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The Third World Water Forum and the Fourth International Conference of Aquapolises (ICAP)

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1. Introduction

To discuss water-related problems in the world and seek appropriate solutions by gathering the wisdom of people from around the world, the 3rd World Water Forum was held from March 16 through 23, 2003, in Osaka, Kyoto and Shiga, Japan. In Osaka, 60 sessions were held at the Osaka International Convention Center (Grand Cube Osaka) on March 18 and 19 on the following six themes: Water and Cities, Water and Information, Groundwater, Public and Private Partnership, CEO Panel and Union Panel. On March 19, the Osaka City Government held the 4th International Conference of Aquapolises (ICAP) at the Main Hall of Grand Cube Osaka, where about 900 representatives gathered from a total of 55 cities in 22 countries.

As a related event of the World Water Forum, Water EXPO was held at INTEX Osaka for five days from March 18 through 22 on the theme: Water, Cities, Industry and Future Water Creation and the Future. Approximately 100,000 people visited this event, which featured exhibitions by a total of about 530 organizations, including private enterprises, national and local governments, international institutes, universities, research institutes, NGOs and other grassroots organizations. (See Photo 1.)

Photo 1 Volunteer interpreter helping overseas guests

2. The 3rd World Water Forum

(1) World Water Forums

Today, water-related problems, including water shortage, water pollution and increasing damage caused by floods, occur in various parts of the world, particularly in developing countries. Combined with famine and the spread of infectious diseases due to water-related issues, these problems are affecting increasing numbers of people around the world.

In this context, in 1996 specialists on water problems, related academic circles and international institutes jointly formed the "World Water Council" (WWC) with the aim of creating an international think-tank on water problems. To hold discussions on and seek solutions to water problems in international society, and to raise public awareness regarding the vital importance of these problems, the WWC holds triennial World Water Forums on and around March 22, World Water Day. The first World Water Forum was held in March 1997 in Marrakech, Morocco; the second in The Hague, the Netherlands in March 2000; and the third in the Lake Biwa and Yodo River Basin (Shiga, Kyoto and Osaka, Japan) in March 2003. In March 2006, the fourth Forum is planned in Mexico City, Mexico.

(2) The 3rd World Water Forum

At the 3rd World Water Forum, held in Osaka, Kyoto and Shiga from March 16 through 23, 2003, representatives of citizens, NGOs, NPOs, national and local governments and specialists gathered to discuss and seek solutions to serious challenges related to water.

During the Forum, 351 sessions were held with the participation of many representatives from 182 countries and regions. Registered participants totaled 24,060, of which 6,056 people were from abroad. In addition, 1,191

reporters, including 270 from overseas, covered the sessions. At the Ministerial Conference, representatives of 170 countries/regions and 43 international institutions assembled and adopted a message that states, "Water is a driving force for sustainable development including environmental integrity and the eradication of poverty and hunger, indispensable for human health and welfare." In this message, the representatives emphasized the vital importance of addressing water problems and asked international society to support initiatives for resolving these problems. At the Forum's three venues in Osaka, Kyoto and Shiga, various programs, events and fairs were held concerning water. (See Photo 2.)

Photo 2 Opening ceremony of 3rd World Water Forum (Kyoto International Conference Hall)

In Osaka, a total of 60 sessions were held primarily at Osaka International Convention Center (Grand Cube Osaka) on March 18 and 19, on the six themes: Water and Cities, Water and Information, Groundwater, Public and Private Partnership, CEO Panel and Union Panel. The total number of participants in these sessions was about 5,400, of which 3,135 registered at the venue in Osaka. In addition, at the Water Workshop in Osaka, held from March 20 through March 22, approximately 6,000 people participated from within and outside Japan.

At the opening ceremony of "Osaka Days" held on March 18, Mr. Ryutaro Hashimoto, Chairman of the National Steering Committee of the 3rd World Water Forum, and His Excellency Dr. Mahmoud Abu-Zeid, President of the WWC, gave opening remarks on behalf of the organizers. Following the opening remarks, Mr. Fidel V. Ramos, former President of the Republic of Philippines, and Ms. Fusae Ota, Governor of Osaka Prefecture, gave speeches, representing guests. Subsequently, Ms. Anna Kajumulo Tibaijuka, Executive Director of United Nations Centres for Human Settlements Programme (UN-HABITAT) declared the opening of the session on the theme of Water and Cities.

From 7:00 p.m. on that day, a welcome reception was held. Following the greeting by Mr. Takafumi Isomura, then-Mayor of Osaka City, performances of *bunraku* (puppet show) and other Japanese traditional performing arts were staged in the presence of approximately 800 guests from Japan and abroad. (See Photo 3.)

On the final day of the 3rd World Water Forum (March 23), following the closing ceremony held at Kyoto International Conference Hall, then-Mayor Isomura reported to Their Imperial Highnesses the Crown Prince and Princess, who served as honorary chairpersons of the 3rd World Water Forum, on Osaka City's initiatives in addressing water problems, including the organizing of such programs as the 4th ICAP and Water EXPO.

Photo 3 Puppet show "*Futari Sanbanso*" performed at the welcome reception

3. The 4th International Conference of Aquapolises (ICAP)

(1) International Conferences of Aquapolises

The first International Conference of Aquapolises (ICAP) was held in Osaka from July 25 through 27, 1990, to celebrate the 100th anniversary of Osaka City as a modern municipality. This first conference, on the theme "Creating Aquapolises of the 21st Century," was the first international conference that Osaka City planned and organized. Mayors, city officials and experts in urban problems gathered at the Conference from 26 overseas cities and seven Japanese cities (including Osaka City), all well known for abundant water and greenery. Participants held lively discussions on diverse aspects of various problems relating to water and greenery, in recognition that such problems comprise not only urban problems, but also global environmental challenges.

To continue personnel exchange among participating cities and promote information exchange on a regular basis, the Osaka Declaration, adopted on the final day of the first ICAP, stipulated that the 2nd ICAP should be held

within three years. In compliance, the 2nd ICAP was held in Shanghai (China) in 1993; the 3rd meeting was held in Piraeus (Greece) in 1997.

(2) The 4th ICAP

The 4th ICAP, held on March 19 at the Osaka venue of the World Water Forum, commenced with the greetings of Mr. Takafumi Isomura, then-Mayor of Osaka City. At the fourth meeting, representatives from a total of 55 cities (28 overseas cities and 27 Japanese cities) gathered from 22 countries. The total number of participants reached 900, including six mayors from such overseas cities as Busan (South Korea), Madrid (Spain), Colombo (Sri Lanka) and Dacca (Bangladesh). During the conference, a total of 17 cities introduced their commitment to maintaining their attractive features as water metropolises. Of these cities, eight presented papers. Following the presentations, panel discussions were held on the theme "The Future Direction and International Role of Aquapolises." (See Table 1.)

Regarding the key concept "aquapolis," representatives of participating cities suggested diverse methods for developing and maintaining harmonious relations between water and people, as well as urban activities and water systems. Participants also described diverse problems confronting their respective cities, including problems related to flood control, water shortage, development of water sources, sanitation and water pollution. The discussion led to common recognition by the participants that there are multi-layered challenges relating to safety and security of water, as well as to securing a sufficient water supply. There was also a voice suggesting the need to raise awareness regarding water problems.

Following the discussions, the coordinator suggested that cities' attractive feature as water metropolises should be called "*shinsui-ryoku*" (capability of promoting water affinity). The coordinator concluded the session with this remark: To maintain each city's "*shinsui-ryoku*," it is essential to build consensus of citizens and develop and retain a public-private collaboration system, with due consideration given to potential international collaboration. (See Photo 4.)

The 4th ICAP reaffirmed that ICAPs should be held, in principle, triennially, and that an information network be established among the "aquapolises" around the world. It was agreed that the next ICAP will be held in Busan, South Korea.

Photo 4 Panel discussion at 4th ICAP

Table 1 4th ICAP programs

March 19 (Wed.)	
14:00 - 14:05	Opening Address by Mr. Takafumi Isomura, then-Mayor of Osaka City
14:05 - 15:50	Part 1: Presentations by representatives of participating cities Budapest "Situation of Water Supply in Budapest" Pal VAJDA, Deputy Mayor Responsible for City Management, Budapest Venice "Venice: New Life for Old Cisterns" Giorgio GIANIGHIAN, Senior Research Professor, Istituto Universitario di Architettura di Venezia Ho Chi Minh "Pollution and International Collaboration" Van Hien GUYEN, Deputy Director in Charge of Technical Works, Project Management Unit of HCMC Environmental Improvement Project, Ho Chi Minh Busan "Ecological Restoration Project in the Onchun River in Busan" Young-Suk JUNG, Director General, Environmental Bureau, Busan Osaka "Aquapolis Osaka: Our Approach to City Reconstruction" Masashi IGOSHI, Deputy Mayor, Osaka City
15:50 - 16:00	Break
16:00 - 17:45	Part 2: Panel discussion by representative of participating cities Theme: Future Direction and International Roles of Aquapolises Coordinator: Professor Akinori KATO, School of Policy Studies, Kwansei Gakuin University Panelists: Representatives from Budapest, Busan, Hiroshima, Ho Chi Minh, Madrid, Osaka and Venice
17:45 - 17:50	Summary by Professor Kato, School of Policy Studies, Kwansei Gakuin University
17:50 - 18:00	Closing

4. Related Events

(1) Water EXPO

Concurrently with the 3rd World Water Forum, many water-related events and fairs were organized, including Water EXPO, held at INTEX Osaka for five days from March 18 through 22. At Water EXPO, about 530 enterprises demonstrated products and technologies related to water, on the theme: Water, Cities, Industry and Future Water Creation and the Future. At the opening ceremony, then-Mayor Isomura greeted on behalf of special guests.

The Water EXPO was a major event of the "*Mizu-En*" Festival, which comprised one of the three major elements of the 3rd World Water Forum (the other two were international ministerial meetings and the international conferences). At the venue many overseas countries and international organizations had booths that demonstrated research outcomes and initiatives addressing water problems in various parts of the world, together with booths of private enterprises that introduced state-of-the-art technologies related to water. In addition, there were a counter where visitors could drink and compare water from various places, a workshop for building a small aquarium, comedian shows and demonstrations of vehicles for use on both water and land (visitors were allowed to get into the vehicles). With such variety, Water EXPO was designed to attract the general public, including children, in addition to government officials, experts and representatives of enterprises, all participating in the 3rd World Water Forum. The ultimate goal of Water EXPO was to share with all visitors information and wisdom related to water and associated problems.

At this EXPO, Osaka City held an exhibition on the theme: Water and People in Osaka City. The City's booth featured a reproduction of a flood-prevention facility construction site, a reproduced natural habitat of aquatic organisms in the urban environment and a panel exhibition introducing urban riverfront improvement projects. During the EXPO period, a total of approximately 100,000 people visited the venue to see exhibitions of various municipalities and enterprises, and to attend an international symposium held there. (Of the 100,000 visitors, 61,764 visited the EXPO special exhibition.) (See Photo 5.)

Photo 5 Osaka City's booth at Water EXPO

(2) Water Workshop in Osaka

In addition to Water EXPO, another event called Water Workshop in Osaka was held from March 20 through 22 by the World Water Forum Osaka Committee. At this event, over 50 grassroots groups and NPOs involved in water-related activities in Japan held exhibitions and symposiums, also giving presentations and live performances. Still more events were organized to celebrate the 3rd World Water Forum, including the summit meeting on a ship on the Yodo River, to which mayors of cities in the Yodo River basin and representatives of economic circles were invited; an exchange meeting with overseas experts called "Acqua Renaissance 2003 and "*Suito* Renaissance," organized by NPOs in Osaka. (See Photo 6.)

Osaka City intends to further develop the outcomes of the 3rd World Water Forum and the 4th ICAP by adhering to the spirit of these international meetings and supporting local NPOs and other organizations in their activities addressing water problems, thereby reviving Osaka as a "*Suito*" (water metropolis), a historical name given to Osaka.

Photo 6 Opening ceremony of the *Suito* Renaissance (by the Okawa River)

Initiatives for Restoring "Water Metropolis Osaka"

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1. Introduction

In recent years in Osaka, there has been increasing interest in restoring the City's status as a water metropolis. One contributing factor in this is the Third World Water Forum in Osaka, held in March 2003. In view of such circumstances, various individuals and organizations have implemented a variety of programs to restore "water metropolis Osaka," including river beautification activities, events featuring ships and vessels, and symposiums on water-related issues.

This paper presents the initiatives for restoring the "water metropolis Osaka," based on the "Vision for Regenerating Water Metropolis Osaka" jointly prepared by the governments of Japan, Osaka Prefecture and City, as well as economic organizations, with the objective of revitalizing the City of Osaka.

2. Background of the "Vision for Regenerating Water Metropolis Osaka"

(1) Potential of Osaka as a water metropolis

Facing the sea, with ancient capitals in its hinterlands, Osaka (formally Naniwa) had in its early days already constructed an international port called Naniwa-zu. Since then, Osaka has developed as a gateway for international exchange. When Naniwa-no-Miya Palace was constructed in the 7th century, Osaka became Japan's political and cultural center, also serving as an international city where people from the Korean Peninsula and ancient China lived.

In the early modern period a castle town was constructed, making use of Osaka's location on the sea. Present-day Osaka City zoning is based on the town lots allocated at that time. Townspeople in Osaka constructed canals, including the Dotombori Canal, in marshes. Sand and soil excavated from the construction work was used in town creation. Also, people developed new rice fields on land reclaimed from the sea, and constructed many bridges. Osaka townsfolk of the Edo Period proudly called these many bridges "*Naniwa Happyakuya-bashi* (Naniwa's 808 bridges)." (In Japanese, the number *Happyakuya* (808) is used simply to designate a very large number.) Created along the canals and waterways, Osaka evolved into the center of economy, taking advantage of its well-developed facilities for water transport. In those days, waterfront areas played an indispensable role in people's daily lives.

On the other hand, Osaka was always vulnerable to massive flooding and other water disasters. In the quest for harmonious relations with rivers, the people of Osaka have taken various flood control measures, including diversion of the Yamato River in the early modern period, and large-scale excavation work on the Shin Yodo River. It can therefore be said that Osaka has developed through its interaction with and use of water.

Source: Osaka Castle Museum's Collection "*Hana*"

Photo 1 Osaka in olden days

Osaka has many river-related historic remains, place names, and other historic resources. As well, traditional water-related events, including the *Tenjin-Matsuri* Festival and *Funanorikomi* (a summer event in which kabuki actors parade the rivers on a boat), are still held in Osaka. Since waterfront areas were integrally linked with citizens' daily lives, those areas were the birthplace of popular culture. Osaka's historical and cultural resources were concentrated around the City's rivers. In the present age as well, there are many cultural and tourist facilities located in waterfront areas. Such facilities include Universal Studios Japan, Osaka Dome, Festival Hall and Minatomachi River Place.

