ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

STUDY ON ASSESSMENT OF WATER RESOURCES OF MEMBER COUNTRIES AND DEMAND BY USER SECTORS

JAPAN:

WATER RESOURCES AND THEIR USE

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FOREWORD

Adequate and comparable information on water resources and their current and future use in various sectors of the economy is essential for taking proper decisions in formulating and implementing national policies on sustainable development and environmentally sound management of water resources. However, in spite of great strides in managing their water resources made by many countries in the Asian and Pacific region during the 1980s, there are still several major constraints that remain to be solved such as wastage and inefficient use of water, and widespread pollution of river systems and aquifers.

In this respect, the experience gained in Japan in the quantitative and qualitative assessment of its freshwater resources and their development and management aimed at the sustainable provision of water supply for population, industries and agriculture and conservation of water resources would certainly be of interest to many developing countries in Asia and the Pacific.

It is hoped that those who are involved in assessing this finite and vulnerable resource and its potential for meeting the current and foreseeable water demand will find this publication of value in their efforts to obtain sustainable use of water resources and to protect them from pollution and depletion.

The report has been prepared by the Natural Resources Division of the Economic and Social Commission for Asia and the Pacific, in collaboration with the Water Resources Department of the National Land Agency of Japan. The Natural Resources Division gratefully acknowledges the latter's contribution to the finalization of the draft report.

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GENERAL

Japan consists of four principal islands – Honshu, Hokkaido, Kyushu and Shikoku, and of about 6,800 small adjacent islands (figure I). The islands of the Japanese archipelago form a slender arc stretching in the Pacific Ocean over 2,800 km from north-east to south-west along the eastern coast of the continent of Asia. The maximum width of the country is less than 300 km.

The islands are separated from the mainland by the Sea of Japan. The nearest point to Japan from the Asian continent is the Korean peninsula, about 200 km away.

The total land area of Japan is 377,719 km^2, of which the four large islands account for about 94 per cent.

About 73 per cent of the total land area in Japan is occupied by mountains. A long chain of mountains runs through the middle of the archipelago, dividing it into the Pacific Ocean side and the Japan Sea side. The plains and intermontane basins scattered throughout the country make up the rest of the land area. The flat lands, where the most of population live, are mainly comprised of flood plains formed by the deposition of soil and rocks transported from the mountains by rivers.

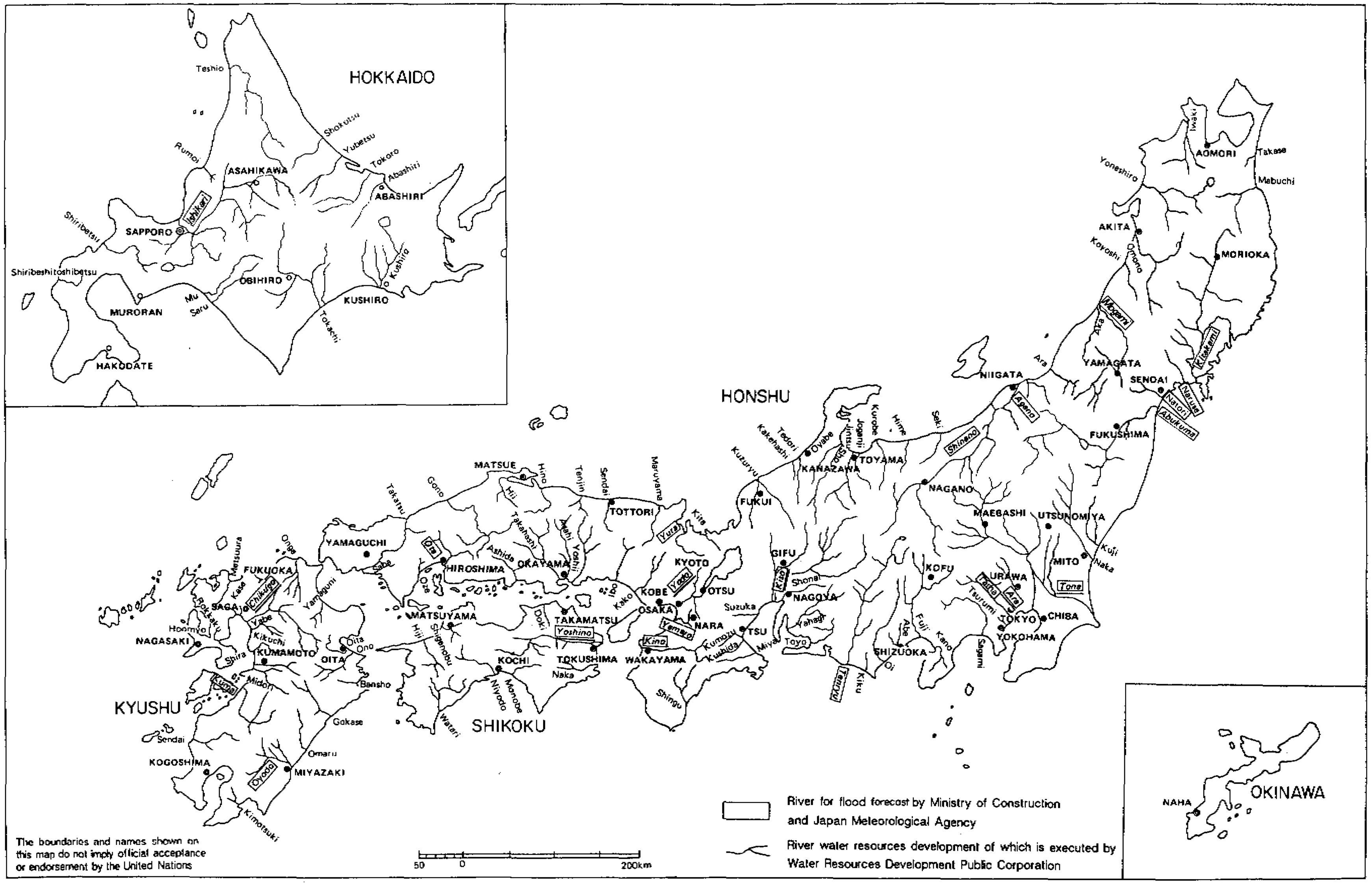

Figure I. Rivers of Japan (Class A)

Source: Rivers in Japan, River Bureau, Ministry of Construction, 1985

PART ONE

WATER RESOURCES AVAILABILITY

A. Climate and precipitation

1. *Climate*

Japan is located at the northeastern end of the so-called monsoon area which also covers the Korean Peninsula, China, India and the countries of South-East Asia. The climate is mainly affected by the continental and the Pacific Ocean air masses. Most of Japan lies in the temperate climate zone, and there are distinct seasonal changes in climate. The islands in the south of the country have a subtropical climate, while the northern part of Japan lies in a subarctic zone.

Remarkable differences in climate also exist between the Pacific Ocean side and the Japan Sea side. The difference in climate between the two zones is caused by the summer monsoon which blows from the Pacific Ocean bringing warmer temperatures and rain, and the winter monsoon from the Asian continent, which brings freezing temperatures and heavy snowfalls to areas on the Japan Sea side. So, in summer the weather on the Pacific Ocean side of Japan is warm and humid, while in winter the weather is dry and windy. The regions facing the Sea of Japan receive much precipitation in the form of snow from December to February.

2. *Precipitation*

There is a marked rainy season in the second half of June and the first half of July, when it rains over a large part of the country generally with moderate rainfall intensity. The rainy season is longer and the rainfall more abundant in the south-west than in the north-east. In August and September, three typhoons ordinarily strike the country every year. During this season certain places receive a heavy precipitation of more than 100 mm a day resulting in disastrous flash floods which sometimes cause significant damage in densely populated short river valleys. The typhoons and the rainy season contribute from 30 to 50 per cent of the annual precipitation, which ranges from 800 mm in the north of the Hokkaido island to 3,600 mm in the southern part of the country (figure II).

Fluctuations in the amount of the average annual precipitation in the country during the period from 1897 to 1992 are shown in figure III. The periods of abundant rainfall have alternated with the periods of relatively low precipitation. Since the 1960s, there is an observed tendency that the volume of precipitation has slightly declined.

Japan seems to have abundant precipitation compared with many other countries of the region. Based on observations of more than 1,300 meteorological stations, the mean annual precipitation for the whole country for the period from 1956 to 1985 is estimated at 1,749 mm, that is equivalent to a total volume of 660.7 billion m^3 (table 1). This figure is almost twice as much as the world annual average precipitation. However, since the density of population in Japan is one of the highest in the world, the amount of average annual precipitation per capita of 5,500 m^3 (1985) is only one-fifth of the world's average of about 27,000 m^3.[1,2] Moreover, there are considerable regional differences in the population density within the country. The precipitation per capita in Kanto and Kinki districts, where the population is excessively concentrated in areas around Tokyo and Osaka, is only as little as 1/3 and 1/2 of the mean national value, respectively.

Precipitation falls during comparatively short periods of time and the rivers in Japan are generally short and steep. Consequently, there is a great difference in the discharge rate of the rivers during floods induced by rains and low water periods. As a result, a considerable portion of rainfall runs off rapidly into the sea leading to the difficulty in proper utilization of surface water resources.

The amount of potential water resources in Japan obtained by deducting the amount of gross evaporation from the amount of gross precipitation is about 435 billion m^3 in an average rain year and around 303 billion m^3 in a low-rain year (table 1). The distribution of precipitation and potential water resources by region is shown in table 2. The theoretically maximum possible amount of utilizable surface water is roughly estimated at 200 billion m^3 a year.[3]

B. Surface water resources

1. *Rivers*

In Japan, there are more than 2,700 river systems with about 347,600 km^2 of the total catchment area, which comprises 92 per cent of the total area of the country. The rivers emanating from both sides of mountain ranges are usually short with steep gradients. There are only 10 rivers more than 200 km long. The longest, the Shinano River, which winds through Nagano and Niigata prefectures of the Honshu island and empties into the Sea of Japan, is only 367 km long (Annex I).

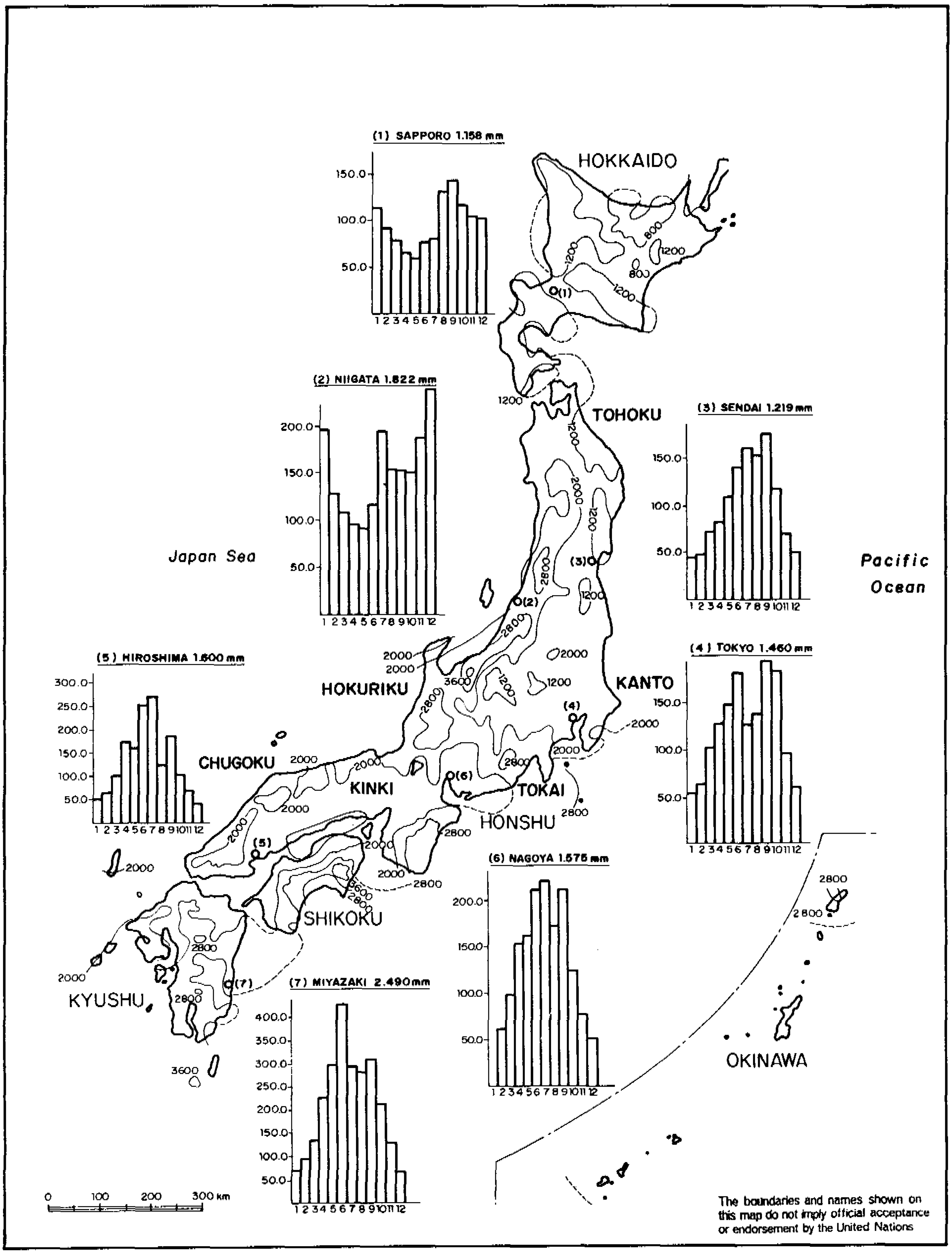

Figure II. Average annual precipitation in Japan, 1951-1980

Source: Multipurpose dams in Japan, River Bureau, Ministry of Construction, 1984.

