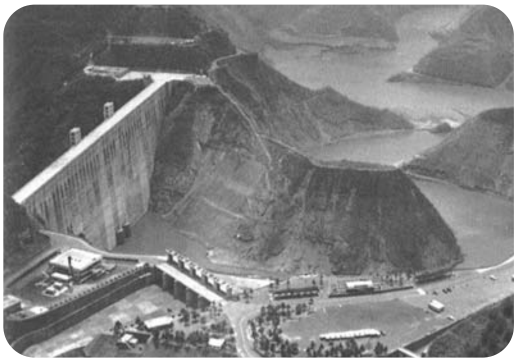
Japan International Cooperation Agency

Japan's Experiences on Water Supply Development







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Water Partners Jp Co.,Ltd.

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Cover photos

Upper left: Leakage survey around 1949, Nagoya City Waterworks and Sewerage Bureau.

Upper right: Construction site of water distribution pipe in 1912, Nagoya City Waterworks and Sewerage Bureau.

Bottom left: Carrying water before the development of water supply, Susumu Hani, the film “Water in Our Life,” Iwanami Productions, 1952.

Lower middle: Water tanker for the drought of 1978, Fukuoka City Waterworks Bureau.

Bottom right: Ogouchi Dam without water during drought of 1964, Bureau of Waterworks, Tokyo Metropolitan Government.

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Preface

Access to safe water is an essential part of human rights and the foundation for a healthy life. However, even today, the world witnesses many instances of people lacking access to this essential commodity. To counter this situation, a new global agenda - the Sustainable Development Goals (SDGs) - was unanimously adopted by the member states of the United Nations in 2015. The agenda included a dedicated goal on water (Goal 6) that aims to "ensure availability and sustainable management of water and sanitation for all." Target 6.1 of Goal 6 estimates that "by 2030, achieve universal and equitable access to safe and affordable drinking water for all." Japan has been contributing for years to the development of the water supply sector.

When Japan started to construct modern water supply systems, it faced vast challenges with regard to expansion of service coverage and improvement of service quality, as is the case in most developing countries. However, it overcame these challenges with the help of proactive efforts, including the introduction of the overseas technology, and achieved the objective of nationwide coverage of safe water supply. These experiences contain useful lessons for developing countries. The Development Cooperation Charter decided by the Cabinet in 2015, the foundation of Japan's Official Development Assistance policy, contains the philosophy, which would help in addressing development challenges facing the world today by utilizing such experience and expertise. However, it is not enough to merely introduce Japan's experiences to the world. They should be sorted out and analyzed, keeping in mind the SDGs and the current challenges encountered by developing countries.

Therefore, this study investigated Japan's historical efforts in the form of acquiring a wealth of experiences in the sphere of water supply and compiling textbooks for the concerned people in developing countries who are facing challenges of service expansion and service quality improvement, and also for the people in the domain of development cooperation.

Japan has attached importance to safe water supply in the interest of public health since 1887 when the first modern water supply system began its operation in Yokohama City. Afterward, Japan faced many difficulties such as the catastrophic World War II damage inflicted on the facilities and consequent high rate of leakage, and skyrocketing demand and water pollution during the high economic growth period, but successfully surmounted them to provide nationwide and equitable access to safe water around the clock. The crucial elements in this success include many characteristics of Japan's waterworks such as the legal and administrative systems, the regulatory framework of the government, collaboration among water supply utilities centered around the Japan Water Works Association, the financing mechanism such as municipal bond to cover capital investment, sound financial management by the public enterprise accounting system and the self-supporting accounting system based on tariff revenue, and the regard for customer service. It should be also noted that officials of the water supply utilities are continue to improve the services they offer with a sense of responsibility and ingenuity. These characteristics will undoubtedly serve as a useful reference for developing countries. However, this study is aimed at bringing their issues to light, and not at transferring Japan's experiences to the developing countries.

This work was supported by advisors Prof. Yasumoto Magara - Japan Small Scale Water Works Association, and Mr. Ikuo Mitake - the Japan Water Works Association. Editorial supervisors Prof. Satoshi Takizawa - the University of Tokyo, and former Senior Advisor Keiko Yamamoto - Japan International Cooperation Agency also provided support. The study was also aided by a wide range of people concerned about Japan's water supply sector who contributed by way of providing reference materials and interviews. I wish to express my sincere appreciation to all of them.

I hope this study will contribute to the improvement of water supply in developing countries.

March 2017

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Japan's Experiences on Water Supply Development: Overview

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1. Introduction

This module summarizes Japan's experience based on Goal 6 of the United Nations' Sustainable Development Goals (SDGs) and provides answer to questions about water supply that were frequently asked by the participants of water supply training courses from developing countries.

Q1. How has Japan achieved close to 100% water supply coverage?

Q2. How can Japanese waterworks provide around the clock supply of safe affordable drinking water?

This module presents an overview of the Japanese experience in archiving SDG 6 in "Goal 6 of SDGs and Japan's Experience." Each topic is explained in more detail in other chapters of this training manual aiming to provide answers to these questions:

3. Universal and Equitable Access (Q1)

4. Safe Drinking Water, 5. Sustainable Water Resources Management, 6. Ensuring Availability, 7. Efficient Water-Use, 8. Sustainable Management, 9. Affordable Drinking Water, and 10. Engaging Local Communities (Q2)

2. Goal 6 of SDGs and Japan's Experiences

Japan has practically achieved SDG Goal 6: "Ensure availability and sustainable management of water and sanitation for all."

Goal 6 of the United Nations' Sustainable Development Goals (SDGs) aims to "ensure availability and sustainable management of water and sanitation for all." Over the years, Japan has achieved an almost 100% water supply coverage. Japanese utilities secured water resources and constructed top-notch facilities to provide 24-hour service. They operate on a cost recovery basis with income from water tariffs, while demonstrating full accountability and transparency to the customers.

Target 6.1 aims to achieve "universal and equitable access to safe and affordable drinking water for all" (by 2030)." Japanese waterworks experienced followings concerning the target:

Universal and equitable access: Japan expanded water supply networks nationwide, including to rural areas, thus achieving 97.8% water supply coverage as of 2014. This was made possible by improving legal systems, securing financial resources, constructing facilities, and developing a skilled workforce.

Affordable drinking water: the Japanese water tariff system is structured with consideration for low-income groups, allowing reductions and exemptions from tariff payment.

Safe drinking water: In Japan, water is safe to drink from the tap anywhere in the country. Water quality and facility standards are stipulated in the Water Supply Act and are carefully followed by operators to ensure that public health will not be compromised.

Target 6.4 aims to "substantially increase **water-use efficiency** across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity (by 2030)." Utilities in Japan have focused on water-use efficiency, achieving one of the lowest water leakage rates in the world (4.69% in fiscal year 2013).

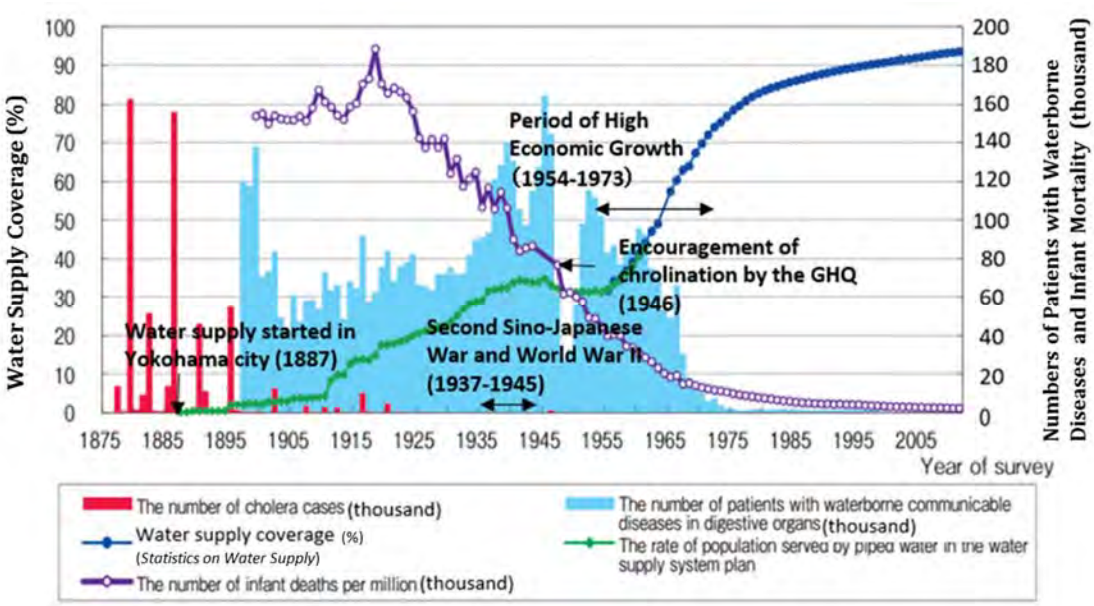
Target 6.5 aims to "implement **integrated water resources management** at all levels, including through transboundary cooperation as appropriate (by 2030)." Japan secures water resources in collaboration and coordination with stakeholders.

Target 6.b aims to "support and strengthen the **participation of local communities** in improving water and sanitation management." Japan has a high collection rate for water tariffs (more than 99%), which is the result of satisfying customer service. Utilities actively engage with customers and reflect their input in planning for the future of the service. The two sides have built a trusting relationship and work closely together solving problems such as water conservation to overcome the adversities during severe droughts.

These Japan's experiences are very useful for others aiming to achieve the SDG on sustainable management of water supply.

3. Universal and Equitable Access

Japan achieved 97.8% water supply coverage in fiscal year (FY) 2014. Almost all residents of Japan enjoy safe drinking water. This is the result of years of effort to improve public health.



Source: Water Resources Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "*Water in Japan*," http://www.mlit.go.jp/common/001044443.pdf

Figure 1. Water Supply Coverage Rate, the Numbers of Patients with Waterborne Diseases, and Infant Mortality Rate

(1) Reducing Incidence of Waterborne Diseases and Emergence of Modern Urban Water Supply System

The modern water supply system was introduced to combat the spread of waterborne diseases, such as cholera. The basic goal was to improve public health by providing every citizen with pressurized clean safe water around the clock.

Japan began constructing waterworks to prevent the spread of waterborne diseases, such as cholera, at port cities. The trading with western countries in the latter half of the 19th century brought cholera epidemics to major port cities. An epidemiological survey conducted in Yokohama, one of major port cities, showed the relationship between outbreaks of cholera and locations of polluted gutters and wells. This result demonstrated that safe drinking water supply was required to prevent cholera. Thus, the first modern water supply system was established in Yokohama in 1887.

The national government subsidised one-third of the construction costs of the project. Other water supply systems began to be built at port cities such as Kobe, and naval ports, such as Maizuru and Sasebo. These systems used slow sand filtration to remove *E. Coli* and imported cast iron pipes to convey treated water under pressure to avoid any contamination on the way to the customers.

The nationwide water supply system was established under the public management principle as stipulated in the Waterworks Ordinance enacted in 1889.

(2) Development of Nationwide Water Supply System

The following comprehensive measures were implemented: development of facilities and securing funds for construction, development of facility standards and human resources. These measures brought coverage from around 30% in 1950 to 80.8% in 1970.