Photo 2 Tenjin-Matsuri Festival

In addition to existing visitor facilities, new facility construction is under way, as part of the project to redevelop the West Section of Nakanoshima Island. Under this project, the National Museum of Art and the Osaka City Museum of Modern Art will be completed in the West Section of Nakanoshima Island, where the Osaka International Convention Center (Grand Cube Osaka) and the Osaka Science Museum have already opened. This project aims to develop the area into a new center for cultural exchange and creative activities in Osaka.

Photo 3 Nakanoshima area

There are many cities called "water metropolis" or "city of water" around the world. Osaka deserves to be called a "water metropolis," in that the City has made the most of its rivers for City activities, and we believe that the City should also continue to seek the optimum use of rivers in the future.

(2) Urban Renaissance Project

We also recognize the fact that the role of rivers has now become less significant for the people of Osaka. This is because, in the early modern period, the main means of physical distribution was shifted from water to land transportation, which led to the reclamation of canals. Another reason for this diminishing significance is the construction of tide walls that separate rivers from towns.

Against this background, in December 2001 the Japanese government decided to include the regeneration of "Water Metropolis Osaka" in its Urban Renaissance Project, to promote programs for redeveloping rivers running through the City center, in tandem with the riverside community development projects. This raised the groundswell among Osaka citizens toward restoring water metropolis Osaka, through citywide efforts involving both the public and private sectors. In October 2002, we established the "Council for Regenerating Water Metropolis Osaka" as a new framework to identify the future vision to be realized by Osaka as a water metropolis. In addition, the Council decided to draw up the "Vision for Regenerating Water Metropolis Osaka," to provide guidelines for working toward restoring the water metropolis through the united efforts of government and people.

3. Outline of the Vision for Regenerating Water Metropolis Osaka

(1) Outline

As set out in the Vision, we will promote citywide efforts to revitalize Osaka's city center, which plays a leading role in reinvigorating the entire Kansai economy. In the Vision, the major rivers surrounding the City center, a hub of economic activities, are regarded as elements comprising a "water corridor." (See the locations of target areas in Figure 1.) The objective of the Vision is "to create a water corridor, through which people can appreciate time." By the word "time" here, we mean the rich history of Osaka, the changing faces of Osaka that vary according to the season and hour of the day, and the spirit of innovation to build a better future.

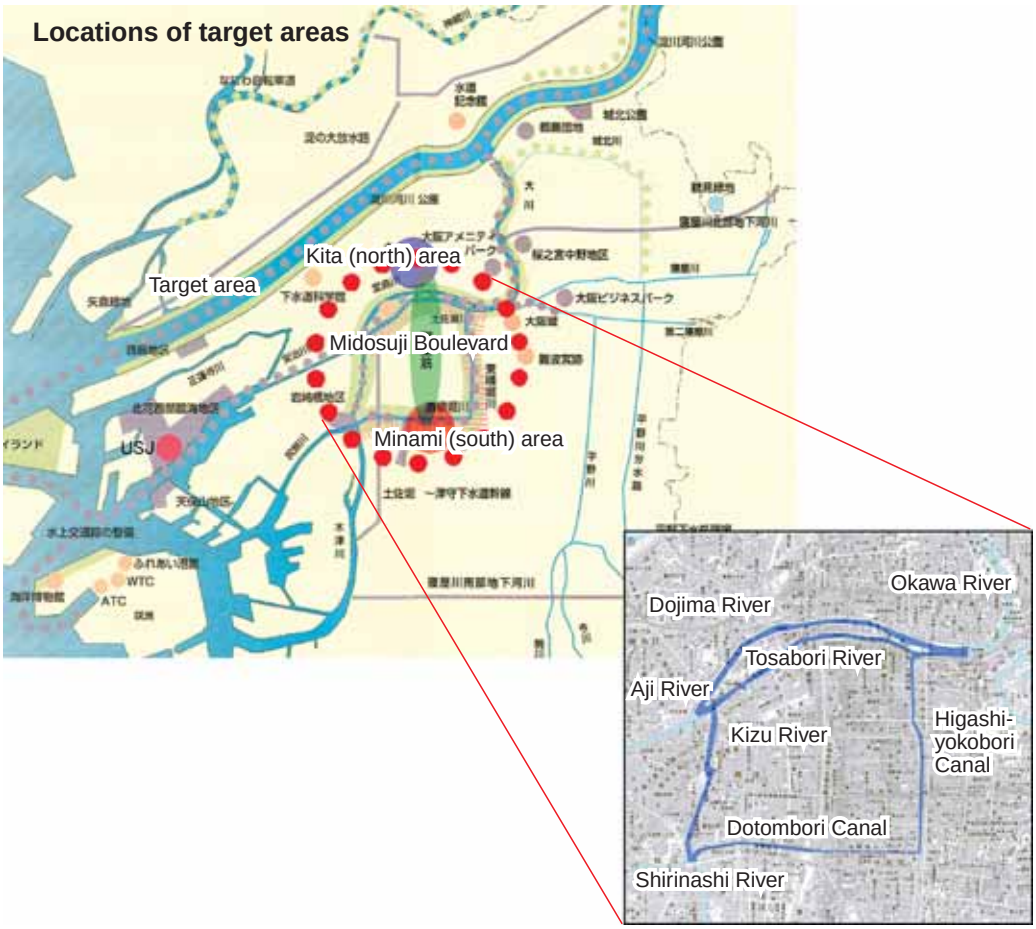

Fig. 1 Location of “water corridor”

(2) Basic policies

The Vision has the following four basic policies for creating a “water corridor.”

① Building a beautiful waterfront city

Currently, rivers cannot be seen from the City streets very well. Also, the City’s landscapes as viewed from the riverside are somewhat marred by the tall embankments that safeguard the City against flooding, and rows of buildings with their backs facing the rivers.

The Vision aims to promote the development of beautiful waterfront areas that will serve as a foundation for restoring water metropolis Osaka, while maximizing each zone’s characteristics. To this end, we will devise unique measures for harmonizing the tall embankments with the river landscape, and encourage the construction of buildings with front entrances facing the rivers. Through these measures we will create pleasant living and working environments in the heart of the City by highlighting the features of waterfronts, in conjunction with the development of riverside communities.

② Creating impressive and lively waterfront areas

Osaka will strive to design new events unique to the water metropolis, featuring the City’s attractiveness each season in the waterfront settings. The City will also seek to establish facilities where inhabitants, workers and visitors can gather together for recreation and relaxation, creating a lively ambience that will attract many more people to waterfront areas. Thus-enhanced attractive features of the water metropolis Osaka will be widely demonstrated to other regions. At the same time, Osaka will strengthen its systems for accepting and entertaining visitors, and vigorously promoting activities to invite many more people.

③ Networking waterfront areas and enhancing their attractiveness

We will promote the concept of the “water corridor” that will link, via rivers and canals, the respective historical and cultural spots that abound in Osaka, and we will improve the pedestrian network and the connection between water and land transportation facilities. Through these efforts, the City can increase visitor mobility and enhance the attractiveness of the waterfront areas as a whole. Moreover, initiatives for revitalizing water transportation systems will be implemented; this will include development of the traffic route network and infrastructure for water transportation.

④ Creating comfortable waterfront areas

(3) Policies of initiatives for developing each zone, making use of its unique characteristics

The Dotombori Canal zone in the Minami (south) area contains the Namba and Shinsaibashi districts, which have one of the largest concentrations of commercial establishments in Osaka. This zone is busy with people at all hours of day and night. Furthermore, the Dotombori Canal zone is home to various facilities related to traditional and modern culture and entertainment. These facilities include the National Bunraku Theater, which stages programs of performing arts of the Kamigata region (Kansai, or Osaka-Kyoto areas) centering on *Ningyo-joruri Bunraku* or Japanese traditional puppet plays, the Osaka Shochikuza Theater, the Shin Kabukiza Theater and Minatomachi River Place, which opened in 2002.

Photo 4 Minatomachi River Place, designed to harmonize the river and town landscapes

On the other hand, the Nakanoshima Island zone, located in the Kita (north) area, is characterized by modern architecture, including the Central Public Hall (Osaka Chuo Kokaido), the Bank of Japan and the Osaka Prefectural Nakanoshima Library. Also, this zone boasts the site of Hakkenya wharf and other historic and cultural assets. Accordingly, Nakanoshima is a historic site representative of water metropolis Osaka, while at the same time it is the City's symbolic business area, with Midosuji Boulevard as nucleus.

The above two zones, presenting unique features of Osaka, are linked via the Higashi-yokobori Canal and Kizu River zones. Figure 2 shows the conceptual designs for developing each zone.

4. Future Directions

We regard the Vision for Regenerating Water Metropolis Osaka not as a simple, conventional river environment improvement plan, but as a program for regenerating the City. In the future, the Vision will be implemented in the following three phases.

- Creating a "water corridor" as Osaka's symbol
  The City will strive to increase interest in its rivers among citizens and visitors, by actively announcing the "water corridor" creation project.
- Preparing systems to create a more vibrant urban ambience to attract many more visitors to Osaka
  The City will promote multipurpose use of rivers and riversides by revising the present river-related legal system with its many restrictions, so as to permit riverside events, open-air cafes and restaurants on riverbanks, as well as more flexible water traffic services, thereby attracting many more people.

Photo 5 River touring

Fig. 2 Each zone's development objective

- Developing tourist routes on water
  Osaka plans to incorporate water traffic in the City's sightseeing courses, so that various tourist programs unique to Osaka can be designed. By so doing, the City intends to attract many more visitors to Osaka, thus encouraging waterfront visitor facilities, and ultimately revitalizing Osaka's economy.

Fig. 3 Current water transportation network in Osaka

As mentioned above, we believe that the key to regenerating water metropolis Osaka is to promote water transportation. We are therefore conducting a social experiment in promoting tourist agencies and waterfront visitor facilities to use water transportation. The findings regarding various water transportation needs will be used in developing waterfront areas and improving relevant systems.

As regards regeneration of water metropolis Osaka, we have received a variety of proposals, not only from those involved in the Vision for Regenerating Water Metropolis Osaka, but also from civic organizations, and from economic and other circles. Thus, many people are interested in rivers and in taking action to regenerate the water metropolis. I believe that this reflects the key characteristic of Osaka's initiatives for restoring its status as a water metropolis.

Photo 6 Water transportation

Dotombori Riverfront Development Project

– Toward Regenerating the Water Metropolis –

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1. Introduction

The Dotombori River runs through the center of Osaka's Minami (South) area, a downtown district symbolic of Osaka. This precious river is a remnant of the period when Osaka flourished as a "water metropolis" in olden days. Along the Dotombori River are the National Bunraku Theater and other theaters, whose origins hark back to the playhouses built during the Edo Period. The Dotombori quarter is a popular area, featuring famous restaurants such as "Kuidaore," with a life-sized moving costumed drummer out in front, and "Kanidoraku," with a giant moving crab. This quarter is also known for its dazzling array of neon signboards, including that of the legendary Glico man (the trademark icon for the Osaka-based candy company, Glico). With these features, the Dotombori quarter attract many Osaka citizens and tourists to Osaka from around the nation.

Meanwhile, as concerns the Dotombori River itself, although the water surface can be viewed from bridges, because of the revetment structure, people cannot stroll along the river nor access the water. This prevents maximizing the open space function of the Dotombori quarter as a valuable waterfront area remaining at the city center.

To address this problem, the Osaka municipal government in FY1990 established the "Committee to Study Dotombori Riverfront Development," and has since discussed the River's development policy. Under those circumstances, the then Ministry of Construction of Japan (now the Ministry of Land, Infrastructure and Transportation) commenced the River Renovation Program in FY1995. At the same time, the Dotombori River was upgraded to a Class A river, and its improvement was included as part of the Program. In FY1996, the "Dotombori Riverfront Development Planning Committee" was organized to devise concrete plans toward implementing riverfront improvement. The Committee submitted a report on its plans in FY1997.

Moreover, the "Committee to Study Dotombori River Promenade and Bridge Designs" was established in FY2002, to examine specific designs to be used when the riverfront development work is actually carried out. On the basis of advice from academic experts and specialists, the Committee has considered what policies and programs should be adopted for the development of individual promenades and bridges, so as to make them appropriate for the Dotombori River.

This paper looks back on the history of Osaka while introducing the background of the Dotombori River, and presents the initiatives currently being undertaken, in close public-private partnership, to restore Osaka's status as a "water metropolis." Also reported herein is the current progress of construction work already ongoing under the Dotombori Riverfront Development Project.

2. History of the "Water Metropolis" Osaka

Osaka City, featuring many waterways developed mostly during the Edo period, has been called a "water metropolis" since olden times. (Figure 1) In former times, people and goods were transported mainly by ship through these waterways. Thus the waterways played a crucial role in the development of Osaka, which enjoyed great prosperity and renown as the "Nation's Kitchen," serving as Japan's distribution center of various goods carried in from around the nation.

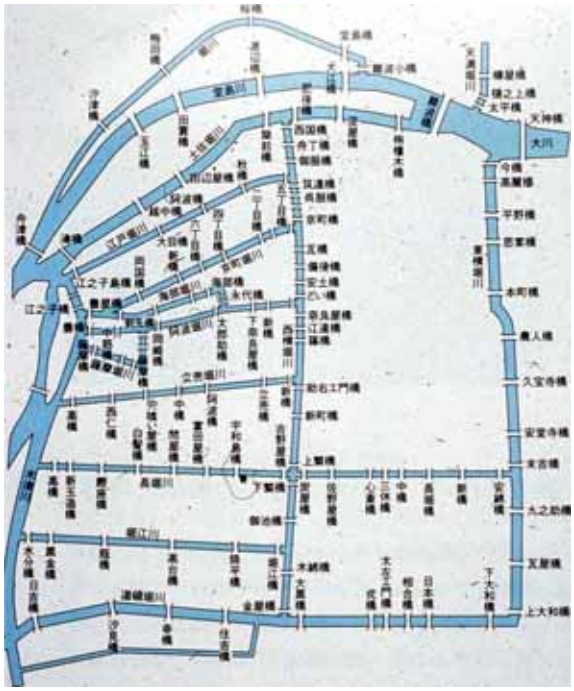


Fig. 1 Waterways in Osaka during the Edo period (Hoei era [1704 - 11])

One of these waterways, the Dotombori River, is actually a canal whose excavation was commenced by Nariyasu Doton, a merchant of the Edo period. The excavation work was completed in 1615. At that time, the Doton was principally used for transporting goods by ship and for discharge of wastewater, sustaining the commercial infrastructures of the present-day Namba district. In the vicinity of the Dotombori River were located the five leading theaters, collectively referred to as "*Namiwa Goza*" (Naniwaza, Nakaza, Kadoza, Asahiza, and Bentenza Theaters), as well as many other playhouses; the Dotombori quarter was therefore always very busy with many people. (Figure 2)

Fig. 2 Dotombori quarter busy with many people, in former days
<Source: "Dotombori" from the Nishikie (multi-colored woodblock print) "*Kokkei Naniwa Meisho*" by Ichiosai Yoshiume (Osaka Castle Museum's Collection)>

However, the role of waterways gradually diminished during the Meiji period and later, as the primary means of moving people and goods shifted from water to land transportation, such as railroads and automobiles. In addition, increased road traffic volume and water quality deterioration became matters of social concern. Under the circumstances, many waterways were filled in one after another, to make way for roads.