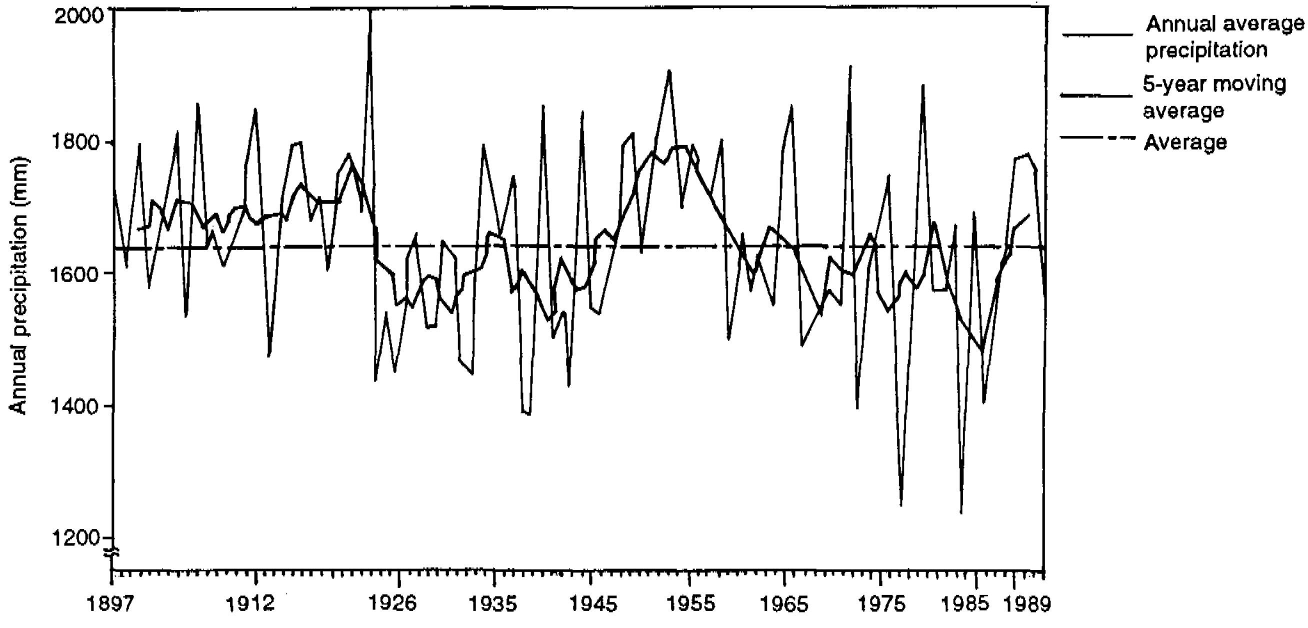

Figure III. Annual precipitation in Japan 1897-1992

Notes:

1. Annual precipitation is calculated as the arithmetic mean of the annual data from 46 meteorological stations throughout the country.
2. 5-year moving average is average precipitation for any 5 consequent years calculated as $\frac{1}{5}\sum_{i-2}^{i+2} P_i$

Sources:

1. 1990 Water Resources in Japan (in Japanese), National Land Agency, August 1990.
2. Fumihide Matsuda, Water Resources in Japan, 1993.

Table 1. Precipitation and potential water resources in Japan, 1956-1985

	Annual rainfall height mm/year	*Annual precipitation volume billion m^3/year*	*Amount of potential water resources billion m^3/year*
Dry year	1,401	529.2	303.4
Average year	1,749	660.7	434.8
Wet year	2,099	792.9	567.2

Notes:

a) Precipitation (i) in the normal year is determined as the average of annual precipitation recorded in the period of 30 years (1956-1985), (ii) in the dry year as the third least precipitation and (iii) in the wet year as the third largest precipitation in the same period.

b) Amount of potential water resources is determined as the difference between amount of precipitation and amount of water lost by evapotranspiration.

Source: 1990 Water Resources in Japan (in Japanese), National Land Agency, August 1990.

Table 2. Precipitation and potential water resources by region in Japan

Region	Population (thousand persons, 1985)	Dry year			Average rain year		
		Precipitation (mm/year)	Amount of potential water resources (million m^3/year)	Amount of potential water resources per capita (m^3/year/capita)	Precipitation (mm/year)	Amount of potential water resources (million m^3/year)	Amount of potential water resources per capita (m^3/year/capita)
Hokkaido	5,679	955	40,200	7,079	1,185	59,400	10,460
Tohoku	12,209	1,370	64,400	5,275	1,669	88,200	7,224
Kanto							
Inland	7,345	1,228	16,200	2,206	1,532	23,300	3,172
Coastal	30,273	1,224	9,100	301	1,527	13,100	433
Tokai	15,943	1,763	53,200	3,337	2,151	69,800	4,378
Hokuriku	3,088	2,132	17,800	5,764	2,612	23,800	7,707
Kinki							
Inland	5,047	1,448	9,600	1,902	1,810	14,000	2,774
Coastal	15,033	1,506	12,700	845	1,931	19,100	1,271
Chugoku							
Sanin	1,411	1,557	9,000	6,378	1,977	13,300	9,426
Sanyo	6,338	1,351	15,000	2,367	1,710	22,800	3,597
Shikoku	4,227	1,688	18,100	4,282	2,145	26,600	6,293
Kyushu							
Northern Kyushu	8,444	1,499	11,600	1,374	1,938	19,500	2,309
Southern Kyushu	4,833	1,854	25,400	5,256	2,425	39,300	8,132
Okinawa	1,179	1,495	1,200	1,018	2,133	2,600	2,205
Whole Country	121,049	1,401	303,400	2,506	1,749	434,800	3,592

Sources: National Land Agency "Survey of the Amount of Potential Water Resources", Statistics Bureau "National Census"

Note: See the notes to table 1.

The discharge of a river fluctuates seasonally to a great extent. The rivers on the Pacific Ocean side reach a maximum discharge in the rainy season and the typhoon season. The rivers on the Japan Sea side discharge a great deal of water in spring, when the snow melts.

Besides, due to the short time required for the rainfall to run off, the torrential rains often result in flash floods and unstable flow regimes of rivers. The river hydrographs are extremely sharp. The coefficient of river regime, i.e., the ratio of maximum discharge to minimum discharge, ranges from 200 to 400 for the majority of rivers in Japan, while for the major continental rivers this coefficient typically varies from 10 to 40. The unstable flow regime creates serious problems for both flood protection and water utilization.

The specific run-off of rivers in Japan is very large compared with continental rivers due to steep topography and torrential rainfall during the rainy and typhoon seasons (table 3).

The sedimentation load is heavy for many rivers since weak igneous rocks are widely distributed and mountains have relatively bold escarpments. Large volumes of sediments usually brought down from upper mountain areas are accumulated in river channels in flood plains, thus reducing their discharge capacity and impeding maintenance of flood mitigation structures.

Table 3. Specific run-off of selected rivers in Japan

River	*Point*	*Catchment area (km^2)*	*Design discharge (m^3/sec)*	*Specific run-off (m^3/sec/km^2)*
Ishikari	Ishikari Ohashi	12,697	9,300	0.733
Kitakami	Kozenji	7,060	13,000	1.841
Tone	Yattajima	5,150	17,000	3.301
Shinano	Ojiya	9,719	13,500	1.389
Kiso	Inuyama	4,688	16,000	3.413
Yodo	Hirakata	7,281	17,000	2.335
Hii	Kamishima	911	5,100	5.598
Chikugo	Yoake	2,860	10,000	3.497
Rhine	Leith	159,683	9,000	0.056
Elbe	Alt Lenburg	134,944	3,600	0.027
Danube	Vienna	101,600	10,500	0.103

Source: Rivers in Japan, River Bureau, Ministry of Construction, 1985

In Japan, about half of the total population and the principal urban areas are concentrated in flood plains which occupy only 10 per cent of the total land area of the country. Sharp seasonal variations in the discharge rate and unstable flow regime of rivers have led to the necessity for extensive development of flood control structures. However, the situation with regard to incidence of water-related disasters has aggravated lately because the construction of flood control facilities has not kept pace with the expansion of urban settlements and industrial activities in flood-prone areas.

Rivers in Japan are grouped administratively under the River Law into two classes: Class A and Class B (table 4). River systems that are of major importance to the national economy and protection of the environment are designated as Class A river systems (Annex I). The administration of those rivers is performed by the Minister of Construction. Class B consists of the other rivers, the management of which is carried out by the governors of prefectures.

Table 4. Classification of river systems in Japan (1989)

	River systems (number)	*Rivers (number)*	*Total length (km)*	*Total catchment area (km^2)*
Class A rivers	109	13,679	86,797	239,912
Class B rivers	2,673	6,875	35,394	107,692

Source: River Bureau, Ministry of Construction, 1990.

2. *Water quality*

Natural raw water in the unpolluted rivers is generally of good quality with low hardness. During rainfall and shortly after it, water in surface streams has high turbidity. However, rapid urbanization and development of industry in the 1960s resulted in the severe pollution of water resources, which reached its peak in 1971.

After introduction of appropriate measures, the quality of water has been improving in recent years (figure IV). Nearly all 135,774 samples taken throughout Japan in 1991 met environmental quality standards related to human health listed in Annex II. However, on 25.0 per cent of the territory under monitoring, the concentration of organic substances yet exceeded water quality standards (BOD in rivers, and COD in lakes and coastal waters)[4]. In addition, eutrophication of lakes and reservoirs might bring about taste and odour problems in water supply. The monitoring of water quality is exercised through an extensive network of stations measuring a range of physical and chemical variables. Water quality monitoring is carried out by regional authorities and coordinated by the national Environment Agency.

In an effort to preserve water quality, national effluent standards for specified facilities discharging wastewater into water bodies have also been set up. In addition, the prefectural authorities may set ordinances for stricter effluent standards in case where national standards are insufficient to improve the water quality in a particular water body up to the environmental quality standard. Nevertheless, water in a number of the rivers and lakes in Japan does not meet yet the environmental water quality standards related to living environment (Annex III).

Therefore, various water pollution control measures are being implemented throughout Japan. More stringent effluent standards work well in controlling industrial effluent discharges, while the treatment of domestic wastewater is still inadequate due to the lack of sewerage systems for a large portion of the population. The dredging of sludge, which has accumulated on river beds and which, in turn, is considered to be a cause of water pollution, is practised on heavily polluted sections of the rivers.

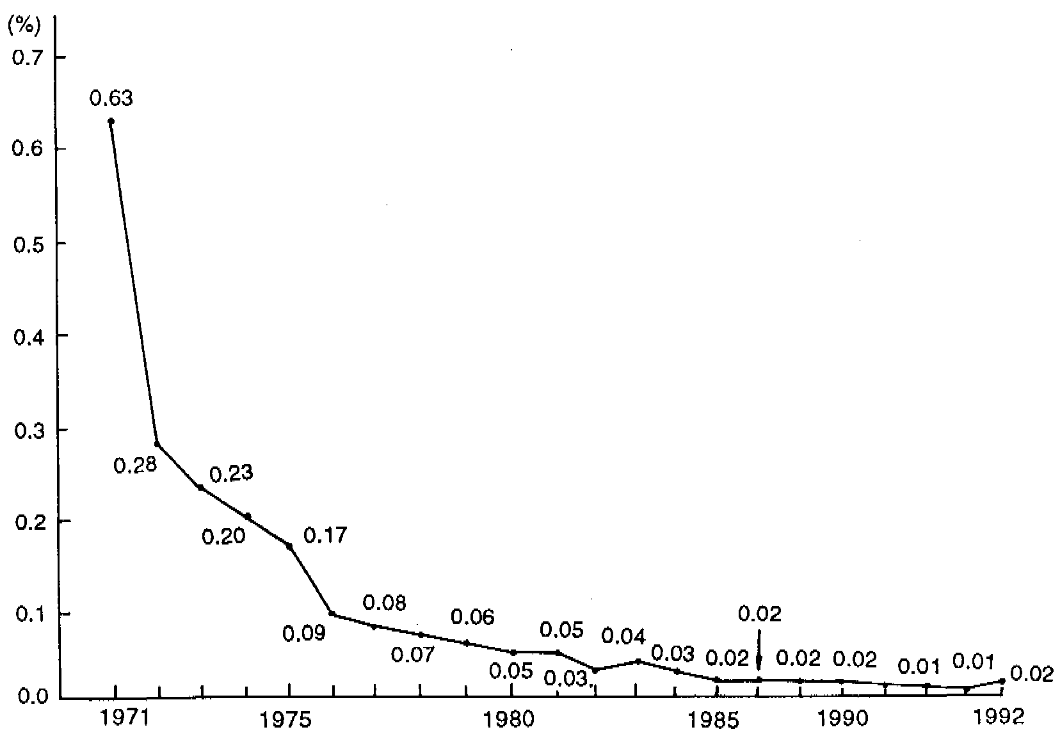

Figure IV. Share of water quality samples exceeding the environmental quality standards related to human health in Japan from 1971 to 1992

Source: Water Japan, Japan's Water Works Yearbook 1993/94

C. Groundwater

1. *Assessment of groundwater resources*

The groundwater, replenished by rainfall and river water, is mostly available in coastal plains, lowlands and upland terraces. The occurrence of groundwater in Japan is known well, as a result of investigation by a number of organizations. There are 247 freshwater aquifers underlying a total area of 69,130 km^2. Out of this, 41,557 km^2 are flood and coastal plains composed of unconsolidated highly permeable quarternary depositions, storing a large volume of fresh groundwater.[5] The renewable potential of groundwater resources is estimated at about 27 billion m^3 a year.[6]

Since the cities and industrial areas in Japan are situated on coastal plains and inland basins, shallow aquifers available there have been developed to a large extent. The groundwater development was crucial immediately after the Second World War especially for the reconstruction of industries and cities and agricultural production. From 1946 to 1960 the coastal areas, where groundwater was easily available for development, were urbanized and industrialized, and newly developed farmlands were partly irrigated by groundwater supplies.

However, from the early 1960s land subsidence, sea-water intrusion and a rapid lowering of the water table level have frequently occurred in areas, experiencing the overexploitation of groundwater mostly for industrial and public water supply. To cope with these groundwater problems, legal regulations and ordinances were applied to some groundwater consuming areas. In areas designated by the law, surface water supplied by municipal and industrial water supply systems has been used to substitute gradually groundwater. Moreover, re-use of municipal sewage and industrial wastewater has been promoted through the introduction at the large scale of appropriate technologies. As a result, annual groundwater withdrawals for industrial and public water supply has been reduced and stabilized at the level of about nine billion m^3, thus accounting for approximately one third of the total water supply for these purposes (figure V). In addition, investigations have been carried out to evaluate the safe yield of groundwater sources, and experiments concerning artificial recharge of groundwater have been conducted. The construction of subsurface dams accumulating groundwater flow or preventing freshwater layers from saltwater intrusion have been promoted in several areas.

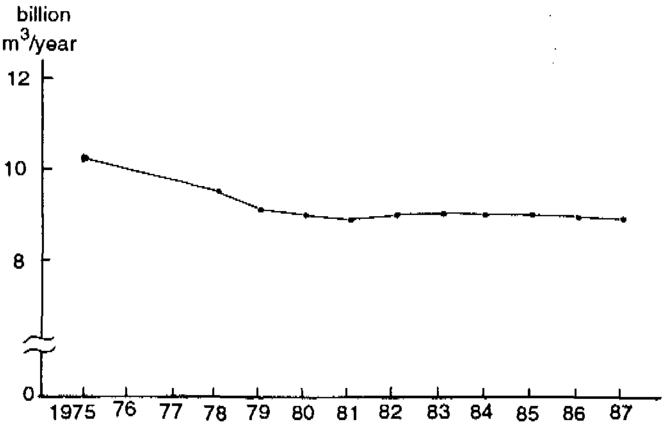

Figure V. Annual amount of groundwater withdrawn for industrial and public water supply in Japan, 1975-1987

Source: River Bureau, Ministry of Construction, 1990

2. *Groundwater quality*

The quality of groundwater is affected mostly by the kinds of surrounding rocks and chemical contents of recharging water. In the plains, the quality of artesian water is better, in general, than that of shallow aquifer water. Quality of groundwater is usually good enough to be used as drinking water without any treatment except disinfection. Therefore, groundwater has also been widely used as the source of water supply for small and medium-size communities.

In several areas, however, groundwater contamination caused by chemical substances has been disclosed. Detailed surveys are being carried out to determine the mechanism of contamination and formulate preventive measures. With a view to preventing groundwater pollution, the Water Pollution Control Law was amended in 1989. This amended law requires that no one should be allowed to discharge hazardous waste into the ground, and the prefectural authorities should monitor groundwater quality in their respective areas.