The Constitution in Japan stipulates that "everybody shall have the right to maintain the minimum standards of wholesome and cultured living" and that "the State shall promote and improve public health." The Water Supply Act was enacted in 1957 based on this principle of the Constitution. Under this law, the national government actively supported the funding of water utilities. This expanded the water supply coverage dramatically.

The main funding instrument for the development of water supply in urban areas was long-term municipal bonds issued by local governments. The national government allowed the issue of bonds, based on the utilities' financial conditions, income projections, project feasibility and priority. The national government purchased 80-90% of the municipal bonds using public funds (from public financial institutions and pension funds).

A subsidy system for small-scale waterworks, established in 1952, contributed to the boost in water supply coverage in rural areas. This served to reduce waterborne diseases in rural villages and the physical burden on women who had to fetch water for their families.

Approval is required when starting a water supply system as stipulated by The Water Supply Act. The application for approval requires the submission of a master plan that describes the development of the system based on demand projections. The other information required for approval include: water demand projections, facility plan and financial plan (proposed water tariff structure, subsidies and funding from enterprise bonds). The master plan is evaluated in terms of technical and financial feasibility.

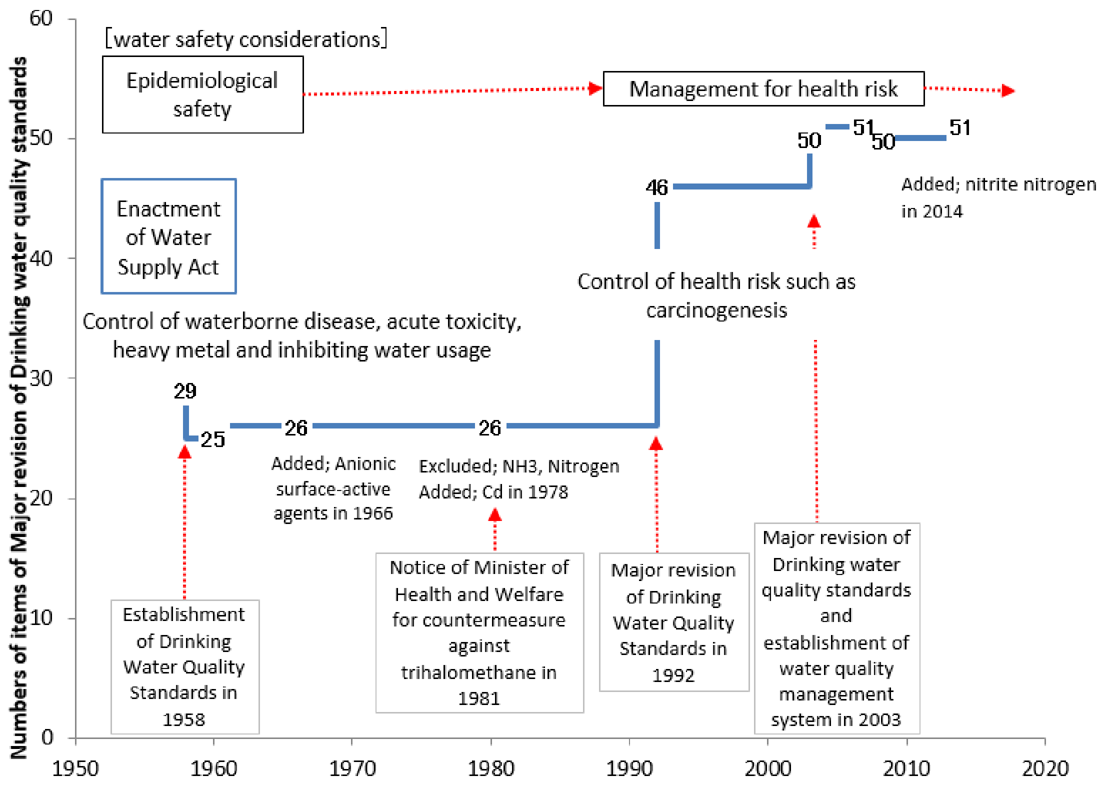
The National Institute of Public Health began to offer a public health engineering course in 1948 for local government employees to develop the much-needed human resources for the water supply sector. Utilities conduct on-the-job training, supplemented with training programs provided by the Japan Water Works Association (JWWA). JWWA published the *Water Supply Facilities Standards* in 1955 and the *Guidelines for Water Supply Facilities Standards* in 1958, leading to the standardisation of design and construction practices. The technical standards are especially helpful to small- and medium-sized utilities which have fewer engineers and skilled workers. These documents were revised and compiled into the *Guidelines for Water Supply Facilities Standards* in 1966.

The success in achieving nationwide coverage can be attributed to strong financial support from the national government, efforts in human resource development and the establishment of technical standards.

4. Safe Drinking Water

(1) Water Quality Standards and Facilities Standards under the Water Supply Act

Improving public health is the foremost reason for developing water supply systems and the safety of drinking water is a very important issue. The Water Supply Act stipulates water quality standards, facility standards and management methods to be followed by utilities.



Source: Material prepared by Koichi Ogasawara

Figure 2. Changes to Drinking Water Quality Standards in Japan 1950-2010

The Water Supply Act defines water quality standards in Article 4 and stipulates facility standards in Article 5. Supervision of facility construction by qualified engineers (Article 12), inspection of facilities and water quality testing before commencement of the treatment facility (Article 13), and use of appropriate service connections (Article 16 and others) are also stipulated.

Water quality standards are revised periodically as new knowledge emerges on toxic substances causing public concern. In addition, available analytical methods and environmental condition of the country are taken into consideration in revising water quality standards. The

Water Supply Act stipulates the appointment of a Technical Administrator (Article 19), regular and ad-hoc water quality testing (Article 20), mandatory medical screening of workers (Article 21), thorough sanitation of facilities by disinfection (Article 22), and provisions on the suspension of water supply in case of accidental contamination (Article 23).

Water utilities conduct water quality testing regularly, secure budgets for water quality management and develop water quality testing management systems for long-term maintenance. In addition the Ministry of Health, Labour and Welfare and the Health Centers conduct onsite inspections. The Health Centres also confirm utilities' water quality testing results and provide technical support to small- and medium-scale utilities (serving population of 50,000 or less) that lack skilled workers.

(2) Chlorination

The implementation of chlorination after World War II contributed considerably to the supply of safe drinking water.

It is ideal to have access to clean and abundant water sources. However, this is sometimes difficult in practice. Water utilities must conduct appropriate water treatment for different water sources to secure water quality. In Japan, chlorination implemented after WWII significantly contributed to making drinking water safe. Chlorine is inexpensive, but has a strong residual effect and can disinfect against pathogenic microorganisms. The concentration of residual chlorine at the tap is required to be ≥ 0.1 mg/l (0.1 ppm) under the Order for Enforcement of the Water Supply Act.

Chlorination has some undesirable side effects, such as the generation of disinfection by-products, corrosion of pipeline materials and equipment and disagreeable odor.

(3) Quality Management of Materials and Equipment

Japan has ensured the safety of drinking water by establishing standards, inspection, and certification processes for materials and equipment, such as pipelines and service connection facilities.

The Water Supply Act requires that tap water meet specific water quality standards. Water quality management is not limited to tasks carried out in the water treatment plant. Since treated water is distributed through pipelines, the quality of materials and equipment, such as distribution pipes, is a critical issue for maintaining water quality.

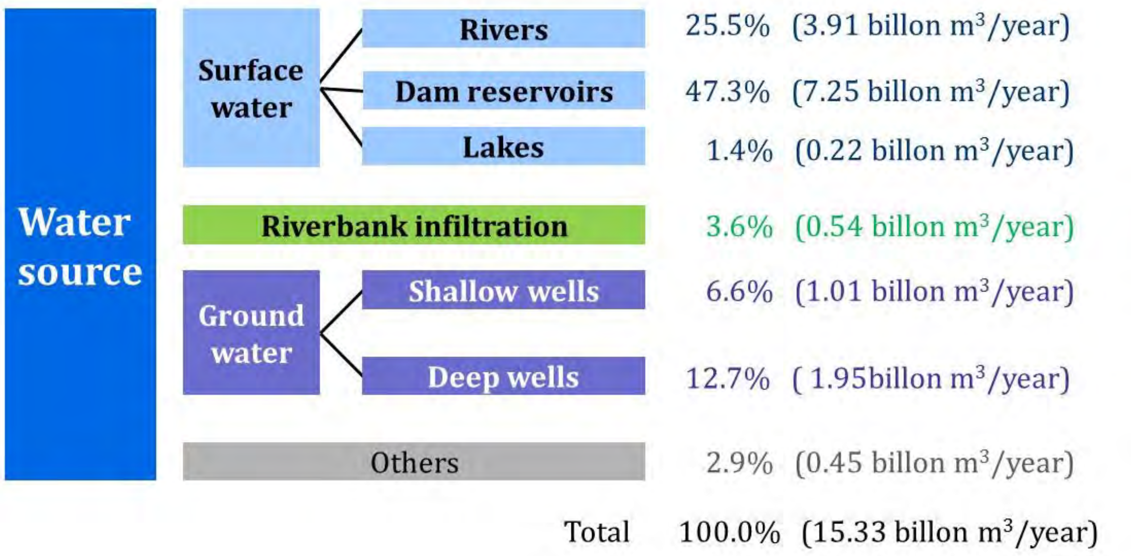
The Japanese Industrial Standards (JIS) and the Japan Water Works Association (JWWA) standards play a key role in ensuring the quality of materials and equipment for water supply. JWWA inspects and certifies the quality of materials and equipment at manufacturing facilities on behalf of the utilities. This approach is very efficient and cost effective for assuring quality of materials and equipment.

In addition, it is important to procure spare parts and repair-materials timely. Utilities used to procure and store them. Inventory control by utilities enabled to keep facilities in good condition. Nowadays, utilities no longer stock spare parts and repair-materials directly from the market, which is well matured and supported by well-developed transportation network.

5. Sustainable Water Resources Management

(1) Securing Water Resources

Utilities collaborate among themselves and with other users in water resources development and water quality conservation. Use of groundwater is strictly regulated to prevent land subsidence, and its use is now mostly replaced by surface water.



Source: JWWA, *Water Sources in Japan (2014)*, http://www.jwwa.or.jp/shiryou/water/water02.html

Figure 3. Water Sources in Japan

Abundant, good-quality water sources are very important to the water supply system. Spring water, groundwater, and water far from contaminated sources upstream of rivers are usually available to rural water supply systems.

In urban areas, the use of groundwater is restricted because excessive abstraction in the past had caused land subsidence that is not reversible. The use of surface water is promoted. Today, 70% of water sources in Japan is surface water and 30% is groundwater (see Figure 3). Many water utilities in urban areas receive water from downstream areas where a larger amount of water is available to meet increasing water demand. However, the water can be contaminated by discharge from households and industries. The national government regulates wastewater discharge and utilities started to install rapid sand filtration systems. Today, many utilities are forced to install expensive advanced treatment methods, such as ozonation and activated carbon treatment.