It can therefore be said that the Dotombori River is a precious waterway that has survived such changing trends of the times to date, in not having been filled in.

3. Outline of Present Dotombori River and Its Riverside Area

The Dotombori River was designated a Class A river in FY1995. Presently, the River is 2,745 m in total length, its catchment basin covering an area of approximately 4 km^2. The river's width differs widely between the west and east sides of the Daikoku Bridge, which is located near the river's midway. On the west side of the Bridge, the river is approximately 50 m wide, whereas on the east side it is approximately 30 m wide. As well, facilities built in the riverside areas also differ between the west and east sides of the Daikoku Bridge. On the west, there is a tidal embankment constructed 1951 - 1958. On the east there is a vegetation-covered revetment in the form of a ship; it was constructed 1966 - 1967. Both these facilities were built as part of the measures against flood tide. However, these tall flood-prevention facilities also prevent public people access to the waterfront, diminishing people's affinity for water. (Photo 1)

Photo 1 Present Dotombori River (viewed from Dotombori Bridge in direction of Ebisu Bridge)

4. Water Quality of the Dotombori River

4-1 Water quality improvement measures in the past

In the mid 1950s to 1960s, the water quality of rivers and canals in Osaka City deteriorated sharply, due to the increase in volume of domestic wastewater and to other reasons, resulting from high economic growth and rapid population concentration in the City. To address these water pollution problems, Osaka actively implemented city-wide measures, including development of the sewerage system and establishment of regulations on industrial effluents. Moreover, in 1973 the City drew up the "Clean Water Plan" (which was replaced by the "EPOC21" in

FY1991), a master plan for water pollution control measures. Principal measures implemented to improve Dotombori River water quality are as follows:

(1) Installation of aeration facilities (1979)

To preserve water quality of rivers in which fish can live, it is important to secure the required DO (dissolved oxygen) levels. Since the Dotombori River flows at very low velocity under normal weather conditions, the river needs measures to keep its DO levels from falling. Also, since the river runs through the center of downtown, its development should be carried out with consideration given to the surrounding townscape. To answer both these needs, a total of 24 fountains were installed in the river zone between Ebisu Bridge and Nippon Bridge. Of these fountains, currently only six remain, as a result of riverfront development work. (Photo 2)

Photo 2 Aeration facilities (viewed from Ebisu Bridge in direction of Tazaemon Bridge)

(2) Installation of micro-strainers (1980)

To keep a clean visual appearance of the river water, it is important to remove suspended solids (SS). To this end, micro-strainers were installed at the north of the Hommachi Bridge crossing the Higashi-yokobori River. With these micro-strainers, river water that has been introduced into the drums can be filtered to reduce suspended solid levels.

(3) Opening/closing of water gates of the Dotombori and Higashi-yokobiri Rivers for water quality improvement

Because of their geographic conditions, most rivers in Osaka City share the characteristic that their water levels change as the tide rises and falls. By making use of this characteristic, water quality of the Dotombori River has been improved in the following manner: When the tide rises, the water gate of the Higashi-yokobori River is opened. When the tide ebbs, the gate is closed and that of the Dotombori River is opened, so as to draw water exclusively from the Okawa River, whose water quality is relatively good.

(4) Dredge work

The particles of sludge accumulated on the Dotombori and Higashi-yokobori River beds are extremely fine. It is therefore difficult to use conventional bucket dredging for sludge removal in these rivers, since this can stir up such fine sludge particles and thus pollute the river water. To prevent this, we have developed and used an original pump dredger that can be operated even in narrow dredging areas, to remove sludge in these rivers.

4-2 Present water quality

Since various measures mentioned above have steadily produced effects, the water quality of the Dotombori River has been considerably improved. This improvement can be shown in the BOD (biochemical oxygen demand) level, which is generally used as a pollution index of water quality in rivers. According to the latest survey, the BOD level in the Dotombori River decreased from 35.8 mg/l in 1970, when the water quality was at its worst, to 2.9 mg/l in 2003. (Figure 3)

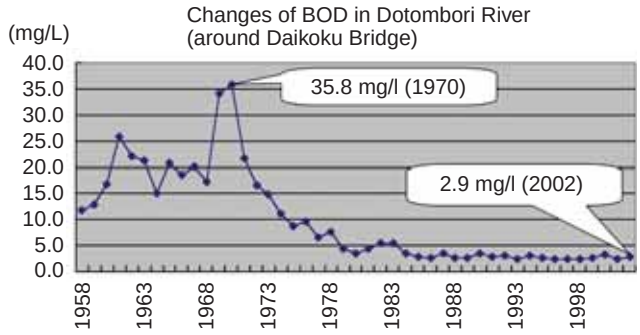


Fig. 3 BOD in Dotombori River (around Daikoku Bridge)

However, currently we have the following problem regarding water quality of the Dotombori River. Drain pipes of the public sewage system have been connected to revetments of the Higashi-yokobori and Dotombori Rivers, and there are 28 outlets of these pipes on the revetments. Accordingly, when it rains, wastewater is directly discharged into these rivers. After the rain the water quality is considerably deteriorated, though only temporarily, and sludge has accumulated on the riverbeds. Therefore it appears that the water quality of the River is extremely bad.

4-3 Future measures

Without resolving this overflow problem of wastewater from the sewage system, radical improvement of Dotombori River water quality is not possible, because even if the river is dredged, sludge will accumulate every time it rains. To address this problem, the Sewerage Works Division is currently planning to build the under-

ground sewers in which wastewater can be temporarily stored during rain. These sewers are slated for completion in FY2010, when they will keep wastewater from overflowing into the Higashi-yokobori and Dotombori Rivers, except during extremely heavy rainfall that may occur only once in a decade.

In addition to this radical measure, we are going to discuss the installation of required water purification facilities, according to the progress of the Dotombori Riverfront Development Project.

5. Advance toward the Creation of a New "Water Metropolis"

At present, we have fewer waterways remaining in Osaka City than we had before. However, approximately 10% of the total area of the City is still covered by water, and these waterways have been regarded as precious urban assets. Osaka City has therefore striven to make the most of such "water" assets. As part of these efforts, in FY1995 the City drew up the "Grand Design of Osaka as a New City of Water," with the view of creating a new water metropolis for the 21st century. Furthermore, in FY2001 the regeneration of "Water Metropolis Osaka" was included in the Urban Renaissance Project by the Japanese government. Against this backdrop, the groundswell in Osaka has been growing to restore the City's glory as a "water metropolis," thereby revitalizing Osaka's economy through various joint programs by the government and financial circles.

6. Outline and Progress of the Dotombori Waterfront Development Project

Under these circumstances, we have implemented the Dotombori Riverfront Development Project since FY1995. This Project is regarded as a leading program of the nation's Urban Renaissance Project.

6-1 Construction of water gates

The Dotombori Riverfront Development Project commenced with the construction of two new water gates. One was built in the lowest reaches of the Dotombori River, the other in the highest reaches of the Higashi-yokobori River, which is located in the upstream portion of the Dotombori River. Both gates were completed in FY2000. (Photos 3 and 4)

These water gates were constructed with the following four purposes:

1) To protect the riverside areas of the Dotombori and Higashi-yokobori Rivers from flood tide by closing both gates accordingly. This enables removal of part of the present flood tide prevention revetments, to lower their heights.
2) To keep the water level of the Dotombori River constant by always closing both gates. This enables the future construction of promenades at a height as close as possible to the water level.
3) To keep the water quality of the Dotombori River clean. This can be done by preventing polluted upstream river water from flowing into the Dotombori River, and by introducing water exclusively from the Okawa River, whose water quality is relatively clean, through opening/closing operation of these water gates.
4) To enable boats and ships to navigate through the Dotombori River, even when the water levels differ between inside and outside of the water gates, which are equipped with lock functions.

Photo 3 Dotombori River water gate

Photo 4 Higashi-yokobori River water gate

6-2 Construction of promenades

As centerpiece of the Dotombori Riverfront Development Project, broad promenades (approximately 8 m in width) will be constructed on both sides of the River. After these promenades are completed, people will gather at the riverside to enjoy close contact with the River, maximizing the river's inherent function.

Currently, all buildings along the Dotombori River have their backs facing the river. However, if more people can be attracted after the completion of the promenades, gradually more and more buildings will be built with their front entrances facing the River, affording people direct access to/from the riverside shops and restaurants from/to the promenades. We expect that these promenades will help create a lively waterfront area that will attract many more people, by harmoniously blending river and town functions. These promenades will serve as open spaces in the Minami (South) area, which is one of Osaka's major downtown areas. We therefore aim to make the promenades not like ordinary riverside facilities, but like facilities that will function as a foundation for creating a vibrant urban ambience.

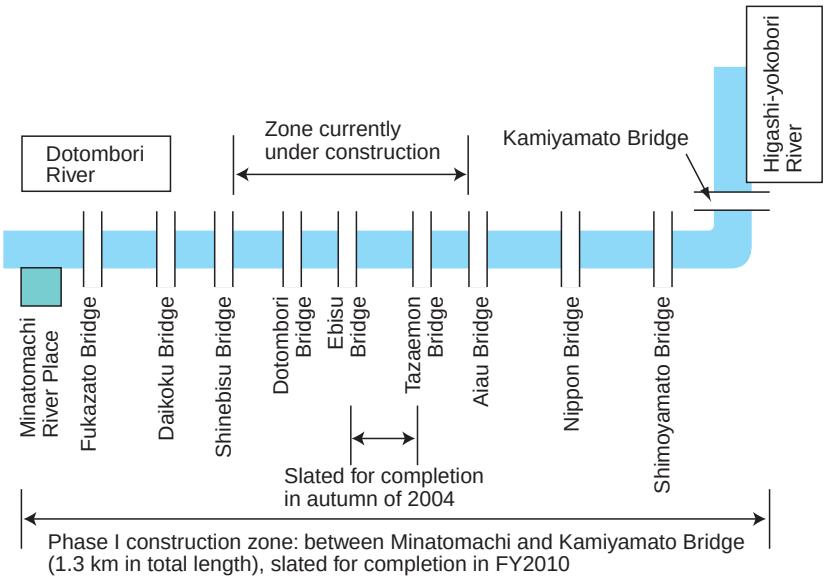


Fig. 4 Outline of Riverfront Development Project

The Dotombori riverside area can be divided into the east and west districts at around the Minatomachi River Place. These districts greatly differ in terms of land use. In the east district, the majority of buildings are for commercial use, whereas in the west district there are many residential buildings. Ultimately, we plan to construct promenades along the entire length of the Dotombori River. But first, part of the east district between Minatomachi and the Kamiyamato Bridge (1.3 km in total length) has been designated the Phase I construction zone, in which promenade construction is currently under way, aiming at completion by the end of FY2010 (Figure 4). Of this Phase I construction zone, along the riverside zone between the Ebisu Bridge and the Tazaemon Bridge, the promenades are scheduled for completion in the autumn of 2004 (Figures 5 and 6).

Moreover, we are considering building boat docks at proper places along the River, in conjunction with promenade construction. By this means, we aim to encourage the use of water transportation facilities, including cruse ships, so as to attract many more people to Osaka.

Fig. 5 Conceptual rendering of promenades (between Ebisu Bridge and Tazaemon Bridge) in daytime

Fig. 6 Conceptual rendering of promenades (between Ebisu Bridge and Tazaemon Bridge) at night

Bridges: Highlights of Osaka's Urbanscape

Hiroshi Matsumura
Osaka City Foundation for Urban Technology

1. Introduction

For tourists to Osaka, I strongly recommend cruises on rivers and in Osaka Port. There are many courses available throughout the year, which can be roughly classified as follows:

- cruises on the Old Yodo and Neya rivers
- cruises on canals and the Old Yodo River, and
- cruises in Osaka Port.

During such cruises, travelers will learn that the highlights of these courses are bridges.

Historically, Osaka has developed thanks to the abundant blessings of water. Located on the coast at the eastern end of the Inland Sea and at the mouth of the Yodo River, Osaka has continuously benefited from water. At the same time, however, this region has been vulnerable to various sorts of natural disasters, including floods and tidal waves. Since ancient times, people in Osaka have developed their City by exploiting the geographical advantages of the City's proximity to water, while at the same time striving to overcome the disadvantages of the City's topographical features.

Early residents reclaimed the wetlands using the earth and sand deposited at the mouth of the Yodo River, and constructed canals and drains, occasionally even diverting rivers from their original courses so as to protect their land and improve agricultural productivity. As a result, Osaka became a City of rivers and canals running in all directions with a great many bridges, essential infrastructure for daily life activities as well as for transportation.

2. Development of Osaka

In Osaka, the first urban development policies were put forth at the end of the 16th century. Even today, the City still observes the essential directions of those policies, i.e., control major rivers and develop land; improve port facilities; and construct roads as urban axes.

At the City center run the Old Yodo River (former mainstream of the Yodo River) and various canals, including the Higashi-yokobori and Dotombori canals. Most of the bridges spanning the river and the canals were originally constructed between the end of the 16th century and the early 17th century. Accordingly, when talking about bridges in Osaka, people usually begin with the history of such old bridges.

During the Edo Period (1603 - 1868), Osaka was under the direct governance of the Tokugawa Shogunate Government. The majority of the City's infrastructures, however, were constructed by wealthy citizens of Osaka, rather than the government in Edo (now Tokyo). During the Edo Period there were about 200 bridges in the urban area, which measured approximately 5 km × 5 km. Of the 200 bridges, only 12 were built by the Shogunate Government. All the others were built and maintained by wealthy merchants and citizens living along the streets of individual bridges. (Figure 1)

At the end of the Edo Period, Japan abandoned its national isolation policy and opened several ports, including Osaka Port, to overseas countries. During the early Meiji Period (1868 - 1912), Western cultures and technolo-

Fig. 1 Bridge on Dotombori Canal as depicted in "Scenic Places in Settsu Domain"

gies were introduced through Osaka Port. Osaka citizens, eager to assimilate advanced technologies, were among the first in Japan to build iron bridges imported from Europe. Today, some of those iron bridges are preserved in parks as important historical monuments attesting to the entrepreneurship of Osaka citizens.

3. Osaka's Modernization and Its Impact on Bridges

Around 1900, Osaka began to modernize its urban infrastructure. Major projects of that time included improvement of the Yodo River, construction of a modern port and widening of streets, accompanied with the introduction of streetcars. As a result of these extensive projects, Osaka's urbanscape changed dramatically.

With increased supplies of steel to the civilian sector, many civil engineers began to use steel in working on bridge construction technologies and designs that incorporated Japanese originality. Bridges typical of the style of this epoch include Hommachi Bridge (completed 1913; see Photo 1) spanning the Higashi-yokobori Canal, and Naniwa Bridge (completed 1915; see Photo 2) over the Old Yodo River. Hommachi Bridge is Osaka's oldest bridge still in service, although it has undergone considerable repairs. Though the superstructure of Naniwa Bridge was recently replaced, the design is a faithful reproduction of the original.