PART TWO

UTILIZATION OF WATER RESOURCES

A. Structural measures for water utilization

In Japan, for many centuries ponds, the simplest water resources development structures, have been traditionally used as a source of water for irrigation of paddy fields. Development of water resources by means of dam construction is traced back to the 1920s. At that time, the majority of dams was built exclusively for irrigation. During the period of economic reconstruction started in the second half of the 1940s and lasted until the beginning of the 1960s, many dams were constructed for power generation, and the hydropower was then a driving force for the industrial development. With the considerable increase in demand for water for domestic and industrial uses a large number of dams have been built for these purposes, too. However, since 1975, when a stable economic growth began, multipurpose dams, rather than dams for any exclusive use, have been mostly constructed around the country. Totally, as of 1989, there were 2,217 dams over 15 m height in service in Japan.[7]

Japan is now one of the most advanced countries in dam construction. However, since dam sites with favourable geological and topographical conditions have been mostly developed, the rate of dam building has recently slowed down. The main modern requirements for dams are safety, mitigation to the full extent of adverse impacts, and at the same time maximizing their beneficial effects.

Dams and associated water reservoirs serve not only for irrigation, industrial and domestic water supply, and hydropower generation, but they also serve for flood control. Retention of flood water in dam reservoirs has become an extremely effective flood control measure in Japan. Besides, other integrated flood control works comprising flood retaining basins, dikes, weirs, channel improvements, etc. have been constructed along many rivers.

Extended networks comprising canals and underground conduits, pumping stations, water treatment plants and water intakes have been also developed in many areas in Japan in order to bring water to various users.

B. Water use in agriculture

1. *Irrigation development*

For centuries, water resources have been used in Japan predominantly for agricultural purposes, mostly for rice cultivation. Even nowadays, agriculture is the largest user of water in this highly industrialized country. The amount of water withdrawn for agricultural purposes in 1991 was estimated at 58.6 billion m^{3*}, or 64.1 per cent of total withdrawals (table 5).

Table 5. Agricultural water use in Japan

(billion m^3, %)

Purpose	*1975*[1]	*1980*[1]	*1983*[2]	*1989*[3]	*2000*[2]
Irrigation of rice fields	56.0 (98.2)	56.5 (97.4)	56.2 (96.1)	55.9 (95.4)	57.6 (92.2)
Irrigation of dry fields	0.7 (1.2)	1.1 (1.9)	1.8 (3.1)	2.2 (3.7)	4.3 (6.9)
Stock-farming	0.3 (0.6)	0.4 (0.7)	0.5 (0.8)	0.5 (0.8)	0.6 (0.9)
Total	57.0 (100)	58.0 (100)	58.5 (100)	58.6 (100)	62.6 (100)

Note: Estimations are based on the area under various crops.

Sources: [1] ESCAP Water Resources Series No. 59.
[2] National Comprehensive Water Resources Plan (Water Plan 2000).
[3] National Land Agency, 1993.

* Statistical information on water use is given for a fiscal year, which lasts from 1 April of the previous year to 31 March of the following year.

The bulk of water has been traditionally used for irrigation of rice fields. In 1975, for example, 98.2 per cent of the water withdrawals for agriculture, estimated at 57.0 billion m^3, was allocated for this purpose, while in 1989 the share of the water intake for rice irrigation was only slightly less (table 5). Irrigation season normally lasts from April to September.

Water is increasingly used for irrigation of dry fields for growing wheat, corn, beans, vegetables and other crops. Due to the over-production of rice in the early 1970s, resulting from an increase in rice yields and a decrease in rice consumption, efforts were made to plant non-rice crops on paddy fields.[8] Through various subsidies and restrictions the conversion of paddy land to dry fields by means of land consolidation and drainage improvement has been carried out successfully. Although the rice cultivation continues to dominate in the agriculture of Japan, covering over 2.9 million ha out of 5.3 million ha of arable land, about 2.4 million ha were used for dry land crops in 1989. About 324,000 ha of dry arable land were irrigated in 1989.[9]

2. *Sources of irrigation water*

The major source of water for agriculture has always been surface water. Since the wide fluctuations in stream flow in the rivers of Japan hamper the use of water for agriculture, hundreds of dams and reservoirs have been constructed throughout the country in order to provide a more stable supply of water for irrigation and other agricultural purposes.

Groundwater is used mostly to supplement irrigation water requirements during the low water season from April to September, especially in August. The total area supplementary irrigated by groundwater is roughly estimated at 0.5 million ha with more than 90 per cent of that area comprising paddy fields and the rest consisting of upland fields, orchards and grasslands.[10] Irrigation facilities using groundwater are generally designed on a smaller scale than those based on surface water from streams and reservoirs. The amount of groundwater used for irrigation varies from 5 to 7 per cent of the total amount of water withdrawn for irrigation and averages around 3.4 billion m^3 per year. Shallow aquifers, from which about three quarters of groundwater is extracted for irrigation, are replenished, in turn, by infiltration of surface water, including the water delivered to irrigate fields. The groundwater also comes from artesian wells and infiltration galleries in river beds and springs.

With the expansion of mechanized harvesting techniques for rice cultivation, which require a larger quantity of water per irrigated hectare, and the introduction of the second crop, the demand for water to irrigate paddy fields is expected to rise moderately in the future in spite of the inevitable decrease in the rice cultivated area due to the diversion of paddy land for urban settlements and dry fields (table 5). The demand for water to irrigate dry fields is expected to increase substantially from 1.8 billion m^3 in 1983 to 4.3 billion m^3 by the year 2000 in line with the development of irrigation for dry land crops.

The total water demand from agriculture is expected to reach 62.6 billion m^3 by the year 2000.

C. Industrial water use

1. *Inception of water supply in industrial zones*

Historically, industrial development was taking place in zones adjacent to large cities located along river estuaries, such as Tokyo, Nagoya and Osaka. In these industrial zones, extended over alluvial plains, water supply for industrial enterprises depended mainly upon groundwater. Groundwater, being of good quality and low development cost, was widely used for various industrial purposes especially for cooling and air-conditioning in factories. However, the heavy pumping of groundwater led to the land subsidence. In Japan, 59 districts of a total area of 9,520 km^2, accounting for 12 per cent of the habitable land of the country, were identified as affected by land subsidence; most of them were located in industrial regions on the coast. The maximum subsidence of 4.57 m was observed over the period 1920-1975 in the north-eastern section of Tokyo.[11]

In the 1960s, when Japan entered the stage of rapid economic growth, demand for water by industry sharply increased. Never before the country had experienced a stronger need for securing a steady supply of water for its water-hungry industrial plants. According to the statistical information compiled by the Ministry of International Trade and Industry (MITI) and related only to the enterprises with the number of employees more than 29, from 1965 to 1974 water use in the industrial sector increased about 2.4 times from about 49 million m^3/day to 120 million m^3/day (figure VI). However, make-up freshwater intake from both groundwater and surface water sources increased during the same period only by 28 per cent from 31.3 million m^3/day to 42.3 million m^3/day due to re-use of water in many technological processes.

2. *Facilities for industrial water supply*

In order to meet the increasing water demands, measures were undertaken to create an industrial water service as a part of government projects for the development of industry infrastructure as in case of roads, ports and harbours.

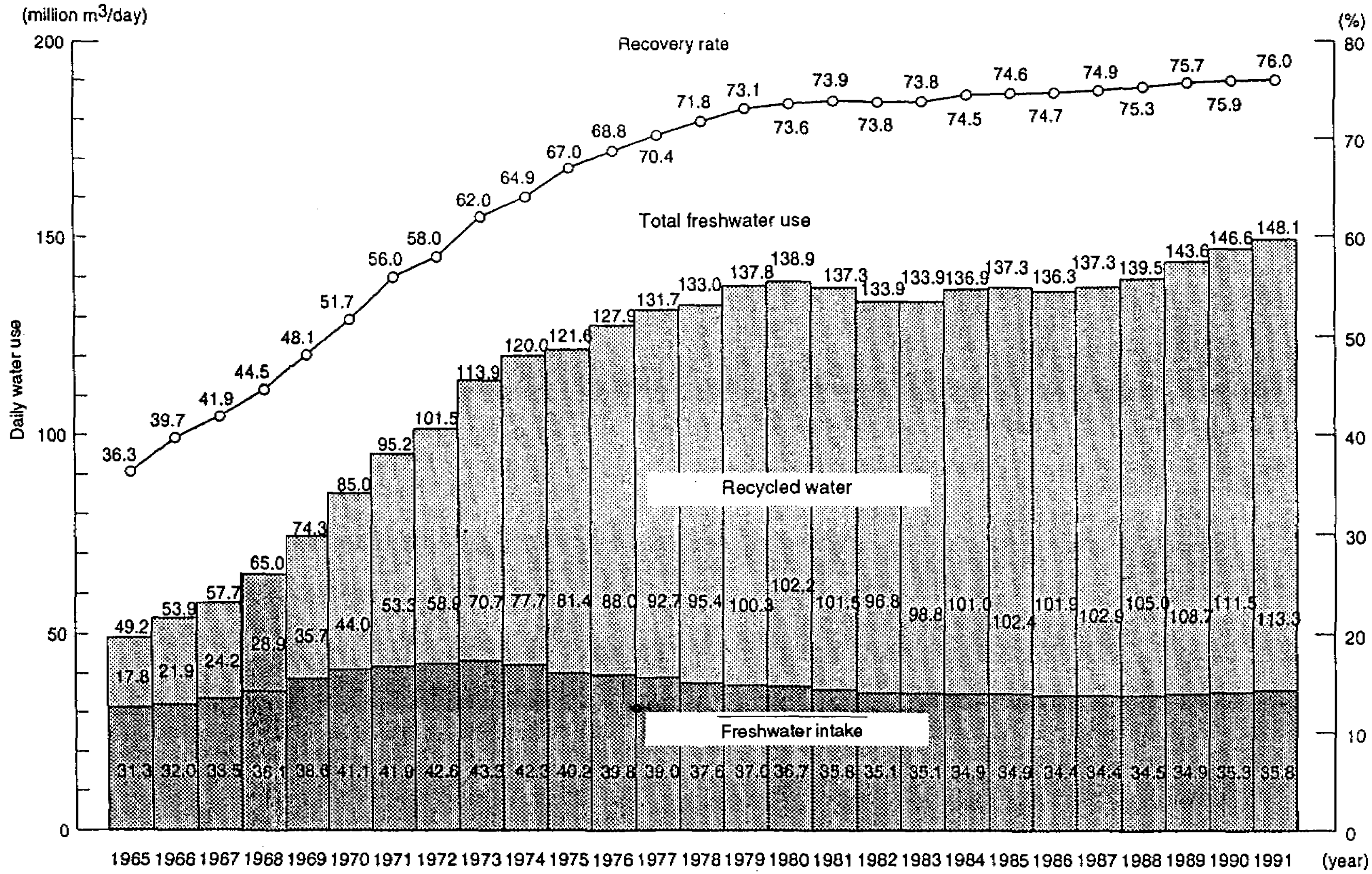

Figure VI. Industrial freshwater use in Japan, 1965-1991

Notes: 1. Data for companies with 30 employees or more
2. Prompt report values in 1991

Source: MITI "Industrial Statistics Tables"

The creation of an extensive nationwide network of industrial water supply systems undoubtedly contributed to a large extent to the vigorous development of the industrial sector in Japan. In addition, the industrial water service played a major role in resolving the aggravating problem of land subsidence, since the construction of industrial water systems based on surface water sources contributed to the substitution of groundwater. Thus, the industrial water service accomplished the dual objectives of securing industrial water supply, on the one hand, and freeing the national industry from its dependence on groundwater, on the other.

Until the early 1970s, more than one third of the total amount of fresh water for industrial purposes was extracted from groundwater sources. The amount of groundwater withdrawn for industry has been decreasing every year since then. The decrease in groundwater pumpage could also be explained by the fact that a number of restrictions had been imposed on groundwater exploitation. After groundwater withdrawal had been reduced, the groundwater levels recovered and land subsidence rate first decreased and then stopped in highly industrialized coastal zones.

Since 1974, the increase in water demand by industry has slowed down due to the decrease in the growth rate of the economy of Japan affected by the first oil crisis. However, the expansion of the industrial water supply systems, specifically designed to provide water for industrial purposes, has continued. As of April 1976, a total of 170 industrial water supply works, both public and private, with an aggregated water supply capacity of 19 million m^3/day, were in operation and 76 projects with a designed water supply capacity of 10 million m^3/day were under construction.[12] Supplies through those systems, generally operated by municipalities, accounted for nearly one-third of the total daily water supplies to the industrial plants. Less than 7 per cent of water for industrial purposes was made available through public water supply systems, and the share of this source has been gradually declining. The rest of water was provided by water supply facilities owned by large industrial enterprises from surface and groundwater sources.

3. *Water use in chemical industry*

The chemical, iron and steel, and pulp and paper industries altogether account for approximately 70 per cent of total industrial water use. Out of them, the chemical industry is the largest freshwater user in the industrial sector in Japan. The chemical industry accounted for about 35 per cent of total industrial water use during the first half of the 1970s, then its share slightly reduced to 31.2 per cent in 1988 (table 6).

The freshwater intake was highest in the early 1970s, when about 10 million m^3 of water was withdrawn daily for needs of the chemical industry. Since then, the daily amount of water withdrawal for the chemical industry reduced by 17 per cent and reached 8.3 million m^3/day in 1988 (table 6, figure VII). In the chemical industry, water is used mostly for cooling, although a certain portion of water is required for some technological processes and steam generation. Therefore, a large amount of water is conserved by recycling of cooling water through cooling towers or ponds. Recycling and re-use of water along with the introduction of water-saving technologies led to the sharp increase in the water re-use ratio in the chemical industry from 49.2 per cent in 1965 to 80.9 per cent in 1988 (table 6).

4. *Water use in iron and steel industry*

The iron and steel industry requires a great deal of water to operate. This industry is the second largest water-using industry in Japan, although the freshwater intake, which was 3.7 million m^3/day in 1988, is less than make-up freshwater requirements of the chemical industry or the pulp and paper industry (table 6 and figure VII). The largest volume of water in the iron and steel industry is utilized for removal and dissipation of heat. About 90 per cent of water, as of 1988, is recycled and re-used. In addition, sea water is used for certain cooling applications at some works.