The development of dams played an important role in securing stable water sources. Dam construction is expensive. In Japan, dams needed to be developed for multiple uses and with the collaboration of different users (e.g. irrigation and flood control, hydropower generation, industrial water) to enhance investment efficiency. The national government established an organization for dam construction to work with prefectures/municipalities, electric power companies and other stakeholders. Engagement of community near the reservoir is critical for securing support for the development and water quality conservation. Approximately half of today's raw water comes from dams. The development of Bulk Water Supply also works well in securing water sources for several utilities to gain the economies of scale. A wider area can be served with reduced investment costs. Bulk Water Supply businesses are publicly-owned in Japan, and can use public funds for the water source development.

6. Ensuring Availability

(1) Operation and Maintenance of Facilities

In Japan, the national government and water utilities work closely together to enhance the operation and maintenance of facilities to prevent drinking water contamination caused by cracked pipes and spreading of waterborne diseases. Preventive maintenance is most efficient for facility management. Its implementation requires scheduled testing, well organized records, and information sharing.

Figure 4. Steps toward Good Practices in Maintenance

Preventive maintenance includes Time Based Maintenance (TBM) that is periodical maintenance, and Condition Based Maintenance (CBM) that is maintenance in response to facilities' condition. Preventive maintenance is implemented by periodically checking the condition of the facilities, keeping good records and sharing information.

To provide a stable continuous water supply, utilities must be able to operate properly all the time. When the focus was mainly on construction of facilities, operation and maintenance tended to be neglected. Outbreaks of waterborne diseases (dysentery and typhoid) brought attention to maintenance issues such as insufficient disinfection, broken equipment, negative pressure in pipelines and accidents due to cracks in aging pipelines. The national and prefectural governments began to strengthen support for utilities by providing guidance and assisting with investigations. Utilities prepared manuals to share knowledge within the organization. They also promoted preventative maintenance. They recorded operating situations and construction activities, gathered and organized data, shared information and prioritised maintenance activities. Senior engineers prepared pipeline inventories so that this information is available and accessible to anyone who needs it.

Using knowledge accumulated by major water utilities, JWWA developed two guidelines, the *Design Criteria for Water Supply Facilities* and the *Water Supply Facilities Maintenance Manual*. These guidelines standardised water supply technology and facilitated sharing of knowledge and training for workers in the sector.

Electric facilities with a certain capacity require an electrical chief engineer (licensed engineer). Water utilities have highly specialized mechanical equipment and electrical instruments, and their maintenance became to be out-sourced these days. Operation and maintenance for water supply facilities often involves private companies.

Many water supply facilities are facing the need to replace aging facilities. Adding to this challenge are social conditions such as declining population, water demand, water tariff revenue and shrinking workforce. Utilities are making efforts in asset management and preparing renewal plans to assure their long-term viability. Maintenance is a key element in these efforts.

(2) Water Supply Operation by Efficient Water Distribution Systems

The water supply network development and block distribution system made it possible to control water pressure, minimize downtime and maintain a stable water supply.

A simple tree (dendritic) system was used in the early water distribution networks. It enables water supply systems to be expanded with the least investment and additional facilities. It is easy to detect failure points in cases of accidental leakage.

When utilities fixed or installed pipelines in the past, they sometimes could not find documentations on layouts or connecting points. In some cases, it was difficult to evaluate the capacity of pipelines for expansion of service areas due to lack of information on existing pipelines. The problems on information management were often pointed out at the time of expansion or accident. Under the situations, a utility had to expand the networks by connecting new pipes to the existing dendritic system so as to form pipeline network. This favored less management because it equalized pipeline pressure and minimized downtime and disruption area using supply from other pipelines. This became a primitive form of block distribution system for more stable supply to customers.

The water supply system has to be robust and efficient enough to sustain its service during disasters and droughts. Utilities introduced block distribution system to: (1) optimize water pressure in distribution pipelines; (2) understand distribution condition and optimize operations, and (3) identify and minimize accidental damage and provide backup water supply from another distribution pipeline routes.

7. Efficient Water-Use

(1) Water Leakage Prevention

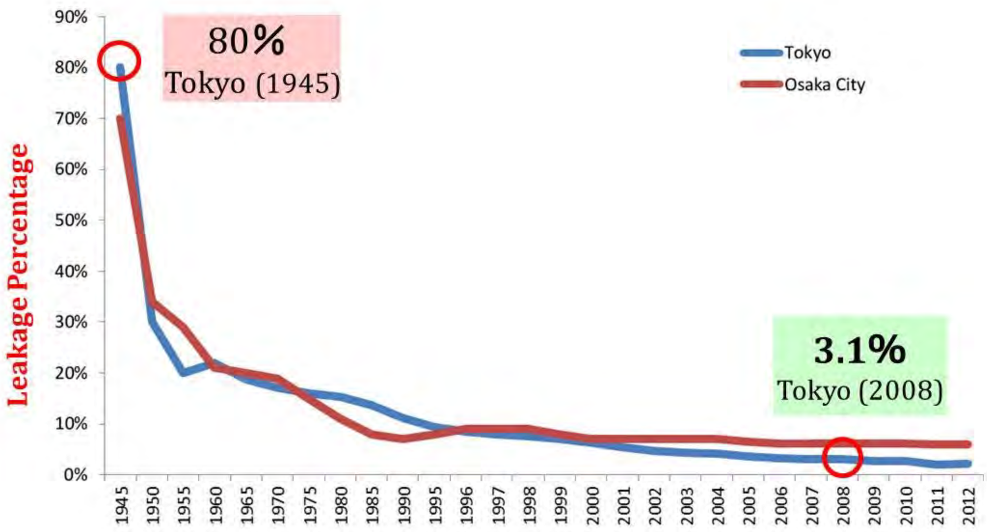
The national average leakage rate is 4.69% (as of FY 2013), much reduced from 70 - 80% in large cities after WW II. This drastic improvement is the result of taking intensive corrective and preventive measures. Utilities have a keen awareness of the importance of leakage control, because of the country's experience with severe droughts and accidents involving the suspension of water supply.

Utilities in large cities in Japan (such as Tokyo and Osaka) had 70-80% leakage rates after WW II. The leakage rate has been brought down to 3% in Tokyo. That is a result of intensive efforts on leakage prevention. Utilities recognized the importance of leakage control through experiences with war destruction, severe droughts and accidental service interruptions. Cities with scarce water resources also took leakage prevention very seriously.

Concretely, utilities continuously improved pipe joints and installation methods, and detected and repaired leakage. They replaced aged pipelines with more durable products and improved pipeline location, earth cover depth, and backfill materials. The block distribution system made it easy to control leakage and reduce disruption caused by construction and repair activities. Manufacturers have also played important roles in reducing leakage through the development of better joints and pipe materials. Preventing leakage reduces contamination in distribution pipelines.

In Japan, the non-revenue water rate is low because (1) metered billing and accuracy of flow meters are well-established, since early stage (2) illegal connection is rare and (3) there is a sustained effort to reduce leakage. The reduction of leakage can ease the pressure on water resources development and improve the financial situation of the utilities. Customers pay for the cost for treated water that reaches their homes and not water that is wasted through leakage.

While the national average leakage rate is 4.69% as of FY2013, it can be more than 20% for some utilities. Those utilities' water supply unit cost is low because they have abundant water sources and favorable land features such as elevation of source and distribution area. High leakage rates are also found in utilities with aging pipelines and undurable pipe materials.



Source: Materials from Osaka Municipal Waterworks Bureau and Bureau of Waterworks, Tokyo Metropolitan Government

Figure 5. Reduction of Water Leakage Rate in Tokyo and Osaka City

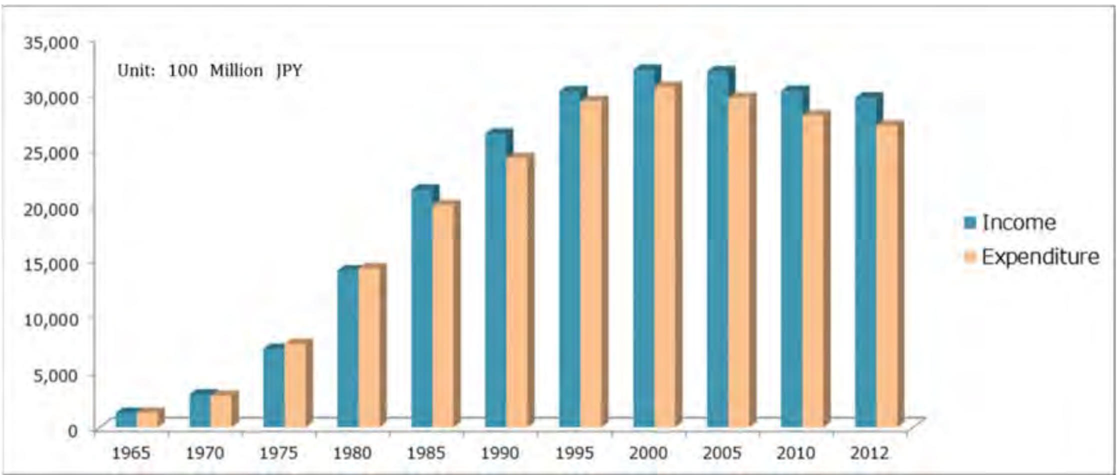
The main causes of non-revenue water are leaks (real loss), measurement error and unauthorized consumption/illegal connections (apparent loss). Utilities in Japan could reduce non-revenue water by preventing leakage. Quality of construction and pipe materials is vital to prevent leakage in distribution pipes and service connections.

To optimize meter accuracy, the equipment should be replaced every eight years as required under the Measurement Act. Utilities are responsible for the management of water meters as stipulated in the Water Supply Act, and this contributes to minimize the apparent loss caused by measurement error.

8. Sustainable Management

(1) Self-Supporting Accounting System and Cost Recovery

Utilities in Japan operate under the self-supporting accounting system. Subsidies were provided based on the policy goals to enhance water supply coverage and the development of water sources, etc. Furthermore, it helped to develop water supply systems especially in rural areas.



Source: Created from JWWA, "*Outline of Water Supply*," 1st ed. 1987 and 6th ed.2015.

Figure 6. Changes in Total Revenue and Expenditures of Waterworks in Japan

Revenue from water tariffs should cover all the expense if the utility is to operate sustainably. The Local Finance Act and the Local Public Enterprise Act stipulate that utilities should be managed under a self-supporting accounting system, using the fully distributed cost method.

Tariffs are determined based on the fiscal balance of the utility and carefully considered by the local assembly. Those Acts require: (1) fully distributed cost method and self-supporting account system, (2) fair cost sharing and clarity in the pricing of water tariffs, and (3) the demonstration of efficient management. The *Water Tariff Setting Manual* plays a key role in providing guidance in the tariff setting process.

When the water supply service was under expansion, many utilities had to raise tariffs frequently to secure the much needed financing. Utilities prepared financial plans, looked for cost saving measures and thoroughly examined their future financial situation before raising tariffs.

Water utilities continue efforts to streamline their operations (cost reduction via proper staffing and the promotion of outsourcing, collection of arrears, effective use of assets and efforts to lower the non-revenue water rate) while disclosing information and focusing on public relations and customer services to be understood by customers.

Tariff collection ratio is close to 100%. The success is attributed to changing collection intervals and payment methods that are more convenient for the customer. Collection notices are sent to delinquent accounts with clear warning of punitive measures for late payment, following to standard procedures. Training and incentive programs for meter readers and bill collectors are effective in improving performance.