Photo 1

Photo 2

Map 1 Bridges in the City center

In addition to historic value, these two bridges feature excellent urban designs. The design of Hommachi Bridge was the same as that of Kizugawa Bridge, both built on Hommachi Street, which was expanded with the introduction of streetcars. Both bridges were modeled after the former Osaka Prefectural Government building, located directly southeast of Kizugawa Bridge. Naniwa Bridge, well known for its stone images of lions and classical lampposts, also features grand stone steps leading to Nakanoshima Island. At the time of the bridge's construction, a waterfront park was also under construction on Nakanoshima Island; the stone steps were designed as an approach to the park.

4. Bridges Constructed in City Planning Projects

The first City Planning Project undertaken during the 1920s and 1930s dramatically converted Osaka into a modern metropolis. In addition to the construction of such infrastructures as roads, sewerage systems, parks, railroads and stations, the Project determined land-use plans, based on which various works were conducted.

Many extant bridges in the City center were constructed under the first City Planning Project. The basic design concept of those bridges was "to seek excellent designs that harmonized with the respective bridge locations, and to seek optimal balance between individual designs' originality and harmony with other bridges." Many bridges representing the style of this epoch remain around Nakanoshima Island, adding attractive features to Osaka's urbanscape.

Tourists on a sightseeing ship cruising down the Old Yodo River will first see Sakuranomiya Bridge (completed 1930; see Photo 3), Japan's largest arch bridge at the time of its construction. To permit ship passage, the bridge span was made 104 m wide. In consideration of the relatively soft ground, the bridge designer adopted a three-hinge structure, effective in protecting the long span arch from potential minor displacement of piers. Accordingly, the bridge design represents the designer's concept. At both ends of the bridge stand bridgeheads, towers whence steps go down to the riverside park. These bridgeheads, indeed, further enhance the beautiful arch design.

Temma Bridge (completed 1935; see Photo 4) was one of the largest girder bridges at the time. The design, featuring the good balance of span proportions and varying height of beams, represents the climax of girder design development. Because of its magnificent, elegant design, Temma Bridge is often compared to a bird spreading its wings. In 1970, the bridge was made two-storied, with the addition of a modern overpass that strongly contrasts with the classical design of the lower bridge.

Tenjin Bridge (completed 1934; see Photo 5) spanning the Old Yodo River and the eastern end of Nakanoshima Island is a highlight of Osaka's waterfront. The main bridge portion comprises three steel arches rhythmically spanning the two streams defining Nakanoshima Island. At each end of the bridge, a heavy concrete arch adds dignity to the design.

Oe Bridge (completed 1935) and Yodoya Bridge (see Photo 6), both part of Midosuji Boulevard, were constructed in the first City Planning Project, together with Midosuji Boulevard, whose construction was the major component of the Project. Since both bridges were at the most strategic points in Osaka, providing access to Osaka City Hall on Nakanoshima Island, the City sought excellent designs in the public design competition. The two bridges, constructed on the basis of the best design, feature reinforced-concrete arches that evoke medieval southern European bridges. Even today, the two bridges are essential landmarks around Nakanoshima Island.

During this period, many other bridges were built over Higashi-yokobori and Dotombori canals; many of those bridges remain today. Those spanning Higashi-yokobori Canal include such concrete arch bridges as Korai and Ote bridges, as well as steel arch bridges, including Hirano and Kunosuke bridges. Concrete bridges and steel bridges

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

alternately span the canal, creating a landscape variety. Over Dotombori Canal, concrete arch bridges such as Ebisu Bridge (see Photo 7), and steel bridges, including Dotombori and Fukari bridges, were constructed. These bridges are still in service today.

Around the 1930s many roads were constructed, branching off in all directions from Central Osaka together with several bridges spanning the Yodo River, including Juso (see Photo 8) and Dempo bridges, both primarily comprising arches. Over the Yamato River, Yamatogawa and Oriono bridges (both steel girder bridges) were constructed.

By this time, modern bridge technologies and designs introduced during the early Meiji Period were fully assimilated, and Japanese civil engineers began to develop original designs incorporating Japanese tradition.

5. Preservation and Renewal of Old Bridges

During and immediately after World War II, all bridge construction projects were suspended in Osaka. Moreover, metal parts of bridges, such as bridge rails and lampposts, were removed for recasting as military products. This fact, combined with insufficient maintenance, resulted in radical degradation of bridges. After 1955, urged on by rapid motorization, many bridges were quickly constructed. In the 1970s, however, Osaka City began to review its bridge designs, particularly from the pedestrian perspective, and commenced to adopt elaborate bridge designs.

Since old bridges in the Osaka City center were originally of excellent design, Osaka City staff began restoring those bridges to their original condition. Other bridges were remodeled with due consideration given to the local environment and pedestrian friendliness. In addition, the City staff began to install monuments explaining the history of bridges, and to conduct PR activities through other means. One typical example of such efforts was the project for remodeling Nishiki Bridge, initially constructed on the movable barrage for purifying river water. In this project, using the wide bridge space, the City staff created stone flowerbeds with ceramic tiles decorated with colorful *ukiyoe* on the theme of bridges. On both ends of the bridge, showcases were installed to display the history of bridges in Osaka (see Photo 9).

6. Design Concepts of New Bridges

Following the 1970s, new bridge projects primarily for pedestrians were planned around Nakanoshima Island. These projects were based on the concept of the first City Planning Project: seeking both variety and harmony in bridge design. For Kawasaki Bridge (See Photo 10), for

example, located between Temma and Sakuranomiya bridges, a contemporary cable-stayed bridge design was adopted. At the same time, however, the City staff also sought a style that created a relaxing atmosphere to match the abundant greenery in the riverside parks, and that had features distinguishing this from other bridges.

In the improvement project of Tenjin Bridge spanning the two streams around Nakanoshima Island, a new ramp was added midway as access to Nakanoshima Park. For the ramp connecting the island with the bridge, an elegant design was adopted that evokes the image of sailboat masts (see Photo 5). The ramp's suspension structure also resembles the gentle shape created by *yukizuri*, the protective ropes that deflect heavy snowfall and prevent damage to trees.

When Osaka City Hall was reconstructed, its design was carefully planned so as to match the designs of surrounding classical architectures and the two adjacent bridges: Oe and Yodoya bridges (see Photo 6). In this way, Osaka City is endeavoring to adopt good designs for its various urban infrastructures, including bridges, with due consideration given to the surrounding environment and urbanscape.

In 2000, the Japan Society of Civil Engineers added the following five bridges to the list of Civil Engineering Assets: Sakuranomiya, Temma, Tenjin, Oe and Yodoya bridges. In 2001, Oe and Yodoya bridges were designated important cultural properties of Osaka City. With this designation, Osaka City determined the two bridges' preservation policy.

7. Bridges Featuring Cutting-edge Technologies in Osaka Port

In the Osaka Port area, port facility improvement projects were initiated in 1958 in response to transport system modernization. The projects, involving large-scale reclamation of the sea, necessitated construction of long bridges linking newly developed artificial islands. In around 1970, construction commenced on the Hanshin Expressway Osaka Bay Route as the trunk road linking the Bay Area.

As part of this trunk road, several bridges were constructed in the Bay Area. Minato Bridge (completed 1974; see Photo 11), spanning the main ship route of the Osaka Port, is the third longest cantilever truss bridge in the world. Osaka Bay Route is highlighted by more huge structures, including Tempozan Bridge (a cable-stayed bridge completed 1990) and Yamatogawa Bridge (completed 1982).

To connect new artificial islands and existing urban areas either directly or indirectly with the Osaka Bay Route as the trunk axis, many long bridges were constructed. From north to south, they are Tsuneyoshi Bridge (a two-span continuous cable-stayed bridge completed 1999), linking Konohana ward with Maishima Island; Konohana Bridge (a very rare three-span, continuous mono-cable, self-anchored suspension bridge completed 1990; see Photo 12), also linking Konohana ward with Maishima Island; and Yumemai Bridge (completed 2001; see Photo 13), linking Yumeshima and Maishima islands. Yumemai Bridge, the world's largest floating swing bridge, permits passage of large vessels in emergency.

Namihaya Bridge (completed 1999; see Photo 14), linking Minato and Taisho wards, a three-span, continuous curved box girder bridge, having the longest span in Japan. Shinkizugawa Bridge (completed in 1994; see Photo 15), linking Taisho and Suminoe wards, is the longest balanced arch bridge in Japan. Chitose Bridge (completed 2003; see Photo 16), located within Taisho Port, is of extremely rare design: a two-span continuous braced rib arch. Finally, Kamome Bridge (completed 1975), a multi-cable-stayed bridge linking the southern end of Sakishima Island with existing urban areas, and Sembommatsu Bridge (completed 1973), dynamically spanning the Kizu River, also highlight the Port landscape.

In this way, tourists to the Osaka Bay Area can enjoy magnificent views of a wide variety of bridges, all featuring the world's highest-level technologies and designs.

Photo 8

Photo 9

Photo 10

Photo 11

Map 2 Bridges in Osaka Port

Photo 12

Photo 13

Photo 14

Photo 15

Photo 16

Development of Water Supply/Distribution Centers by Osaka Municipal Waterworks Bureau

– Nagai and Sakishima Water Distribution Plants –

Masashi Ohara

Engineering Department, Engineering Division, Waterworks Bureau

1. Introduction

The Great Hanshin-Awaji Earthquake that occurred on January 17, 1995 inflicted unprecedented damage to waterworks in the region. In particular, the prolonged water supply suspension resulting from the damaged waterworks seriously affected the daily lives of citizens in the post-quake reconstruction process. The Great Hanshin-Awaji Earthquake disaster was a direct-hit earthquake that far exceeded any existing hypothesis, necessitating drastic review and strengthening of conventional anti-earthquake measures.

To meet this necessity, the Osaka Municipal Government amended the Osaka City Regional Disaster Prevention Plan, which describes programs for disaster prevention, emergency countermeasures and post-disaster reconstruction. As a result of this amendment, the Osaka City Regional Disaster Prevention Plan now assumes near-field earthquakes of class 7 seismic intensity, in addition to distant inter-plate earthquakes of seismic intensity 5 to 6, already assumed in the previous Plan.

In conjunction with review of the Osaka City Regional Disaster Prevention Plan and other related schemes, the Osaka Municipal Waterworks Bureau drew up its Earthquake Preparedness Improvement Plan 21 (hereinafter "Plan 21") in March 1996, with a view toward the 21st century. Plan 21 includes the basic earthquake disaster prevention measures to be taken with regard to waterworks in Osaka City.

Plan 21's basic concept for strengthening earthquake preparedness is to establish a water service system capable of smooth and speedy water supply in emergencies, even amidst the confusion seen after serious disasters like the Great Hanshin-Awaji Earthquake. To this end, Plan 21 aims to promote eight basic measures for improving and strengthening earthquake preparedness.

The Waterworks Bureau has implemented key priority measures based on Plan 21. Above all, during the five years from 1996 to 2000, the Bureau vigorously promoted measures essential for early establishment of the emergency water supply system. These measures include projects for the following: improving earthquake resistance of water distribution pipelines leading to shelters and other disaster relief centers, as well as important facilities such as hospitals; providing emergency water supply equipment and instruments, such as temporary water tanks, portable taps and water tank trucks; and developing the radio transmission system for waterworks service and constructing seismic research and observation facilities. Most of these projects have been completed.

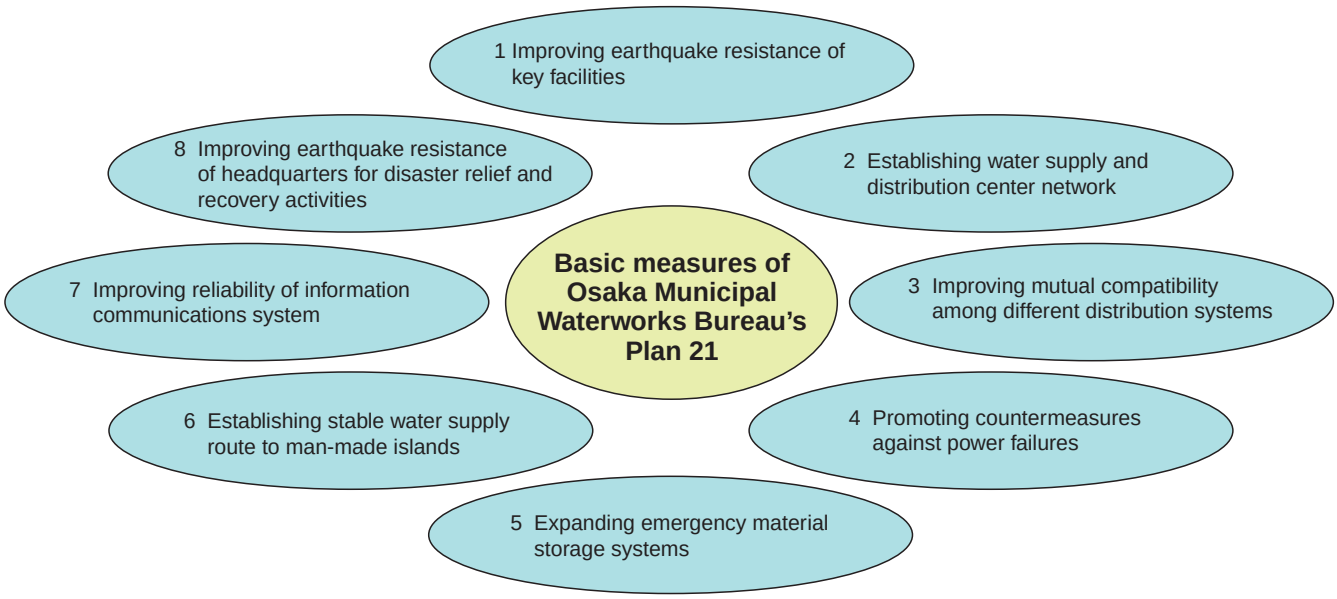


Fig. 1 Basic measures of Osaka Municipal Waterworks Bureau's Earthquake Preparedness Improvement Plan 21

2. Establishing a Water Supply and Distribution Center Network

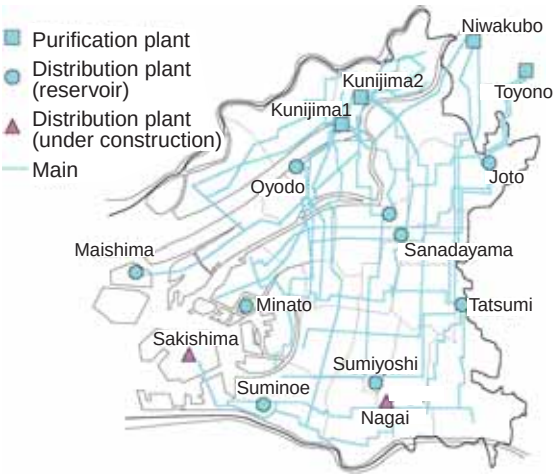


Fig. 2 Water distribution facilities in Osaka City

To improve post-disaster measures, it is important to address the following: Management of emergency water distribution service, securing drinking water and water supply for fire protection, establishment of centers for emergency water supply and urgent reconstruction activities, designation of main facilities to accept emergency aid from other municipalities, and storage at diverse locations of equipment needed in emergency.