5. *Water use in pulp and paper industry*

The pulp and paper industry is another major industrial water user in Japan, since large quantities of water are used in pulp- and paper-making operations. This industry accounted for about 11 per cent of total industrial freshwater use and 25 per cent of total industrial freshwater intake (table 6). Since most of water in the pulp and paper industry is used as process water, which is partly consumed in various technological operations, the ratio of water re-use in the industry is less than in the steel industry or the chemical industry. There seems to be an upper limit of the share of water that could be recycled or re-used in the pulp and paper industry because freshwater must be added continuously to replenish the water consumed and to keep the required quality of process water, which becomes contaminated as a result of contact with raw materials, by-products and residues. The raw wastewater from the pulp and paper mills is one of the main sources of water pollution in the industrial sector. However, the pulp and paper industry has also responded to the environment protection regulations by recycling process water and thus reducing wastewater discharge. Due to many technological improvements, the water re-

Table 6. Industrial water use in Japan by major industry sector, 1965-1988

(1000 m³/day)

	Total industrial fresh-water use	*Chemical industry*					*Steel industry*					*Pulp and paper industry*				
		Fresh-water use	*Share of total %*	*Fresh-water intake*	*Recycled water*	*Water re-use ratio %*	*Fresh-water use*	*Share of total %*	*Fresh-water intake*	*Recycled water*	*Water re-use ratio %*	*Fresh-water use*	*Share of total %*	*Fresh-water intake*	*Recycled water*	*Water re-use ratio %*
1965	49,162	16,445	33.4	8,354	8,092	49.2	6,727	13.7	2,695	4,032	59.9	10,927	22.2	8,262	2,665	24.4
1970	85,042	29,664	34.9	10,315	19,349	65.2	17,118	20.1	4,319	12,799	74.8	13,495	15.7	9,815	3,580	27.3
1975	121,625	42,624	35.0	9,468	33,156	77.8	29,411	24.2	4,480	24,931	84.8	13,851	11.4	9,727	4,124	29.8
1980	138,927	46,041	33.1	8,551	37,489	81.4	35,530	25.6	3,931	31,599	88.9	16,135	11.6	9,505	6,630	41.1
1985	137,309	42,014	30.6	8,330	33,684	80.2	37,413	27.2	3,835	33,578	89.7	15,524	11.3	9,024	6,499	41.9
1986	136,290	41,750	30.6	8,279	33,471	80.2	36,148	26.5	3,781	32,367	89.5	15,116	11.1	8,877	6,239	41.3
1987	137,303	42,190	30.7	8,272	33,918	80.4	36,164	26.3	3,741	32,423	89.6	15,167	11.0	8,821	6,346	41.8
1988	139,527	43,519	31.2	8,318	35,201	80.9	36,537	26.2	3.701	32,836	89.9	15,265	10.9	8,844	6,421	42.1

Source: "Industrial Statistics Tables", Ministry of International Trade and Industry.

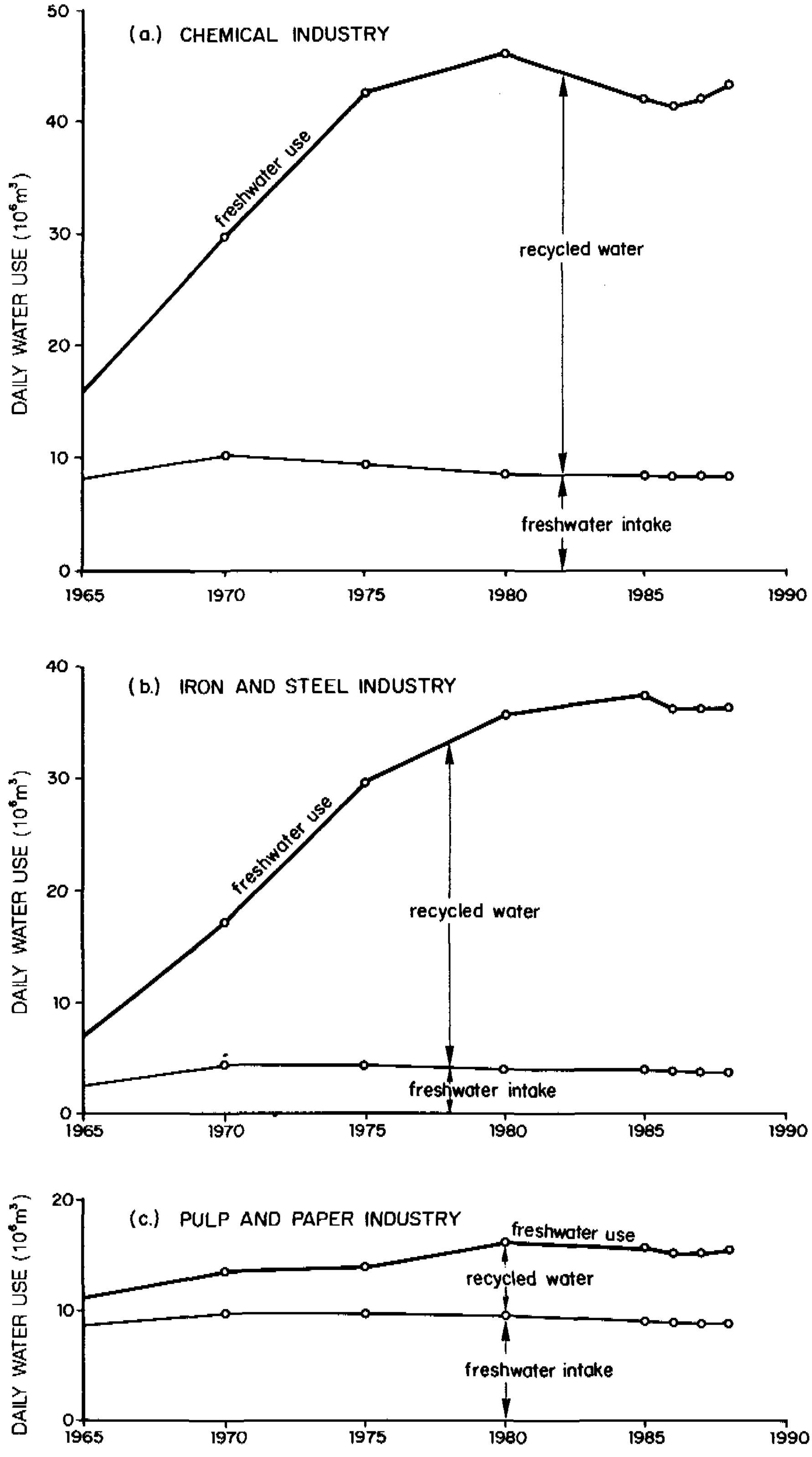

Figure VII. Industrial water use in Japan by major industry sector, 1965-1988

Source: Based on data from the Ministry of International Trade and Industry.

use rate in the pulp and paper industry in Japan increased from 24.4 per cent in 1965 to 42.1 per cent in 1988 (table 6).

6. *Water re-use*

On the whole, industrial water use in Japan levelled off in 1974 and freshwater intake began to decline in the same year. In the succeeding 14 years, gross water use by industry rose only by 16 per cent from 120 million m^3/day in 1974 to 139.5 million m^3/day in 1988, while freshwater intake fell by 18.4 per cent from 42.2 million m^3/day in 1974 to 34.5 million m^3/day in 1988. However, during the last few years the freshwater use by industries has slightly increased (figure VI).

Water recycling and water re-use were the main techniques employed by industry during the 1970s to bring about the reduction in specific water use and to reduce the waste discharge. This policy has been pursued by the Water Re-use Promotion Centre, established by the Ministry of International Trade and Industry, with the aim of promoting the development and application of the technologies required for the re-use of industrial wastewater and the reclamation of municipal sewage, as well as for the desalination of sea water. The recovery rate, i.e. the amount of water re-used divided by gross water use for various types of the industry in 1988 is shown in table 7. The share of the re-used water was around 90 per cent in the iron and steel and transport equipment industries, and exceeded 80 per cent for chemical and oil/coal industries. The average recovery rate for all types of the industry rose from 65 per cent to 76 per cent in the period from 1974 to 1991 (figure VI).

The recovery rate has remained at approximately the same level since the early 1980s because possibilities for wider application of water recycling and re-use almost came to the technological limits in major water-consuming industries, such as chemicals or steel, where re-use of water was relatively easy to introduce on a large scale. There exist some modernized steel producing plants where the share of the recycled water exceeds 95 per cent.[13] However, there are some industries, such as textiles or food processing where the water recovery rate is still relatively low. It is estimated that by the year 2000 the industrial water recovery rate for the industry on the whole will increase slightly, while freshwater intake for industrial water supply will be expected to rise by about 2 per cent a year to an estimated 22.2 billion m^3 a year, depending on the growth rate of the country's economy.

Table 7. Water use and water re-use rates by various industries in Japan, 1988

(1,000 m^3/day)

Type of industry	*Freshwater use*	*Share of total %*	*Freshwater intake*	*Recycled water*	*Water re-use ratio %*
Chemical	43,519	31.2	8,318	35,201	80.9
Iron and steel	36,537	26.2	3,701	32,836	89.9
Pulp and paper	15,265	10.9	8,844	6,421	42.1
Transport equipment	11,200	8.0	849	10,351	92.4
Oil and coal products	6,267	4.5	760	5,507	87.9
Food processing	5,336	3.8	3,454	1,883	35.3
Electrical machinery	4,705	3.4	1,379	3,326	70.7
Pottery and masonry	3,382	2.4	933	2,449	72.4
Textile	3,167	2.3	2,515	652	20.6
Others	10,150	7.3	3,734	6,414	63.2
Total	139,528	100	34,487	105,040	75.2

Note: Data refer to the enterprises with more than 29 employees.

Source: "Industrial Statistics Tables", the Ministry of International Trade and Industry.

D. Public water supply

1. *Water supply coverage*

In highly urbanized Japan, water supply for domestic and public purposes is one of the most essential services provided by municipalities and supported by the Government. In addition to domestic water supplied to the population to meet personal needs, water is also provided to hotels, offices, department stores and other public and commercial structures. This water supply called commercial accounts for about 30 per cent of the total supply of domestic and commercial water.

Remarkable progress has been achieved in the development of public water supply in Japan during the past 40 years. In 1950, only about a quarter of the population was served with safe drinking water from public water supply systems. In 1960, however, the percentage of the population provided with piped water supply doubled and reached 53.4 per cent. The rapid expansion of water supply services continued till the second half of 1970s. By 1980, 91.5 per cent of the total population already had access to public water supply. From the beginning of the 1980s, therefore, the rapid increase in the population served with piped water slowed, and in 1991, 94.9 per cent of the total population was served. The data on population covered with water supply are given on figure VIII and in table 8.

The number of people to whom public water services were not available was 6.3 million in March 1991. Although the final goal set by the Government is to make public water supply available to all people, the target is to bring the percentage of population served up to 99 per cent by the year 2000.

Table 8. Population served with water supply in Japan, 1950-1991

	1950	*1960*	*1970*	*1980*	*1985*	*1989*	*1990*	*1991*
Total Population (millions)	83.20	93.42	103.72	116.86	121.01	123.28	123.28	124.12
Population Served (millions)	21.80	49.91	83.75	106.91	112.87	116.38	116.96	117.80
%	26.2	53.4	80.8	91.5	93.3	94.3	94.7	94.9

Source: Water Japan, Japan's Water Works Yearbook 1993/94

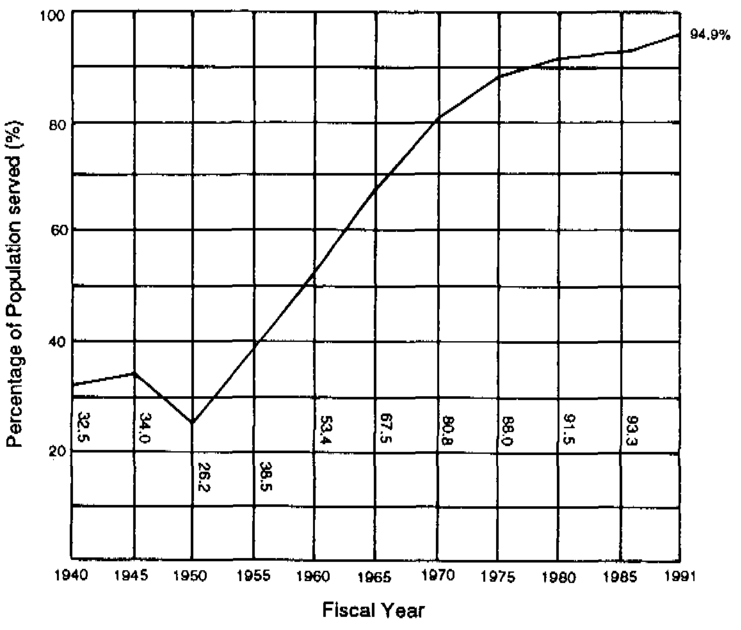

Figure VIII. Share of the population served with water supply in Japan, 1940-1991

Source: Water Japan, Japan's Water Works Yearbook 1993/94

2. *Water supply systems*

Water supply systems in Japan are classified as follows:

- a large water supply system which is designed to serve more than 5,000 persons;
- a small water supply system or sometimes called a rural water supply system which is designed to serve from 101 to 5,000 persons;
- a private water supply system designed to serve more than 100 persons in company-owned blocks of apartments, dormitories, etc.;
- a bulk water supply system which supplies potable water to large/small water supply systems.[14]

Totally, there were 16,711 water supply systems in Japan as of the end of March 1992 (figure IX). Besides, there were 137,656 private household water distribution systems with a capacity of water storage tanks more than 10 m^3, which receive treated water normally from small water supply systems or sometimes from large ones. The annual amount of water supplied by all types of water supply systems increased by 2.5 times since 1965 and reached 16.78 billion m^3 in 1991 (table 9). The rate of increase was nearly 10 per cent per year in the 1960s, 3.1 per cent in the 1970s and reduced to 1.0 per cent in 1991.

Table 9. Annual water supply by system type in Japan, 1965-1991

(million m^3)

Type / *Year*	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*1991*
Large water supply systems	6,066	9,367	11,998	12,864	14,290	15,736	15,917
Small water supply systems	437	555	661	721	791	815	808
Private water supply systems	186	166	123	81	68	59	58
Total	6,683	10,088	12,782	13,666	15,149	16,610	16,782

Source: Water Japan, Japan's Water Works Yearbook 1993/94.

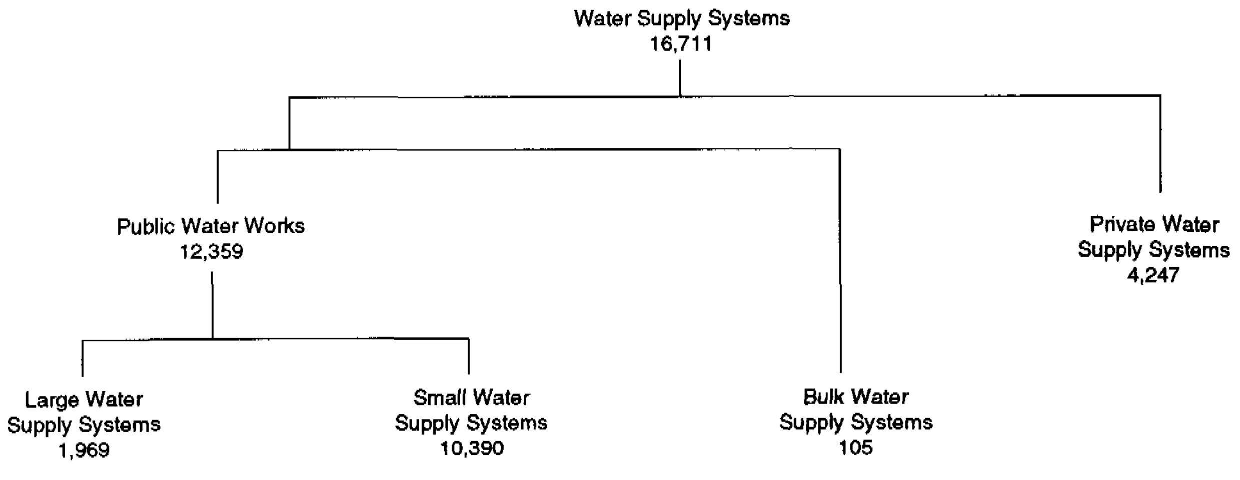

Figure IX. Classification and the number of water supply systems in Japan, March 1992

Source: Water Japan, Japan's Water Works Yearbook 1993/94

About 95 per cent of the amount of water supplied to the population was provided in 1991 by large water supply systems, which account for 11.4 per cent of the total number of systems. In 1991, the total production capacity of large systems reached 64.7 million m^3 per day, while maximum daily water supply was 53.9 million m^3, i.e. 83 per cent of the supplying capacity was used. The maximum daily water supply is generally about 1.25 times higher of the average daily supply due to the seasonal changes in water demand (figure X).

