Seomjin in the same period.

H 4 PROJECTION OF INDUSTRIAL WATER REQUIREMENT

H 4.1 General

The future industrial water requirement was projected on the basis of the present industrial water supply mentioned before in H 2.2.2. It was projected for 24 selected industrial cities in total of the Han (8 cities), the Nagdong (12 cities) and the Seomjin (4 cities).

The basic methods of projection in this study are as follows:

(i) for matured industrial cities that have enough data to estimate future trend of their industrial water requirement, the annual increase rates were estimated from the historical data taking into account of their future development potentials,

(ii) for such industrial cities as were newly constructed, under-construction or under-planning, unit industrial water requirements per ha of factory area were applied to the projected expansion of factory site, and

(iii) for some industrial cities having the industrial development plans to be completed before 2001, the water requirement after the said completion year was estimated by applying the annual increase rates of 1 to 5 % assuming that the factory site would further expand by such a small increase rates as above.

Available projections were gathered through MOC and local governments and they were, after reviewing, esteemed as far as possible. This came from the view that these existing projections could be considered to reflect the industrial development policies of the government.

H 4.2 Industrial Cities

Industrial cities in the studied three basins were selected based on the existing industrial establishments and future industrial development plans as follows:

The Han basin	:	Seoul, Incheon, Anyang, Seongnam, Weonju, Chuncheon (Inside basin) Suweon, Banweol (Outside basin)
The Nagdong basin	:	Daegu, Gumi, Jinju, Yangsan (Inside basin) Busan, Pohang, Masan, Jinhae, Changweon, Ulsan, Onsan, Samcheonpo (Outside basin)
The Seomjin basin	:	Yeosu, Yeocheon, Gwangyang (Outside basin)

Banweol, Samcheonpo and Gwangyang industrial development are now under planning stage. Judging from the recent rapid economic growth of Korea, these new industrial estates are deemed to be realized in the foreseeable future. Therefore the industrial water requirement of these three districts were projected and counted in this study.

H 4.3 Unit Requirement of Industrial Water

In projecting the future industrial water requirement, unit industrial water requirement per ha of factory area was applied for such new industrial cities as Banweol, Changweon, Samcheonpo, Yangsan and Gwangyang.

In determining the unit industrial water requirement, Japanese industrial statistics were referred to (Ref. H 7). Korean data available were also referred to which were presented in some reports such as the "Present Conditions of Industrial Water Supply in Korea" (Ref. H 1) and the "Basic Plan for Wide Range City Development of Yeosu and Suncheon" (Ref. H 8). These unit requirements including the adopted ones are indicated in Table H 23.

In applying the above unit industrial water requirement to an industrial estate, the composition in terms of field of industry was studied and one unit industrial water requirement was assumed to represent the average requirement of industrial water in the industrial estate.

The above-mentioned unit industrial water requirements are the net requirement after deducting reuse and sea water use. As the industrial water consumption increases in the future, industrial water re-use,

which works to decline the unit industrial water requirement, will prevail. At the same time, productivity in industries in terms of factory area can be expected to increase with time, which will work to raise the unit industrial water requirement. In this study, these two factors were assumed to be balanced, which is reasonable judging from the historical data of Japan. Thus, constant figures were adopted for the study time through 2001.

H 4.4 Projection of Industrial Water Requirement

On the basis of the aforementioned procedures, the future industrial water requirement was projected for each industrial city as briefly described below.

H 4.4.1 The Han basin

(1) Seoul

In Seoul, most manufacturing factories are concentrated in Yeongdeungpo district comprising the industrial estate of Korean Export Industries Corporation. Major industries of this area are foods and beverage, textile, steel, machinery, glasses, chemicals and medical drugs industries. Factories located outside Yeongdeungpo district are gradually having been moved to the delineated industrial area as mentioned before (H 2.2.3).

Industrial water supplied to Yeongdeungpo district has been pumped from the Han through Yeongdeungpo industrial water pipeline. The historical consumption is estimated at 50,000 m^3/d in 1971 and 110,000 m^3/d in 1976. The capacity of this pipeline has been expanded to 130,000 m^3/d in 1977. To the other factories located outside Yeongdeungpo district, industrial water has been supplied through municipal water pipeline, which currently amounts to about 15 % of the total municipal water supply.

Future requirement was projected on basis of increase ratio in the past.

Namely, the industrial water requirement in Yeongdeungpo was assumed to increase by the rate of 10 % annually after 1982 (the present supply capacity of 130,000 m^3/d was assumed to reach its maximum in 1981). For the factories located outside Yeongdeungpo district, annual increase of 1 % was assumed.

On the basis of the above assumptions, the future industrial water requirement of Seoul area was projected as shown below.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	214.6	423.2	482.6	574.8	717.6	931.9	1,271.5

(2) Incheon

Incheon is ranked with Busan as one of the oldest industrial cities in Korea. Recently, Incheon has been shifting from the light industrial to the heavy chemical industrial district in which concentrated are steel, plate glass, machinery, chemical, oil refinery and thermal power industries.

Water supply in Incheon has been almost wholly depended on the Han except small amount of groundwater. As no industrial water supply pipeline is installed, whole amount of industrial water is supplied through municipal water pipeline, which currently amounts to about 30 % of the total water supply to Incheon.

Future industrial water requirement was projected on the basis of the estimated demand of 63,300 m^3/d in 1976 and the estimated supply of 100,000 m^3/d in 1981 projected by city office. By applying the annual increase ratio of 10 % derived from the above historical and estimated amounts, the future requirement of Incheon was projected as shown below.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	34.4	63.3	100.0	162.4	264.0	429.1	697.3

(3) Chuncheon

Chuncheon, located in the upstream reaches of the Han is characterized as an administrative center of Gangweon Do. At the same time, it is an educational, cultural and commercial center of the Province. Industrial development has comparatively small significance at the present time as well as in the future.

At the beginning of 1970s, a small scale industrial estate has been established with the area of about 50 ha. The major industry is textile followed by foods processing, casting and metal industries.

Industrial water is supplied through municipal water pipeline, being estimated at 2,600 m^3/d in 1976. Future requirement was projected assuming an annual increase ratio of 5 % referring the historical increase of industrial water in Chuncheon.

	Historical						
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	1.8	2.6	3.6	5.4	6.5	7.7	8.9

(4) Weonju

Located in the middle of the trunk highway combining Seoul and east coast, Weonju occupies an important position in transportation as well as in trading of commercial goods.

Industrial establishment are not many in number, with the total estimated factory area of about 400 ha, which, according to the city office, is expected to be doubled in the future. The primary industry is paper followed by edible oil, electrical, medical machinery and leather processing industries.

At present (1978), there exists an industrial water supply pipeline with the supply capacity of 10,000 m^3/d. Current supply is estimated at 7,400 m^3/d in which about 7,000 m^3/d is supplied to a paper factory.

According to the city office, the supply capacity will reach its maximum in 1991. On the basis of this estimation, future requirement was projected as shown below.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	6.8	7.0	8.0	9.0	10.0	11.0	12.0

(5) Seongnam

Seongnam is one of the satellite towns of the capital, being characterized more as a "bed-town" of Seoul than as an industrial city. It has been newly established as a "Si" (city) in 1973 along with the population dispersing policy.

At the present time, there scatter about 150 manufacturing factories in the suburbs with the total factory area of 160 ha. Main industries are foods processing, electrical, textile, medical drugs, chemicals and light metal processing. There exists no concrete plan of establishing a new industrial estate at present.

Industrial water is supplied through municipal water pipeline, which amounts to 5,000 m^3/d in 1976. In 1981, it is estimated to amount to 12,000 m^3/d by city office. Future industrial water requirement after 1982 was projected assuming the moderate increase ratio of 5 % by analogy of Chuncheon that has the similarity to Seongnam in industrial charactaristics, resulting the projection as shown below.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	1.0	5.0	12.0	18.9	23.5	28.5	33.4

(6) Suweon/Anyang

Suweon/Anyang district, located within the metropolitan zone has developed as an industrial area rapidly since the beginning of 1970s. There concentrated are the light and chemical industries

such as textile, paper, electrical code, electrical equipment, chemical and foods processing industries.

At present, industrial water is supplied through Suweon/Anyang industrial water supply pipeline that has been installed in 1974 with the capacity of 100,000 m^3/d.

In projecting the future requirement, the estimation indicated in the "Basic Planning Report on Water Supply in Metropolitan Zone" (Ref. H 4) was adopted until 1986. After 1987, the said estimation was extrapolated by the annual increase of 10 % that was derived from the above estimate, resulting the future requirement as shown below.

I-Water Requirement	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
Suweon	-	23.3	48.9	63.0	101.5	163.4	263.2
Anyang	-	47.3	98.7	119.0	191.7	308.7	497.1
Total	-	70.6	147.6	182.0	293.2	472.1	760.3

(7) Banweol

Under the on-going Fourth Five-Year Plan, the establishment of a new industrial town in Banweol district has been declared and presently the construction is being under way. This new town aims to mitigate the excessive concentration of population into the metropolitan zone and to lessen the industrial pollution hazards by relocating manufacturing factories now too densely established in and around Seoul.

Banweol new industrial town located 35 km southwest of Seoul will encompass planned city area of 317.7 km^2 in which the industrial district will occupy 8.2 km^2.

Land preparation of the planned industrial estate has been partly completed and some factories will start their operation by the end of 1978. As of October, 1977, the number of industrial establishment to have applied for entrance amounts to 484 corresponding an area of 482 ha in total.

Major industries planned to be established are light and chemical industries such as textile, leather processing, chemical including plastic processing, machinery, electrical, furniture and food processing.

Being located in the vicinity of the metropolis, a rapid industrial development can be expected in this district. Therefore, in projecting the future industrial water requirement, the whole area of industrial estate (783 ha in net) was assumed to be developed fully by 1986. The unit industrial water requirement of 150 m^3/ha/d was applied to the planned factory area to derive the requirement in 1981 and 1986. After 1987, the annual increase ratio of 17 % was assumed from the similar increase of industrial water requirement of Yeongdeungpo district in the period of its initial development stage of 1971-76.

Based on the above assumptions, future industrial water requirement in Banweol was projected as shown below.

I-water Requirement	Projected				
	1981	1986	1991	1996	2001
(10^3 m^3/d)	23.6	117.5	258.6	569.4	1,253.7

H 4.4.2 The Nagdong basin

(1) Daegu

Daegu is a typical inland industrial city located in the midway of the Seoul-Busan highway. The major industry is textile followed by machinery, chemical, foods processing, wood processing and paper processing industries.

Presently in Daegu, industrial water is supplied through the industrial water supply pipeline with the capacity of 35,000 m^3/d by pumping the Gachang reservoir water that is located in one of the tributaries of the Geumho river. As the supply capacity is small compared to requirement, municipal water is also used for industrial purpose, which currently amounts to about 20 % of the

total municipal water supply. In addition, some factories have their own water supply facilities by pumping groundwater.