The Ministry of Health, Labour and Welfare has instructed each municipality to secure an amount of water equivalent to half the planned maximum water supply volume per day, as the effective capacity of clean water/service reservoirs. However, Osaka City has thus far secured only approximately 690,000 m^3 of water as the effective capacity of clean water/service reservoirs. This corresponds to an amount enabling Osaka to continue its maximum water supply for only 6.8 hours; this figure is rather low compared with other large cities in Japan.

Given these circumstances, along with construction of new service reservoirs Osaka City is now implementing a program for developing and expanding a well-balanced network of water supply and distribution centers, to ensure a uniform supply of water in emergency. In this relation, construction projects for new distribution plants are being realized in the southern and coastal areas of the City, respectively: one is the Nagai Distribution Plant; the other is the Sakishima Distribution Plant.

3. Nagai Distribution Plant

(1) Site selection

Nagai Park, a safety evacuation site with a large land area, is located in the southern part of Osaka City. Based on the judgment that building a water distribution plant in Nagai Park would significantly improve the Park's function as a disaster prevention center, the Park was selected as a candidate site for plant construction. During the site selection process, a plan for constructing underground parking facility in the Park was also proposed. Thus Nagai Park was coincidentally selected as a candidate site for a water distribution plant, as well as for underground parking. We therefore decided to construct a joint-facility combining the functions of both water distribution plant and underground parking facility.

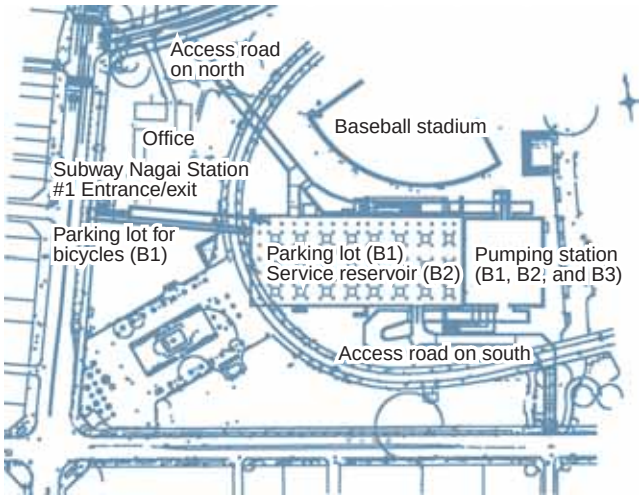


Fig. 3-1 Top view of Nagai Distribution Plant/ underground parking facility

(2) Planned structure

The water distribution plant and the underground parking facility should meet their target earthquake-resistant performance and construction guidelines, which differ from each other. Therefore we decided to design the two facilities to have different structures, without providing common structural elements between them. Moreover, for

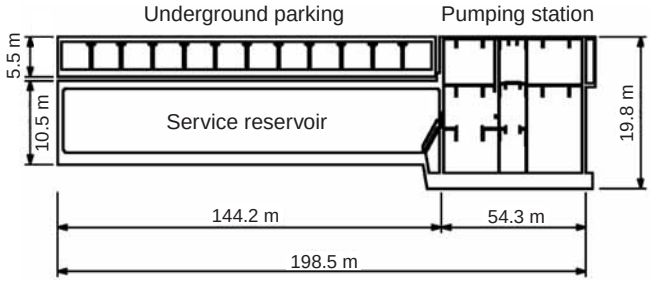


Fig. 3-2 Plane cross-section of Nagai Distribution

the distribution plant, to ensure water-tightness, we selected the bearing wall structure, which can maintain high stiffness. This selection was based on the assumption that if an underground parking facility is constructed above a service reservoir, a high load will be applied to the interface between them in the event of earthquake.

Furthermore, a corrugated partition is installed on the contact surface in the horizontal direction between the underground parking facility and the distribution plant, to prevent relative displacement in the event of earthquake. This corrugated partition will transmit to the distribution plant, as an external force, earth pressure received by the underground parking facility during earthquake.

In addition, waterproofing is necessary between the distribution plant and underground parking facility, since the underground parking facility above the service reservoir will be used by the general public. However, as the corrugated partition is installed at the interface between reservoir and parking facility, commonly used waterproof sheeting may break if an earthquake occurs. We therefore employed the waterproofing applied by stainless steel sheets.

The vertical air gap between the pumping station and the underground parking facility is backfilled with expanded polystyrene (EPS) resin having a low spring constant, to eliminate interaction between the two structures in the event of earthquake.

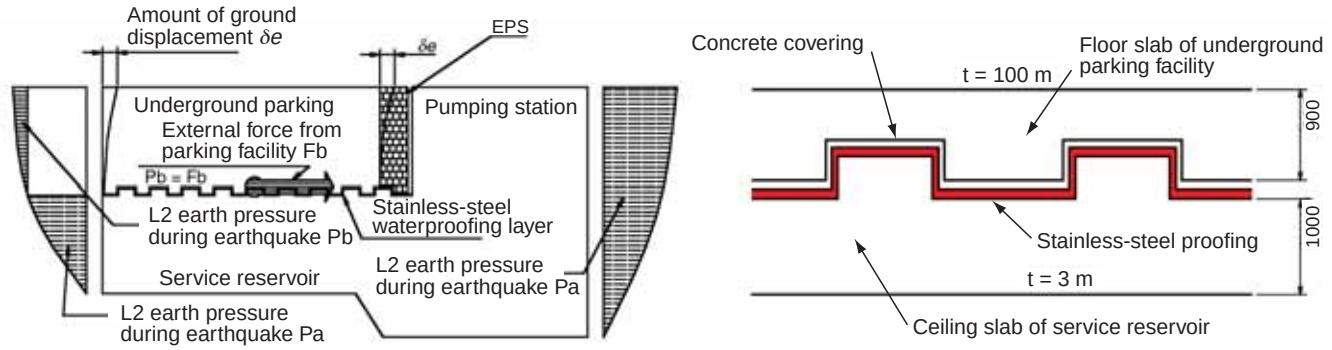


Fig. 4 Cross-sectional views of EPS backfill and stainless-steel waterproofing structures

(3) Facility outline

❍ **Service reservoir**

① Effective capacity: Approx. 42,000 m^3
② Number of reservoirs: 3
③ Dimensions: 60 m (width) × 144.2 m (length) × 6.5 m (effective depth)
④ Form of foundations: Spread foundation
⑤ Structure: Reinforced concrete, bearing wall structure (underground)
Double-deck structure (with underground parking facility)

❍ **Distribution pumping station**

① Dimensions: Total floor area of 14,340.35 m^2
(60 m [width] × 54.3 m [length] × 3 floors)
Number of stories: Three stories below ground level
② Form of foundations: Spread foundation
③ Structure: Reinforced concrete structure

(4) Construction work outline

❍ **Term of construction**

March 12, 1999 to March 31, 2002

❍ **Description of the work**

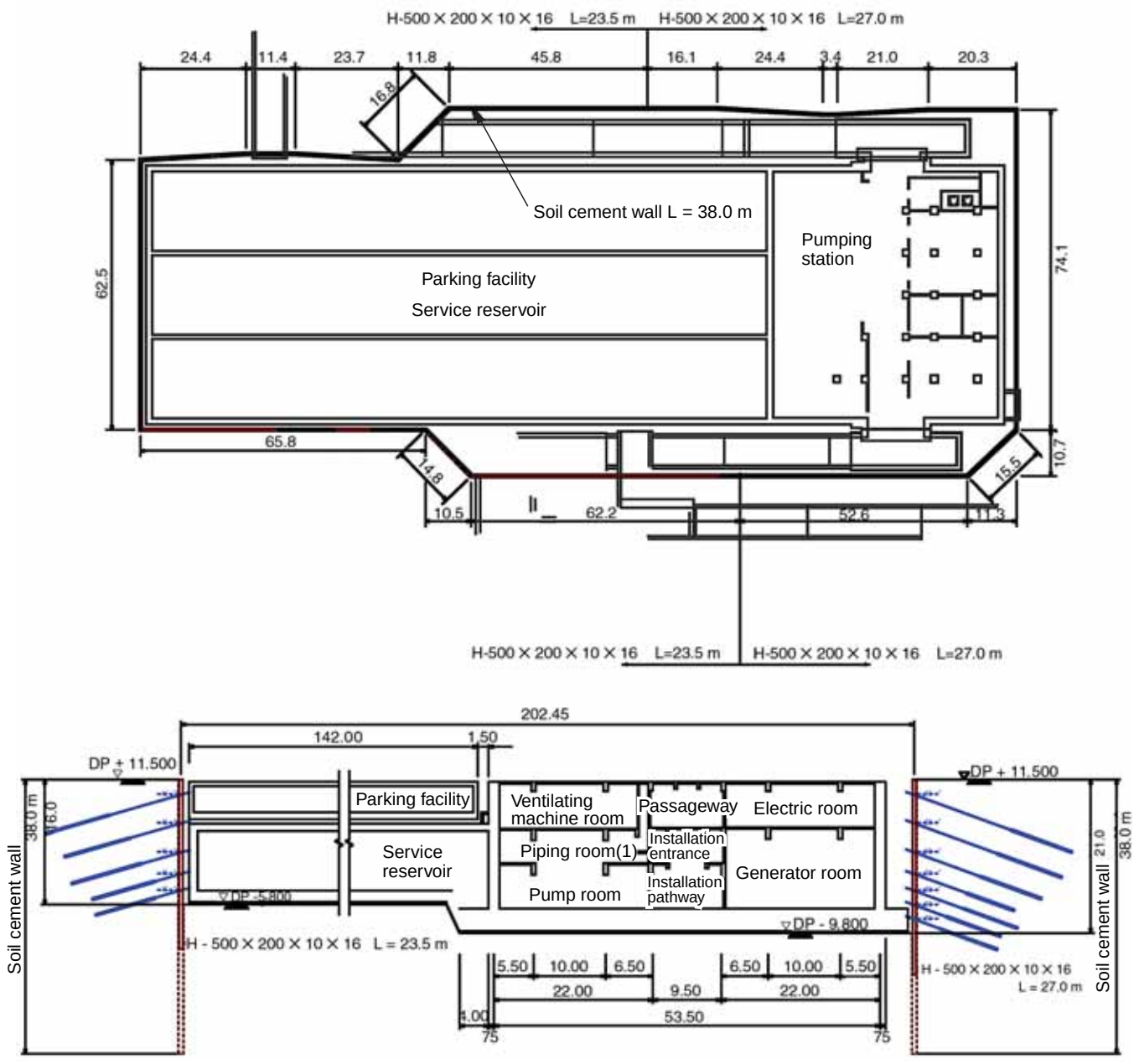
① Preparatory works for main structure
1) Soil cement wall installation (by trench cutting remixing deep wall [TRD] method)
Horizontal distance …… Approx. 555.0 m
Expanded area …… Approx. 21,100 m^2
Core material:
H500 × 200, used at interval of 600 mm
Service reservoir …… L = 23.5 m
Pumping station …… L = 27.0 m
2) Earth anchoring …… 24,885 m
② Entrance/exit pathway
1) Sheet steel pile installation
IV type: L = 18.5 m …… 4,300 m
III type: L = 7.5 m to 12.5 m … 13,200 m
2) Earth anchoring …… 4,133 m
③ Main construction work (including entrance/exit pathway)
1) Excavation work …… 313,447 m^3
2) Concrete placing …… 75,198 m^3

(5) Construction report

❍ Earth retaining

Prior to construction work, underground water survey drilling was carried out. Results confirmed the presence of confined ground water. Since confined ground water could cause ground heaving during pumping station site excavation, we decided to construct earth-retaining walls reaching the impermeable layer located 38.0 m below ground level, to block water flow. To meet construction conditions, including a limited construction period until commencement of parking service, we employed the trench cutting re-mixing deep wall method (TRD method). In this method, after earth and sand are mixed and churned with cement fluid, reinforcing members (H steels) are inserted in the cement slurry to create an earth-retaining wall.

Moreover, the survey found a gravel layer 10 - 20 m below ground level, causing concern that underground water or earth and sand might come out of the layer when



Extended horizontal length : 554.8 m			Total area : 21,090 m²			
	Wall thickness	Depth	Core material specifications	Length	Quantity	
Service reservoir	650 mm	38.0 mm	H-500 × 200 × 10 × 16	23.5 m	547 pcs.	926 pcs.
Pumping station	650 mm	38.0 mm	H-500 × 200 × 10 × 16	27.0 m	379 pcs.	

Fig. 5 Top and cross-sectional views of earth retaining system

anchor holes were drilled. To prevent such flow, at the second anchoring level bags inflated with cement fluid in close contact with the walls were installed in the anchor holes.

At the third or higher anchoring level where earth pressure is higher, in addition to these bags guide pipes were installed with mouth pipes attached at their ends. A Kronen bit with a check valve was also used to prevent cement fluid backflow.

❍ Concrete placement

The service reservoir must be sufficiently watertight and earthquake-resistant. However, massive concrete elements were used for Nagai Distribution Plant's floor and ceiling slabs and walls, more than 1.0 m thick, and for the pumping station's floor slab, 3.0 m thick. It was therefore necessary to take adequate countermeasures against thermal cracking resulting from the cement hydration reaction.

Among other countermeasures, we conducted thermal stress analysis before deciding the concrete mix design.

We then set the thermal cracking indexes for the respective components as follows, according to their levels of importance.

① The thermal index was set at more than 1.2 for the Distribution Plant's external walls, which particularly require water-tightness.

② A thermal index of more than 0.7 was assumed for the internal walls, since these walls do not require water-tightness, but need thermal cracking control to prevent steel frame corrosion.

③ Thermal analysis was not conducted on the concrete components to be used in the pumping station, since in their case priority was on structural durability.

Based on the above analysis, the concrete mix design was determined as shown in the table below.

Thermal stress analysis also identified some components that could not achieve the target thermal cracking indexes, even if low-heat cement and hydration heat control type expansive additive were used. For these components, we used cracking-inducing joints as well.

Table 1 Concrete mix design for service reservoir of Nagai Distribution Plant

Component	Cement	Nominal strength (N/mm^2)	Slump (cm)	Maximum size of coarse aggregate (mm)	High-range water-reducing admixture	Expansive additive	Viscous agent
Floor slab	Low-heat portland cement	24	12	40	None	None	None
External wall	Low-heat portland cement	24	15	20	None	Hydration heat control type	None
Training wall	Low-heat portland cement	24	15	20	None	None	None

Fig. 6 Concrete placement for floor slab

❍ Other

The park above Nagai Distribution Plant is a designated safety evacuation area. The Plant has emergency water-supply equipment storage, where temporary water taps are stored. In emergency, the temporary water taps will be installed at fire hydrants in the park. Also, temporary water tanks will be set up there. Thus, the park will serve as an emergency water supply center.