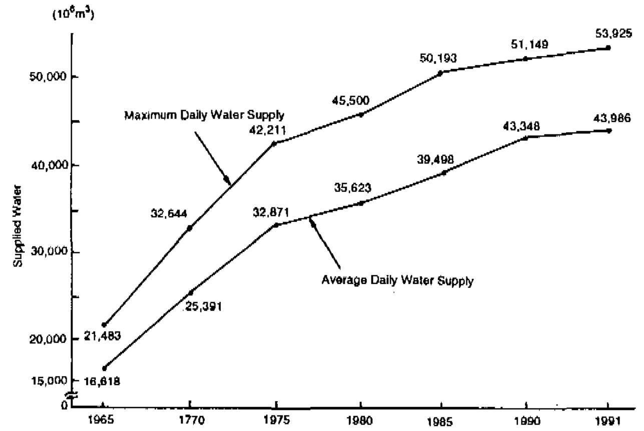

Figure X. Average and maximum daily water supply by the large water supply systems in Japan, 1965-1991

Source: Water Japan, Japan's Water Works Yearbook 1993/94

Small water supply systems served only 6.1 per cent of the population in 1991 providing 4.8 per cent of the annual water supply, although the number of the small systems assumed 62.2 per cent of the total number of systems. The role of private systems in water supply of the population has been declining. In 1991, only 0.34 per cent of annual water supply was provided through 4,247 private water supply systems.

3. *Per capita water use*

Although the total amount of annual water supply has been steadily increasing, per capita use of water has been relatively stable during the recent years. The water supplied to households is used for laundry, bathing and washing, toilet flushing, cleaning, garden sprinkling, etc. Besides the household uses, piped water is used to meet various needs in public offices and agencies, medical and welfare facilities, and for small commercial activities. With all these uses accounted for, the average net daily water use amounted to 335 litres per capita in 1990 (figure XI).

The amount of per capita water use, both maximum and average, depends on the size of a settlement. The highest per capita water use has been registered in the large cities, although it has been gradually diminishing there. Thus, the maximum daily amount of water supplied in the cities with population over 1.0 million was about 550 litres per capita on an intake basis in 1977 and around 480 litres in 1988. In regard to small communities with

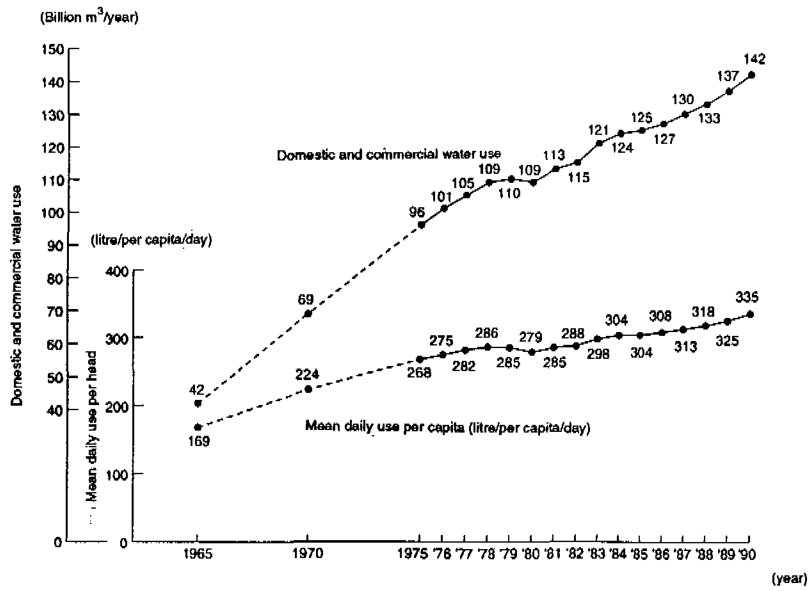

Figure XI. Domestic and commercial water use in Japan, 1965-1990

Note: Net water use

Source: National Land Agency

population from 5,000 to 10,000, maximum daily water use has increased there from around 410 litres per capita to about 470 litres per capita over the same period. Obviously, the gap in per capita water use between large cities and smaller settlements has been gradually closing.

4. *Seasonal fluctuations in water demand and supply*

There are distinct fluctuations in the monthly water demand and correspondingly in water supply, which reflect accurately well-defined seasonal weather changes in Japan (figure XII). The monthly supply during the summer season usually exceeds the supply in winter time by about 20 to 25 per cent. However, the difference in the amount of water supplied in the summer and winter seasons, respectively, tends to reduce along with the expansion of water supply systems and the growth in household uses of water.

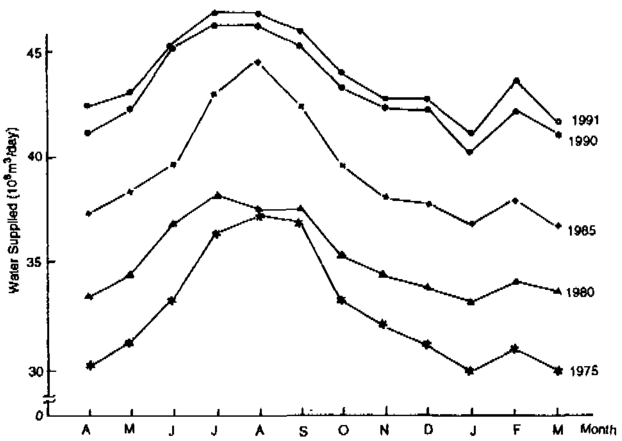

Figure XII. Monthly water supply by the large water supply systems in Japan, 1975-1991

Source: Water Japan, Japan's Water Works Yearbook 1993/94

Shortages of water supply have been experienced in many parts of the country due to the inadequate capacity of the water supply industry to meet the rising demand. Thus, during the drought of 1978 approximately 9 million persons on 396 communities in the western part of the country were forced to contend with a suspended or restricted water supply for a long period.[15]

5. *Water charges*

The water supplied to consumers is charged according to the volume delivered. The level of charges is fixed by each waterworks depending on its actual expenditures, and there are big differences in water charges imposed by various waterworks. Besides, there are separate tariffs for different uses classified into four major categories, namely, domestic, commercial, industrial and public baths. For domestic water supply, the spectrum of monthly charges among 1,882 waterworks for every 20 m^3 of water is shown in figure XIII.

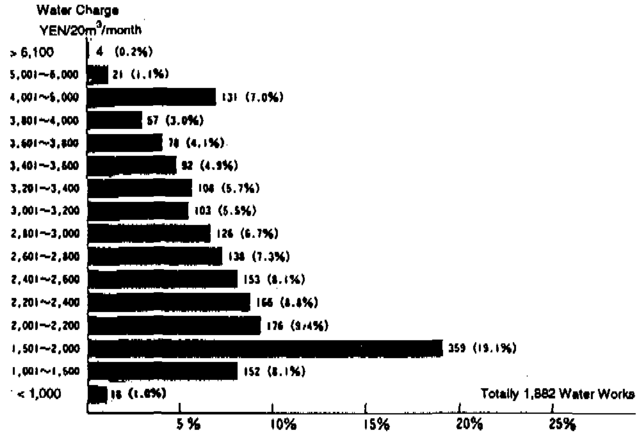

Figure XIII. Charges for domestic water supply, April 1992

Source: Water Japan, Japan's Water Works Yearbook 1993/94

6. *Sources of water supply*

There are two main water sources for large public water supply systems in Japan: surface water and groundwater. In 1991, over 70 per cent of the water supplied originated from surface water sources and 26 per cent was withdrawn from groundwater sources (table 10 and figure XIV). Since major cities have large-scale facilities for surface water intake, roughly the same proportion was maintained in the previous years (table 10). However, in respect of smaller scale facilities, where the population to be supplied is less than 50,000, the share of groundwater is higher, from 50 per cent to 60 per cent of the total. Furthermore, 75 per cent of small and private water supply systems utilize groundwater. Brackish water is used only in a few areas as a source of water supply since the cost of desalination is much higher than the cost of development of freshwater.

7. *Water purification*

Industrial development and growing urbanization in Japan have increased the number of contaminants in both surface water and groundwater. The contamination of water by hazardous chemicals has become a public concern. The first national water quality standards were

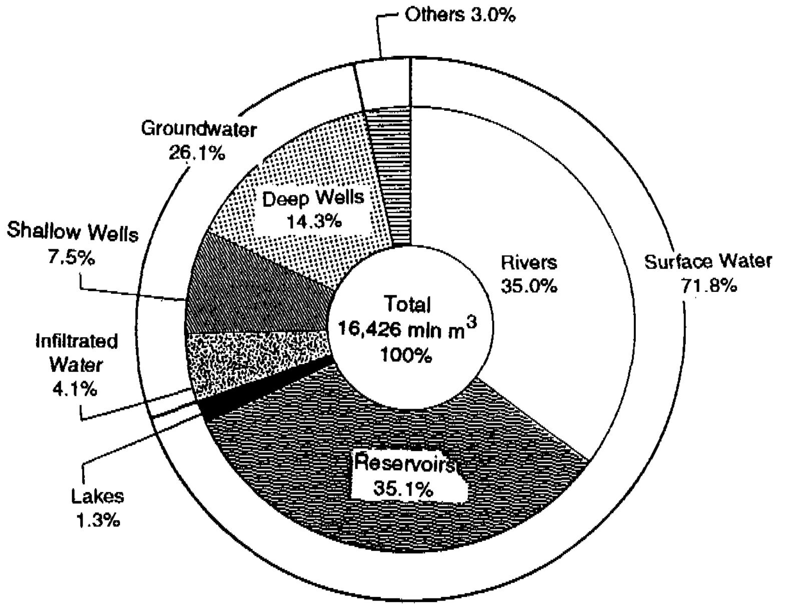

Figure XIV. Water sources for large/bulk water supply systems in Japan, 1991

Source: Water Japan, Japan's Water Works Yearbook 1993/94

Table 10. Water sources for large/bulk water supply systems in Japan, 1965-1991

(million m^3)

Sources / Year	1965	1970	1975	1980	1985	1990	1991
Rivers	3,581	4,745	5,804	5,400	4,873	5,732	5,747
Dam reservoirs	756	1,904	2,774	3,645	5,287	5,610	5,822
Lakes	56	88	117	179	190	219	225
Infiltrated water	947	1,041	1,072	954	738	709	679
Wells	935	1,830	2,494	2,844	3,307	3,613	3,615
Others	378	244	281	473	488	493	337
Total	6,653	9,851	12,542	13,495	14,884	16,376	16,426

Source: Water Japan, Japan's Water Works Yearbook, 1990/94

promulgated by the Ministry of Health and Welfare in 1958 and were revised in 1978. Japan's Water Works Law stipulates 26 examination items of water quality requirements, e.g. nitrite and nitrate, chlorine, organic substances, coliform group bacterial count, mercury, organic phosphorus, pH, odour, taste, colour, turbidity, phenol and several metal ions.

Water abstracted from water sources for piped supply is treated generally by conventional methods, including sedimentation, sand filtration and chlorination. In Japan, slow sand filtration process has mainly been used to purify water for decades since the establishment of public water supply services. However, due to the deterioration of the water quality in water sources and the shortage of land available for siting treatment plants, rapid sand filtration has been introduced in almost all newly built purification plants. Thus, in 1988 the rapid sand filtration systems were used for treatment of 73 per cent of water supplies, slow sand filtration systems – for 5 per cent of water supplies, and for the remaining 22 per cent only disinfection was used (table 11).

Table 11. Annual amount of water treated at large/bulk water supply systems in Japan, 1970-1991

(million m³)

Type of treatment / *Year*	*1970*	*1980*	*1985*	*1990*	*1991*
Rapid sand filter	5,903	9,203	10,578	11,890	12,089
Slow sand filter	1,241	868	763	763	763
Special treatment	356	480	–	–	–
Disinfection only	2,514	2,683	3,242	3,430	3,439
Total	10,015	13,234	14,583	16,083	16,290

Source: Water Japan, Japan's Water Works Yearbook 1993/94.

In Japan, the use of chlorine is legally obliged for the disinfection of water supply. The Water Works Law requires that certain amount of residual chlorine should be present in tap water so terminal disinfection should always be done by chlorine. Liquid chlorine is mostly utilized for this purpose, while hypochlorite is widely used at small and medium-scale purification plants. Raw water is seldom further treated in addition to conventional methods. However, in some cases removal of iron or manganese from groundwater is carried out. Advanced water purification techniques such as activated carbon treatment, ozonation and biological treatment are applied in some purification plants where raw water is highly polluted by organic matters.

The renewal of aged leaking water mains is of major concern to most water utilities in Japan. The renewal of main is an important part of efforts to keep the level of non-accounted-for water low, which is at present around 15 per cent as the overall average in Japan. Of 400,000 km of total length of water mains in Japan, about 20 per cent is made of asbestos-cement pipes (ACP). Although early replacement of ACP is mandated, smaller water utilities are experiencing financial difficulties in doing this.

8. Prospects for public water supply

By 2000, the water supply to the population is expected to reach about 20.8 billion m³ per year.[16] The rise in demand for domestic water will be induced by the growth of population, improvement of living standards, wider application of waterusing household appliances and devices, such as washing machines, showers and flush toilets, etc. Improvements in the existing water supply systems will lead to the provision of more stable supply. Water demand will also increase substantially in areas such as Shikoku and Hokkaido islands, where at present per capita water use is relatively low. Besides, water supply facilities are planned to be constructed in still unserved areas with unfavourable geographical conditions.

The greatest challenge facing Japan's water supply is a need to obtain sufficient water resources and provide stable water supply even during a severe drought. Meanwhile, developing water resources through the construction of dams, reservoirs and other facilities is becoming more difficult for such reasons as the lack of sites suitable for water resources development projects and social and environmental problems connected with dam construction. On the other hand, in Japan stable water supply is considered to be a life line for the society, which depends greatly on safe water piped to the overwhelming majority of the population. In order to stabilize water supply and improve its management, priority will be given to the formation of regional networks comprising small water supply systems.