Through field survey, no more information was obtained than was indicated in the "Nagdong River Basin Delta Study" 1976 (Ref. H 6) concerning the future industrial water requirement of this area. According to the above study, the total industrial area will be enlarged to 835 ha by 1981. The total area of the six existing industrial zones encompassing 1,040 ha will be developed by 1986. It is further estimated in the above study to be doubled by 2001.

In the above study, the unit industrial water requirement 200 m^3/ha/day has been adopted, which was judged reasonable when reviewing the industrial composition of this area.

Thus in this study, the projection of industrial water requirement by the "Nagdong River Basin Delta Study" was adopted.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	28.8	51.6	167.1	207.9	278.1	347.9	415.9

(2) Gumi

Industrial development of Gumi started in 1968 aiming at being an inland industrial city specialized in textile manufacturing and electronic products.

Presently installed are industrial water supply pipelines with a capacity of 50,000 m^3/d. The current factory area comprises 680 ha in total, which, according to the city office, will expand to 750 ha by 1981.

According to the most up-to-date plan of water supply expansion, made by the city of Gumi (Ref. H 10), the industrial water requirement will reach 155,000 m^3/d in 1991. This estimation gives the unit industrial water requirement of about 200 m^3/ha/d which seems

reasonable when referred to the industrial composition of Gumi. In this study the above estimation was adopted. After 1992, the requirement was extrapolated by the annual increase rate of 1 % assuming the factory site expansion of 1 % per annum.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	18.7	38.9	66.9	113.2	155.0	162.9	171.2

(3) Jinju

The main industries of Jinju are textile, farm equipment and machinery parts industries. Presently industrial water is supplied by pumping groundwater by factories individually.

According to the "Masterplan of Jinju City Development" (Ref. H 12), the development of industrial area of 334 ha including semi-industrial area is planned. The kinds of industries expected to be established are similar to those currently existed.

In this study, adopting the area extent indicated in the above masterplan and assuming its full development in 2001, the industrial development of Jinju was projected as shown below.

The unit industrial water requirement of 200 m^3/ha/d was adopted based on the estimated composition of field of industries.

	Projected				
	1981	1986	1991	1996	2001
Industrial Development (ha)	80	140	200	260	334
I-water Requirement (10^3 m^3/d)	16.0	28.0	40.0	52.0	66.8

(4) Masan

Masan, Jinhae and Changweon districts, being closely located each other, are supplied with the Nagdong water from the common pumping station at Bonpori.

In Masan, a large textile factory is the major consumer of

industrial water that currently (1978) amounts to 60,000 m^3/d followed by Masan Free Export Zone and some other industries (15,000 m^3/d).

According to the "Masterplan of Masan City, 1976" (Ref. H 13), industrial area of Masan, in 1986, exclusive of the Free Export Zone (54 ha) is expected to be 130 ha in which the textile factory occupies 55 ha.

In projecting the future water requirement, the requirement in 1986 was estimated on the basis of current requirement at 92,600 m^3/d in total, i.e. 65,000 m^3/d for the textile factory, 16,200 m^3/d for the Free Export Zone and 11,400 m^3/d for the other industries. To obtain the requirement after 1987, the annual increase in industrial site, consequently in water requirement, of 1 % was applied.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	28.9	71.0	85.3	92.6	97.3	102.3	107.5

(5) Jinhae

In Jinhae, major industries are a fertilizer plant, an edible oil factory, a slate factory and a P.V.C. plant. Currently (1978) total water use is estimated at 14,500 m^3/d. The construction of a ship building yard is now under planning.

The future requirement was projected applying the minimum increase rate of 1 % per annum assuming the factory site increase of 1 % per annum. The planned ship building yard was assumed to operate in 1991 of which water use was assumed to be 2,000 m^3/d equal to the actual use of Ulsan ship-building yard.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	10.0	10.0	14.9	15.7	18.5	19.4	20.4

(6) Changweon

Changweon is the newly established industrial estate specialized in machinery industries comprising industrial, precision, electrical and transportation machineries. Currently (1978) 49 factories are operating in the area of 1,005 ha.

In projecting the future requirement, the planned total factory area of 2,310 ha was assumed to be fully developed by 2001. The unit industrial water requirement of 150 m^3/ha/day was applied.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
Industrial Development (ha)	-	237	1,180	1,460	1,750	2,040	2,310
I-water Requirement (10^3 m^3/d)	-	21.6	177.0	219.0	262.5	306.0	346.5

(7) Busan

Busan is the primary coastal industrial area in Korea. Industries of every field are gathering in this district comprising ship-building, chemical, car-assembling, electronics, rubber and foods processing and others.

Presently industrial water is mainly supplied through municipal water pipeline except small scale (5,000 m^3/d) industrial water supply. Like Seoul, dispersing the densely located manufacturing factories is now under planning in Busan.

Through field survey, the previous projection indicated in the "Nagdong River Basin Delta Study" (Ref. H 6) was reviewed and adopted in this study. The unit industrial water requirement applied in the above study of 200 m^3/ha/day seems reasonable as an average water use of industries located in Busan.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	80.0	165.0	350.1	470.1	560.0	640.0	720.0

(8) Pohang

Pohang is an industrial city of iron and steel industries, which has been constructed in 1973 with the steel production capacity of 1.0×10^6 tons/year. Steel mill will reach 5.5×10^6 tons/year after the completion of third phase expansion expected by the end of 1978. After the fourth phase expansion, it will reach 8.5×10^6 tons/year and finally 10.0×10^6 tons/year is planned.

Current industrial water is supplied from the Angye reservoir located in the Hyeongsan river outside the Nagdong basin. Presently construction of pipeline from Yeongcheon reservoir located in an upper tributary of the Geumho river is underway. It is expected to complete in March, 1979. The supply capacity of the Yeongcheon pipeline (38 km) is restricted to 220,000 m^3/day. This capacity seems to be the maximum to be diverted from the Nagdong with the storage capacity of the Yeongcheon reservoir. The exceeding requirement must be met by local water source development or by sea water use.

Future requirement was projected here in total basis including the requirement exceeding the possible supply from the Nagdong. In projecting the future requirement of the steel mill industry, the future expansion in terms of steel production capacity was assumed and unit industrial water requirement of 9 m^3 per steel production (crude basis) was applied referring to Japanese industrial statistics. The water requirement of steelallied factories was projected until 1991 on the basis of the estimation indicated in the "Design Report of Industrial Water Supply Expansion in Pohang" (Ref. H 14). After 1992, minimum increase of 1 % per annum was applied assuming the factory site increase of 1 % per annum.

	Historical	Projected				
	1976	1981	1986	1991	1996	2001
Steel Prod. Capacity (10^6 ton)	2.6	5.5	8.5	10.0	10.0	10.0
I-water Requirement (10^3 m^3/d)	51.8	135.6	209.6	246.6	246.6	246.6
Steel-Allied (10^3 m^3/d)		30.0	67.0	103.0	108.3	113.8
Total I-water Requirement (10^3 m^3/d)	51.8	165.6	276.6	349.6	354.9	360.4

(9) Ulsan/Onsan

Ulsan and Onsan constitute a heavy and chemical industrial zone located in the east coast of Korea. In Ulsan, factories started operation in 1968. Main industries comprise oil refinery, petrochemical, fertilizer plant, ship-building, thermal power and car-assembly industries.

Industrial water to this district is supplied from the Nagdong river pumping at near Mulgeum (see H 2.2.3).

In Onsan area, construction of factories are now under way. A number of factories are already in operation. A water consuming pulp factory is planned to be established. The full development was assumed at 1986 in this study on the basis of field survey.

The current (1978) industrial water requirement is 240,000 m^3/d in Ulsan and 30,000 m^3/d in Onsan. Referring to the "Design Report of Industrial Water Supply in Onsan District" (Ref. H 15), water requirement for Ulsan district in 1986 was estimated at 325,000 m^3/d. In case of Onsan, assuming that a pulp factory will start operation in 1991, water requirement in 1986 was estimated at 155,000 m^3/d. After 1987, 1 % annual increase was applied assuming the industrial site expansion of 1 % per annum.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	77.3	138.5	349.0	480.0	573.6	602.8	633.6

Although there are development plans of local water sources such as Hoeya reservoir and Taewa reservoir. Their capacities are small compared with the Mulgeum - Daeam system. The bulk of requirement was assumed to be met by the expansion of Daeam supply pipeline.

(10) Samcheonpo

Samcheonpo is a fishing port town located in the south coast of Korea. At the present time, there are 45 factories major of which are foods processing, machinery and textile manufacturing. Under the Second Five-Year Plan, Samcheonpo has been nominated as an planned industrial area.

According to the latest information (Ref. H 5), the total industrial area of 1,500 ha is planned. Out of this total area, 770 ha is scheduled to complete land preparation in 1991. But, in this study, taking into consideration the government's policy to postpone the new large scale project of industrial development prospecting the oil supply difficulty, the full operation of 770 ha was assumed to be delayed by ten years in 2001. Although the kinds of industries are not determined, 150 m^3/ha/day of unit industrial water requirement referring to that of Yecheon was applied to derive the future industrial water requirement of Samcheonpo.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
Industrial Development (ha)	-	-	50	230	410	590	770
I-water Requirement (10^3 m^3/d)	0.5	1.5	7.5	34.5	61.5	88.5	115.5

Presently water requirements are met by local water sources from the Samcheonpo and Bonghyeon rivers with total supply capacity of 7,800 m^3/d. In the future, the Namgang reservoir located in the Nam river, one of the main tributaries of the Nagdong, is planned to supply water to this area through long distance pipeline.

Sacheon has been also planned as an industrial area under the Second Five-Year Plan. Through field survey, the plan was found to be limited to farm products processing and comparatively in small scale (about 8 ha including semi-industrial area). Therefore, industrial water requirement was assumed to be negligible in this study.

(11) Yangsan

Yangsan is a rural area located in the vicinity of northern boundary of Busan city. A small scale (150 ha) industrial development is planned here and the land preparation is now under way expected to be completed in 1979. Foods processing and other light industries are planned to be established. As the expansion of factory are cannot be expected, future industrial water requirement was assumed to be constant of 15,000 m^3/d applying 100 m^3/ha/day of unit requirement.

	Historical						
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	-	-	15.0	15.0	15.0	15.0	15.0

H 4.4.3 The Seomjin basin

Inside the basin, any industrial development cannot be expected either at present or in a foreseeable future. However, outside the basin, in the Gwangyang bay area in the southern coast, Yeocheon industrial area is now in operation. Further, Gwangyang district is under planning for its large scale industrial development. In Suncheon, one industrial site is now under preparation and another district is under planning.

(1) Yeosu

Yeosu is a fishing port town located in the south coast. Under the city masterplan, an industrial area of 450 ha has been delineated but at present no industry is established. According to the development plan for Yeocheon and Suncheon areas (Ref. H 8),

an area adjacent to Yeocheon industrial estate is planned for industrial establishment. A synthetic fibre, a fishing net and an automobile tire manufacturings are expected to enter.