Moreover, ports for feeding water to tank trucks are installed on the third basement floor. In emergency, water will be supplied by gravity flow via the ports to emergency water-tank vehicles that have come in through the two approach ramps located on the north and south sides of the Distribution Plant. These vehicles will then transport the water to other emergency water supply centers and facilities to which water should be supplied preferentially, such as medical care facilities and social welfare facilities for the elderly.

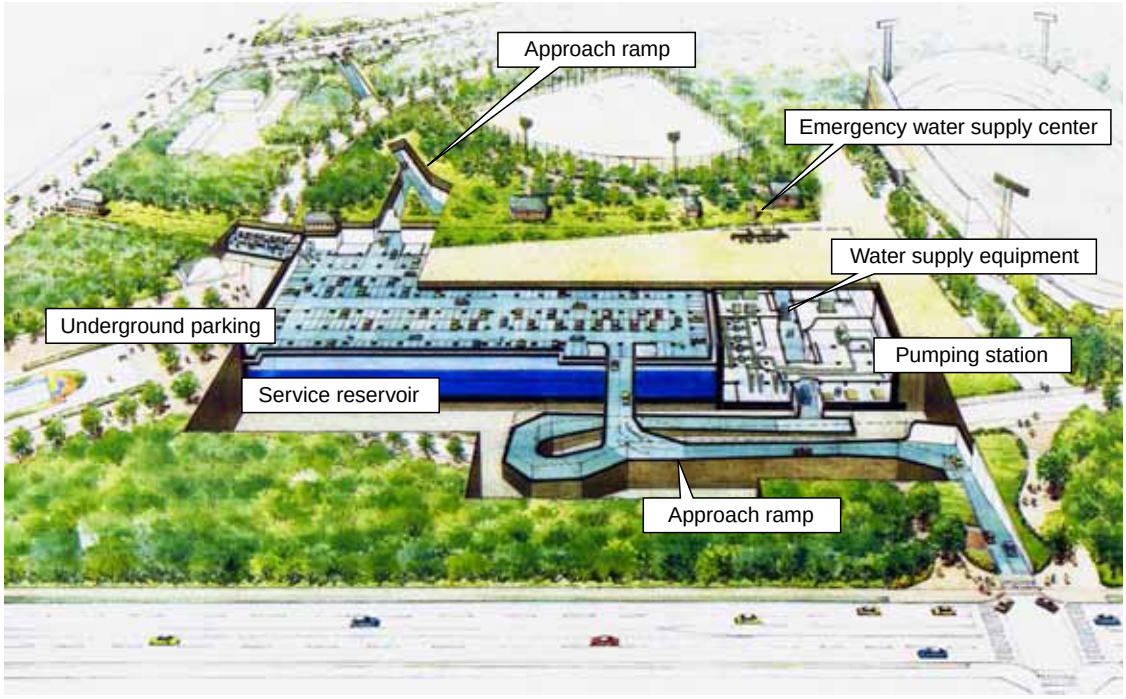


Fig. 7 Perspective drawing of Nagai Distribution Plant

4. Sakishima Distribution Plant

(1) Site selection

Sakishima is a man-made island with 30,000 residents. The present water distribution service in the Sakishima district has been dependent on only one water distribution route coming from the coastal area. For this reason it is feared that, if an accident occurs to the water service pipe on this single distribution route, water supply suspension may be extensive in the Sakishima district.

To prevent this, a water distribution plant construction site was carefully selected that fulfilled the following conditions:

- Able to increase and equalize water pressure applied during daily water supply service for city residents
- Distribution plant easily accessible from residential quarters
- Able to improve emergency water supply system reliability
- Consistent with Osaka City Regional Disaster Prevention Plan

As a result, Nanko Park was chosen as the site for Sakishima Distribution Plant.

(2) Planned structure

After completion of Sakishima Distribution Plant, the area above the Plant will be restored to a city park, as before. For this Plant, flat slab construction was selected, since it is advantageous under relatively homogeneous loading conditions.

Since the area above the service reservoir is a city park open to the general public, waterproofing has been done from the exterior, in view of controlling hygienic conditions for a water service facility. We selected synthetic polymer roofing, which features a higher elongatio percentage than

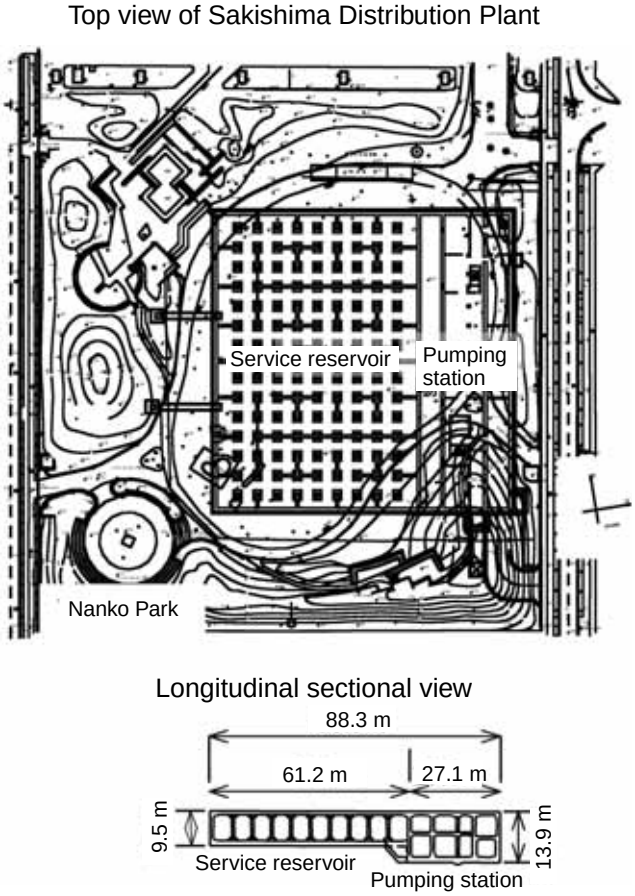


Fig. 8 Top and cross-sectional views of Sakishima Distribution Plant

other waterproofing sheets. This material is not only highly durable and chemical resistant, but also relatively inexpensive. No particular internal waterproofing has been performed for the service reservoir, but the water-tightness of the concrete has been improved.

(3) Facility outline

❍ Service reservoir

① Effective capacity: Approx. 30,000 m^3
② Number of reservoirs: 2
③ Dimensions: 88 m (width) × 61.2 m (length) × 6.5 m (effective depth)
④ Form of foundation: Spread foundation
⑤ Structure: Reinforced concrete, flat slab structure

❍ Distribution pumping station and pump unit

① Dimensions: Total floor area 4,200 m^2 (88.8 m [width] × 27.1 m [length] × 13.9 m [height])
Number of stories: Two stories below ground level
② Form of foundation: Spread foundation
③ Structure: Reinforced concrete structure

(4) Construction work outline

❍ Term of construction

July 13, 2000 - March 31, 2004 (scheduled)

❍ Description of work

① Preparatory works for main structure
1) Soil cement wall installation (by soil mixing wall [SMW] method)
Horizontal distance …… Approx. 358.0 m
Expanded area …… Approx. 8,000 m^2
Core material:
H440 × 300, used at intervals of 450 mm
H700 × 300, used at intervals of 600 mm
Service reservoir …… L = 21.5 to 22.0 m
Pumping station …… L = 26.5 to 27.0 m
② Approach ramps
1) Sheet steel pile installation
II type: L = 7.0 to 8.0 m …… Approx. 25 m
III type: L = 9.0 to 10.5 m … Approx. 55 m
V type: L = 12.0 to 13.5 m … Approx. 25 m
③ Main construction work (including approach ramps)
1) Excavation work …… 114,255 m^3
2) Concrete placement …… 19,978 m^3

(5) Construction report

❍ Earth retaining

Underground water survey drilling was conducted prior to construction work. Results confirmed that the ground-water level was about 3.0 m below ground surface, and

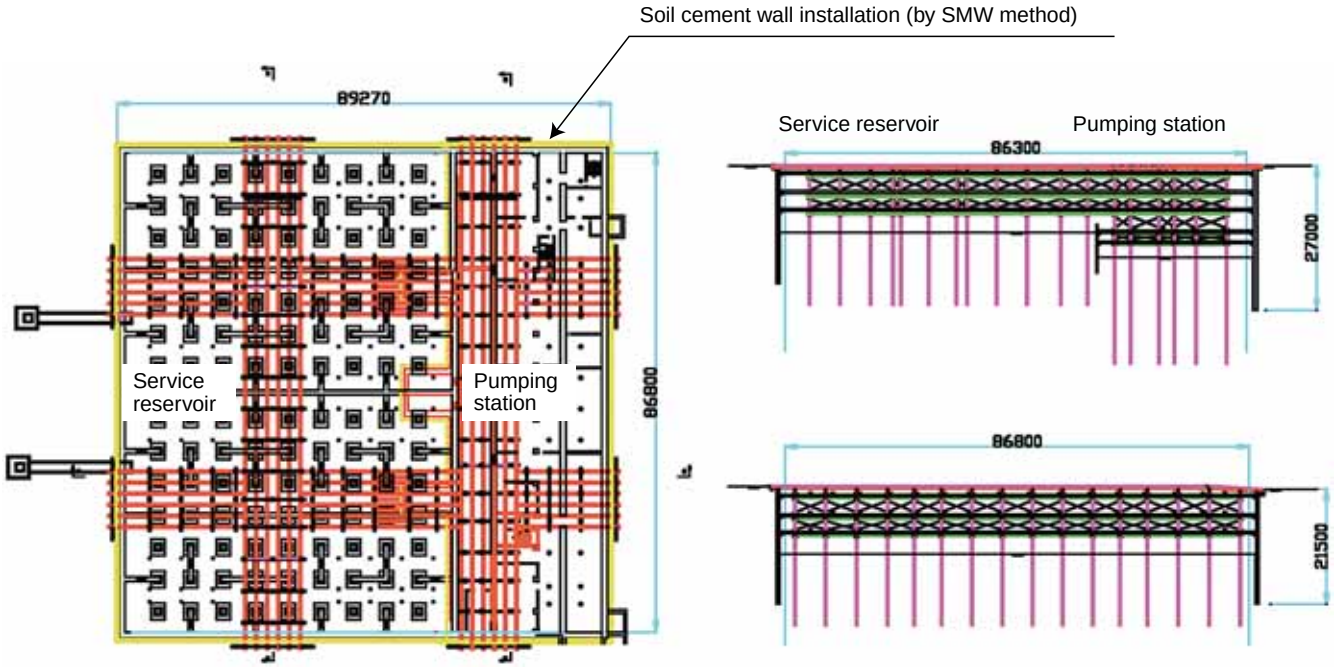


Fig. 9 Top and cross-sectional views of earth retaining system

that the foundation should be embedded up to the impermeable layer located 18.65 m below ground level, thus requiring excavation about 15 m deeper than the groundwater level. We compared various construction methods in terms of these conditions, as well as ease of installation, impact of work on the surrounding environment, construction cost, and duration of construction. As a result, we selected the soil mixing wall (SMW) method, a variation on the soil cement wall method.

❍ **Concrete placement**

To improve workability while ensuring sufficient earthquake resistance and water-tightness for a water tank structure, we decided to use a slump value of 18 cm for concrete placement to construct the Sakishima Distribution Plant. Also, a high-range water-reducing and air entraining admixture was used to prevent segregation.

Moreover, on the basis of thermal stress analysis results we selected types of cement for respective components, so as to achieve target thermal cracking indexes. For floor slab and training walls, portland blast-furnace slag cement was selected. For ceiling slab, pillars integrated into external walls and earthquake-resisting walls, low-heat portland cement was used. Furthermore, regarding Plant sections where reinforcing bars should be densely arranged, concrete placement tests were conducted using life-size models, to judge whether or not ordinary concrete could be properly placed. For sections where ordinary concrete placement could not be used, we used high-flow concrete with a viscous agent added.

❍ **Other**

As in the Nagai Distribution Plant, in emergency the park located above Sakishima Distribution Plant will be used as an evacuation area for local residents, serving as an emergency water supply center as well as a center for transporting water by tank vehicles.

5. Conclusion

Heavily built-up urban areas like Osaka City suffer from chronic shortage of available sites for urban facilities. Also, the need for urban open spaces has increased, in terms of establishing disaster prevention centers for use in times of disaster. It is therefore all the more difficult to newly secure sites for developing large-scale public facilities. To address this dilemma, Nagai Distribution Plant has been completed and Sakishima Distribution Plant is now under construction, both beneath city parks. These facilities will function not only as water distribution plants, but also as open spaces in urban areas.

The Osaka Municipal Waterworks Bureau intends to continue actively using the design approaches adopted for these two Plants, in order to expand a well-balanced water supply/distribution network in Osaka and further improve preparedness against earthquakes.

Table 2 Concrete mix design for Sakishima Distribution Plant service reservoir

Component	Cement	Nominal strength (N/mm^2)	Slump (flow) (cm)	Maximum size of coarse aggregate (mm)	High-range water-reducing admixture	Expansive additive	Viscous agent
Floor slab	Portland blast-furnace slag cement	24	18	20	High-range water-reducing and air-entraining admixture	None	None
External wall, pillar and quake-resistant wall	Low-heat portland cement	24	18	20	High-range water-reducing and air-entraining admixture	Hydration heat control type	None
	Low-heat portland cement	24	(60)	20	High-range water-reducing and air-entraining admixture	Hydration heat control type	Added
Training wall	Portland blast-furnace slag cement	24	18	20	High-range water-reducing and air-entraining admixture	None	None
	Portland blast-furnace slag cement	24	(60)	20	High-range water-reducing and air-entraining admixture	None	Added
Upper wall	Low-heat portland cement	24	18	20	High-range water-reducing and air-entraining admixture	None	None
	Low-heat portland cement	24	(60)	20	High-range water-reducing and air-entraining admixture	None	Added
	Low-heat portland cement	24	(60)	20	High-range water-reducing and air-entraining admixture	Hydration heat control type	Added

Initiatives to Improve Combined Sewer Systems

Environmental and Sewerage Bureau

1. Introduction

Osaka City's sewage systems, covering nearly 100% of the City area, play substantial roles in controlling flooding, improving citizens' living environment, and preserving the water quality of public waters. Osaka City, however, still has various problems relating to sewage systems, including occasional flooding; poor water quality (below the level specified by the environmental water quality standards) of several rivers/canals running in the City; water pollution caused by overflow from combined sewer systems; red tides in Osaka Bay; and declining functions of aged sewage treatment facilities. To improve water quality and create an excellent water environment befitting the metropolis of the 21st century, Osaka City prepared Water Environment Plan of Osaka City in May 1999. In addition to the introduction of advanced wastewater treatment facilities, the Plan stipulates improvement of existing combined sewer systems in order to control pollutant load in public waters, for which the combined sewage systems are responsible.