E. Non-consumptive use of water

1. Hydroelectric power generation

In Japan, where mountains are high, rivers steep and rainfall abundant, the energy of running water has been widely harnessed for generating electricity by various types of hydroelectric power plants. Hydroelectric power generation, being an entirely non-consumptive water use, may nevertheless require temporary withdrawal of water from watercourses, as in the case of pumped storage power plants. In 1990, the total installed capacity of about 1,700 hydroelectric plants amounted to 37,831 MW, thus accounting for 80.9 per cent of the country's economic hydropower potential estimated at 46,742 MW (table 12).

Table 12. Hydropower in Japan, 1955-1990

Year	*Installed capacity*		*Production of electricity*	
	MW	*% of the national total*	*billion KWh*	*% of the national total*
1955	8,909	61.4	48.5	74.4
1960	12,678	53.6	58.5	50.6
1965	16,275	39.7	75.2	39.5
1970	19,994	29.3	80.1	22.3
1975	24,853	22.1	85.9	18.1
1980	29,776	20.7	92.1	15.9
1985	34,337	20.3	87.9	13.1
1990	37,831	19.7	95.8	11.2

Sources: ESCAP Water Resources Series No. 59, 1985
Electric Power in Asia and the Pacific 1985 and 1986
Electric Power in Asia and the Pacific 1989 and 1990

In the first half of the twentieth century, hydroelectric plants, mainly of "run-of-the-river-type" dominated the electricity generating sector of Japan. Since the 1950s, however, the share of hydropower in electricity generation has been shrinking owing to the diversification of power sources, with the priority given to the development of, first, thermal power plants and, later, nuclear power plants. In 1963, the installed generating capacity of thermal power plants surpassed that of hydropower plants for the first time. Since 1966, when the first commercial nuclear power plant went into operation, the contribution of nuclear energy to electricity generation in Japan has also been increasing.

With the rapid development of large-scale thermal and nuclear power plants, bearing the most of the base load, hydropower has been used to cover peak loads. In this connection, the construction of pumped storage power plants has been emphasized in hydropower development. As a result, the share of pumped storage hydropower plants in hydropower generation expanded yearly and reached about 50 per cent of the aggregated hydropower installed capacity in the middle of the 1980s.[17] In 1990, 11.2 per cent of the total electricity production in Japan was by all types of hydropower plants, while their aggregated installed capacity accounted for 19.7 per cent of the total electricity generating capacity in the country (table 12).

Nowadays, the preference is given to the construction of the small-scale and medium-scale hydroelectric power plants to meet the base-load demand, while the development of pumped storage power facilities will be continued to meet the peak-load requirements. Therefore, water demand for electricity generation by hydroelectric power plants is expected to increase slightly in the future.

2. *Water for snow melting*

The use of water to melt snow began in 1963, when several areas in the Niigata prefecture receiving abundant snow suffered serious damage from a snowfall. By this technique, warm water, mostly pumped from shallow wells, is sprayed over the streets by sprinkler systems when snow begins to fall. Water is also used to remove snow by snow-flowing drains into waterways. Since the temperature of the groundwater is higher than the temperature of the air in winter time, the use of groundwater for snow melting has proved to be economical compared with any other method; therefore, it has spread rapidly and widely in all snowy areas of Japan.

The total length of pipes laid along streets to deliver water for snow melting reached about 3,500 km, as of March 1989, while the amount of water used in 1991 was 102 million m^3, out of which 77 per cent was extracted from groundwater sources. In addition, about 582 million m^3 of water withdrawn mostly from surface sources was used for discharging snow by drains.[18]

Since effective and rapid removal of snow is essential for keeping urban life uninterrupted and maintaining economic activities in areas with high snowfall in the winter season, the use of water for snow melting will be on rise in the future as more main streets and roads are equipped for snow melting with sprayed water. However, the excessive abstraction of groundwater during short time periods, especially in winter when groundwater replenishment is slowed down, may lead to adverse environmental impacts such as land subsidence and sea-water intrusion. Therefore, it is anticipated that groundwater for snow melting will be partly substituted with surface water and/or treated sewages.

3. Water for fish farming

Large amounts of water are required for freshwater fish cultivation. Although it is difficult to estimate the quantity of water used for fish farming, about 8.2 billion m^3 of water was reportedly allocated for this purpose in 1991. The breeding of several species of fish, such as eels or ayus (sweetfish), requires large amounts of groundwater. For this purpose, about 2.4 billion m^3 of groundwater, or 29.5 per cent of the total amount, was withdrawn from aquifiers.[20] With the further development of fisheries in inland waters, the demand for high quality water needed for fish breeding will increase accordingly.

4. Water for environmental conservation

In Japan, the role of water for preservation of beautiful scenery and environment has been traditionally appreciated. Open spaces along many rivers in and around cities have been used as parks or sports grounds for relaxation and recreation of residents. In order to maintain the required amount of water in streams flowing through human settlements and its adequate water quality as well as to create comfortable waterside environment, several hundred projects specifically targeted at these purposes have been under implementation throughout the country.

Recreational water-related activities such as swimming, sailing and fishing also make demands on water resources. With increase in the standard of living, water needs for the preservation of environment and recreational activities will grow substantially.

5. Inland navigation

Rivers in Japan are unsuitable for inland navigation due to their steep gradients and large flow fluctuations. However, the lack of inland navigation is compensated for by extensive coastal shipping. The coastline on the Pacific side is characterized by long, narrow, gradually shallowing inlands resulting from river depositions, which create many natural habours, while the Sea of Japan coast and the Pacific coastline north of Tokyo provide few natural ports.

F. Management of water resources development

1. Administrative structure

The administrative system of water resources development management in Japan is shown on figure XV. There are several ministries and agencies directly concerned with various aspects of water resources development in the country.

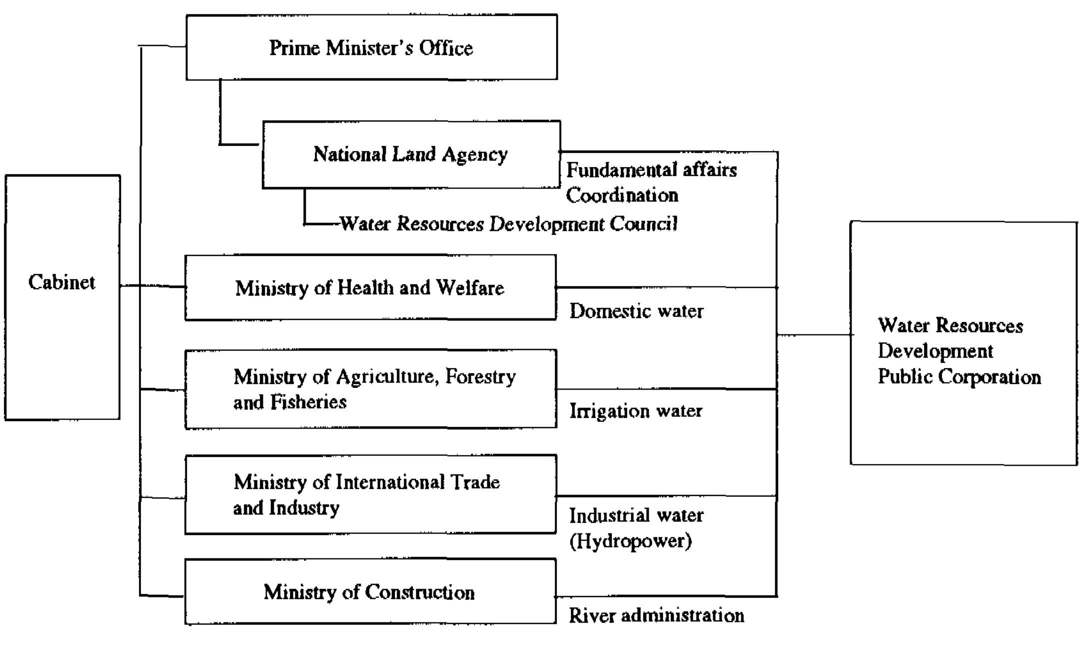

Figure XV. Administrative structure concerned with water resources development and management in Japan

Source: Water Japan, Japan's Water Works Yearbook 1993/94

The National Land Agency works out water resources development plans in cooperation with the other related governmental organizations, coordinates their activities in the water sector and supervises the Water Resources Development Public Corporation.

The Water Resources Development Council has been established as an auxiliary organ in the Prime Minister's Office. The Council, composed of 15 members, offers its opinion to the Prime Minister or the heads of the administrative agencies on matters concerning basic plans for water resources development in selected river systems.

The Ministry of Health and Welfare is the central governmental organization dealing with public water service. It is not involved directly in the management of particular water works, which is the responsibility of local authorities in cities, towns and villages, but the ministry issues regulations and provides guidance for water supply in accordance with the Water Works Law.

The Ministry of Agriculture, Forestry and Fisheries is responsible for the planning, construction and management of irrigation and drainage projects. The Ministry prepares plans, executes and provides management for large-scale irrigation and drainage projects implemented as governmental projects, while medium- and small-scale projects are undertaken by prefectures and farmers' organizations, respectively.

The Ministry of International Trade and Industry is concerned with industrial water supply and hydropower generation.

The Ministry of Construction is in charge of river conservancy works, including flood control, erosion control and river training. It is also in charge of construction and operation of multipurpose dams and reservoirs. Rivers of class A are administered by the Ministry. In the Ministry, the main unit which deals with water resources development projects is the River Bureau.

Under the joint jurisdiction of those organizations, the Water Resources Development Public Corporation has been established with the objective to promote the construction of water resources development facilities and provide efficient and integrated operation and maintenance of such facilities. The Corporation has been carrying out projects such as dams, estuary weirs, water level regulating facilities and multipurpose canals in seven principal river basins of Japan – Tone, Ara, Kiso, Yodo, Yoshino, Chikugo and Toyo.

In addition to the above mentioned governmental organizations engaged in the management of water resources development, the Environment Agency sets up standards for water quality and carries out water pollution control, the Ministry of Finance allocates funds for water projects, the Meteorological Agency collects and analyses precipitation data and hydrological information.

2. *Legislation*

The water legislation in Japan is well developed. There are several basic laws for water resources development and management, namely:

- Water Resources Development Promotion Act (1961), under which seven major river systems, listed in the previous section, have been selected for planned development;
- River Act (1964), which deals with such matters as comprehensive management of rivers, water utilization, prevention of water-related disasters;
- Water Works Law (1957), which contains major provisions concerning water supply facilities and services;
- Flood Control Act (1949), which stipulates necessary matters concerning flood control such as flood forecasting and warning, flood control measures and financing of those activities; etc.

The public awareness of high value of water resources has been also promoted by governmental agencies. Thus, the National Land Agency organizes various activities and initiates public campaigns aimed at enhancing the public's understanding of the limited availability of water resources and importance of sustainable water resources development. One of the most prominent public campaigns is the Water Week beginning every year on August 1, which is proclaimed as the Water Day.

PART THREE

TRENDS IN WATER USE

A. Changes in the water use pattern

In Japan, river water has been utilized for centuries mainly for agriculture, particularly for rice cultivation. In the 1960s, however, the rapid economic growth and the concentration of population in urban areas brought about increasing demands for water and keen competition among water users. Demand for water by both industry and population increased drastically during the decade from 1965 to 1975 keeping pace with industrial development and the improvement of living standards. During this period, water withdrawals for industry rose about 1.4 times, while the use of water for domestic purposes increased almost twice. In this period of rapid economic development, Japan failed to secure sufficient supply to meet sharply increased demand for domestic and industrial water.

Since 1975, while the total volume of water withdrawals has been steadily growing, non-consumptive water users, such as hydroelectric power generation, inland water fisheries and recreational activities have been claiming more persistently their shares of water (figure XVI).

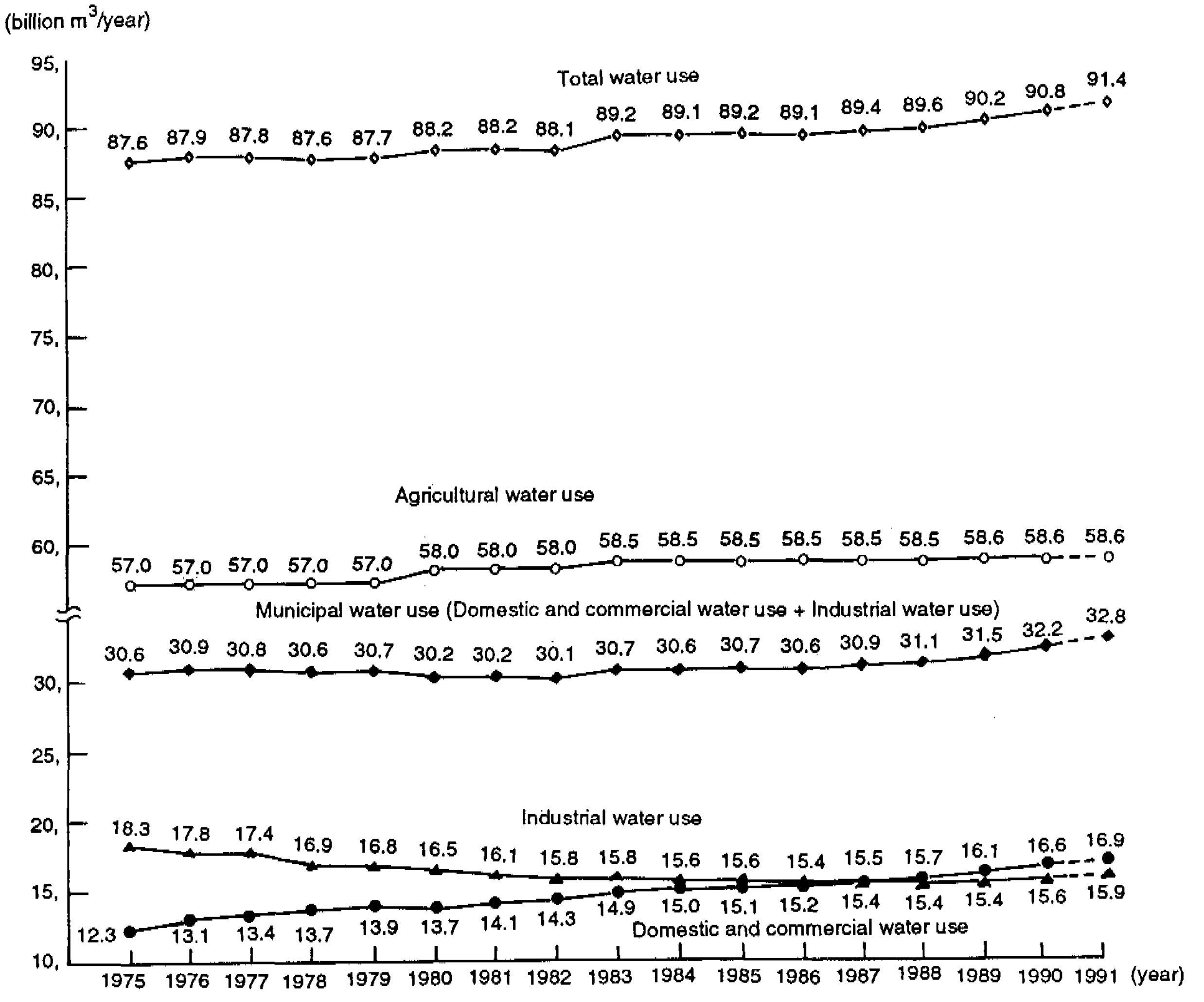

Figure XVI. Water use in Japan, 1975-1991

Note: Values calculated on an intake basis

Source: Fumihide Matsuda "Water Resources in Japan 1993"

B. Water demand projections by the year 2000

Under these circumstances, the National Comprehensive Water Resources Plan ("Water Plan 2000") was formulated in the middle of the 1980s by the National Land Agency with a view to undertaking adequate measures needed to meet water demands anticipated by the year 2000. In the Plan, projected water requirements by the year 2000 have been compared with water needs in 1983.