According to the above development plan, the future industrial water requirement for this area was estimated at 22,800 m^3/d in full operation. Though its timing is not indicated in the above plan, the full operation was assumed at 1991 in this study, corresponding to the assumed full operation time of Yeocheon district. Future increase in water requirement after 1992 was projected assuming the expansion of factory site by 1 % per annum in average.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	-	-	-	15.0	22.8	24.0	25.2

(2) Yeocheon

Yeocheon is located at south-eastern part of the Gwangyang bay. It has been planned as a petrochemical industrial center. Currently (1978) operated are an oil refinery, a series of petrochemical plants, a fertilizer plant, a thermal plant and other petrochemical-allied industries. The total planned area encompasses 674 ha of which 412 ha is now under operation. The present (1978) industrial water requirement amounts to 50,000 m^3/d which is supplied through Sueo route pipeline.

The total industrial development is expected by 1991 with another series of petrochemical plant and the water requirement at that time is estimated at 360,000 m^3/d (Ref. H 8), which was adopted in this study. Future increase in requirement after 1992 was estimated assuming the expansion of factory site by 1 % per annum in average.

	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
I-water Requirement (10^3 m^3/d)	7.5	13.0	275.3	323.9	360.0	378.5	397.6

(3) Gwangyang

Gwangyang is now a coastal rural area located in the northern part of the Gwangyang bay. According to the development plan of this area (Ref. H 8), the total area encompassing 3,570 ha is planned to be developed by 2001. The major planned industries are an iron and steel mill plant with the steel production capacity of 12 x 10^6 tons in the final stage, a ship-building yard, an oil refinery, a series of petrochemical plant and a thermal plant.

In projecting the future industrial water requirement, the target year of total completion which is planned in 2001 was postponed by 5 years to 2006 taking into account of the recent government's policy to postpone the new large scale project of industrial development prospecting the oil supply difficulty and other economic conditions. Assuming the starting operation in 1986 (Ref. H 8) and applying the unit requirement of 330 m^3/ha/d calculated from the above plan, future industrial development and water requirement of Gwangyang area were projected as shown below.

		Projected			
	1981	1986	1991	1996	2001
Industrial Development (ha)	-	650	1,230	1,780	2,310
I-water Requirement (10^3 m^3/d)	-	214.5	405.2	586.3	761.5

(4) Suncheon

Suncheon is an inland city located near to the Suncheon bay in the southern coast of the Jeonlanam Province. Being situated in the midway between the Gwangju/Jeonju zone and the Busan/Masan zone, Suncheon is characterized as an important city for traffic and transport in the southern coastal zone. Suncheon is also characterized, ranked with Yeosu city, as a local center of trade and commerce in the eastern area of the Jeonlanam Province.

In Suncheon, except an alcohol factory, there are only a few small scale factories most of which are foods and beverage manufacturing. There are no water supply system specified for industrial

purposes. Industries scattered in the city have self-supplied industrial water by their own facilities from river water or from groundwater. The industrial water consumption through municipal water pipeline is only a small amount.

Currently (1978), an industrial district of 68 ha is under construction at Seonpyeong-ri beside the express highway. The land preparation is expected to be completed by the end of 1978. Thirteen light industries including foods, light machinery, electrical, electronic and chemical industries are planned to be established.

Another new industrial estate is planned at Weoljeon-ri of Haeryeong-myeon located south-east of Suncheon (Ref. H 8). Industries to be established include machinery industries, fabric, textile and leather processing industries and plastic and aluminum processing industries. The total factory area will extend in 118 ha, which is planned to be fully developed by 2001.

In projecting the industrial water requirement, a unit water requirement of 200 m^3/ha/d was assumed for the two industrial estates after reviewing their composition of field of industries.

Industrial water requirement of Suncheon comprising the above two industrial estates were projected as shown below.

	Projected				
	1981	1986	1991	1996	2001
Industrial Development (ha)	43	73	104	133	161
I-water Requirement (10^3 m^3/d)	8.6	14.6	20.8	26.6	32.2

H 4.4.4 Annual industrial water requirement

The present and future industrial water requirement as estimated hereinbefore are summarized in Table H 24 and are depicted in Fig. H 5 to show the trend.

As shown in the above table, in the Han, industrial water requirement is projected to increase to 7.1 times during the period of 1976-2001

from 210 x 10^6 m^3/yr to 1,470 x 10^6 m^3/yr with the average increase rate of 8.1 % per annum. Since water requirement of Banweol new industrial estate, estimated to be in full operation in 1986, was projected to grow at a comparatively high increase rate, industrial water requirement in the Han will show a steep rise after 1991. In the Nagdong, it is projected to increase to 5.4 times during the same period from 200 x 10^6 m^3/yr to 1,080 x 10^6 m^3/yr with the average increase rate of 7.0 % per annum. In the Seomjin, as the present demand is so small compared with the projected industrial development in Gwangyang bay area that the future increase in industrial water requirement reaches as high as 95 times compared with 1976 amounting to 450 x 10^6 m^3/yr in 2001, with the average increase rate of 20 % per annum.

H 5 ANNUAL M&I WATER REQUIREMENT

The projected M&I water requirement is summarized for each basin in Table H 25. In the Han, total M&I-water requirement is projected to increase to 3.8 times during the period of 1976-2001 from 990 x 10^6 m^3/yr to 3,700 x 10^6 m^3/yr with the average increase rate of 5.4 % per annum. During the same period, the proportion of industrial water requirement to the total M&I water requirement is projected to be nearly doubled from 21 % to 40 %. In 2001, 3,100 x 10^6 m^3 or 83 % of the total amount will be required inside the basin, within which 2,200 x 10^6 m^3 or 70 % of the total amount will be for municipal water use. Most of the requirement outside the basin is projected for industrial use in 2001 (87 % of the total outside basin requirement).

In the Nagdong, total M&I water requirement is projected to increase 4.7 times during the period of 1976-2001 from 500 x 10^6 m^3/yr to 2,500 x 10^6 m^3/yr with the average increase of 6.4 % per annum. Peculiar to the Nagdong is that more water is required outside the basin than inside the basin. The situation will be unchanged even in the future, namely in 2001, 1,800 x 10^6 m^3 or 72 % of the total amount will be required outside the basin. In this outside basin requirement, the proportion between municipal and industrial water is projected in 2001 to be 53 % for municipal and 47 % for industrial water use.

In the Seomjin, total M&I water requirement is projected to increase as high as 24 times during the period of 1976-2001 from 20 x 10^6 m^3/yr to 530 x 10^6 m^3/yr with the average increase of 14 % per annum. The industrial water requirement is projected to increase as rapidly as 20 % annually, all of which will be required outside the basin. In 2001, 440 x 10^6 m^3 or 84 % of the total amount is projected to be required for industrial use outside the basin.

Fig. H 5 was prepared for the convenience of comparison with the previous projections.

In case of the Han, the present projection was compared to the "net surface water demand" of HRBS (Ref. H 37). However, the "contingency" demand included in the HRBS's projection was excluded to compare the two projections on the same basis.

H 6 NET M&I WATER WITHDRAWAL

H 6.1 Method of Calculation

The net M&I water withdrawal was estimated to supply the basic data for the water budget analysis. The "net M&I water withdrawal" is defined in this study as the net reduction in the river flow by the M&I water use.

H 6.1.1 Basin-division

Based on the need coming from water budget analysis, each basin was divided into a number of basins-divisions depending on the location of major gauging stations, the location of the existing and proposed dams and the confluence of the major tributaries and main stem. The Han Basin was divided into 20, the Nagdong into 19 and the Seomjin into six basins-division, respectively.

The basin-divisions were delineated principally corresponding to those that were determined in estimating the net agricultural water withdrawals (ANNEX G). However, for the purpose of water budget analysis, the basin-divisions for M&I net water withdrawal are not required to be divided into so small area as required in the calculation of agricultural one. Therefore, some sub-basins for net agricultural water withdrawal were aggregated into one basin-division for the estimate of net M&I water withdrawal. The basin-divisions are indicated in Fig. H 6 for each basin and their correlations to sub-basins for net agricultural water withdrawal calculation is shown in Table H 26.

H 6.1.2 Method of calculation

Net water withdrawal was calculated in the following way:

(1) For inside basin:

First, water requirement was classified by the location of intake of each demand center into the requirement depending on main stem and that depending on tributaries. In this calculation,

the "main stem" was defined as the flows downstream of the existing dams (including the authorized ones) and the proposed dams; others than the above were dealt with as the "tributaries". The water requirement of non-water-served population in the rural areas was all dealt with as tributary depending.

Second, net M&I water withdrawal was calculated for main stem as well as for tributaries by:

Net water withdrawal = Water requirement x 30 %

In other words, the return flow was assumed at 70 % of withdrawal. As the data on return flow of M&I water are not available, the return flow indicated in the "Nagdong River Basin Delta Study" (Ref. H 6) was applied in this study.

In case of Incheon though located inside the Han basin, as its sewerage is drained directly into the Yellow Sea, the net water withdrawal was calculated as 100 % of its water withdrawal.

In case of Paldang route pipeline after its completion, the water pumping from the Paldang reservoir that belongs to Basin-division H-14 will be conveyed through pipeline to Seoul, Incheon, Bucheon, Anyang, Seongnam, Suweon and Banweol all of which belong to Basin-division H-13-3 and be drained into the Basin-division H-13-3. Thus, for these water withdrawals, the return flow in Basin-division H-14 was claculated nil. Consequently, in Basin-division H-13-3, the return flow amounts more than water withdrawal resulting the net water withdrawal to be negative.

In case of Daegu in the Nagdong, water is pumped from three basin-divisions separately and drained into one basin-division. Namely, in Daegu, water is pumped from the Nagdong main stem (Basin-division N-7), the Geumho main stem (N-6-1) and the Geumho tributary (N-6-2), while sewerage is all drained into the Geumho main stem (N-6-1). Thus, like the aforementioned Paldang case, the net water withdrawal was calculated to be negative in the Geumho main stem (N-6-1).

(2) For outside basin:

After the requirement was classified into main stem depending and tributary depending requirements in the same way as for inside basin as mentioned above, the net water withdrawal was calculated by:

Net water withdrawal = Water requirement - Local water sources

The "local water sources" were defined here as such water sources available outside the basin as groundwater, reservoir and surface water of local rivers.

The supply capacity of local water sources were assumed to be constant at the level as of the end of 1976 in this calculation. However, for some basin-divisions in which the change in supply capacity of local sources is expected in the near future, the up-to-date information was incorporated. For example, Yeosu now supplied from the Isa river, a local river outside the Seomjin, is planned to switch its water source to the Seomjin through the Sueo route pipeline. Thus, in case of Yeosu, the local water source capacity was reduced after 1981 compared with 1976.

In case of Pohang outside the Nagdong, to which the Yeongcheon reservoir water will be diverted from 1979, the net water withdrawal was calculated through 2001 as 220,000 m^3/d that is considered the possible maximum supply of the reservoir.