Subsidies made for water sources development and water facility expansion were instrumental in expanding and improving the water supply coverage. Subsidies were especially necessary for less-populated regions, as they were not able to generate enough tariff income to finance facilities construction. Small-scale utilities continue to experience tight financial conditions after construction, due to the small revenue base. They are aiming to gain economies of scale by integrating their operations through various means, including consolidation and joint operation/management.

(2) Customer Relations

Customers pay water tariffs for water supply services. Tariffs are the revenue source and the basis of the water supply business. Utilities put high priority on customer relations and improve their operations and management by enhancing their customer services.

The Water Supply Act stipulates the obligations of utilities to their customers and the rights of customers. Utilities pay a lot of attention to customer relations based on the stipulation. The relationship between the customer and the utility is clearly defined in the water service contract. The customer pays the water tariffs in exchange for water supply services. Good customer service leads to the enhancement of the operation of the utility. The high service level and technological strength and superb organization of Japanese utilities all originate from their customer-oriented attitude and sense of responsibility to supply safe drinking water.

(3) Master Plan, Business Plan and PDCA (Plan-Do-Check-Act) Cycle

A master plan and/or business plan is needed when building or expanding facilities and when water tariffs are being revised. These plans set the foundation for the sustainable operation of the business. The PDCA cycle is a very effective tool for the development of business plans.

A master plan is required in applying for Approval (License) to operate a utility, and a business plan is required to applying for subsidy, and raising water tariffs. It explains the water supply operations and commits the utility to set clear goals to meet business objectives.

With the focus on operation and maintenance, utilities are encouraged to prepare the long-term business plan (Local Water Supply Vision), which include the following: (1) analysis and evaluation of the current business situation, (2) future direction, (3) objectives, (4) means to achieve the outcomes, and (5) evaluation procedures and periodic reviews.

Those plans are guideposts for sound day to day management, while visualizing the path toward future directions. The preparation of the plan is a process that engages all employees and an opportunity for team building and improving performance. In the past, master plans were prepared to deal with increasing population and the long time line to develop water resources. Later, population growth has stopped and there are some cases of overcapacity at some utilities. Therefore, planning with a sufficiently long-term outlook to foresee and address new challenges is paramount. Asset management and the PDCA cycle have led to the enhancement of operating systems and the realization of sustainable business operations.

(4) Public-Private Partnership

Outsourcing is gradually increasing. Private sector participation has improved operational efficiency. Now public-private partnerships are promoted, and regulatory frameworks have been developed to clearly define the allocation of risks among the partners.

Utilities used to rely on their own expertise for carrying out all their activities including design and building facilities. These and other tasks such as meter reading are gradually outsourced. With the aging society and declining population, the concern about the long term sustainability of public enterprises is growing. The involvement of private companies in the water supply sector now includes public-private partnerships in facility development and operation and maintenance. In promoting public-private partnerships, regulatory frameworks are being strengthened to protect public good, including ensuring water quality, safety and affordability, and the clear understanding on allocation of risks between the partners.

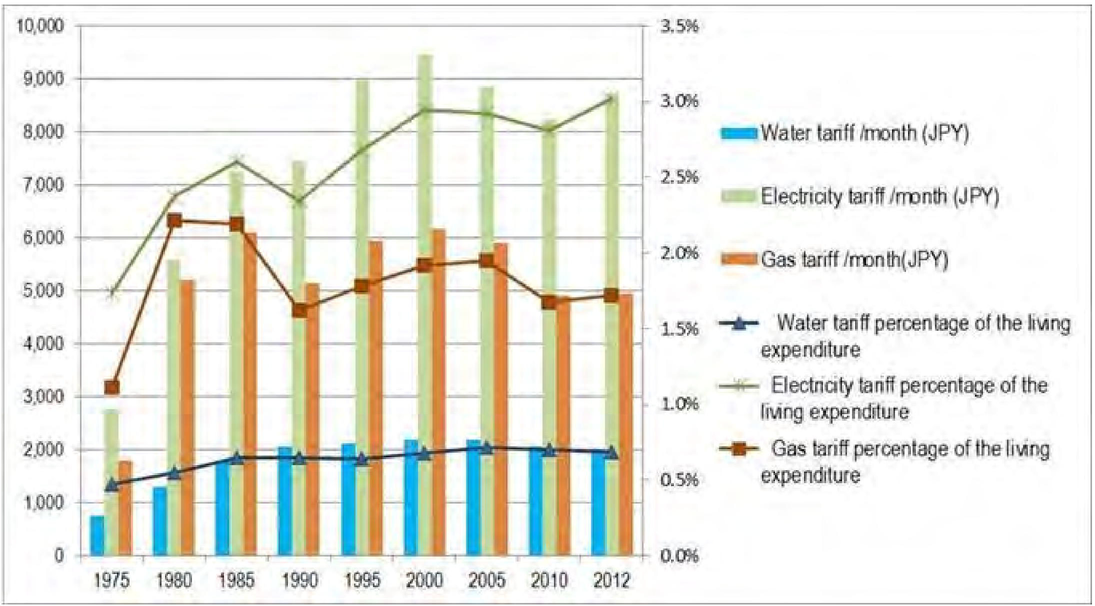
9. Affordable Drinking Water

(1) Consideration for the Low-Income Group

The water tariff structure always considers affordability. Tariff reduction and exemption are utilized for the low-income groups, which are clearly defined.

Water tariffs in Japan consist of minimum and volumetric rates. Many utilities set a minimum volume in the minimum rate that is affordable for most households. The minimum rate does not cover the cost to supply the minimum volume of non-charged water that comes with it. This low rate is off-set by higher rates charged to large-volume users as a cross subsidy to avail inexpensive rating of minimum required volume of water for living. Some utilities clearly define the low-income groups and provide tariff reduction and exemption for them on social welfare programs of the local government. Based on the definition they are applied to the customers who are in case of illness or unemployment.

In the past, some utilities used installment plans and encouraged citizens to set aside money in a systematic manner to pay for connection charges.



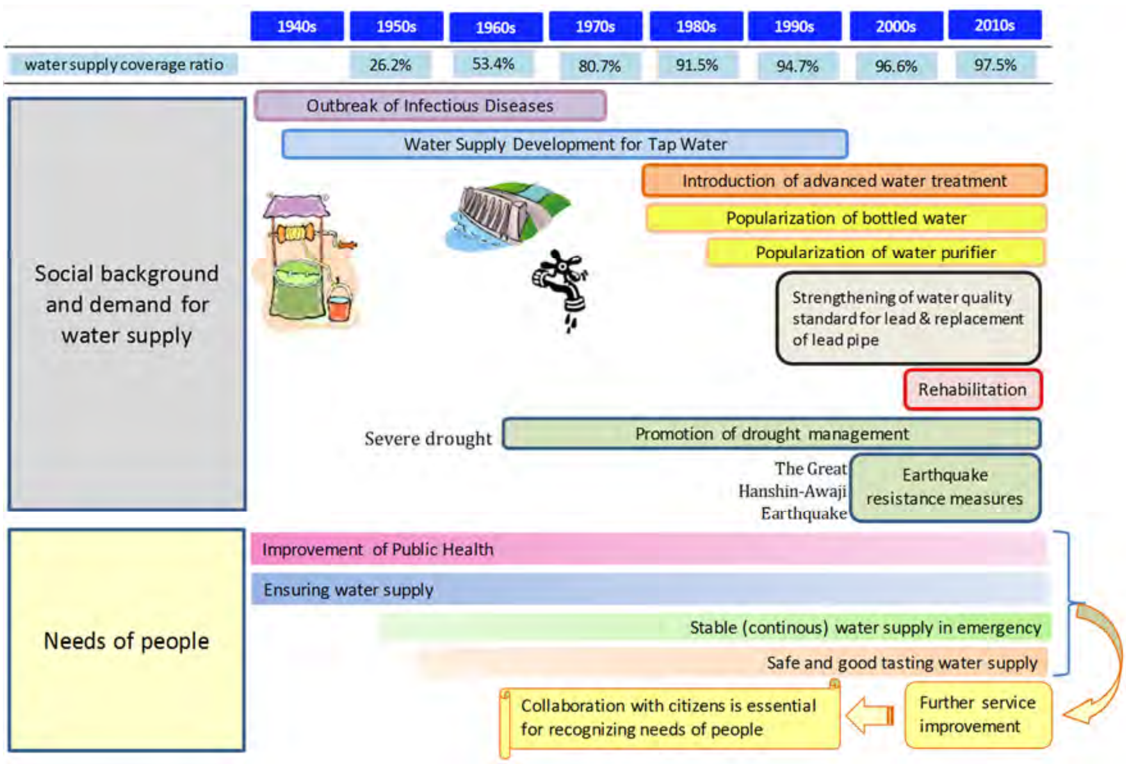
Source: Created from JWWA, "*Outline of Water Supply*," 6th ed. 2015.

Figure 7. Water Tariff Affordability Compared with Electricity and Gas

10. Engaging Local Communities

(1) Participation of Residents

Residents in rural areas contributed funds and labor to speed up the development of water supply systems to improve their living conditions. Increasingly in recent years, utilities seek input from residents in preparing business plans, tariff revisions, and on day to day issues related to water supply services. This kind of engagement ensures that the needs of the customers are met. It also requires that utilities demonstrate accountability and transparency and conduct public relations (PR) activities. Support from the residents can be directly linked to the improvement of sustainable management of the utilities.



Source: Ministry of Health, Labour and Welfare

Figure 8. Changes in the Roles of Waterworks and Needs of Customers

To improve poor sanitation and nutritional conditions in rural areas after World War II, the Ministry of Agriculture and Forestry expanded the Livelihood Improvement Movement nationwide while the Ministry of Health and Welfare[1] established a subsidy system to promote

[1] The Ministry of Health and Welfare was merged with the Ministry of Labour to form the Ministry of Health, Labour and Welfare in 2001.

water supply development. Residents in rural communities worked voluntarily on facilities construction. They sold timber from their common forests and farm produce to add to the subsidies to accelerate water supply development. These contributions from local communities made the nationwide coverage possible.

The operation of waterworks in Japan relies on revenues from water tariffs that are set based on the water service contract between water utilities and customers. Utilities promote citizens' understanding of the water supply business by practicing fair billing based on the management of meter accuracy and persistently conducting public relations activities to build trusting relationships. Public relations activities have been always on-going. They help customers understand how tariffs are set (transparency in tariff calculations) and why increases are necessary for good water service. The engagement of the residents is very helpful in gaining their broad and strong acceptance in and contribution to water conservation and use of water-saving devices.

Public consultations, customer satisfaction surveys, and supporter groups are some examples of outreach efforts. Utilities organize many activities in the national campaign during “Water Week.” School children and citizens participate in facility tours. Through these efforts, it is widely recognized that water tariffs are necessary for good water services. In addition to supplying safe water without water outage, transparency of tariff calculation and promotion of positive public relations are also recognized as important services. Public relations are recognized as an important service component. Dialogue with residents can build good relationships. These activities lead to the improved water supply services and the sustainable operation. Some large-scale utilities have customer service centers to serve customers at any time. The combination of these activities has led to the improved water supply services and the sustainable operation of waterworks.

11. Lessons Learned

Japan has achieved nationwide water coverage and high quality of potable water. The following Japanese experience could be useful for other countries.