The total amount of water used in 1983 has been estimated at 89.2 billion m^3, out of which 58.5 billion m^3 were withdrawn for agriculture, 15.8 billion m^3 for industry and 14.9 billion m^3 for domestic water supply. The water resources utilization ratio calculated as a proportion between the annual amount of water withdrawals and the amount of water available in a dry year (303.4 billion m^3) was 29.4 per cent.

The increase in annual water demand from 1983 to 2000 has been projected at 12.3 billion m^3 for domestic and industrial water supply and 4.1 billion m^3 for agricultural water or a total of 16.4 billion m^3. Thus, the total demand for domestic, industrial and agricultural water estimated on the assumption of a relatively low growth rate, will reach 105.6 billion m^3 in the year 2000 and the water resources utilization ratio in a dry year will rise up to 34.8 per cent accordingly.

In addition, in areas prone to land subsidence about 2.3 billion m^3 of water is planned to be withdrawn in the year 2000 from surface water sources in order to substitute for the extraction of groundwater. Besides, the annual intake capacity of 3.2 billion m^3, which cannot be used in low-water flow periods, is expected to be switched to more stable water sources. Thus, the total annual increase in water demand in the year 2000 in comparison with 1983 will be about 21.9 billion m^3 of water.

To cope with the projected rise in water demand, water supply is expected to be increased by 23.0 billion m^3 in the year 2000. Additional water supply will be made available mostly by the construction of new multipurpose dams and reservoirs and other waterworks. However, the development by structural measures is becoming more and more difficult due to the shortage of sites suitable for dams and reservoirs. Besides, in Japan the cost-effectiveness of dam construction is comparatively low, since expenses relating to the resettlement of population and conservation of the environment are steadily growing. The cost of development of one cubic metre of water per second, which was several hundred million yen early in the 1960s, rocketed to 10-20 billion yen late in the 1980s. This is a tremendous increase of dozen times, if compared with overall five times increase in prices during the same period.[20] Therefore, attention will also be given to the rational use of water resources, including application of water-saving techniques and technologies in all branches of the national economy.

In Japan, water demand is expected also to be on rise after the year 2000 in line with the development of the economy and improvement of living standards. The rate of growth in water demand will depend mainly on the growth rate of the national economy since population growth should be low and, accordingly, the water demand for domestic needs will increase slightly.

Non-conventional water sources, such as desalination of sea water will also be tapped. As of January 1990, there were already 64 seawater desalination facilities producing about 75,800 m^3 of water per day for industrial purposes and 29 facilities with an aggregated capacity of 11,500 m^3 per day for domestic water supply.[21] The desalination of sea water would be further promoted in areas, such as small remote islands with an acute shortage of conventional water.

C. Regional differences in water demand and supply

It appears that according to the National Comprehensive Water Resources Plan, a sufficient water supply of adequate quality will be ensured by the year 2000 on a nation-wide scale. However, several regions including Kanto, Tokai, Kinki and Kyushu are expected to have difficulties in securing needed water supply (figure XVII).

The areal availability of water resources in a dry year and the rate of their utilization, in terms of the volume of withdrawals from water sources in 1983 and the rate of their expected use in the year 2000 are shown in tables 13 and 14. As mentioned earlier, the amount of run-off in a dry year has been estimated at 303.4 billion m^3 for the whole country. Actually, the amount of water readily available for development is considerably smaller, because of rapid outflow of rainfall to the sea due to the short length and steep gradient of most rivers. The ratio of utilization of water resources in 1983 to the full volume of run-off in a dry year was estimated at 29.4 per cent, while in several areas such as Kanto, Kinki and North Kyushu the ratio reached 64.0, 42.7 and 47.3 per cent, respectively. By the year 2000, the average national ratio of water utilization is expected to rise to 34.8 per cent, while in Kanto the water utilization ratio is projected to reach 77.8 per cent, in Kinki 50.8 per cent and in North Kyushu 57.3 per cent (table 15). Since a large portion of the water withdrawn, especially for agricultural and domestic needs, comes back to surface and groundwater sources, the ratio of consumptive utilization of water resources is, in fact, much less; however, the data on the amount of return water are not available.

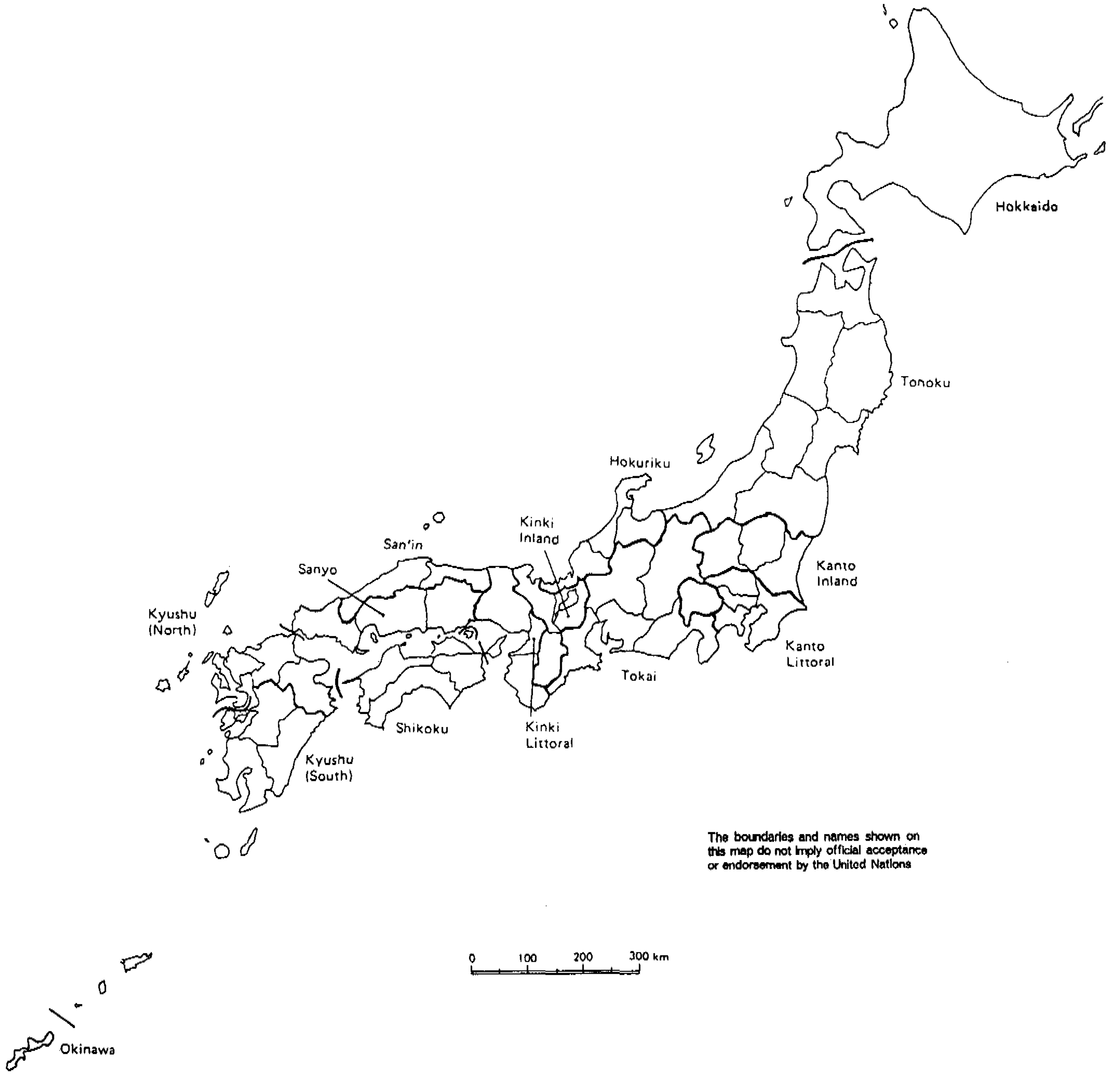

Figure XVII. Administrative areas in Japan

Source: National Comprehensive Water Resources Plan (Water Plan 2000)

Table 13. Water use by administrative area in Japan, 1983 and 2000

(billion m^3)

Area		*1983*				*2000*			
		Agriculture	*Industry*	*Domestic supply*	*Total*	*Agriculture*	*Industry*	*Domestic supply*	*Total*
Hokkaido		4.45	1.25	0.55	6.24	4.76	1.91	0.79	7.46
Tohoku		16.68	1.65	1.28	19.61	17.98	2.74	1.82	22.54
Kanto	Inland	6.07	0.87	0.79	7.73	6.46	1.52	1.23	9.21
	Littoral	2.75	1.61	4.05	8.41	2.81	2.14	5.44	10.39
	Sub-total	8.82	2.48	4.84	16.14	9.27	3.66	6.67	19.60
Tokai		5.46	3.40	2.08	10.94	5.81	4.38	2.84	13.03
Hokuriku		3.31	0.92	0.39	1.62	3.55	1.21	0.55	5.31
Kinki	Inland	2.18	0.47	0.68	3.32	2.27	0.69	0.94	3.90
	Littoral	2.54	1.50	2.16	6.20	2.62	1.83	2.99	7.45
	Sub-total	4.72	1.97	2.84	9.52	4.89	2.52	3.93	11.34
Chugoku	Sanin	1.42	0.21	0.15	1.78	1.52	0.32	0.22	2.06
	Sanyo	3.67	1.50	0.74	5.91	3.93	1.90	1.08	6.90
	Sub-total	5.09	1.71	0.90	7.69	5.45	2.22	1.30	8.96
Shikoku		2.44	0.98	0.50	3.93	2.62	1.34	0.70	4.66
Kyushu	North	4.03	0.63	0.83	5.49	4.38	1.04	1.22	6.65
	South	3.42	0.77	0.50	4.68	3.77	1.12	0.74	5.63
	Sub-total	7.45	1.39	1.33	10.17	8.15	2.17	1.96	12.28
Okinawa		0.07	0.04	0.17	0.28	0.09	0.08	0.25	0.42
National total		58.49	15.80	14.86	89.15	62.57	22.22	20.81	105.60

Source: National Comprehensive Water Resources Plan, October 1987 (Water Plan 2000).

Table 14. Expected increase in water demand and supply in Japan from 1983 to 2000

(billion m^3)

Area		*Increase in demand*					*Increase in supply*	*Balance of water demand & supply in 2000*
		By agriculture	*By domestic sector and industry*	*To replace unstable water intake*	*To substitute groundwater withdrawals*	*Total*		
Hokkaido		0.31	0.90	0.00	0.03	1.25	1.30	0.05
Tohoku		1.30	1.63	0.06	0.16	3.14	3.43	0.29
Kanto	Inland	0.39	1.09	0.32	0.21	2.01	2.03	0.02
	Littoral	0.06	1.92	1.58	0.57	4.13	4.18	0.05
	Sub-total	0.45	3.01	1.90	0.78	6.14	6.22	0.08
Tokai		0.35	1.73	0.15	0.64	2.87	3.22	0.35
Hokuriku		0.24	0.45	0.09	0.13	0.91	0.94	0.03
Kinki	Inland	0.09	0.49	0.03	0.12	0.72	0.74	0.02
	Littoral	0.08	1.16	0.77	0.17	2.18	2.21	0.02
	Sub-total	0.17	1.65	0.80	0.28	2.91	2.95	0.05
Chugoku	Sanin	0.10	0.18	0.00	0.02	0.30	0.32	0.03
	Sanyo	0.26	0.73	0.07	0.06	1.12	1.22	0.10
	Sub-total	0.36	0.91	0.07	0.08	1.42	1.55	0.13
Shikoku		0.18	0.55	0.00	0.11	0.84	0.92	0.07
Kyushu	North	0.35	0.81	0.02	0.00	1.18	1.25	0.06
	South	0.35	0.60	0.03	0.08	1.07	1.10	0.03
	Sub-total	0.70	1.41	0.05	0.09	2.25	2.34	0.09
Okinawa		0.02	0.12	0.03	0.00	0.17	0.19	0.01
National total		4.08	12.37	3.16	2.30	21.90	23.04	1.14

Source: National Comprehensive Water Resources Plan, October 1987 (Water Plan 2000).

Table 15. Dry year water resources by area and ratio of their presumed utilization in Japan for 1983 and 2000

(billion m^3)

Area		*Dry year water resources*	*1983*		*2000*	
			Water use	*%*	*Water use*	*%*
Hokkaido		40.2	6.24	15.5	7.46	18.6
Tohoku		64.4	19.61	30.4	22.54	35.0
Kanto		25.2	16.14	64.0	19.60	77.8
Tokai		53.2	10.94	20.6	13.03	24.5
Hokuriku		17.8	4.62	25.9	5.31	29.8
Kinki		22.3	9.52	42.7	11.34	50.8
Chugoku	Sannin	9.0	1.78	19.8	2.06	22.9
	Sanyo	15.0	5.91	39.4	6.90	46.0
	Sub-total	23.9	7.69	32.2	8.96	37.5
Shikoku		18.1	3.93	21.7	4.66	25.7
Kyushu	North	11.6	5.49	47.3	6.65	57.3
	South	25.4	4.68	18.4	5.63	22.2
	Sub-total	37.1	10.17	27.4	12.28	33.1
Okinawa		11.6	0.28	24.1	0.42	36.2
National total		303.4	89.15	29.4	105.6	34.8

Source: National Comprehensive Water Resources Plan, October 1987 (Water Plan 2000).

Conclusions

Japan has accumulated essential experience and knowledge in carrying out large water resources development programmes. The achievements in the water resources assessment, long-term planning of water resources development, water pollution control and flood mitigation as well as in the rational utilization of water for various purposes are indisputable. In this highly urbanized and industrialized country, stable water supply for population and municipal needs, industry and agriculture has been secured by means of construction of multiple structures, including dams and reservoirs, canals, water intakes, water purification plants, pumping stations, etc. Building of dikes and water retention reservoirs and other structural measures have led to tangible reduction in the damage caused by floods.

Japan has also developed a comprehensive and advanced water legislation and efficient administration for water resources management. The public awareness of the value of water has been promoted and public involvement in water management decision-making has been encouraged.

Undoubtedly, this experience and knowledge could be very useful for all developing countries of the region, especially for the newly industrialized countries, which plan or implement national or subregional water resources development programmes, in helping them to adapt the rationale of the policies and practices in the water sector in Japan to their local conditions.