H 6.2 Net M&I Water Withdrawal

The net water withdrawal calculated based on the aforementioned procedure is summarized for each basin in Table H 27. In 2001, the net water withdrawal amounting to 1.9×10^9 m^3/yr (5.3 times comparing to that of 1976) is estimated in the Han, 1.9×10^9 m^3/yr (6.1 times) in the Nagdong and 0.5×10^9 m^3/yr (172 times) in the Seomjin basins respectively.

In case of the Seomjin basin, the net water withdrawal that will be diverted to and around the Gwangyang bay area (Basin-division S-5-2)

including Yeosu, Suncheon, Gwangyang and Yeocheon is projected to occupy almost all 99 % of the net water withdrawal in 2001.

The calculation of net M&I water withdrawal for each basin-division is compiled in Table H 28.

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Table H 1 MUNICIPAL WATER SUPPLY IN KOREA (1971 & 1976)

1971

Groupings by Population	Total Population (10^3)	Pipe-served Population (10^3)	Service Factor (%)	Water Supply ($10^3 m^3/d$)	Per capita Daily Use (lpcd)
More than 3 mil.	5,850	5,120 (44)	88	1,075	210
500,000 - 3 mil.	4,270	3,160 (27)	74	566	179
100,000 - 500,000	2,320	1,620 (14)	70	199	123
Less than 100,000	4,290	1,700 (15)	40	125	74
Pipe-served Area Total	16,720	11,600 (100)	69	1,965	169
Non-water-served Area Total	16,163	-	-	-	-
Nation Total	32,880	11,600	35	1,965	169

1976

Groupings by Population	Total Population (10^3)	Pipe-served Population (10^3)	Service Factor (%)	Water Supply ($10^3 m^3/d$)	Per capita Daily Use (lpcd)
More than 3 mil.	7,260	6,820 (38)	94	2,075	304
500,000 - 3 mil.	5,910	5,460 (31)	92	1,170	214
100,000 - 500,000	3,940	3,230 (18)	82	445	138
Less than 100,000	4,350	2,400 (13)	55	257	107
Pipe-served Area Total	21,450	17,920 (100)	84	3,947	220
Non-water-served Area Total	14,410	-	-	-	-
Nation Total	35,860	17,920	50	3,947	220

Table H 2 FACILITIES OF INDUSTRIAL WATER SUPPLY IN KOREA (1974)

Unit : $10^3 m^3/d$

1. Han River Basin

Industrial District	Supply capacity
Seoul	110
Suweon/Anyang /2	100
Seongnam /1	5
Chuncheon /1	4
Weonju	10
Sub-Total	229

2. Nagdong River Basin

Industrial District	Supply capacity
Ulsan /2	170
Masan/Jinhae /2	85
Pohang /2	100
Daegu	35
Gumi	55
Sub-Total	445

3. Seomjin River Basin

Industrial District	Supply capacity
Yeocheon /2	25

4. Other Basins

Industrial District	Supply capacity
Cheongju /1	2
Daejeon /1	1
Jeonju	35
Mogpo /1	10
Sub-Total	48
Nation Total	747

Remarks ; /1 : Supplied through M-water pipeline

/2 : Under administration of MOC

Source : Ref. H 1.

Table H 3 MUNICIPAL WATER SUPPLY IN THE HAN RIVER BASIN (1971)

Municipalities	Total Population (10^3persons)	Pipe-served Population (10^3persons)	Service Factor (%)	Water Supply /1 (10^3m^3/d)	Per-capita Daily Use (lpcd)
A. Inside Basin					
Seoul	5,850	5,120	88	1,075.2 (88)	210
Incheon	670	590	87	112.0 (9)	191
Chuncheon	130	90	74	10.5	112
Weonju	110	60	54	6.0	97
Chungju	90	50	54	3.4	68
Seongnam	140	100	71	3.8	38
Anyang	90	10	13	0.6	47
Bucheon	60	10	21	1.5	127
Euijeongbu	100	30	29	3.7	135
Less than 100,000	300	70	22	6.4 (1)	98
Inside Total	7,540	6,130	81	1,223.1	200
B. Outside Basin	0	0	-	0	-
Pipe-served Area Total (A+B)	7,540	6,130	81	1,223.1 (100)	200
Non-water-served Area (Inside) Total	2,810	-	-	-	-
Han Depending Area Total	10,350	6,130	59	1,223.1	200

Remarks ; /1 : Including supply for industrial use

Table H 4 MUNICIPAL WATER SUPPLY IN THE HAN RIVER BASIN (1976)

Municipalities	Total Population (10^3persons)	Pipe-served Population (10^3persons)	Service Factor (%)	Water Supply /1 ($10^3 m^3$/d)	Per-capita Daily Use (lpcd)
A. Inside Basin					
Seoul	7,260	6,820	94	2,075.0 (86)	304
Incheon	830	730	88	208.0 (9)	283
Chuncheon	140	110	79	13.6	121
Weonju	120	100	80	16.1	163
Chungju	110	80	71	7.6	101
Seongnam	290	230	82	20.0	85
Anyang	150	110	73	9.5	90
Bucheon	120	80	69	12.3	150
Euijeongbu	110	80	73	7.0	85
Less than 100,000	410	150	37	17.7 (1)	115
Inside Total	9,530	8,500	89	2,386.8 (99)	281
B. Outside Basin					
(1) 100,000 - 500,000					
Suweon	240	200	83	18.4 (1)	94
Pipe-served Area Total (A+B)	9,820	8,700	89	2,405.2	277
Non-water-served Area (Inside) Total	2,160	-	-	-	-
Han Depending Area Total	11,990	8,700	73	2,405.2 (100)	277

Remarks ; /1 : Including supply for industrial use

Table H 5 MUNICIPAL WATER SUPPLY IN THE NAGDONG RIVER BASIN (1971)

Municipalities	Total Population (10^3persons)	Pipe-served Population (10^3persons)	Service Factor (%)	Water /1 Supply ($10^3m^3/d$)	Per-capita Daily Use (lpcd)
A. Inside Basin					
Daegu	1,130	850	75	135.5	160
Andong	80	50	60	4.1	85
Jinju	130	90	69	11.2	129
Less than 100,000	640	230	36	19.4	85
Inside Total	1,980	1,210	61	170.2	140
B. Outside Basin					
Busan	1,940	1,430	74	266.0	187
Masan	200	160	81	22.0	139
Jinhae	90	70	71	4.5	66
Outside Total	2,230	1,650	74	292.6	177
Pipe-served Area Total (A+B)	4,210	2,860	68	462.8	162
Non-water-served Area (Inside) Total	3,670	-	-	-	-
Nagdong Depending Area Total	7,880	2,860	36	462.8	162

Remarks ; /1 : Including supply for industrial use

Table H 6 MUNICIPAL WATER SUPPLY IN THE NAGDONG RIVER BASIN (1976)

Municipalities	Total Population (10^3persons)	Pipe-served Population (10^3persons)	Service Factor (%)	Water /1 Supply ($10^3m^3/d$)	Per-capita Daily Use (lpcd)
A. Inside Basin					
Daegu	1,360	1,320	96	256.7 (27)	195
Gumi	50	30	51	16.1	607/2
Andong	100	90	86	9.0	105
Jinju	160	150	95	16.4	107
Less than 100,000	920	540	58	44.7	83
Inside Total	2,590	2,120	82	343.0 (36)	162
B. Outside Basin					
Busan	2,570	2,360	92	550.0 (59)	233
Masan	380	280	74	39.4 (4)	140
Jinhae	104	97	93	6.8 (1)	70
Outside Total	3,060	2,740	90	596.2 (64)	217
Pipe-served Area Total (A+B)	5,650	4,860	86	939.2 (100)	193
Non-water-served Area (Inside) Total	3,460	-	-	-	-
Nagdong Depending Area Total	9,110	4,860	53	939.2	193

Remarks ; /1 : Including supply for industrial use

/2 : 255 lpcd excluding industrial use

Table H 7 MUNICIPAL WATER SUPPLY IN THE SEOMJIN RIVER BASIN (1971)

Municipalities	Total Population (10^3persons)	Pipe-served Population (10^3persons)	Service Factor (%)	Water/1 Supply ($10^3m^3/d$)	Per-capita Daily Use (lpcd)
A. Inside Basin					
Less than 100,000	38	9	24	0.9	101
B. Outside Basin					
Gwangju	520	315	61	72.5	230
Pipe-served Area Total (A+B)	558	324	58	73.4	227
Non-water-served Area (Inside) Total	860	-	-	-	-
Seomjin Depending Area Total	898	324	36	73.4	227

Remarks ; /1 : Including supply for industrial use

Table H 8 MUNICIPAL WATER SUPPLY IN THE SEOMJIN RIVER BASIN (1976)

Municipalities	Total Population (10^3persons)	Pipe-served Population (10^3persons)	Service Factor (%)	Water/1 Supply ($10^3m^3/d$)	Per-capita Daily Use (lpcd)
A. Inside Basin					
Less than 100,000	89	32	36	1.8	56
B. Outside Basin					
Gwangju	625	586	94	81.5	139
Pipe-served Area Total (A+B)	714	618	87	83.3	135
Non-water-served Area (Inside) Total	776	-	-	-	-
Seomjin Depending Area Total	865	618	71	83.3	135

Remarks ; /1 : Including supply for industrial use

Table H 9 MUNICIPAL WATER USE BY PURPOSES IN SEOUL AND INCHEON

	Domestic Use	Industrial Use	Commercial Use	Bath Use	Public Use	Special Use	Total Use
Seoul (1978)	62.6	20.5/1	5.5/2	4.5	0.5	6.4/3	100.0
Incheon (1976)	29.3	31.1	25.6	N.A.	4.6	9.4	100.0

Remarks; /1: Includes water use in factories and restaurants of big scale.

/2: Includes water use in marketing stores and hospitals.

/3: Includes water use in government offices, army and social organizations.

Table H 10 HISTORICAL NON-ADJUSTED RATIO IN METROPOLITAN ZONE

Unit: %

Municipalities	1970	1971	1972	1973	1974	1975	1976
Seoul	45.9	44.7	46.2	44.8	44.0	43.0	38.5
Incheon	41.0	42.0	42.3	43.1	38.3	34.1	32.9
Seongnam	-	-	52.0	21.0	29.0	44.0	42.0
Suweon	-	-	-	-	5.7	17.0	28.2
Anyang	-	-	-	20.0	10.0	9.0	7.0

Source; Ref. H 4.