(Laws and regulations for nationwide coverage of water supply service) >>> [Details are explained in Theme 1. Sector Governance and Regulation for Nationwide Full Coverage of Water Supply Service]

- The national government established the legal frameworks to support utilities in securing funds and in standardizing technical requirements in developing water supply system. Utilities could issue public enterprise bonds for long-term financing. Small utilities in rural areas could not recover the cost with their operation and utilized national subsidies for facility construction.

(Sustainable Water Resources Management) >>> [Details are explained in Theme 2. Water Supply System: from Water Resources to Distribution]

- Sustainable water resources management is crucial for stable water supply. In Japan, new water sources were developed to meet increasing demand and allocations have been adjusted to accommodate the competing needs of various users. The national government established an organization responsible for multi-purpose dam constructions and coordination of dam users. By sharing both the costs and benefits of dam construction, the financial burden for each water utility was reduced. In cities located downstream, where water quality is poor, raw water has to be treated with rapid sand filters, and with advanced treatment systems in the worst cases. Measures and new laws to improve and protect raw water quality, have helped to restore water quality.

(Safe water supply) >>> [Details are explained in Theme 3. Water Quality Management]

- To operate a stable supply of good quality water for 24 hours a day, the national government established water quality standards and evaluates each utility’s master plan through the Approval (License) process as stipulated in the Water Supply Act. Water utilities are responsible for implementing water quality analysis, and made efforts to secure quality pipe materials and equipment. The JIS and other standards, and JWWA inspection played key roles to guarantee the quality of pipe materials and equipment.

(Sustainable operation) >>> [Details are explained in Theme 4. Operation and Maintenance of Facilities]

- Preventive maintenance is very important for a stable water supply. Accidents can be prevented by analyzing data and information of daily inspections, operation, and repairs. Sharing know-how among workers was also promoted to set the priority for maintenance. Knowledge, experience and technical know-how were passed on from the senior to junior staff, by manuals and OJT. Regulations and guidance by the national government also played an important role for the prevention of accidents and problems.

(Leakage reduction for efficient water use) >>> [Details are explained in Theme 5. Reducing Non-Revenue Water]

- The average leakage rate in Japan’s water supply is 4.7%. The dramatic drop from 70-80% after the war was the result of corrective and preventive measures implemented after experiencing severe droughts and water scarcity. These include detection and repair of leaking pipes, replacement of aging pipes and installation of new pipes with better materials and improvement of construction methods such as standardizing pipe placement, earth cover depth and backfill materials. Pipe networks organized in distribution blocks facilitates the leakage reduction activities. Manufacturers also improved the quality and reliability of joints and materials. Leakage reduction saves limited water resources, contributes to reduce investment cost on water source development, makes water usage more efficient, and prevents groundwater intrusion which causes water quality deterioration.

(Finance and tariff for sustainable management) >>> [Details are explained in Theme 6. Financial Management: Finance and Tariffs]

- The Local Public Enterprise Act in Japan requires utilities to use the self-supporting accounting system. National subsidies were provided for water supply expansion, water resources development, installation of advanced treatment facilities and Small Scale Public Water Supply in rural areas. The national government supported a bond financing scheme for utilities to secure funding for the construction and expansion of water supply systems. During the period of rapid economic growth, water utilities often fell short of the necessary funds for expansion of water supply systems, which occasionally forced them to raise the water tariff. Utilities are required to prepare a financial plan, clearly describe future conditions demonstrate efforts for cost reduction, to convince the local assembly on the need for tariff increases.

- The water tariff system in Japan consists of a minimum rate and a volumetric rate. The minimum rate including minimum water is set relatively low making it affordable for low-income households. The progressive rates allocate more financial liabilities to high-volume users. Low-income group can apply for tariff reductions or exemptions which are established by a local government as a part of the welfare policy, if they are in difficult financial or social situations such as illness and/or unemployment.

(Human resource development for sustainable management) >>> [Details are explained in Theme 7. Institutional Management: Governance, Human Resources Development, Consolidation of water utilities, Public-Private Partnerships]

- The National Institute of Public Health developed the human resources required to establish the nationwide water supply system. Utility workers were trained through OJT and attended training programs conducted internally. JWWA organizes seminars and committees for knowledge sharing and professional development.

(Communication with customers for safe, equitable and affordable water service) >>> [Details are explained in Theme 7. Institutional Management: Governance, Human Resources Development, Consolidation of water utilities, Public-Private Partnerships]

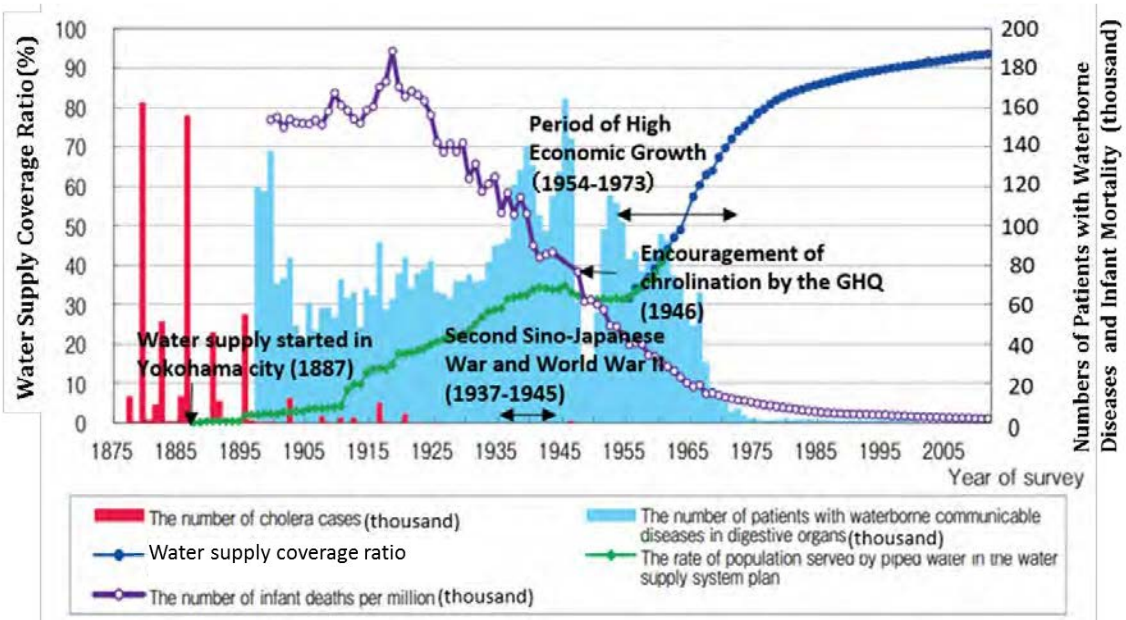
- Utilities make continuous effort to provide residents with a better understanding of the water supply business and importance of water supply. They conduct PR activities and facility tours for school children and interested citizens. Public relations activities and mechanisms for public participation are important to building mutually supportive relationship between the utility and its customers Staff of each utility understand that customers' willingness to pay is directly related to their level of satisfaction with the quality of service (i.e. safe, reliable, stable water supply). Customers also appreciate transparency on tariff calculations, easy to understand tariff structures and the utilities' outreach efforts. Some large-scale utilities have customer service centers. Maintaining trusting relationships with customers is a very important component of the water supply service.

Theme 1. Sector Governance and Regulation for Nationwide Full Coverage of Water Supply Service

Contents

1. Introduction

Japan has achieved 98% of water supply coverage and almost all residents in Japan can enjoy a high level of public health with safe drinking water. This success is a result of many years of effort not only in the building of the physical infrastructures but also in establishing the legislative and administrative frameworks needed to support the developments. This module explains the historical path towards universal coverage and the legislative and regulatory environment for the water supply business as well as the administrative aspects of the system.



Source: Water Resources Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism, "*Water in Japan*," http://www.mlit.go.jp/common/001044443.pdf

Figure 1. Water Supply Coverage, Number of Patients with Waterborne Diseases and Infant Mortality

This module will answer to the following questions frequently asked by the participants of water supply training courses from developing countries based on Japan's experience in waterworks.

Q1. How did the Japanese water utilities take measure against waterborne diseases such as cholera? How did water utilities in Japan become successful in providing safe drinking water on tap for 24 hours a day?

Q2. How did Japan achieve universal coverage of water supply service including rural areas?

Based on what kind of legislative and regulation frameworks it has been achieved?

Q3. What is the historical path to Japan’s development of laws, regulations and standards for water supply? What kinds of factors helped water utilities to comply with them?

Q4. Why can small- and medium-scale water supply utilities, which are insufficient with funding and personnel, comply with the laws, regulations and standards and appropriately maintain their facilities?

The following sections attempt to provide answers to these questions:

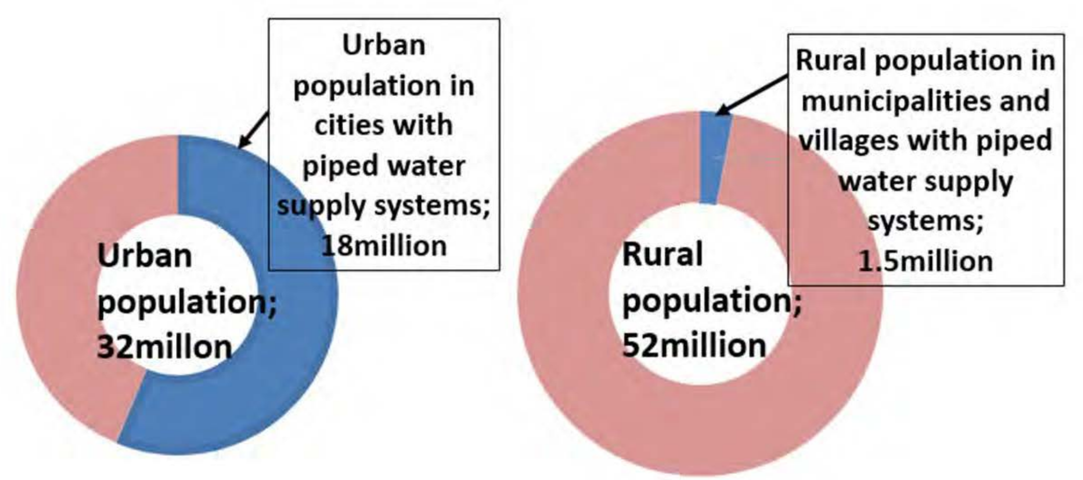
2. The Purpose of Water Supply: Public Health (Q1)
3. Historical Path towards Nationwide Coverage (Q2)
4. Regulatory framework and Administration (1), (2) and (3) (Q3)
4. Regulatory framework and Administration (4) and 5. Challenges in Maintaining Universal Coverage (Q4)

2. Purpose of Water Supply: Public Health

(1) Public Health Objective

> The Water Supply Act clearly states that water supply development must be promoted to enhance public health in Japan.

Since Japan began active trading with foreign countries in late 19th century, epidemics of waterborne diseases including cholera, spread from its ports. In 1879, of the 160,000 patients who had cholera, more than 100,000 died[1]. People in those days obtained domestic water from wells, open ditches or street vendors, and did not have access to clean water. The installation of modern water supply systems was implemented to prevent waterborne diseases. When the country started to construct safe and stable water supply systems, the foremost objective was to protect human health.