2. Osaka City's Initiatives to Improve Its Combined Sewer Systems

To provide sanitary systems and control flooding at the same time, Osaka City has primarily adopted combined sewer systems that collect both sanitary sewage and stormwater in the same sewer. The combined sewer system offers such advantages as lower construction cost and shorter construction period, both facilitating prompt expansion of sewage networks. In wet weather, however, sanitary sewage together with stormwater is directly discharged from stormwater outlets into public waters. Since solid pollutants deposit in sewers during dry weather, the first flush of effluent is particularly contaminated, and partially responsible for the pollution of public waters. (See Figure 1.)

To overcome such problems associated with the combined sewer systems, during the latter half of the 1970s Osaka City began studying actual sewage conditions in wet weather. On the basis of the results the City developed various sewage treatment mechanisms, including a high-rate plate settler module, activated sludge treatment method for wet weather wastewater and the fine screen processing technique; as well as such simulation methods as the wet weather pollutant load analysis method. In addition, the City held meetings with academicians and experts, to reflect their professional opinions and suggestions in systematically improving the combined sewer systems.

Meanwhile the national government also decided to encourage the improvement of existing combined sewer systems. In fiscal 2002 the Ministry of Land, Infrastructure and Transport initiated the Urgent Project to Improve Combined Sewer System; within this framework, the national government began providing appropriate municipalities with subsidies for implementing urgent improvement projects. To use this subsidy system for

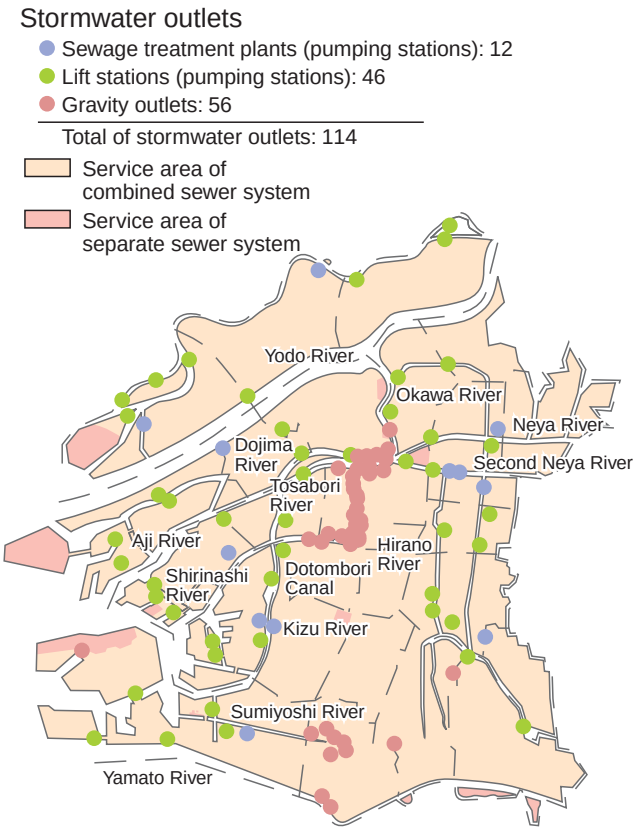


Fig. 1 Stormwater outlets in Osaka City

improving the City's combined sewer systems, Osaka City prepared an urgent program for combined sewer system improvement that places priority on prompt implementation of feasible initiatives. The Plan's period was determined at five years from fiscal 2002; its allocated budget was 65 billion yen. Specific initiatives to be taken are as follows:

(1) Decreasing pollutant load
- Inverting manholes
- Introducing the activated sludge treatment method for wet weather wastewater at sewage treatment plants
- Controlling the deposition of solid pollutants in stormwater grit chambers and removing the pollutants from the grit chambers
- Promoting construction of stormwater reservoirs

(2) Improving hygiene and public health
- Improving sewers and reducing the number of outlets

(3) Preventing discharge of solid wastes
- Introducing finer screens in stormwater grit chambers
- Installing filter screens at storm overflow chambers

Of these initiatives, particularly important ones are described below.

3. Activated Sludge Treatment Method for Wet Weather Wastewater

The activated sludge treatment method for wet weather wastewater (3W treatment method [Wet Weather Wastewater Treatment Method]) is an original method developed by Osaka City. Over the past 15 years, engineers of the City's sewage treatment plants have been developing the method, which is applicable to existing facilities and provides an affordable and effective solution for resolving problems of combined sewer systems.

(1) Outline of the 3W treatment method

To date, in wet weather Osaka City has fed up to three times the volume of the design maximum hourly wastewater flow in dry weather (1 Qsh): i.e., in wet weather, the maximum volume to be fed to treatment plants has been 3 Qsh. Of this volume, 1 Qsh has undergone activated sludge treatment; the remaining wastewater (2 Qsh) has been discharged to public waters after sedimentation treatment alone. In the 3W treatment method, however, the remaining wet weather wastewater is step-fed to the final aeration tank, where activated sludge treatment is applied before the wastewater is fed to sedimentation tanks. Since this method can improve wastewater quality to a level virtually equivalent to that of secondary effluent, introduction of this method can significantly reduce the pollutant load of wet weather wastewater. (See Figure 2, Photos 1 and 2.)

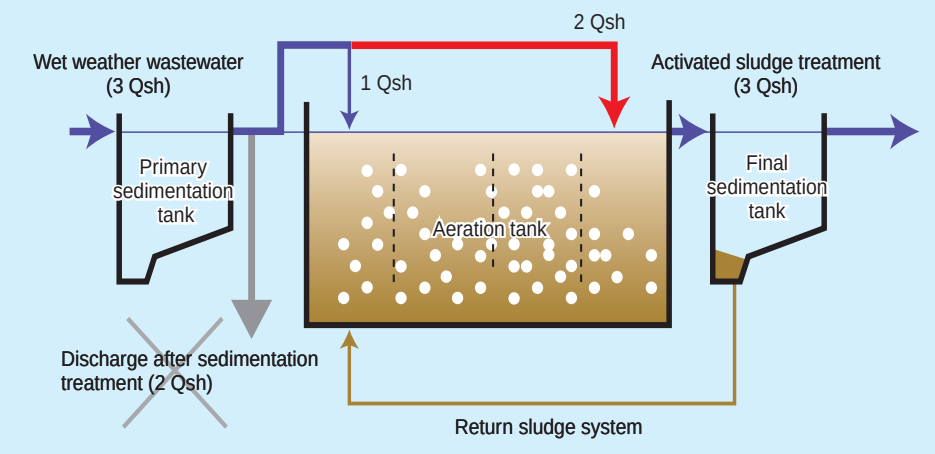


Fig. 2 Activated sludge treatment method for wet weather wastewater

(2) Basic mechanism of the 3W treatment method

In general, during the first 20 - 30 minutes of activated sludge treatment, pollutants in wastewa-

Photos 1 and 2 Motorization of a step gate

ter are adsorbed by activated sludge; the adsorbed pollutants subsequently decompose slowly. In the 3W treatment method, wet weather wastewater is fed to the final aeration tank, where activated sludge adsorbs pollutants. Since this treatment removes pollutants to a level equivalent to that of dry weather wastewater, the treatment facilitates subsequent solid-liquid separation in the final sedimentation tank, in turn resulting in improved water quality of final effluent. Meanwhile, the activated sludge that has adsorbed pollutants is fed back to the first aeration tank using return sludge system, and adsorbed pollutants are decomposed during the detention in the aeration tanks. As a result, when the activated sludge runs to the final aeration tank, the sludge, having already recovered its adsorption capacity, is capable of continual adsorption of pollutants, with high stability. Although mixed liquor suspended solids (MLSS; see Note 1) flow from the final aeration tank into the final sedimentation tank immediately after initiation of 3W treatment, the amount of MLSS soon decreases. Accordingly, in the steady state, acceptable solid loading levels can be maintained in the final sedimentation tank. The researchers believe that the final sedimentation tank can adequately achieve solid-liquid separation, if the tank retains its functions during the initial operation stage, when solid loading level is relatively high.

(Note 1) MLSS (mixed liquor suspended solids) refers to the content of suspended solids in mixed liquor in aeration tanks of the activated sludge treatment system.

(3) Effects of the 3W treatment method on water pollution control

Osaka City has already introduced the 3W treatment method to Suminoe and Hirano sewage treatment plants (partial introduction to Hirano Plant), and will introduce it to the remaining sewage treatment plants in the City, one by one.

Table 1 shows results of simulated calculations regarding the effect of the 3W treatment method at Suminoe Sewage Treatment Plant, in terms of BOD (biochemical oxygen demand) loading in final effluent. In this calculation, on the basis of actual volume of wastewater treated by the 3W treatment method, the researchers calculated BOD loading levels of the final effluent treated by the 3W treatment method. For the sake of comparison, the researchers also simulated the loading levels of final effluent containing at least 1 Qsh wastewater treated by the sedimentation process alone. The result of this simulation shows that the 3W treatment method can reduce BOD loading by 78% from the level of final effluent that underwent sedimentation treatment alone.

(4) Challenges related to the 3W treatment method

Actual operation of the 3W treatment method at sewage treatment plants has proven the method effective in resolving problems associated with the combined sewer systems. However, the method is not free from potential problems, including suspected negative impact on such advanced wastewater treatment methods as the step feed biological nitrogen removal process, as well as a decline in the adsorption capacity of activated sludge after many hours of continual operation.

To study the impact of 3W treatment on advanced wastewater treatment, surveys were conducted at Hirano Sewage Treatment Plant. Results showed that despite researchers' concerns, 3W treatment proved to have no impact on the advanced treatment systems' capacity to recover their nitrogen and phosphorus removal functions. To accelerate the recovery of nitrogen and phosphorus removal functions, however, various measures should be studied toward actual application. For instance, when influent has low organic content (particularly after rainfall

Table 1 Simulation of BOD loading (Rainfall on December 4, 2001)

Time	Sedimentation process to over 1 Qsh wastewater						3W treatment method		
	Loading by sedimentation process alone			Loading in secondary effluent			Treated volume m^3	C-BOD mg/L	Loading kg
	Discharged volume m^3	BOD mg/L	Loading kg	Secondary treatment volume m^3	C-BOD mg/L	Loading kg			
4:00	2,506	100	251	9,300	3.2	30	11,806	4.3	51
5:00	17,711	76	1,346	9,300	3.2	30	27,011	10	270
6:00	19,272	58	1,118	9,300	3.2	30	28,572	12	343
7:00	13,394	53	710	9,300	3.2	30	22,694	7.8	177
8:00	13,103	51	668	9,300	3.2	30	22,403	6.4	143
9:00	9,018	50	451	9,300	3.2	30	18,318	5.1	93
10:00	5,112	60	307	9,300	3.2	30	14,412	4.0	58
Total	80,116		4,851	71,007		210	151,123		1,135

Note: C-BOD levels of secondary effluent are based on mixed liquor water quality tests conducted in December 2001.

has flushed pollutants away), either the influent should bypass the primary sedimentation tank, or primary sludge should be fed to aeration tanks. When rainfall continues for many hours and the organic content of influent continues to decline, 3W treatment could be replaced by primary treatment. As an indicator necessary for decision regarding such replacement, turbidity should be measured with greater accuracy. In this context, Osaka City will study the accuracy of turbidity meters, essential tools for introducing the 3W treatment method to more facilities.

4. Stormwater Storage Plan for Dotombori and Higashi-yokobori Canals

Dotombori Canal, running in Minami or the southern downtown of Osaka, and Higashi-yokobori Canal, located in the upper reaches of Dotombori Canal, have a total of 28 stormwater inlets, through which stormwater flows into the canals from the western section of the Uemachi Plateau. Since the existing trunk sewer running along Higashi-yokobori Canal is of relatively small capacity, wastewater also outflows from the trunk sewer into the canal during rainfall; this inflow, occurring about 70 times out of some 85 annual rainfalls, is partially responsible for the water pollution of Higashi-yokobori and Dotombori canals.

To address this problem, Osaka City plans to construct a stormwater storage pipeline (Kitahama - Ousaka storage pipeline; internal diameter 6 m; length 4 km; capacity approximately 140,000 m^3). So long as the rainfall does not exceed the probable maximum precipitation (rainfall on a probability of once every ten years), the storage pipeline when completed will store 100% of the stormwater that otherwise would be discharged into Dotombori and Higashi-yokobori canals through 25 existing outlets, thus protecting Dotombori Canal from the inflow of sanitary sewage and solid waste. The City intends to construct the storage pipeline under Matsuyamachi Avenue (Nagae - Abeno Line). Below the avenue, however, there are such underground facilities as a subway track and a telephone cable tunnel. The entire portion of the storage pipeline, therefore, will be constructed by the shield tunneling method about 50 m below the ground surface. Stormwater to be stored in the pipeline will be fed into a sewage treatment plant after the termination of each rainfall, and subsequently will be discharged into the canals. Since Dotombori Canal runs amid the thriving downtown, to create a pleasant waterfront environment in the central section of "Water Metropolis Osaka," the City is constructing promenades and other amenity-rich spaces along the canal. Pipeline construction will be undertaken in tandem with the progress of the Dotombori Riverfront Development Project. (See Figure 3.)

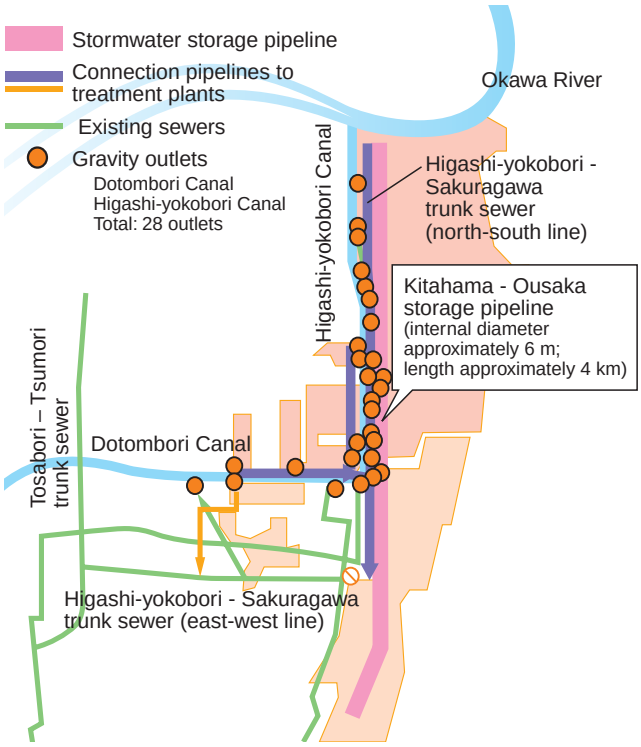


Fig. 3 Plan of Kitahama - Ousaka storage pipeline

5. Construction of a Stormwater Storage Pipeline between Chishima and Konohana Sewage Treatment Plants

To reduce pollutant discharge into public waters, Osaka City intends to construct stormwater storage pipelines that will temporally store the first flush of wastewater (which is particularly contaminated), and feed it to treatment plants after rainfall termination. At the same time, to improve sludge treatment efficiency, the City is constructing sludge force mains between sewage treatment plants, in addition to a central sludge treatment plant (Maishima Sludge Center). Since the sludge force main linking Chishima and Konohana sewage treatment plants must cross rivers at three points, the City decided to adopt the shield tunneling method in constructing the force main equipped with a pipe gallery. The City has also decided to use the pipe gallery space in constructing a stormwater storage pipeline for the service areas of Chishima and Konohana treatment plants. The stormwater storage pipeline will have an internal diameter of 3,000 mm, length approximately 5,700 m and capacity 33,500 m^3. The sludge force main will comprise ductile iron pipes of 150 - 300 mm internal diameter; two to five such pipelines will be installed, the number depending on installation sites.