Remarks; Non-adjusted Ratio = (Production - Revenued Volume) ÷ Production

Table H 11 HISTORICAL WATER CHARGES IN MAJOR CITIES

Unit: ₩/m3

Municipalities	1971	1972	1973	1974	1975	1976
Seoul	14.90	29.2	29.9	30.5	39.0	54.7
Busan	25.20	28.4	30.4	34.7	39.8	52.9
Daegu	23.27	28.5	31.2	32.7	37.1	44.8
Incheon	25.20	29.96	30.8	33.6	57.1	50.5
Gwangju	17.20	28.1	30.2	35.9	54.3	53.0
Daejeon	21.50	30.9	35.9	39.2	42.0	53.9
Masan	18.40	23.9	28.0	30.5	33.3	42.6
Jeonju	20.0	20.0	36.0	N.A.	32.3	41.3
Seongnam	21.0	21.9	22.5	25.3	31.7	44.5
Ulsan	18.30	25.9	29.1	33.1	39.7	49.4
Suweon	16.40	18.4	20.7	22.3	31.9	41.1
Cheongju	12.70	21.0	24.9	31.4	36.5	49.5

Source; Ref. H 4.

Remarks; (1) Water charges of treated water.

(2) Water charges in average of all kinds of usage.

Table H 12 WATER CHARGES BY USES (1977)

	Domestic Use	Industrial Use/1	Commercial Use/2	Bath Use	Public Use
Seoul					
Basic Charge					
Quantities (up to) (m^3/month)	15	30	30	600	100
Flat Charge (₩)	226	1,500	1,200	15,000 - 60,000	1,000
Excess Charge (₩/m^3)	25 - 60	80 - 160	50	30 - 250	10
Daegu					
Basic Charge					
Quantities (up to) (m^3/month)	15	30	20	N.A.	30
Flat Charge (₩)	440	1,650	980	N.A.	900
Excess Charge (₩/m^3)	50 - 85	75 - 160	70 - 100	N.A.	37

Source; Seoul: Ref. H 4.
Daegu: "Water Works Project" City of Daegu, Oct., 1977

Remarks; /1: Includes water supply for factories and restaurants of big scale.

/2: Includes water supply for marketing stores and hospitals.

Table H 13 FACILITIES OF DRAINAGE AND SEWERAGE IN SEOUL

Unit: Area : ha
Length: km

	Drainage		Sewerage					
			Planning		Established		Non-established	
	Sewerage Plant	Pump	Sewer Pipe	Area	Sewer Pipe	Area	Sewer Pipe	Area
1971	1	8	5,000	26,170	1,713	8,740	3,287	17,430
1972	1	7	5,000	26,170	1,845	9,430	3,156	16,740
1973	1	12	5,000	26,170	2,109	10,545	2,891	15,625
1974	1	13	5,000	26,240	2,343	11,574	2,657	14,666
1975	2	15	5,000	26,240	2,517	12,442	2,483	13,798
1976	2	16	5,000	26,240	2,780	12,856	2,220	13,384

Source; Ref. H 42.

Table H 14 POPULATION INCREASE RATIO AND PERCENT TO NATIONAL POPULATION OF MAJOR CITIES

Unit : %

	Annual Increase Ratio			As Percent of National Population									
	Historical	Projected		Historical					Projected				
	'55-'75	'76-'91	'92-2001	'55	'60	'66	'70	'75	'81	'86	'91	'96	2001
1. The Han													
Seoul	7.7	1.6	1.3	7.3	9.8	13.0	17.6	19.8	21.0	21.0	21.0	21.0	21.0
Incheon	4.7	3.5	1.2	1.5	1.6	1.8	2.0	2.3	2.6	2.9	3.1	3.1	3.1
Seongnam	-	3.1	1.7	-	-	-	-	0.8	0.9	0.9	1.0	1.0	1.0
Suweon	5.2	4.5	2.0	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.1
Anyang	-	5.5	1.7	-	-	-	-	0.4	0.5	0.6	0.7	0.7	0.8
Euijeongbu	-	5.6	2.3	-	-	0.3	0.3	0.3	0.4	0.5	0.6	0.6	0.6
Chuncheon	3.7	2.2	1.4	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5
Bucheon	-	3.0	1.3	-	-	-	-	0.3	0.4	0.4	0.4	0.4	0.4
Weonju	2.3	1.4	0.9	0.4	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Chungju	-	0.8	0.8	-	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Banweol	-	17.1	2.3	-	-	-	-	0.1	0.2	0.4	0.5	0.5	0.5
2. The Nagdong													
Busan	4.3	2.4	1.3	4.9	4.7	4.9	6.0	7.0	7.5	7.7	8.0	8.0	8.0
Daegu	5.1	2.0	1.1	2.3	2.7	2.9	3.4	3.8	4.0	4.0	4.1	4.0	4.0
Masan	5.4	6.7	1.8	0.6	0.6	0.5	0.6	1.1	1.6	2.0	2.4	2.4	2.5
Ulsan	-	4.6	1.4	-	-	0.4	0.5	0.7	0.9	1.1	1.2	1.2	1.2
Pohang	4.8	6.0	1.6	0.2	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.8	0.8
Jinju	3.5	3.4	1.2	0.4	0.3	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6
Gumi	4.3	13.1	2.1	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.7	0.7	0.7
Jinhae	2.1	1.4	0.7	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Samcheonpo	-	5.4	2.0	-	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3
Andong	-	1.5	0.8	-	-	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Gimcheon	1.9	1.9	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Chungmu	0.5	1.1	0.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3. The Seomjin													
Yeosu	3.0	5.5	1.6	0.3	0.3	0.3	0.4	0.3	0.5	0.6	0.7	0.7	0.7
Suncheon	2.8	7.1	2.1	0.3	0.3	0.3	0.3	0.3	0.5	0.7	0.7	0.8	0.8

Table H 15 HISTORICAL AND PROJECTED POPULATION OF PIPE-SERVED MUNICIPALITIES

Han River Basin

Unit: 10^3 persons

	Historical[1]						Projected				
	1955	1960	1966	1970	1975	1976[2]	1981	1986	1991	1996	2001
A. Inside Basin											
Seoul Si	1,575	2,445	3,803	5,525	6,889	7,255	7,970	8,630	9,250	9,910	10,510
Incheon Si	321	401	527	643	800	830	1,000	1,190	1,380	1,465	1,550
Chuncheon Si	68	83	100	122	141	142	162	181	200	215	230
Weonju Si	76[3]	77	104	112	120	124	130	140	150	157	164
Chungju Si	-	69	80	87	105	197	112	116	120	125	130
Seongnam Si	-	-	-	-	272	285	333	387	440	480	520
Anyang Si	-	-	-	-	135	146	202	261	320	350	380
Bucheon Si	-	-	-	-	109	120	134	155	175	188	200
Euijeongbu Si	-	-	75	94	108	113	165	213	260	293	325
Jecheon Ebu	32	39	50	61	74	76	82	88	94	96	98
Guri Ebu	(14)[4]	(22)	(14)	(28)	(45)	(47)	(54)	62	70	72	75
Sabug Eub	-	-	-	-	47	47	50	53	55	58	63

Remarks; /1: Population Census data for 1955 - 1975.
/2: Estimated by Statistics Bureau, EPB.
/3: Hyphen shows pre-establishment of Si, Eub on Myeon.
/4: Figures in parentheses show the population before being pipe-served and are not included in total figures.

Table H 15 Continued (2)

Han River Basin

Unit: 10^3 persons

	Historical						Projected				
	1955	1960	1966	1970	1975	1976	1981	1986	1991	1996	2001
A. Inside Basin (cont'd)											
Byeolnae Myeon	(9)	(11)	(14)	(17)	(22)	(23)	(24)	26	28	30	32
Migeum Myeon	(9)	(10)	(14)	(17)	(26)	(27)	(29)	31	34	35	36
Wabu Myeon	(10)	(12)	(20)	(24)	(20)	(20)	(21)	22	23	24	25
Yeoju Eub	13	15	18	18	21	21	22	22	23	23	24
Icheon Eub	(14)	(17)	(19)	(19)	23	23	26	26	26	26	27
Yongin Myeon	(13)	(14)	(15)	(14)	(20)	(20)	(21)	22	23	24	25
Danyang Myeon	9	12	17	19	19	19	19	20	20	21	21
Naesogri Myeon	(5)	(5)	(7)	(7)	7	7	7	7	7	7	7
Sangmo Myeon	(9)	(10)	(12)	(10)	10	10	10	10	10	10	10
Hongcheon Eub	16	20	23	26	29	29	32	34	36	37	39
Yeongweol Eub	14	22	26	29	32	32	35	38	41	43	46
Sangdong Eub	(19)	(19)	(22)	(24)	22	23	23	23	24	25	25
Jeongseon Eub	12	13	17	20	21	21	22	23	24	25	25
Nam Myeon	(5)	(6)	(7)	(11)	(23)	(24)	(30)	35	40	43	45
Sindong Myeon	(7)	(17)	(23)	(22)	(24)	(24)	25	27	28	29	30
Hoengseong Myeon	12	15	16	16	20	20	22	23	25	26	28
Pyeongchang Myeon	(15)	(17)	(19)	(19)	18	18	18	18	18	18	18
Hwacheon Myeon	15	13	15	14	14	14	14	14	14	14	14
Yanggu Myeon	(21)	(13)	(19)	(18)	(17)	(17)	17	17	17	17	17

Table H 15 Continued (3)

Han River Basin

Unit: 10^3 persons

	Historical						Projected				
	1955	1960	1966	1970	1975	1976	1981	1986	1991	1996	2001
A. Inside Basin (cont'd)											
Inje Myeon	18	11	15	15	14	14	14	14	14	14	14
Yangpyeong Myeon	17	15	17	16	18	17	18	19	19	20	20
Gwacheon Myeon	(5)	(6)	(7)	(9)	(13)	(14)	(17)	21	23	26	30
Euiwang Myeon	-	-	(10)	(12)	(19)	(20)	(25)	30	35	37	39
Girin Myeon	(5)	(12)	(13)	(12)	(15)	(15)	16	17	18	19	20
Bug Myeon	16	9	11	11	11	16	11	11	11	11	11
Inside Basin Total	2,214	3,259	4,914	6,828	9,070	9,527	10,691	12,026	13,095	14,013	14,873
B. Outside Basin											
Suweon Si	82	91	128	170	224	235	310	380	450	500	550
Banweol Myeon	-	-	-	-	(16)	(28)	88	416	200	228	250
Songtan Eub	(19)	(34)	(44)	(51)	(57)	58	62	66	70	72	74
Giheung Myeon	(9)	(9)	(8)	(9)	(13)	(13)	13	14	15	15	16
Dongtan Myeon	(8)	(9)	(9)	(10)	(10)	(10)	10	10	10	10	10
Outside Basin Total	82	91	128	170	224	293	483	616	745	825	900

Table H 15 Continued (4)