Source: Susumu Hani, the film "*Water in Our Life*," 1952

Figure 2. Water Supply Coverage

Public health is "the science and art of promoting health, preventing disease, and prolonging life through the organized efforts of society."[2] In Japan, although there are no regulations clarifying the definition of public health, public health in society is enshrined through the regulations under the Community Health Act, aiming to maintain and promote local residents'

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[1] Ministry of Health, Labour and Welfare, "*Annual Health, Labour and Welfare Report 2014*," p.4, http://www.mhlw.go.jp/wp/hakusyo/kousei/14/dl/1-01.pdf

[2] WHO, "Health Promotion Glossary" p.3. http://www.who.int/healthpromotion/about/HPR%20Glossary%201998.pdf

health. Public health efforts can be in promotion of basic social security such as healthy lifestyle, infectious disease control, protection from health hazards posed by such things as contaminated water, provision of water supply and sewerage services and food sanitation. Provision of water supply and sewerage services is the most important element in the health protection responsibility to prevent infectious diseases.

Article 1 of the Water Supply Act stipulates that the purpose of the act is to "contribute to improving public health and the living environment." Article 2 states that waterworks are indispensable for protecting the health of the people.

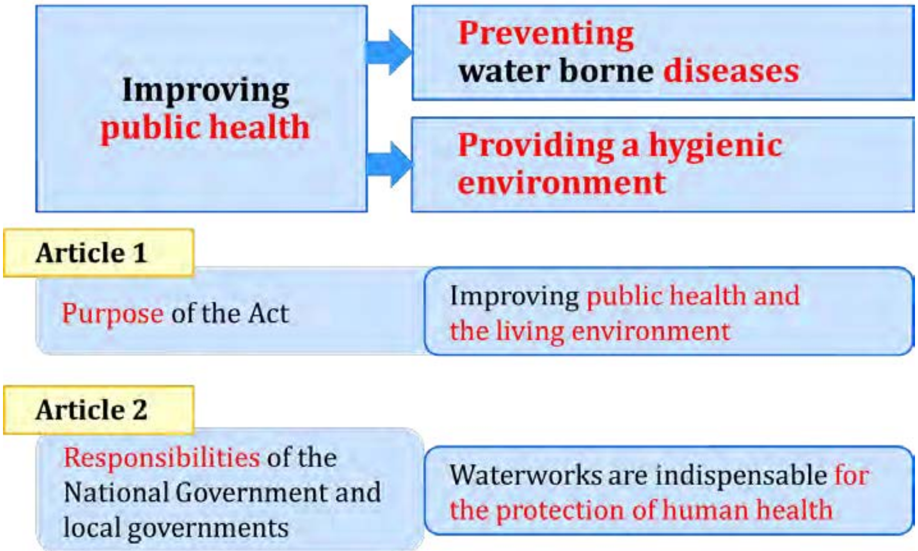

Figure 3. Relation between Public Health and Article 1 and 2 of the Water Supply Act

Water Supply Act – Articles 1 and 2

(Purpose of the Act)

Article 1: This Act is designed to make the construction and operation of water supply services appropriate and reasonable, to improve water supply networks systematically, to strive for the supply of wholesome, plenty and affordable water by protecting and developing water supply service, and thereby to contribute to the enhancement of public health and improvement of living environment for residents of community.

(Responsibilities)

Article 2:

1. In view of the facts that water supply services are directly connected with the daily life of the people of this nation, that they are indispensable to protect the health of the people, and that water is valuable resources, the state and local public entities must take necessary measures for the maintenance of the cleanness of water sources, facilities for water supply, and their surroundings, as well as the appropriate and reasonable use of water.

2. The people of this nation must cooperate with the measures of the state and local public entities, provided for in the preceding paragraph, and personally strive for the maintenance of the cleanness of water sources, facilities of water supply services, and their surroundings, as well as for appropriate and reasonable use of water.

(2) Water Quality and Facility Standards to Secure Public Health

Articles 4 and 5 of the Water Supply Act stipulate the water quality and facility standards required for water utilities to ensure public health.

To ensure drinking water quality, the Water Supply Act stipulates the water quality and facility standards in Articles 4 and 5.

Article 4 stipulates that the water supply must: (1) be absent of contaminants such as pathogens; (2) not contain toxic substances; (3) not contain excessive metal substances like copper and iron; (4) not show abnormal pH level; (5) not include abnormal odors; and (6) be nearly colorless and transparent. As of 2016, 51 parameters for water quality have been stipulated in the Ordinances for Water Quality Standards issued by the Ministry of Health, Labour and Welfare (MHLW).

Water Supply Act - Article 4 Water Quality Standards

1. Water to be supplied through water supply services must meet requirements shown in the following items:
   1) Not containing organisms or substances that indicate or are suspected to indicate contamination by pathogenic organisms.
   2) Not containing cyanogens, mercury, or other poisonous substances.

> 3) Not containing copper, iron, fluorine, phenol, etc. beyond their permissible volumes.
> 4) Not showing any abnormal acidity or alkaline nature
> 5) Not including any abnormal odor, excluding such an order due to disinfection.
> 6) External appearance shall be almost colorless and transparent.
>
> 2. Matters required for the standards shown in the items of the preceding paragraph shall be determined through orders of the Ministry of Health, Labour and Welfare.

Article 5 stipulates the requirements for intake facilities, water storage facilities, raw water transmission facilities, water purification facilities, water conveyance facilities, and water distribution facilities (Paragraph 1). In determining the location and arrangements of water supply facilities, it is necessary to keep their construction, operation, and maintenance as economical and simple as possible, and to give consideration to reliability of water supply (Paragraph 2). These facilities must be able to withstand water pressure, earth load, seismic activities, and there should be no risk of water contamination or leakage (Paragraph 3); and in addition to the standards provided for in Paragraphs 1-3, technical standards required for water supply facilities shall be stipulated by ordinance of the MHLW (Paragraph 4). The "Ordinance for Technical Standards of Water Supply Facilities" is issued by the MHLW.

> **Water Supply Act -** Article 5 Facility Standards
>
> 1. Water supply services shall have all or part of intake facilities, water storage facilities, raw water transmission facilities, water purification facilities, water conveyance facilities, and water distribution facilities in accordance with the quality and quantity of raw water, geographical conditions, type of the said water supply services, and the like. These water supply facilities shall meet the requirements shown in items below:
> 1) Water intake facilities shall be able to take in the necessary volume of raw water whose quality is as excellent as possible.
> 2) Water storage facilities shall have the water storage ability capable of supplying raw water required even at the time of draught.
> 3) Raw water transmission facilities shall have pumps, raw water transmission pipes, and other equipment required to provide the necessary volume of raw water.
> 4) Water purification facilities shall have a sedimentation tank, a filter basin, other facilities required to obtain a necessary volume of purified water, meeting the water

quality standards, based on the provisions of the previous water, meeting the water quality standards, based on the provisions of the previous Article, and disinfection facilities, in accordance with the quality and volume of raw water.

5) Water conveyance facilities shall have pumps, water conveyance pipes, and other facilities required to convey the necessary volume of purified water.

6) Water distribution facilities shall have service reservoirs, pumps, distribution pipes, and other equipment required to continually distribute the necessary volume of purified water at a pressure above a fixed level.

2. In determining the location and arrangements of water supply facilities, it is necessary to make their laying, operation and maintenance as economically and easily as possible, and to give consideration to assurance of water supply.

3. With regard to the structure and material of water supply facilities, these facilities shall have sufficient durability against water pressure, earth load, earthquake force, and other loads, and there should be no fear of water contamination or leakage.

4. In addition to the standards provided for in the (3) preceding paragraphs, technological standards required for water supply facilities shall be stipulated under orders of the Ministry of Health, Labor and Welfare.

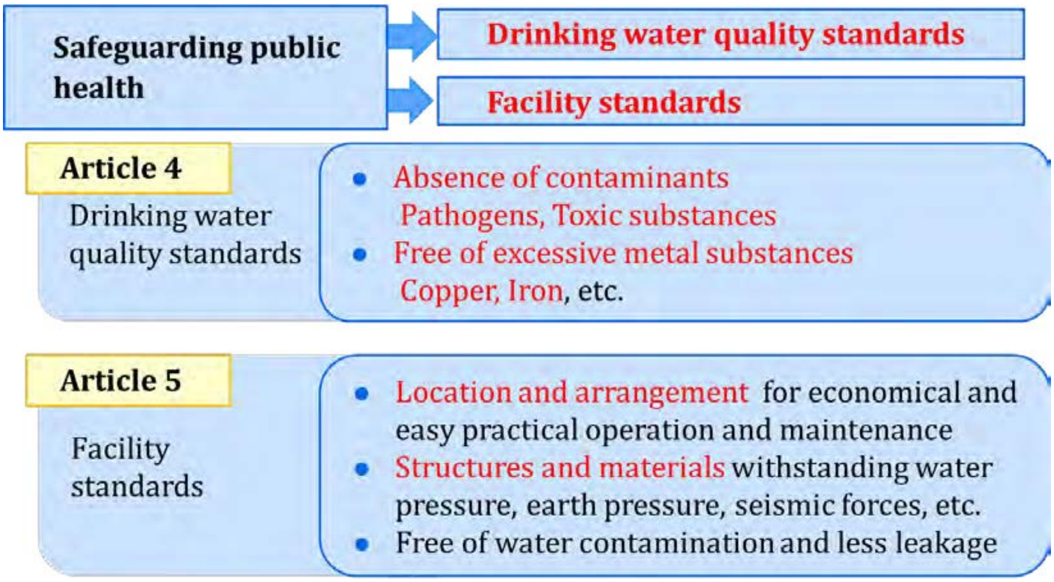

Figure 4. Public Health Protection in the Water Supply Act

(3) Modern Water Utilities and Their Contribution to Public Health

In Japan, 24-hour chlorinated water supply under sustained pressure contributed to the reduction of waterborne diseases and infant mortality, and the improvement of public health.

Public Health in Japan improved with the installation of the modern water supply systems. As the contact with overseas countries increased through trading in the late 19th century, the spread of cholera caused many deaths. The awareness of the necessity to enhance public health increased and the development of water supply systems began.

Initially, there were arguments on whether to invest limited budgets on other infrastructures rather than in improving water supply systems. As a leading trading port, Yokohama City was the first to modernize its waterworks in order to present a good image to visitors from overseas. Other cities followed suit. However, this was not enough to fully achieve public health. Diseases caused by untreated water such as diarrhea had still been serious problems until the wide coverage of water supply systems and thorough chlorination were achieved.

As shown in Figure 1, cholera outbreaks significantly diminished with the increase in water supply coverage. However incidences of waterborne diseases and infant deaths remained high until after Tokyo City Waterworks (later became Bureau of Waterworks, Tokyo Metropolitan Government) started chlorination in 1921. Even though no adequate statistics are available, it is believed that waterborne diseases were prevalent during the WWII period. After the war, the GHQ[3] enforced disinfection practice. Increased water supply coverage along with chlorination significantly diminished incidences of waterborne diseases, clearly proving that clean water supply contributed to public health.

What is potable water? In Japan, modern water supply systems are designed to distribute potable water under pressure to the consumers. Treated water can be contaminated in the distribution pipelines. Interruption in the distribution system poses a risk to public health. Around the clock water supply can greatly minimize this risk.