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Annex I

CLASS A RIVERS IN JAPAN

River	*Total Drainage Area (km^2)*	*Length of River (Km)*	*Key Station*	*Unregulated Peak Discharge (m^3/sec)*	*Channel Design Discharge (m^3/sec)*
Teshio	5,590	256	Ponpira	4,400	3,800
Shokotsu	1,240	84	Kamishokotsu	1,300	1,300
Yubetsu	1,480	87	Kaisei	1,800	1,800
Tokoro	1,930	120	Kitami	1,900	1,600
Abashiri	1,380	115	Bihoro	1,200	1,200
Rumoi	270	44	Owada	1,000	800
Ishikari	14,330	268	Ishikariohashi	18,000	14,000
Shiribetsu	1,640	126	Nakoma	3,300	3,000
Shiribeshitoshibetsu	720	80	Imagane	1,600	1,250
Mu	1,270	135	Mukawa	3,600	3,600
Saru	1,350	104	Biratori	5,400	3,900
Kushiro	2,510	154	Shibecha	1,200	1,200
Tokachi	9,010	156	Moiwa	15,200	13,700
Iwaki	2,540	102	Goshogawara	5,500	3,800
Takase	867	64	Takasebashi	1,400	1,400
Mabuchi	2,050	142	Kenyoshi	2,7900	2,700
Kitakami	10,150	249	Kozenji	13,000	8,500
Naruse	1,130	89	Sanbongi	4,100	3,100
Natori	939	55	Natorihashi	3,200	2,400
Abukuma	5,400	239	Iwanuma	10,700	9,200
Yoneshiro	4,100	136	Futatsui	9,200	8,200
Omono	4,710	133	Tsubakigawa	9,800	8,700
Koyoshi	1,190	61	Todorokibashi	1,800	1,800
Mogami	7,040	229	Ryoubashi	9,000	8,000
Aka	857	70	Kumaide	5,300	3,000
Kuji	1,490	124	Yamagata	4,000	3,400
Naka	3,270	150	Noguchi	6,200	5,200
Tone	16,840	322	Yattajima	22,000	16,000
Area	2,940	169	Iwabuchi	14,800	7,000
Tama	1,240	138	Ishihara	8,700	6,500
Tsurumi	235	43	Sueyoshibashi	2,300	1,800
Sagami	1,680	109	Atsugi	10,100	7,300
Ara	1,151	73	Hanatate	8,000	6,500
Agano	7,710	210	Maoroshi	13,000	11,000
Shinano	11,900	367	Ojiya	13,500	11,000
Seki	1,140	64	Takada	3,700	3,700
Hime	722	60	Yamamoto	5,000	5,000
Kurobe	682	85	Aimoto	7,200	6,200
Joganji	368	56	Kameiwa	4,600	4,600
Jintsu	2,720	120	Jintsuohashi	9,700	7,700
Sho	1,180	115	Sho	4,500	4,500
Oyabe	667	68	Tsuzawa	1,300	1,300
Tedori	809	72	Tsuruki	6,000	5,000
Kakehashi	271	42	Komatsuohashi	1,700	1,000

River	Total Drainage Area (km^2)	Length of River (Km)	Key Station	Unregulated Peak Discharge (m^3/sec)	Channel Design Discharge (m^3/sec)
Kano	852	46	Ohito	4,000	4,000
Fuji	3,990	128	Kitamatsuno	16,600	16,600
Abe	567	51	Tegoshi	5,500	5,500
Oi	1,280	160	Kanza	11,500	9,500
Kiku	158	28	Kuniyasu	1,500	1,500
Tenryu	5,090	213	Kashima	19,000	14,000
Toyo	724	77	Ishida	7,100	4,100
Yahagi	1,830	117	Iwazu	8,100	6,400
Shonai	1,010	96	Biwajima	4,500	4,200
Kiso	9,100	227	Inuyama	16,000	12,500
Suzuka	323	38	Takaoka	3,900	3,900
Kumozu	550	55	Kumozubashi	5,000	4,500
Kushida	461	85	Ryogunbashi	4,800	4,300
Miya	920	91	Iwaide	8,400	7,600
Yura	1,880	146	Fukuchiyama	6,500	5,600
Yodo	8,240	75	Hirakata	17,000	12,000
Yamato	1,070	68	Kashiwara	5,200	5,200
Maruyama	1,300	68	Tateno	4,500	4,500
Kako	1,730	96	Kunikane	9,000	7,400
Ibo	810	70	Tatsuno	3,300	2,900
Kino	1,660	136	Funado	16,000	12,00
Shingu	2,360	183	Oga	19,000	19,000
Kuzuryu	2,930	116	Nakatsuno	8,600	5,500
Kita	224	50	Takatsuka	1,900	1,900
Sendai	1,190	52	Gyotoku	6,300	5,500
Tenjin	500	32	Oda	3,500	3,500
Hino	860	77	Kuzumo	4,300	4,000
Hii	2,070	153	Kamishima	5,100	4,500
Gono	3,870	194	Ozekiyama	10,200	7,600
Takatsu	1,080	81	Takatsu	4,200	4,200
Yoshii	2,060	133	Iwato	11,000	7,500
Asahi	1,800	142	Shimomaki	6,000	5,000
Takahashi	2,670	111	Sakatsu	6,900	6,900
Ashida	870	86	Kamijima	3,500	2,800
Ota	1,700	103	Kumura	12,000	7,500
Oze	342	59	Ryogokubashi	3,400	1,000
Saba	446	56	Shibashi	35,000	2,900
Yoshino	3,750	194	Iwazu	24,000	18,000
Naka	874	125	Furusho	11,200	9,000
Doki	140	33	Haraikawabashi	1,100	1,100
Shigenobu	445	36	Deai	3,150	2,900
Hiji	1,210	103	Ozu	6,300	4,700
Monobe	508	71	Fukabuchi	5,400	4,740
Niyodo	1,560	124	Ino	13,500	12,000
Watari	2,270	196	Gudo	17,000	14,000
Onga	1,030	61	Hinodebashi	4,800	4,800
Yamaguni	540	56	Shimotobara	4,800	4,300

River	*Total Drainage Area (km²)*	*Length of River (Km)*	*Key Station*	*Unregulated Peak Discharge (m³/sec)*	*Channel Design Discharge (m³/sec)*
Chikugo	2,860	143	Yoake	10,000	6,000
Yabe	620	61	Funagoya	3,500	3,000
Matsuura	446	47	Matsuurabashi	3,800	3,400
Rokkaku	341	47	Suminoe	2,200	2,000
Kase	368	57	Kanninbashi	3,400	2,500
Honmyo	87	21	Urayama	810	810
Kikuchi	996	71	Tamana	4,500	3,800
Shira	480	74	Yotsugibashi	3,400	3,000
Midori	1,100	76	Medomachibashi	4,300	3,650
Kuma	1,880	115	Hagiwara	9,000	7,000
Oita	650	55	Funaiohashi	5,700	5,000
Ono	1,460	38	Shiratakibashi	11,000	9,500
Bansho	464	38	Banshobashi	3,000	3,000
Gokase	1,820	106	Miwa	6,000	6,000
Omaru	474	75	Takajo	3,600	3,000
Oyodo	2,230	107	Miyazaki	7,500	7,000
Sendai	1,600	137	Sendai	9,000	7,000
Kimotsuki	485	34	Matase	2,500	2,300

Source: Rivers in Japan, 1985, published by the River Bureau, Ministry of Construction, Japan

Annex II

NATIONAL WATER QUALITY STANDARDS RELATED TO THE PROTECTION OF HUMAN HEALTH

No	*Item*	*Standard Value*	*No*	*Item*	*Standard Value*
1	Cadmium	not more than 0.01 mg/*l*	13	cis-1,2-Dichloroethylene	not more than 0.04 mg/*l*
2	Cyanide	not to be detected	14	1,1,1-Trichloroethane	not more than 1 mg/*l*
3	Lead	not more than 0.01 mg/*l*	15	1,1,2-Trichloroethane	not more than 0.006 mg/*l*
4	Chromium (VI)	not more than 0.05 mg/*l*	16	Trichloroethylene	not more than 0.03 mg/*l*
5	Arsenic	not more than 0.01 mg/*l*	17	Tetrachloroethylene	not more than 0.01 mg/*l*
6	Mercury	not more than 0.0005 mg/*l*	18	1,3-Dichloropropene	not more than 0.002 mg/*l*
7	Alkyl mercury	not to be detected	19	Thiram	not more than 0.006 mg/*l*
8	PCB	not to be detected	20	Simazine	not more than 0.003 mg/*l*
9	Dichloromethane	not more than 0.02 mg/*l*	21	Thiobencarb	not more than 0.02 mg/*l*
10	Carbon Tetrachloride	not more than 0.002 mg/*l*	22	Benzene	not more than 0.01 mg/*l*
11	1,2-Dichloroethane	not more than 0.004 mg/*l*	23	Selenium	not more than 0.01 mg/*l*
12	1,1-Dichloroethylene	not more than 0.02 mg/*l*			

Note: Yearly average value, but Cyanide is maximum value.

Annex III

NATIONAL WATER QUALITY STANDARDS RELATED TO THE CONSERVATION OF THE LIVING ENVIRONMENT

a. Rivers

Category	Item / Purposes of water use	Standard Values*				
		pH	*Biochemical Oxygen Demand (BOD)*	*Suspended Solids (SS)*	*Dissolved Oxygen (DO)*	*Number of Coliform Groups*
AA	Water supply, class 1; conservation of natural environment; and uses listed in A-E	6.5 - 8.5	1 mg/*l* or less	25 mg/*l* or less	7.5 mg/*l* or more	50 MPN/100 ml or less
A	Water supply, class 2; fishery class 1; bathing, and uses listed in B-E	6.5 - 8.5	2 mg/*l* or less	25 mg/*l* or less	7.5 mg/*l* or more	1,000 MPN/100 ml or less
B	Water supply, class 3; fishery, class 2; and uses listed in C-E	6.5 - 8.5	3 mg/*l* or less	25 mg/*l* or less	5 mg/*l* or more	5,000 MPN/100 ml or less
C	Fishery, class 3; industrial water, class 1; and uses listed in D-E	6.5 - 8.5	5 mg/*l* or less	50 mg/*l* or less	5 mg/*l* or more	
D	Industrial water, class 2; agricultural water **; and uses listed in E	6.0 - 8.5	8 mg/*l* or less	100 mg/*l* or less	2 mg/*l* or more	
E	Industrial water, class 3; conservation of the environment	6.0 - 8.5	10 mg/*l* or less	Floating matter such as garbage should not be observed	2 mg/*l* or more	

* The standard value is based on the daily average value. (The same applies to the standard value for lakes and coastal waters.)

** At the inlet of an agricultural water diversion structure, pH shall be between 6.0 and 7.5 and dissolved oxygen shall not be less than 5 mg/*l*. (The same applies to the standard value for lakes.)

Notes:
1. Conservation of natural environment; Conservation of scenic spots and other natural resources.
2. Water supply, class 1: Water that requires treatment by simple cleaning operation, such as filtration.
   Water supply, class 2: Water that requires treatment by normal cleaning operation, such as sedimentation and filtration.
   Water supply, class 3: Water that requires treatment by highly advanced cleaning operation including pretreatment.
3. Fishery, class 1: For aquatic life, such as trout and bull trout inhabiting oligosaprobic water, and those of fishery class 2 and class 3.
   Fishery, class 2: For aquatic life, such as fish of the salmon family and sweetfish inhabiting oligosaprobic water and those of fishery class 3.
   Fishery, class 3: For aquatic life, such as carp and silver carp inhabiting β -mesosaprodic water.
4. Industrial water, class 1: Water given normal cleaning treatment such as sedimentation.
   Industrial water, class 2: Water given advanced treatment by chemicals.
   Industrial water, class 3: Water given special cleaning treatment.
5. Conservation of the environment: Up to the limits at which no unpleasantness is caused to people in their daily life (including a walk by the riverside, etc.)

b-1. Lakes (natural lakes, reservoirs, marshes and artificial lakes with a volume more than 10 million m^3 of water)

Category	*Item* / *Purposes of water use*	*Standard Values**				
		pH	*Chemical Oxygen Demand (BOD)*	*Suspended Solids (SS)*	*Dissolved Oxygen (DO)*	*Number of Coliform Groups*
AA	Water supply, class 1; fishery, class 1; conservation of natural environment, and uses listed in A-C	6.5 - 8.5	1 mg/*l* or less	1 mg/*l* or less	7.5 mg/*l* or less	50 MPN/100 ml or less
A	Water supply, class 2 and 3; fishery, class 2; bathing, and uses listed in B-C	6.5 - 8.5	3 mg/*l* or less	5 mg/*l* or less	7.5 mg/*l* or more	1,000 MPN/100 ml or less
B	Fishery, class 3; industrial water, class 1; agricultural water, and uses listed in C	6.5 - 8.5	3 mg/*l* or less	15 mg/*l* or less	5 mg/*l* or more	
C	Industrial water, class 2; conservation of the environment	6.0 - 8.5	8 mg/*l* or less	Floating matter such as garbage shall not be observed	2 mg/*l* or more	

* With regard to fishery, classes 1, 2 and 3, the standard value of suspended solids shall not be applied for the time being.

Notes: see notes for Rivers.

b-2. Lakes

Category	*Purpose of water use*	*Standard values*	
		Total nitrogen	*Total phosphorus*
I	Conservation of natural environment, and uses listed in II-V	0.1 mg/*l* or less	0.005 mg/*l* or less
II	Water supply classes 1, 2 and 3 (excluding special types); Fishery type 1, bathing; and uses listed in III-V	0.2 mg/*l* or less	0.01 mg/*l* or less
III	Water supply class 3 (special types), and uses listed in IV-V	0.4 mg/*l* or less	0.03 mg/*l* or less
IV	Fishery type 2, and uses listed in V	0.6 mg/*l* or less	0.05 mg/*l* or less
V	Fishery type 3; industrial water; agricultural water; conservation of the living environment	1 mg/*l* or less	0.1 mg/*l* or less

Notes: 1. The Standards are measured in terms of yearly average.
2. The Standards for total nitrogen are applicable to lakes and reservoirs where nitrogen is judged to be the causal factor the growth of phytoplakton.
3. The Standards for total phosphorus are not applicable to agricultural water use.

c. Coastal Waters

Category	*Item* / *Purposes of water use*	*Standard Values**				
		pH	*Chemical Oxygen Demand (COD)*	*Dissolved Oxygen (DO)*	*Number of Coliform Groups*	*N-hexane Extracts*
A	Fishery, class 1; bathing; conservation of natural environment, and uses listed in B-C	7.8 - 8.3	2 mg/*l* or les	7.5 mg/*l* or more	1,000 MPN/100 ml or less	Not detectable
B	Fishery, class 2; industrial water, and uses listed in C	7.8 - 8.3	3 mg/*l* or less	5 mg/*l* or more	–	Not detectable
C	Conservation of the environment	7.0 - 8.3	8 mg/*l* or less	2 mg/*l* or more	–	–

* With regard to the quality of fishery, class 1 for planting oysters, the number of coliform groups shall be less than 70 MPN/100 ml.

Notes: 1. Fishery, class 1; For aquatic life such as red sea-bream, yellow tail, seaweed and those of fishery, class 2.
Fishery, class 2; For aquatic life such as gray mullet, laver, etc.

2. Conservation of the environment; Up to the limits at which no unpleasantness is caused to people in their daily life (including a walk by the shore, etc.)