Nagdong River Basin

Unit: 10^3 persons

	Historical						Projected				
	1955	1960	1966	1970	1975	1976	1981	1986	1991	1996	2001
A. Inside Basin											
Daegu Si	489	677	848	1,081	1,311	1,359	1,500	1,650	1,800	1,900	2,000
Gumi Si	18	20	21	23	42	50	160	230	300	335	370
Andong Si	-	-	64	76	95	98	104	112	120	125	130
Jinju Si	78	87	107	122	155	161	210	238	266	283	300
Gimcheon Si	46	51	57	62	67	69	72	81	90	90	90
Gimhae Eub	41	38	39	45	56	56	59	62	65	66	68
Yeongju Eub	25	32	46	58	71	73	80	88	96	101	107
Sangju Eub	41	47	47	52	52	54	55	56	57	59	60
Yeongcheon Eub	34	39	44	49	51	53	53	55	56	58	60
Hwangji Eub	-	-	-	-	61	59	62	63	63	64	65
Jangseong Eub	-	(67)	(87)	(102)	(56)	(56)	57	58	58	59	60
Jinyeong Eub	19	21	22	20	20	20	20	20	20	20	20
Milyang Eub	33	36	40	41	43	43	45	46	47	49	50
Samrangjin Eub	18	21	22	20	19	19	19	19	19	19	19
Hanam Eub	18	20	20	21	17	17	17	17	17	17	17
Seonsan Myeon	(16)	(17)	(18)	(17)	(18)	(18)	18	19	19	20	20
Gunwi Myeon	(13)	(15)	(16)	(14)	(15)	(15)	15	15	15	15	15
Changnyeong Myeon	18	22	23	23	23	23	23	23	23	23	23
Namji Eub	(17)	(20)	(21)	(20)	(20)	(20)	20	20	20	20	20
Sancheong Myeon	13	14	15	13	14	14	14	14	14	14	14
Habcheon Myeon	13	15	17	16	16	15	17	18	19	19	20
Gaya Myeon	11	18	20	17	13	18	13	13	13	13	13
Euiryeong Myeon	12	14	15	14	14	14	14	14	14	14	14
Goryeong Myeon	12	15	15	14	14	14	14	14	14	14	14
Munsan Myeon	(9)	(10)	(11)	(10)	12	12	12	12	12	12	12

Table H 15 Continued (5)

Nagdong River Basin

Unit: 10^3 persons

	Historical						Projected				
	1955	1960	1966	1970	1975	1976	1981	1986	1991	1996	2001
A. Inside Basin (cont'd)											
Jeongchon Myeon	(9)	(10)	(11)	(11)	(6)	(6)	6	6	6	6	6
Geochang Myeon	20	24	35	36	42	42	44	46	48	50	52
Gaeun Eub	(15)	(20)	(24)	(21)	(20)	(20)	20	20	20	20	20
Yangsan Myeon	8	8	8	9	10	9	10	10	10	10	10
Jeomchon Eub	-	28	32	37	42	42	44	46	47	49	51
Waegwan Eub	15	18	28	30	31	30	33	35	36	38	40
Bugsam Myeon	(7)	(8)	(9)	(8)	(7)	(7)	(7)	7	7	7	7
Yagmog Myeon	(15)	(17)	(18)	(17)	(17)	(17)	(17)	17	17	17	17
Yecheon Eub	(22)	(25)	(26)	(27)	28	28	29	30	31	32	33
Euiseong Eub	20	23	24	24	26	26	27	29	30	31	32
Angye Myeon	(12)	(14)	(15)	(14)	(14)	(14)	14	14	14	14	14
Bongyang Myeon	(12)	(13)	(13)	(12)	(12)	(11)	12	12	12	12	12
Cheongdo Eub	23	26	27	26	26	25	26	26	26	26	26
Cheongsong Myeon	9	10	11	12	12	12	12	12	12	12	12
Bonghwa Myeon	-	(18)	(19)	(18)	20	20	21	22	23	24	25
Ansim Eub	(13)	(16)	(18)	(23)	31	31	33	35	37	38	40
Seongju Myeon	(16)	(18)	(20)	(19)	19	19	20	21	21	22	23
Yeongyang Myeon	12	14	16	17	19	19	19	20	21	21	23
Seohu Myeon	(10)	(11)	(12)	(10)	(10)	(10)	(10)	10	10	10	10
Pungsan Eub	(21)	(23)	(25)	(22)	(22)	(22)	(22)	22	22	22	22
Pungcheon Myeon	(14)	(15)	(18)	(16)	(15)	(15)	(15)	15	15	15	15
Namseon Myeon	(8)	(8)	(9)	(8)	(8)	(8)	(8)	8	8	8	8
Namhu Myeon	(8)	(8)	(9)	(8)	(8)	(8)	(8)	8	8	8	8
Iljig Myeon	(11)	(12)	(13)	(12)	(12)	(12)	(12)	12	12	12	12
Homyeong Myeon	(10)	(11)	(12)	(11)	(10)	(10)	(10)	10	10	10	10
Danchon Myeon	(7)	(8)	(9)	(8)	(8)	(8)	(8)	8	8	8	8
Inside Basin Total	1,028	1,318	1,642	1,935	2,473	2,594	3,043	3,458	3,748	3,931	4,117

Table H 15 Continued (6)

Unit: 10^3 persons

	Historical						Projected				
	1955	1960	1966	1970	1975	1976	1981	1986	1991	1996	2001
Nagdong River Basin											
B. Outside Basin											
Busan Si	1,049	1,164	1,430	1,876	2,454	2,574	2,840	3,180	3,520	3,760	4,000
Masan Si	130	158	155	191	372	425	620	835	1,050	1,150	1,250
Jinhae Si	68	68	81	92	104	104	114	122	130	135	140
Ulsan Si	-	-	113	159	253	270	350	435	520	560	600
Pohang Si	52	60	66	79	134	152	208	274	340	370	400
Samcheonpo Si	-	50	53	55	60	60	90	115	140	155	170
Chungmu Si	(61)	(48)	(51)	(55)	67	68	72	76	80	80	80
Sacheon Eub	(22)	(17)	(17)	(17)	18	17	19	21	22	24	25
Goseong Eub	(21)	(24)	(25)	(25)	27	27	28	30	32	33	35
Georyu Myeon	(9)	(11)	(11)	(10)	(11)	(11)	11	11	11	11	11
Gwangbo Myeon	(9)	(10)	(11)	(10)	(10)	(10)	10	10	10	10	10
Outside Basin Total	1,299	1,500	1,898	2,452	3,489	3,699	4,362	5,109	5,855	6,288	6,721
The Seomjin River Basin											
A. Inside Basin											
Namweon Eub	(28)	(39)	(44)	(46)	51	52	53	55	57	60	62
Boseong Eub	(17)	(19)	(22)	(21)	(20)	(20)	20	20	20	20	20
Gurye Eub	(16)	(20)	(20)	(20)	(20)	(20)	20	20	20	20	20
Gogseong Myeon	(15)	(16)	(17)	(15)	(16)	(16)	16	16	16	16	16
Sunchang Myeon	(14)	(16)	(17)	(16)	(16)	(16)	16	16	16	16	16
Imsil Myeon	(13)	(15)	(16)	(15)	(15)	(15)	15	15	15	15	15
Dunnam Myeon	(13)	(14)	(15)	(14)	(14)	(14)	14	14	14	14	14
Hadong Eub	17	19	21	20	20	20	20	20	20	20	20
Geumnam Myeon	14	17	19	17	17	17	17	17	17	17	17
Inside Basin Total	31	36	40	37	88	89	191	193	195	198	200
B. Outside Basin											
Yeosu	73	87	102	114	131	135	180	240	300	325	350
Suncheon	62	69	79	91	108	110	205	265	325	363	400
Outside Basin Total	135	156	181	205	239	245	385	505	625	688	750

Table H 16 SERVICE FACTORS BY MUNICIPALITY SIZE GROUPS

Unit : %

Municipality Size Groups by Population	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
More than 3,000,000	87.5	94.0	95	95	95	98	98
500,000 - 3,000,000	74.0	92.4	93	93	95	95	98
100,000 - 500,000	70.0	82.1	85	85	90	90	95
Less than 100,000	39.7	55.2	60	60	65	65	70

Table H 17 PER CAPITA DAILY USE OF MUNICIPAL WATER

Unit : lpcd

Groupings	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
Pipe-served :							
More than 3 million	210	300	320	350	380	410	450
500,000 - 3 million	180	210	250	300	320	350	380
100,000 - 500,000	120	140	170	210	230	250	270
50,000 - 100,000	70	110	140	180	190	210	220
Less than 50,000			130	150	160	180	190
Others :							
Non-Pipe-Served	-	-	30	30	30	30	30
Non-Water-Served	-	-	30	30	30	30	30

Table H 18 SERVICE FACTOR AND PER CAPITA DAILY USE

Municipalities	Service Factor and Per Capita Daily Use											
	Historical		Projected									
	1976 /1		1981		1986		1991		1996		2001	
	%	lpcd	%	lpcd	%	lpcd	%	lpcd	%	lpcd	%	lpcd
Han River Basin												
A. Inside Basin												
(1) More than 3 mil.												
Seoul	94	258	96	330	97	350	97	380	98	410	98	450
(2) 500,000 - 3 mil.												
Incheon	88	197	90	250	95	300	95	320	98	350	98	380
(3) 100,000 - 500,000												
Seongnam	82	64	85	170	93	210	93	230	95	250	95	270
Anyang	73	90	85	170	93	210	93	230	95	250	95	270
Bucheon	69	150	85	170	93	210	93	230	95	250	95	270
Chuncheon	79	121	85	170	93	210	93	230	95	250	95	270
Weonju	80	163	85	170	93	210	93	230	95	250	95	270
Euijeongbu	73	85	85	170	93	210	93	230	95	250	95	270
Chungju	71	101	85	170	93	210	93	230	95	250	95	270
(4) Less than 100,000	42 /2	109 /2	60	140	60	180	65	190	65	210	70	220
B. Outside Basin												
(1) 100,000 - 500,000												
Suweon	83	94	85	170	85	210	90	230	90	250	95	270
Banweol	-	-	85	170	85	210	90	230	90	250	95	270
(2) Less than 100,000	66 /2	76 /2	70	130	70	150	70	160	70	180	70	190

Remarks; /1: Excluded industrial use supplied through municipal water pipeline

/2: Including data of municipalities supplied from other rivers than the Han

Table H 18 Continued (2)