In fiscal 2003, the City commenced constructing vertical shafts and producing shield machines for use in this project. Since such storage facilities are rare in Japan, Osaka City should thoroughly study facility maintenance and operation methods as well. (See Figures 4 and 5.)

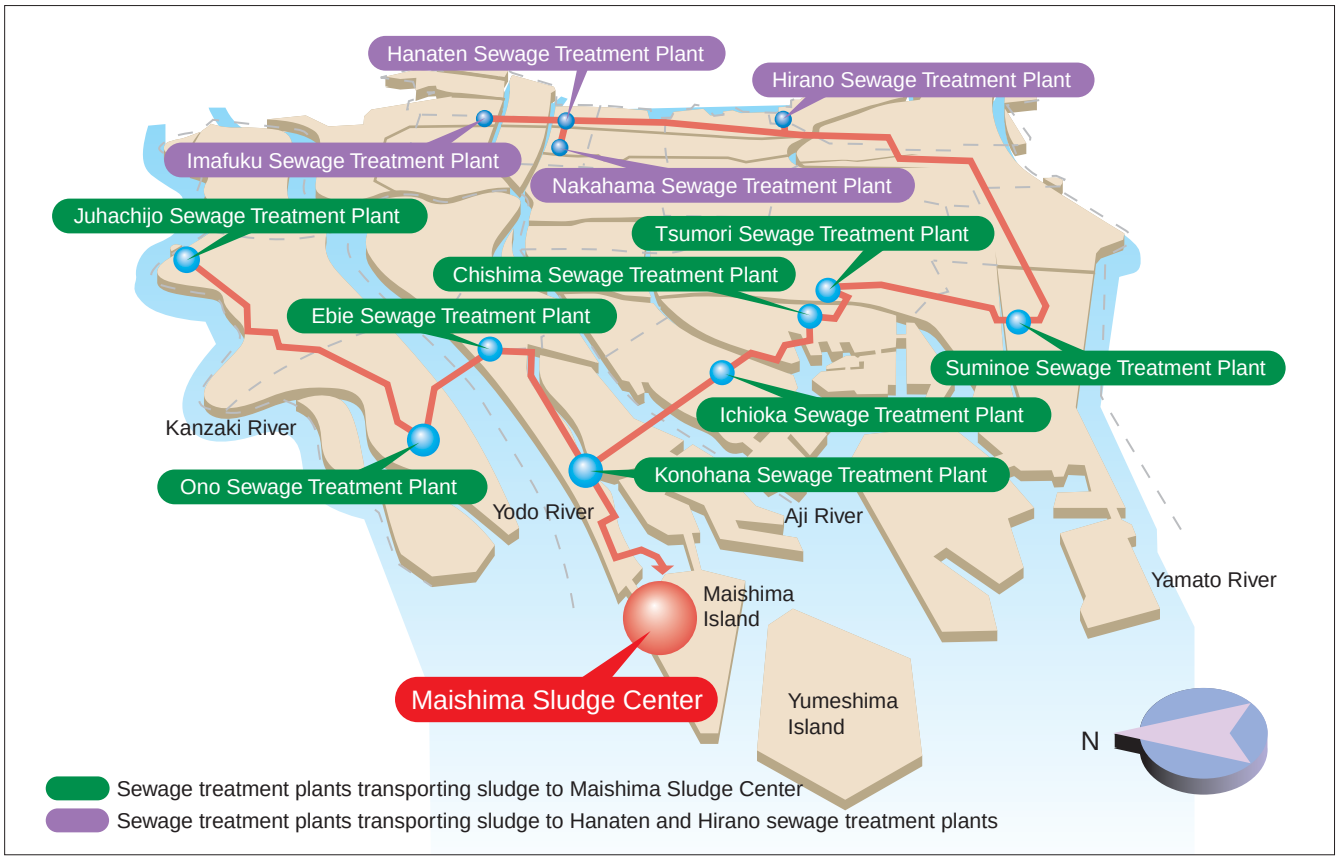


Fig. 4 Sludge transportation networks

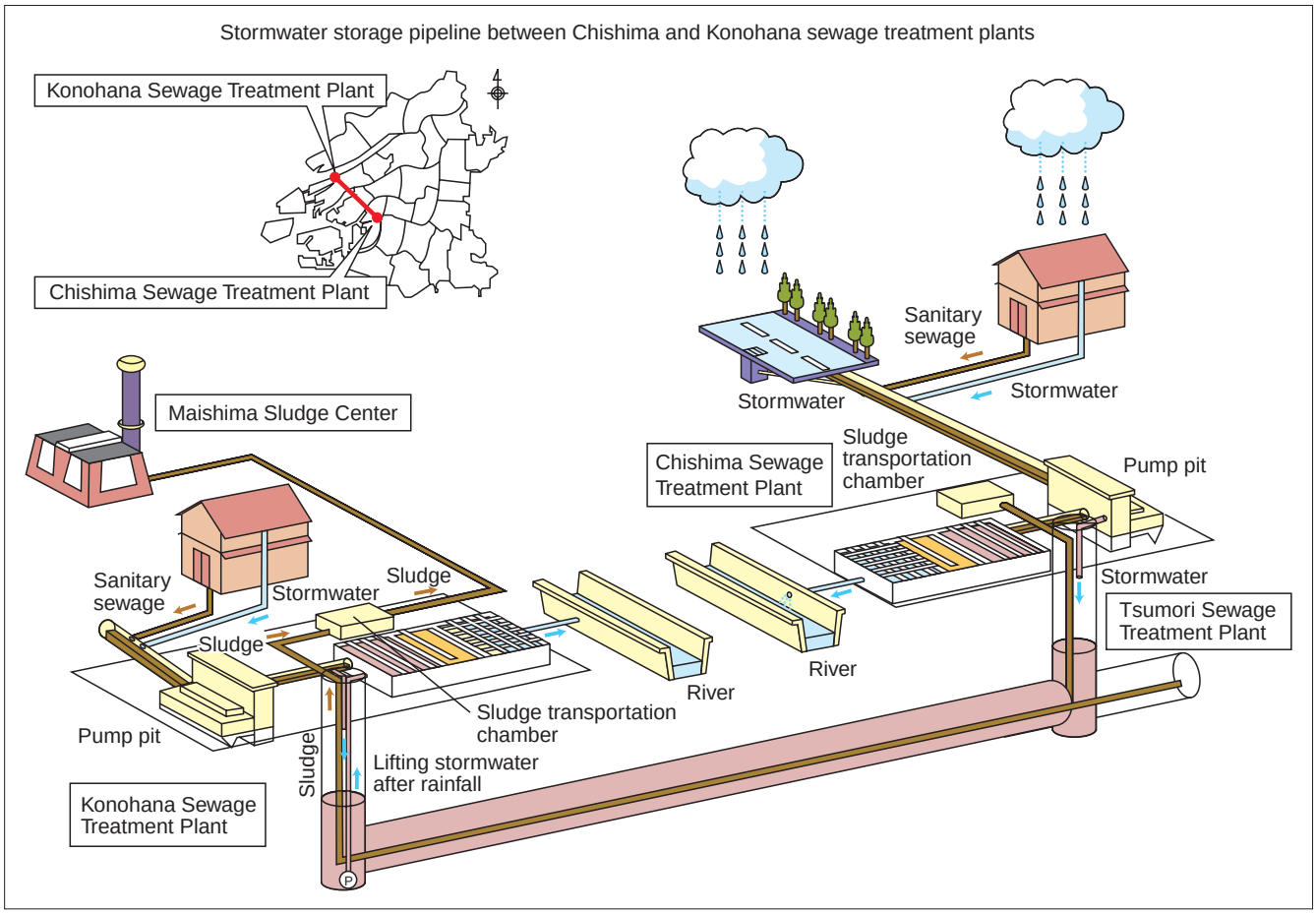


Fig. 5 Chishima – Konohana stormwater storage pipeline

6. Construction of Stormwater Reservoir at Hirano Sewage Treatment Plant

To improve the water quality of the Hirano River system, where treated wastewater is discharged from Hirano Sewage Treatment Plant, Osaka City introduced its first advanced wastewater treatment facility (rapid sand filtration tank, daily treatment capacity 120,000 m^3) in Hirano Sewage Treatment Plant in 1981. However, the plant had difficulty in stably sustaining sufficiently high water quality level to meet the environmental water quality standards. One factor in this difficulty was the insufficient volume (less than half) of wastewater that underwent advanced wastewater treatment; another was the outflow of untreated wastewater into the river in wet weather.

To improve the water quality of final effluent by applying advanced wastewater treatment to 100% of design wastewater flow, and to reduce the wet weather pollutant load to the level of a separate sewer system by storing the first flush of wastewater, Osaka City constructed a complex facility comprising another advanced wastewater treatment facility (rapid sand filtration tank, daily treatment capacity 192,000 m^3) and a stormwater reservoir (capacity 40,000 m^3) on the premises of Hirano Sewage Treatment Plant. Construction of the complex facility began in fiscal 2002, and its operation commenced in May 2003. On the roof of the facility, a spacious roof garden (1,500 m^2) was constructed with an artificial stream (approximately 30 m). The roof garden is open to the public, providing access to an amenity-rich, relaxing space amid the busy urban area. (See Figure 6.)

7. High-Rate Plate Settler Module Sedimentation Tank at Ebie Sewage Treatment Plant

Since the latter half of the 1970s, Osaka City has been developing high-rate plate settler modules for sedimentation tanks to treat stormwater with high efficiency in a continual manner. By installing plates diagonally in a tank, the tank's sedimentation area can be expanded, increasing the tank's pollutant removal rates. The new sedimentation tank in Ebie Sewage Treatment Plant has been designed to increase sedimentation area via the installation of the plates diagonally. Construction of this sedimentation tank commenced in fiscal 1991, with the aim of resolving problems associated with the combined sewage system. Ebie Sewage Treatment Plant commenced operating the new tank in fiscal 2003. To prevent debris adhesion to the diagonal plates, a fine (5 mm mesh) screen is used in the process precedent to sedimentation. The new tank, equipped with several plates installed at the intervals of 100 mm and a tilting angle of 60º, treats 464,000 m^3 of wastewater daily. Because of the high-rate plates, the sedimentation tank's treatment capacity is equivalent to an ordinary tank with about three times the area. The new sedimentation tank has demonstrated that high-rate plate settler modules are effective in reducing pollutant load of the combined sewer system in the limited space of a sewage treatment plant. (See Figure 7, Photos 3 and 4.)

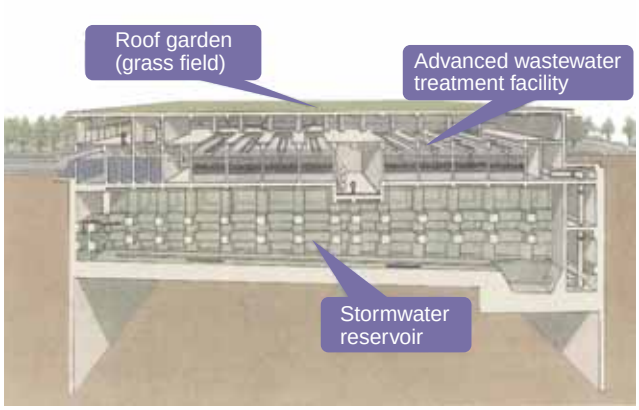


Fig. 6 Stormwater reservoir at Hirano Sewage Treatment Plant

8. Conclusion

Although the water quality of rivers in Osaka is generally improving, some rivers in the Neya and the Yamato river systems still fail to achieve water quality levels that meet the environmental water quality standards. Accordingly, Osaka City must continue its efforts to construct more advanced wastewater treatment facilities and other treatment facilities, to resolve problems associated with the existing combined sewer systems. In addition, the City must take measures to protect Osaka Bay from eutrophication. To address these problems, the City must build partnerships with the municipalities and prefectures located in the upper basin of the river systems. By sharing common goals and determining the responsibilities of individual prefectures/municipalities, all related parties must work together to create an excellent water environment.

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Photo 3 High-rate plate settler module sedimentation tank 1

Photo 4 High-rate plate settler module sedimentation tank 2

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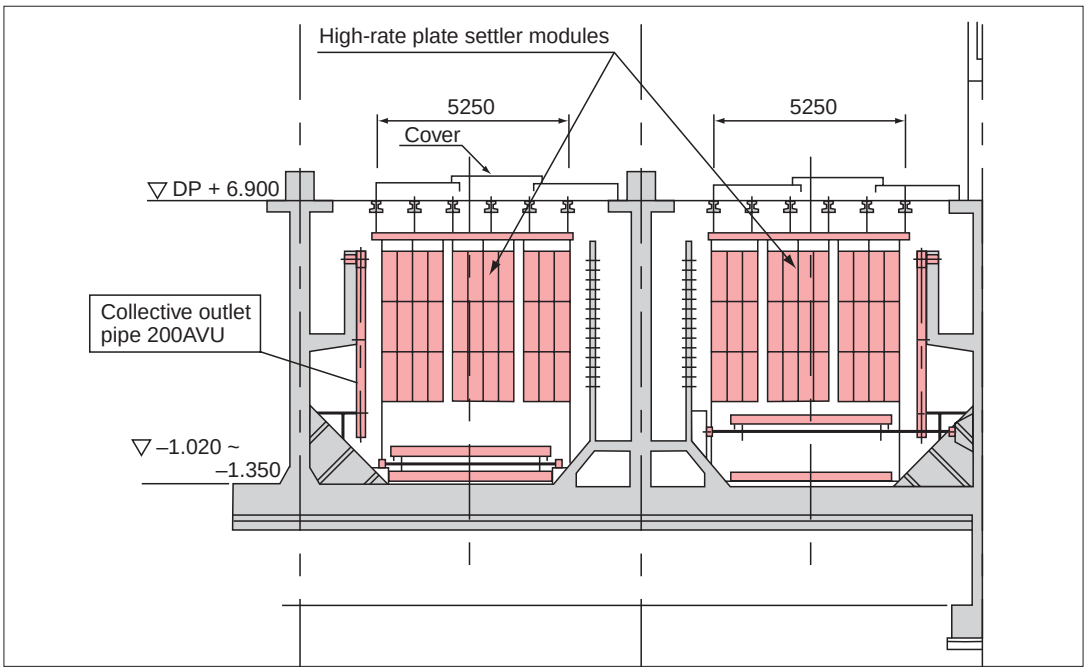

Fig. 7 Cross section of a high-rate plate settler module sedimentation tank

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