MHLW, not the Ministry of Construction[4], is responsible for waterworks under the Water Supply Act, showing that public health is the over-riding concern and that public health and waterworks are intricately linked. This principle is the basis for the service standards of present

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[3] General Headquarters, 1945 – 1952, an organization established by the Allies led by the US government to implement and manage the occupation policies

[4] The Ministry of Construction was merged with the Ministry of Transport and two Agencies to form the Ministry of Land, Infrastructure, Transport in 2001.

day waterworks in Japan.

Column: Contamination of Drinking Water

Water supply must not have stoppages or interruptions in the modern water supply systems.

Fukuoka City could only distribute water for 9 hours in a day during the severe drought in 1978. More than 1600 complaints from residents about contamination and no water supply were received every day. After this experience, Fukuoka city was determined to develop enough water resources to overcome these adversities.

In Japan, modern water supply systems are expected to distribute treated water under sustained pressure. The key is to sustain the pressure. A slight crack on the distribution pipeline may lead to leakage but not infiltration of contaminants if appropriate pressure can be maintained. Water stoppage for any period of time would create negative pressure in the pipe, allowing underground water with contaminants to seep in, posing a risk to the safety of the drinking water and to public health.

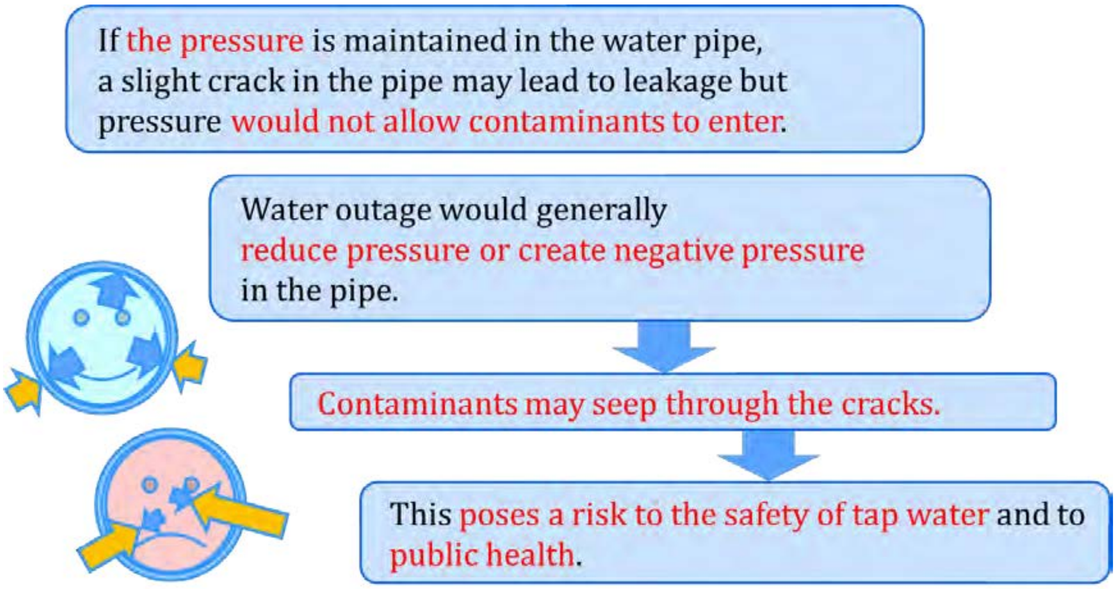


Figure 5. Importance of Uninterrupted Water Supply

3. Historical Path towards Nationwide Coverage

(1) Public Ownership

> The Waterworks Ordinance was the first national regulation on waterworks in Japan. Promulgated in 1890, it stipulates that utilities must be managed by municipal governments. Municipalities are therefore responsible for the construction and operation of utilities and for providing water supply across the country. The Japanese Constitution guarantees the right to life for all persons in Article 25. This concept of right to life is relevant to the nation's responsibility for public health and is the primary "raison d'etre" for the drive toward nationwide water supply coverage.

Privately-managed waterworks in Japan in the early days did not provide good service and were partly responsible for the spread of infectious diseases. They would even cease operation due to lack of funding. The Waterworks Ordinance promulgated in 1890 placed water supply under the municipal governments making them responsible for funding the construction of waterworks.

Article 25 of the Constitution (1946) stipulates that every person shall have the right to maintain the minimum standards of wholesome and cultured living (right to life) (Paragraph 1); and that the State shall promote and improve public health, (Paragraph 2) as a responsibility towards its citizens. The government is mandated to promote nationwide water supply coverage. The Waterworks Ordinance was not adequate for the launch of new waterworks. The Water Supply Act was established in 1957, making the creation of new water supply projects possible.

The right to life, guaranteed under the Constitution, applies to everyone and thus calls for access to water by all citizens (i.e. universal water supply). Therefore, the government must extend water supply systems and sanitation services to rural areas, leading to the construction of many small-scale public water supply systems.

These principles correspond to Goal 6 of the Sustainable Development Goals (SDGs): "ensure availability and sustainable management of water and sanitation for all," which was adopted in 2015.

Source: Susumu Hani, the film "*Water in Our Life*," 1952

Photo 1. Carrying Water Before the Development of Water Supply

Constitution of Japan - Article 25

1. All people shall have the right to maintain the minimum standards of wholesome and cultured living.

2. In all spheres of life, the State shall use its endeavor for the promotion and extension of social welfare and security and public health.

(2) Water Supply Development in Urban Areas

Water utilities in urban centers were developed using tariff revenue as the main source of funding, with the rest from bond issues and equity capital, and a certain amount of government subsidy. The dense population in urban areas guarantees sizable revenue from tariff income. Large operations provide greater efficiency and opportunity to improve the facilities. During the period of high economic growth (1954 – 1973), water utility expansions were financed through bond issues, and made possible by securing engineering expertise and serious efforts in water resources development.

Water supply facilities in high density urban areas and sparsely populated rural areas are very different in size and their ability to recover costs. The development of urban and rural utilities followed different routes. Urban utilities were developed since around 1900. Construction of efficient facilities were financed by bond issues, equity capital and government subsidies. Independent accounting was adopted as required by the Local Public Enterprise Act in 1952. When government subsidies were discontinued in 1954, the procuring of funds for new facilities turned to more bond issues.

After WW II, the availability of technical expertise from GHQ, repatriation of engineers, and elimination of debt by inflation, benefited the rapid expansion of water supply facilities.

During the period of high economic growth and rapid increase in urban population, it became extremely urgent to continue improving water resources and expanding distribution networks. Water utilities used bond issues to procure the funds by relying on their sound financial condition. The bonds were underwritten by public funds and procured by the national government. Furthermore, the government re-established the subsidies for improvement of water supply facilities and water resources and for dam construction in 1967. Water supply systems in urban areas were dramatically expanded as a result of active water resources development and human resources development.

Table 1. Development of Water Supply in Urban Areas

Period	Characteristics of waterworks
Early stage of construction (1887 – 1945)	● Mainly funded by bond floatation and own funds, financed by tariffs ● Small portion of subsidy by the state government
After World War II (1945 – 1954)	● Technical support from GHQ (widespread introduction of chlorination) ● Subsidy for reconstruction following the war until 1954
Early period of high economic growth (1954 – 1967)	● Rapid population growth and water demand ● Massive water resources development and expansion of water supply service areas by bond floatation ● No subsidy from the state government
Late period of high economic growth to the present (1967 –)	● Targeted subsidy for water resources development, advanced water treatment, replacement of aging pipes, disaster risk reduction, etc. ● Debt repayment ● Asset management for rehabilitation

(3) Development of Small Waterworks in Rural Areas

The development of water supply in rural areas started relatively slowly as it was managed by local communities. The momentum came with the Water Supply Act in 1957. The national government promoted human resources development and provided subsidies. These together with active campaigning by provincial politicians and financing by local residents, small utilities in rural areas began to fill the gaps in the nationwide coverage.

Water supply in rural areas started as simple water sources for communal use, built by residents in local communities. Facilities supplying 100 or less people are not covered under the Water Supply Act. Those supplying 100 or more people were transferred to municipalities for management as the Small Scale Public Water Supply.

Very few people in rural areas had access to piped water until 1973. Under the movement to improve quality of life, residents gathered money by selling what they had such as wood and eggs and began to construct and manage waterworks by themselves. This situation is similar to residents participation projects in some developing countries. Water supply in rural areas was more fully developed only after the national government aggressively injected funds for Small Scale Public Water Supply.

The Water Supply Act defines “waterworks” as facilities supplying domestic water for more than 100 people. The Act defines Small Scale Public Water Supply as a system that supplies water to a population of less than 5,000 and Water Supply as a system that serves a population of more than 5,000. They all have to comply with water quality and facility standards.

Small Scale Public Water Supply does not imply that the operation is technologically simple, only that the utility supplies water to a small population. As shown in Table 2, utilities serving a population of 5,001 or more are subject to the Local Public Enterprise Act, and to corporate accounting rules based on cost recovery. The Small Scale Public Water Supply is not regarded as a public corporation under the Local Public Enterprise Act and is often managed using municipal general accounting.

Table 2. Difference between Water Supply and Small Scale Public Water Supply

Type	Population served	Accounting system	Funding source	Location
Water supply	≧5,001	Public enterprise accounting system	(mainly) Bond issues	Urban area
Small Scale Public Water Supply	101-5,000	General account	National subsidy and bond issues	Rural area
Facility for drinking water supply	≦100	financed by local residents	Residents and community	Rural area

The funding for the development of rural utilities came from subsidies and bond issues. Development of waterworks in rural area was boosted by government subsidies provided after the Water Supply Act was promulgated in 1957. The bond issue system was developed around this time and has been used widely since as the incomes of municipalities were expected to grow during the high economic growth period.

Government subsidies for the Small Scale Public Water Supply are for facility improvement only. Operation and maintenance of these facilities is the responsibility of the utilities, on a financially self-sustaining basis. However since the tariff revenue from low population bases cannot cover the operation and maintenance costs, many utilities have to transfer funds from general accounting.

Skilled workers are needed in the development of the Small Scale Public Water Supply. It is very difficult to providing the training for a small number of workers spread across many small utilities. After World War II, the National Institute of Public Health of MHLW trained a core group of personnel from prefectural or local government agencies. These trained personnel in turn provided technical support to the municipalities during the construction of the water supply facilities. They also supported the development of master plans to apply for subsidies, facilities design and technical management. The water supply coverage to the rural areas increased thanks to government subsidies, technical support from trained personnel, politician pushing for these improvements and financing by local residents.