Municipalities	Historical 1976/1		Projected 1981		1986		1991		1996		2001	
	%	lpcd	%	lpcd	%	lpcd	%	lpcd	%	lpcd	%	lpcd
Nagdong River Basin												
A. Inside Basin												
(1) 500,000 - 3 mil.												
Daegu	96	156	96	250	97	300	97	320	98	350	98	380
(2) 100,000 - 500,000												
Gumi	51	255	85	260	85	265	90	265	90	270	95	270
Jinju	95	107	95	170	95	210	95	230	95	250	95	270
Andong	86	105	90	170	93	210	93	230	95	250	95	270
(3) Less than 100,000	/2 59	/2 107	60	140	60	180	65	190	65	210	70	220
B. Outside Basin												
(1) More than 3 mil.												
Busan	92	163	93	300	95	330	95	350	98	400	98	450
(2) 500,000 - 3 mil.												
Musan	74	140	93	250	93	300	95	320	95	350	98	380
(3) 100,000 - 500,000												
Ulsan	91	165	93	200	95	250	95	300	98	350	98	380
Pohang	92	127	92	170	93	210	93	230	95	250	95	270
Jinhae	93	70	93	170	94	210	94	230	95	250	95	270
Samcheonpo	83	151	90	170	93	210	93	230	95	250	95	270
(4) Less than 100,000	/2 80	/2 128	80	140	80	180	80	190	80	210	80	220
Seomjin River Basin												
A. Inside Basin												
(1) Less than 100,000	36	56	60	130	60	150	65	160	65	180	70	190
B. Outside Basin												
(1) 100,000 - 500,000												
Yaosu	91	118	93	170	94	210	94	230	95	250	95	270
Suncheon	78	76	85	170	85	210	90	230	90	250	95	270
(2) Less than 100,000	63	77	65	130	65	150	70	160	70	180	70	190

Remarks; /1: Excluded industrial use supplied through municipal water pipeline

/2: Including data of municipalities supplied from other rivers than the Han

Table H 19 POPULATION DEPENDING ON THE THREE RIVERS

Unit: 10^3 persons

Grouping	Historical 1976	Projected 1981	1986	1991	1996	2001
Han River Basin						
A. Inside Basin	11,900 /1	12,800	13,900	14,800	15,700	16,500
Pipe-served	8,512	9,894	11,304	12,354	13,406	14,276
Non-pipe-served	1,017	797	722	741	607	597
Non-water-served	2,371	2,209	1,874	1,705	1,687	1,627
B. Outside Basin						
Pipe-served	233	398	510	652	724	831
C. The Han Depending						
Population	12,133	13,298	14,410	15,452	16,424	17,331
Index (1976=100)	(100)	(110)	(119)	(127)	(135)	(143)
Nagdong River Basin						
A. Inside Basin	6,000 /1	6,260	6,490	6,690	6,890	7,020
Pipe-served	2,106	2,511	2,863	3,200	3,389	3,641
Non-pipe-served	488	532	595	548	542	476
Non-water-servev	3,406	3,217	3,032	2,942	2,959	2,903
B. Outside Basin						
Pipe-served	3,264	4,034	4,807	5,529	6,080	6,537
C. The Nagdong Depending						
Population	9,264	10,294	11,297	12,219	12,970	13,557
Index (1976=100)	(100)	(111)	(122)	(132)	(140)	(146)
Seomjin River Basin						
A. Inside Basin	870 /1	830	800	770	760	750
Pipe-served	32	115	116	127	129	140
Non-pipe-served	57	76	77	68	69	60
Non-water-served	781	639	607	575	562	550
B. Outside Basin						
Pipe-served	208	341	451	575	637	713
C. The Seomjin Depending						
Population	1,078	1,171	1,251	1,345	1,397	1,463
Index (1976=100)	(100)	(109)	(116)	(125)	(130)	(136)

Remarks; /1: Derived from Fig. A 3

Table H 20 PIPE-SERVED MUNICIPAL WATER REQUIREMENT

Unit : $10^3 m^3/d$

Groupings	Historical	Projected				
	1976	1981	1986	1991	1996	2001
Han River Basin						
A. Inside Basin						
Seoul si	1,761.8	2,524.8	2,929.9	3,409.7	3,981.9	4,635.0
Incheon si	144.7	225.0	339.2	419.5	502.5	577.2
Chuncheon si	13.5	23.4	35.3	42.8	51.1	59.0
Weonju si	16.1	18.8	27.3	32.1	37.3	42.1
Chungju si	7.6	16.2	22.7	25.7	29.7	33.3
Seongnam si	15.0	48.1	75.6	94.1	114.0	133.4
Anyang si	9.5	29.2	51.0	68.4	83.1	97.5
Bucheon si	12.3	19.4	30.3	37.4	44.7	51.3
Euijeongbu si	7.0	23.8	41.6	55.6	69.6	83.4
Less than 100,000	17.7	40.5	80.6	98.1	112.7	132.6
Inside Basin Total	2,005.2	2,969.2	3,633.5	4,283.4	5,026.6	5,844.8
B. Outside Basin						
Suweon si	18.4	44.8	67.8	93.2	112.5	141.1
Banweol Myeon	-	12.8	26.0	41.4	51.3	64.3
Less than 100,000	4.0	7.7	9.5	10.7	12.4	13.3
Outside Basin Total	22.4	65.3	103.3	145.3	176.2	218.7
C. Han Depending Area Total	2,027.6	3,034.5	3,736.8	4,428.7	5,202.8	6,063.5

Remarks ; Industrial use through municipal water supply pipeline is excluded.

Table H 20 Continued (2)

Unit: 10^3 m^3/d

Grouping	Historical 1976	Projected 1981	1986	1991	1996	2001
Nagdong River Basin						
A. Inside Basin						
Daegu Si	205.1	360.0	480.0	558.7	651.7	744.8
Gumi Si	16.1	35.4	51.8	71.6	81.4	94.9
Andong Si	9.0	15.9	21.9	25.7	29.7	33.3
Jinju Si	16.4	33.9	47.5	58.1	67.2	77.0
Less than 100,000	44.7	89.8	132.6	155.9	175.8	202.8
Inside Basin Total	291.4	535.0	734.0	870.0	1,005.8	1,152.8
B. Outside Basin						
Busan Si	385.0	792.4	996.9	1,170.4	1,473.9	1,764.0
Masan Si	39.4	144.2	233.0	319.2	382.4	465.5
Jinhae Si	6.8	18.0	24.1	28.1	32.1	35.9
Ulsan Si	40.6	65.2	103.9	148.2	192.2	223.4
Pohang Si	17.8	32.5	53.6	72.7	88.0	102.6
Samcheonpo Si	6.0	13.8	22.5	29.9	36.8	43.7
Less than 100,000	8.3	15.4	21.4	23.8	26.5	28.4
Outside Basin Total	503.9	1,081.5	1,455.4	1,792.3	2,231.9	2,663.5
C. Nagdong Depending						
Area Total	795.3	1,616.5	2,189.4	2,662.3	3,237.7	3,816.3
Seomjin River Basin						
A. Inside Basin						
Less than 100,000	1.8	14.9	17.4	20.3	23.2	26.6
B. Outside Basin						
Yeosu Si	14.2	28.4	47.5	64.9	77.3	89.9
Suncheon Si	6.5	29.6	47.3	67.3	81.7	102.6
Outside Basin Total	20.7	58.0	94.8	132.2	159.0	192.5
C. Seomjin Depending						
Area Total	22.5	72.9	112.2	152.5	182.2	219.1

Table H 21 HISTORICAL AND PROJECTED MUNICIPAL WATER REQUIREMENT

Han River Basin

Unit: 10^6 m^3/yr

Municipalities	Historical		Projected				
	1971	1976	1981	1986	1991	1996	2001
Seoul	340.4	647.8	925.0	1,072.1	1,247.4	1,455.3	1,693.7
Incheon	29.3	53.9	83.2	124.4	153.9	183.7	211.0
Chuncheon	3.6	5.3	8.8	13.0	15.8	18.8	21.7
Weonju	2.8	6.2	7.1	10.1	11.8	13.7	15.4
Chungju	1.7	3.1	6.1	8.4	9.5	10.9	12.2
Seongnam	1.5	6.0	18.1	27.9	34.7	41.9	49.0
Anyang	1.1	3.9	11.0	18.8	25.2	30.5	35.8
Bucheon	1.0	4.9	7.3	11.2	13.8	16.4	18.8
Euijeongbu	2.1	6.7	16.4	24.7	34.0	41.0	51.5
Suweon	3.3	6.7	16.4	24.7	34.0	41.0	51.5
Banweol	- /1	- /1	4.7	9.5	15.1	18.7	23.5
Less than 100,000	35.1	36.5	43.8	56.9	61.4	67.3	74.4
Total	421.9	777.2	1,140.5	1,392.3	1,643.1	1,923.8	2,237.6

Remarks; The requirements include those of non-pipe-served and non-water-served population.

/1: Included in "Less than 100,000".

Table H 21 Continued (2)

Unit: 10^6 m^3/yr

Municipalities	Historical 1971	Historical 1976	Projected 1981	Projected 1986	Projected 1991	Projected 1996	Projected 2001
Nagdong River Basin							
Busan	68.1	140.5	289.2	363.9	427.2	538.0	643.9
Daegu /1	42.1	75.3	132.1	175.8	204.5	238.3	272.3
Musan /1	8.0 /2	14.4	52.6	85.0	116.5	139.6	169.9
Gumi	- /2	6.2	13.2	19.3	26.4	29.8	34.8
Andong	1.8	3.4	5.9	8.1	9.5	10.9	12.2
Jinju	4.5	6.1	12.5	17.5	21.4	24.7	28.3
Ulsan	4.3	14.8	23.8	37.9	54.1	70.1	81.6
Jinhae	1.7	2.5	6.6	8.8	10.3	11.7	13.1
Pohang	2.4	6.5	11.9	19.5	26.5	32.1	37.4
Samcheonpo	0.8	2.2	5.0	8.2	10.9	13.4	16.0
Less than 100,000	53.8	61.5	78.3	95.3	102.6	111.2	120.0
Total	187.5	333.4	631.1	839.3	1,009.9	1,219.8	1,429.5
Seomjin River Basin							
Yeosu	4.2	5.2	10.4	17.3	23.7	28.2	32.8
Suncheon	1.5	2.4	10.8	17.3	24.6	29.8	37.4
Less than 100,000	10.1	9.8	13.3	13.9	14.5	15.4	16.4
Total	15.8	17.4	34.5	48.5	62.8	73.4	86.6

Remarks; The requirements include those of non-pipe-served and non-water-served population.

/1: Includes requirement of Changweon.
/2: Included in "Less than 100,000".

Table H 22 SUMMARY OF ESTIMATED M-WATER REQUIREMENT AND POPULATION

	Historical	Projected					Annual Growth Rate
	1976	1981	1986	1991	1996	2001	1976-2001 (%)
Han River Basin							
M-Water Req. (10^6 m^3/yr.)	777.2 (100)	1,140.5 (147)	1,392.3 (179)	1,643.1 (211)	1,923.8 (248)	2,237.6 (288)	4.3
Han Depending Population (10^6)	12.1 (100)	13.3 (110)	14.4 (119)	15.5 (127)	16.4 (135)	17.3 (143)	1.4
Nagdong River Basin							
M-Water Req. (10^6 m^3/yr.)	333.4 (100)	631.1 (189)	839.3 (252)	1,009.9 (303)	1,219.8 (366)	1,429.5 (429)	6.0
Nagdong Depending Population (10^6)	9.3 (100)	10.3 (111)	11.3 (122)	12.2 (132)	13.0 (140)	13.6 (146)	1.5
Seomjin River Basin							
M-Water Req. (10^6 m^3/yr.)	17.4 (100)	34.5 (198)	48.5 (279)	62.8 (361)	73.4 (422)	86.6 (498)	6.6
Seomjin Depending Population (10^6)	1.1 (100)	1.2 (109)	1.3 (116)	1.3 (125)	1.4 (130)	1.5 (136)	1.2

Table H 23 UNIT REQUIREMENT OF INDUSTRIAL WATER

Unit: m^3/ha/day

Field of Industries	Japanese Date	Korean Data		Adopted
	Ref. H 7	Ref. H 8	Ref. H 1	
Flood Processing	484	351	125	350
Textile	483	N.A.	448	450
Pulp & Paper	1,781	N.A.	540	600
Chemical	719	240	403	500
Oil Refining	172	51	46	100
Steel	271	354	N.A.	300
Machinery	89	160	N.A.	150
Electrical	137	113	N.A.	150

Table H 24 HISTORICAL AND PROJECTED INDUSTRIAL WATER REQUIREMENT

Unit: 10^6 m^3/yr

	Historical	Projected				
	1976	1981	1986	1991	1996	2001
Han River Basin						
Seoul	154.5	176.1	209.8	261.9	340.1	464.1
Incheon	23.1	36.5	59.3	96.4	156.6	254.5
Chuncheon	0.9	1.3	2.0	2.4	2.8	3.2
Weonju	2.6	2.9	3.3	3.7	4.0	4.4
Seongnam	1.8	4.4	6.9	8.6	10.4	12.2
Suweon	8.5	17.8	23.0	37.0	59.6	96.1
Anyang	17.3	36.0	43.4	70.0	112.7	181.4
Banweol	-	8.6	42.9	94.4	207.8	457.6
Total	208.7	283.6	390.6	574.4	894.0	1,473.5
Index (1976=100)	(100)	(136)	(187)	(275)	(428)	(706)
Nagdong River Basin						
Daegu	18.8	61.0	75.9	101.5	127.0	151.8
Gumi	14.2	24.4	41.3	56.6	59.5	62.5
Jinju	-	5.8	10.2	14.6	19.0	24.4
Masan	25.9	31.1	33.8	35.5	37.3	39.2
Jinhae	3.7	5.4	5.7	6.8	7.1	7.4
Changweon	7.9	64.6	79.9	95.8	111.7	126.5
Busan	60.2	127.8	171.6	204.4	233.6	262.8
Pohang	18.9	60.4	101.0	127.6	129.5	131.5
Ulsan/Onsan	50.6	127.4	175.0	209.4	220.0	231.3
Samcheonpo	0.5	2.7	12.6	22.4	32.3	42.0
Yangsan	-	5.5	5.5	5.5	5.5	5.5
Total	200.7	516.1	712.5	880.1	982.5	1,084.9
Index (1976=100)	(100)	(257)	(355)	(439)	(490)	(541)
Seomjin River Basin						
Yeosu	-	-	5.5	8.3	8.8	9.2
Yeocheon	4.7	100.5	118.2	131.4	138.2	145.1
Gwangyang	-	-	78.3	147.9	214.0	281.1
Suncheon	-	3.1	5.3	7.6	9.7	11.8
Total	4.7	103.6	207.3	295.2	370.7	447.2
Index (1976=100)	(100)	(2,204)	(4,411)	(6,281)	(7,887)	(9,515)

Table H 25 M&I WATER REQUIREMENT IN THREE BASINS

Unit: 10^6 m^3/yr

	Historical	Projected					Annual Increase Ratio
	1976	1981	1986	1991	1996	2001	1976-2001 (%)
Han River Basin							
Inside:							
M-Water Requirement	769.0	1,116.7	1,354.6	1,590.0	1,859.6	2,157.9	4.2
I-Water Requirement	200.2	257.3	324.7	442.9	626.7	919.9	6.3
M&I Water Requirement	969.2	1,374.0	1,679.3	2,032.9	2,486.3	3,077.8	4.7
Outside:							
M-Water Requirement	8.2	23.8	37.7	53.0	64.3	79.8	9.5
I-Water Requirement	8.5	26.5	65.9	131.4	267.5	553.7	18.2
M&I Water Requirement	16.7	50.3	103.6	184.4	331.8	633.5	15.7
Basin Total:							
M-Water Requirement	777.2	1,140.5	1,392.3	1,643.0	1,923.9	2,237.7	4.3
I-Water Requirement	208.7	283.8	390.6	574.3	894.2	1,473.6	8.1
M&I Water Requirement	985.9	1,424.3	1,782.9	2,217.3	2,818.1	3,711.3	5.4
Nagdong River Basin							
Inside:							
M-Water Requirement	149.5	236.4	308.0	355.6	405.2	457.1	4.6
I-Water Requirement	33.0	96.7	132.9	178.2	210.9	244.1	8.3
M&I Water Requirement	182.5	333.1	440.8	533.7	616.1	701.3	5.5
Outside:							
M-Water Requirement	183.9	394.7	531.2	654.2	814.6	972.2	6.9
I-Water Requirement	167.7	419.5	579.8	701.9	771.6	840.8	6.7
M&I Water Requirement	351.6	814.3	1,111.0	1,356.1	1,586.2	1,812.9	6.8

Table H 25 Continued (2)

Unit: 10^6 m^3/yr

	Historical	Projected					Annual Increase Ratio
	1976	1981	1986	1991	1996	2001	1976-2000 (%)
Nagdong River Basin (cont'd)							
Basin Total:							
M-Water Requirement	333.4	631.1	839.2	1,009.8	1,219.9	1,429.3	6.0
I-Water Requirement	200.7	516.3	712.7	880.1	982.5	1,084.9	7.0
M&I Water Requirement	534.1	1,147.4	1,551.9	1,889.9	2,202.4	2,514.3	6.4
Seomjin River Basin							
Inside:							
M-Water Requirement	9.7	13.4	13.9	14.5	15.4	16.4	2.1
I-Water Requirement	-	-	-	-	-	-	-
M&I Water Requirement	9.7	13.4	13.9	14.5	15.4	16.4	2.1
Outside:							
M-Water Requirement	7.6	21.2	34.6	48.2	58.0	70.3	9.3
I-Water Requirement	4.7	103.6	207.3	295.2	370.6	444.4	20.0
M&I Water Requirement	12.3	124.8	241.9	343.4	428.6	514.3	61.1
Basin Total							
M-Water Requirement	17.3	34.6	48.5	62.7	73.4	86.7	6.7
I-Water Requirement	4.7	103.6	207.3	295.2	370.6	444.0	20.0
M&I Water Requirment	220.0	138.2	255.8	357.9	444.0	530.7	13.6

Table H 26 CORRELATION OF BASIN DIVISIONS FOR NET M&I WATER WITHDRAWAL TO SUB-BASINS FOR NET AGRICULTURAL WATER WITHDRAWAL

1. The Han

M&I Water Withdr'l	Agr'l Water Withdr'l
H - 1	HN-16(2)
H - 2	HN-16(1)
H - 3	HN-15(1)
H - 4	HN-15(2)
H - 5	HN-10(2)
H - 6	HN-10(3)
H - 7-1/1	HN-10(1)
H - 7-2	HN-07(2) HN-08 HN-09 HN-10(1)
H - 8	HN-07(1)
H - 9	HN-06(1)
H - 10-1/2	HN-05
H - 10-2	HN-02 HN-03(1) HN-03(2) HN-05
H - 10-3	HN-04(1)
H - 11	HN-04(2)
H - 12	HN-13
H - 13-1	HN-14
H - 13-2/3	HN-14
H - 13-3	HN-11 HN-12
H - 14	HN-01(1) HN-01(2)
H - 15	HN-06(2)

2. The Nagdong

M&I Water Withdr'l	Agr'l Water Withdr'l
N - 1	NSB-01
N - 2	NSB-02
N - 3	NSB-03
N - 4-1/4	(NSB-05)
N - 4-2	NSB-04
N - 4-3	NSB-05 NSB-06(1) NSB-06(2) NSB-06(3) NSB-06(4) CSB-05 CSB-06(1) CSB-06(2)
N - 5	CSB-07
N - 6-1/5	CSB-08 CSB-09
N - 6-2	
N - 7	CSB-10
N - 8-1	CSB-13
N - 8-2	CSB-14
N - 9	CSB-12
N - 10	SSB-15(2) SSB-15(3)
N - 11	SSB-15(1)
N - 12	SSB-16
N - 13	SSB-19
N - 14	SSB-17 SSB-18
N - 15	CSB-11

3. The Seomjin

M&I Water Withdr'l	Agr'l Water Withdr'l
S - 1	SM-05
S - 2	SM-02(3)
S - 3	SM-02(2)
S - 4	SM-03 SM-04 SM-02(1)
S - 5-1	SM-01
S - 5-2	(Downstream of Abrug : diversion water to outside basin.)

Remarks ;

/1 : A part of Sub-basin HN-10(1); upstream of the confluence of the flows of Gujeol dam downstream and Imgye dam downstream

/2 : A part of Sub-basin HN-05; upstream of the confluence of the flows of Dalcheon dam downstream and Chungju dam downstream

/3 : A part of Sub-basin HN-14; upstream of the confluence of the flows of Hwacheon dam downstream and Soyang dam downstream

/4 : A part of Sub-basin NSB-05; upstream of the confluence of the flows of Andong dam downstream and Imha dam downstream

/5 : CSB-08 and -09 are sub-divided into N-6-1 and N-6-2; N-6-1 covering the main stem of the Geumho, N-6-2 its tributaries

Table H 27 NET M&I WATER WITHDRAWAL

Unit: 10^6 m^3/yr

	Historical				Projected					Annual Growth Rate 1976-2000 (%)
	1967	1968	1971	1976	1981	1986	1991	1996	2001	
Han River Basin										
Inside Basin	84.1	104.7	183.0	344.5	501.1	640.1	794.6	995.6	1,262.3	5.3
Outside Basin	0	0	0	10.8	44.5	97.7	178.6	325.9	627.7	17.6
Area Total	84.1	104.7	183.0	355.3	545.6	737.8	973.2	1,321.5	1,890.0	6.9
Nagdong River Basin										
Inside Basin	23.9	24.8	35.4	55.2	99.9	132.2	159.9	184.8	210.4	5.5
Outside Basin	45.2	47.1	114.1	247.9	702.3	989.7	1,201.1	1,423.8	1,643.1	7.9
Area Total	69.1	71.9	149.5	303.1	802.2	1,121.9	1,361.0	1,608.6	1,853.5	7.5
Seomjin River Basin										
Inside Basin	3.3	3.3	3.3	3.2	4.2	4.3	4.5	4.8	5.1	1.0/1
Outside Basin	0	0	0	0	109.3	221.9	323.5	408.7	494.3	7.8/1
Area Total	3.3	3.3	3.3	3.2	113.5	226.2	328.0	413.5	499.4	7.7/1

Remarks; /1: Annual growth rate for the period of 1981-2001.