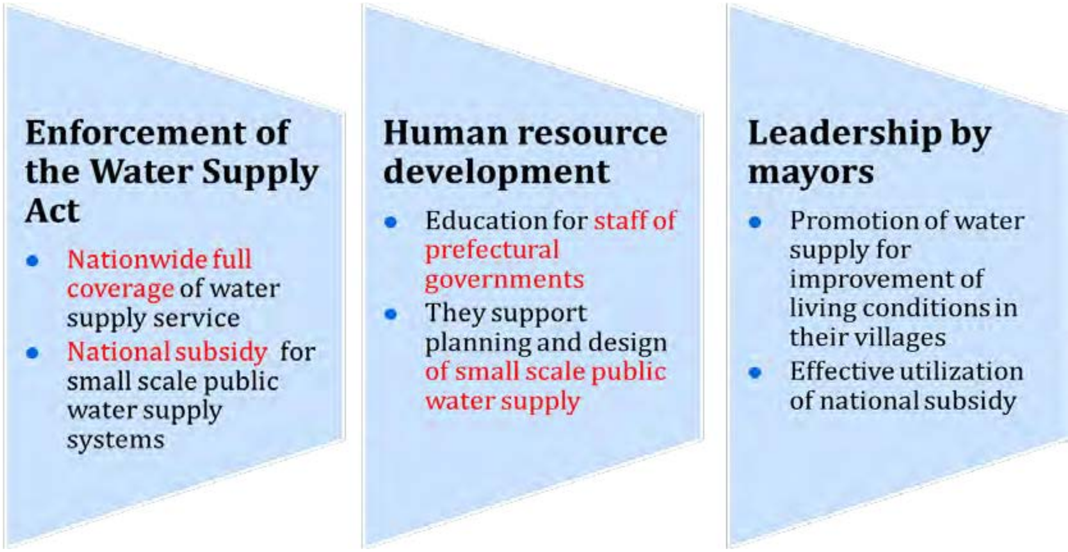


Figure 6. Development of the Small Scale Public Water Supply

The development of the Small Scale Public Water Supply is generally difficult in small municipalities, but Japan achieved this during the high economic growth period. This was because self-financing and reimbursement of bond issues were relatively easy for municipalities after deducting government subsidies for facility development.

Source: Susumu Hani, the film “*Water in Our Life*,” 1952

Photo 2. Consultation with Engineers from the Prefectural Government and Health Center

4. Regulatory Framework and Administration

(1) Legal System

The Japanese legal system is based on the country's Constitution. Various laws, ministerial orders, and public notices made up the legal framework for water supply. Details are stipulated in the order for enforcement of law and ordinances.

The Japanese legal framework for water supply is shown in Figure 7

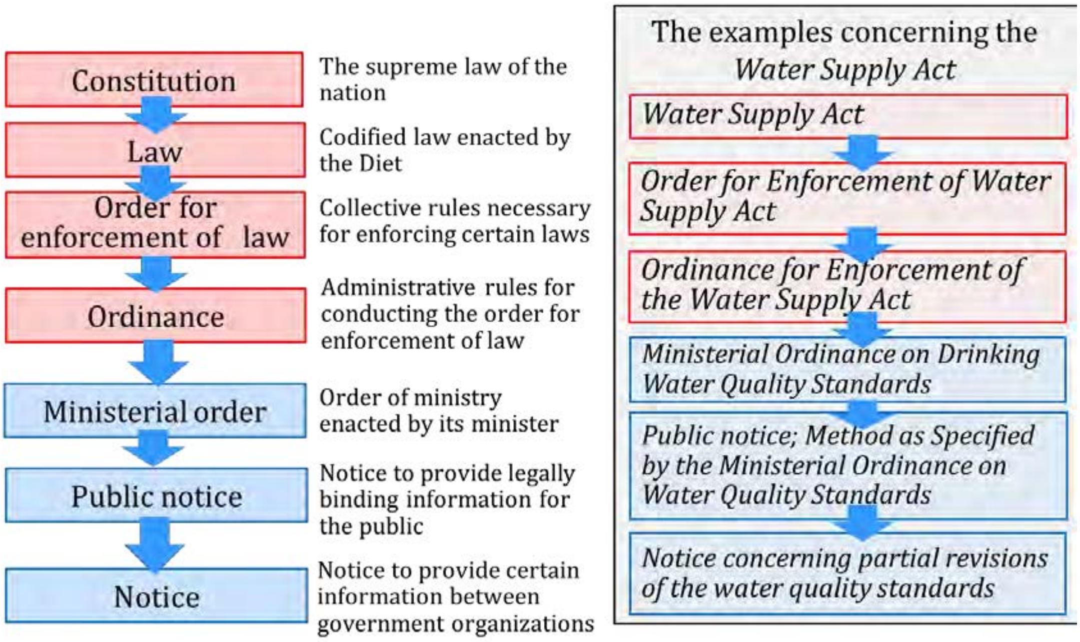


Figure 7. Legislative Framework for Water Supply in Japan

The details of the Water Supply Act are stipulated in the order for enforcement of the Act and ordinances. Ministerial orders and public notices and if necessary, guidance from MHLW can also be stipulated. In this way the Acts stipulate the principle concepts and related ordinance/notices define detailed operations. These all together support operation of legal system and make it possible to comply with laws.

(2) Approval (License) System of the Waterworks

According to the Water Supply Act, utilities must obtain government permission to operate water supply services. The Approval (License) process requires the development of a master plan and the criteria for approval are clearly defined. This ensures the quality of the water supply and the efficient operation of utilities.

The Waterworks Ordinance was established in 1890 when the construction of modern water supply facilities started and new technologies were sought. Some of the existing water supply facilities were privately owned and did not supply water of uniform quality. The Ordinance stipulated that facilities must supply water not harmful to health, be managed as public entities, be approved by the government, provide around the clock service and conduct water quality testing. In 1957, the Water Supply Act added other stipulations, including provisions for water quality and facility standards, and the management by qualified technical managers.

The requirement of Approval (License) in Article 6 is one of the important implications of the Act. A special license must be obtained from the Minister of Health, Labour and Welfare (or in some cases from the prefectural governor), according to the application procedures stipulated in Article 7. In the process, the government scrutinizes the master plan, construction design and determines if the proposed business would improve public health. Article 52 stipulates the penalties for those who manage waterworks without Approval (License).

The following list stipulates further points to be included in the master plan and design drawings.

Water Supply Act - Article 6. Project Approval (License) and Managing Agent; Article 7. Application for Approval (License)

2. The application for Approval (License) in Clause 1 must include the following information:
(1) Name and address of the applicant (details omitted)
(2) Address of the water utility office

3. (details omitted)

4. The master plan must include the following information:
(1) Water supply zone, population size for water supply and supply capacity
(2) Water supply facility summary
(3) Expected water supply start date
(4) Estimated total construction cost and expected sources of financing
(5) Basis for calculating water supply population size and capacity
(6) Current balance estimate
(7) Water supply conditions including water tariffs, shared responsibilities for water supply facility construction expenses
(8) Other matters determined by the ordinances of the Ministry of Health, Labour and Welfare

5. The design drawings in Clause 1 must include the following information:
(1) Daily maximum and daily average water supply capacity
(2) Type of water source and water intake location
(3) Estimated water source capacity and results of water quality testing
(4) Water supply facility location (including altitude and water level), size and structure
(5) Method of water purification
(6) Maximum hydrostatic pressure and minimum hydrodynamic pressure in distribution pipelines
(7) Expected construction start and completion dates
(8) Other matters determined by the ordinances of the Ministry of Health, Labour and Welfare.

Articles 1 and 2 of the Ordinance for Enforcement of the Water Supply Act stipulate that the following information (documents and drawings) are required by MHLW.

Ordinance for Enforcement of the Water Supply Act

Article 1-2. Documents to Be Attached to Applications for Approval (License)

(1) For applicants other than local public agencies, provide a document stating reasons for managing waterworks.

(2) For corporations or associations other than local public agencies, provide a document to certify the decision on managing waterworks.

(3) For applicants other than municipalities, provide a document to certify the agreement obtained under Article 6-2 of the Act.

(4) A document to state the conditions which ensure water intake.

(5) For corporations or associations other than local public agencies, provide the articles of incorporation or agreement.

(6) A document to certify that the water supply zone is not overlapping with other waterworks' water supply, a document to certify the existing waterworks in the water supply zone, and a map to clarify the above.

(7) A map to clarify the location of the water supply facility.

(8) A map to clarify the general situation around the water source.

(9) Plans, elevations, sections and structural drawings to clarify the structure of the main water supply facilities (not including the following facilities).

(10) Plans and longitudinal sections to clarify raw and treated water transmission and distribution pipelines.

The legal requirements serve to ascertain the following details:

- Water supply zone, population size for water supply and supply capacity
- Expected water supply start date
- Water source location, quality and quantity
- Sites/drawings of water intake, treatment plant and distribution reservoir
- Estimated construction cost and source of financing, construction period
- Water tariff and management plan

Applications for Approval (License) should contain the information on (1) water source capable of providing continuous supply, (2) facilities plan, (3) source of financing for construction, (3) construction schedule, (4) proof of cost recovery, and (5) management plan for sustainable water supply after commissioning.

Article 8 stipulates that Approval (License) should not be granted unless the applications are deemed to meet all the conditions. The application is judged on the project's ability to meet public demand; effective and reasonable plans; and construction designs in compliance with facility standards.

Water Supply Act - Article 8. Approval (License) should not be granted unless the application meets the following conditions:

(1) The utility is implemented to meet the public demand.
(2) The waterworks plan is effective and reasonable.
(3) The water supply facility construction designs are in compliance with the facility standards under the provision of Article 5.
(4) The water supply zone is not overlapping with water supply zones of other waterworks.
(5) The supply conditions meet all the requirements under Article 14-2.
(6) Waterworks applicants other than local public agencies must have a sufficient business foundation for conducting the project.
(7) Starting such waterworks will serve the public interest.

These strict procedures for Approval (License) emphasize the utilities' responsibility in protecting public health and to supplying clean, safe, reliable drinking water to the citizens. It clearly shows that the Water Supply Act is a legislation aiming to enhance public health in Japan.

Column: Waterworks Ordinance

As shown in Figure 1, waterborne diseases such as cholera were common in Japan until modern water supply systems were installed. At that time, residents obtained drinking water from wells, open channels, and street vendors who drew river water. These water sources were often contaminated.

The government issued drinking water warnings in 1878 and encouraged proper management of wells and wastewater storage. At the same time, there was a growing trend to use steel for distribution pipes. The Yokohama City water supply system was installed in 1887, followed by ones in Sasebo, Hakodate and other cities. Some were run privately, and fell short of meeting facility standards and lacked proper management.

Under these circumstances, there was a need to develop basic principles for operating waterworks, preparing development plans and supervising facilities construction and management of the system. The Waterworks Ordinance was proclaimed in 1890 after two years of negotiation between the Hygiene Bureau of the Ministry of Home Affairs and Legislation Bureau.

Although the Waterworks Ordinance is simple compared to the Water Supply Act, it advocates the basic principle of public management and government approval of utilities. It played an important role in the implementation of nationwide coverage of water supply systems targeted in the Water Supply Act.

Waterworks Ordinance

Article 2 Municipalities may not install a waterworks facility without public funds.
Article 3 Municipalities must provide a prospectus containing the following details to the Home Minister for Approval (License), through a prefectural governor to install a waterworks system.
Articles 1 – 10 (encompass almost all of Article 7 “Application for Approval (License)” of the current Water Supply Act)
Article 10. Anyone who has access to water supply services may request testing of water quality and quantity at tap. (Adopted by Article 18 of the Water Supply Act).

(3) Other Relevant Laws

In addition to the Water Supply Act, there are other laws relevant to water intake, water resource development, collection of adequate water tariffs and business accounting based on the principle of cost recovery.

There are other laws that are relevant to the management and facility construction of utilities in Japan.

The Local Public Enterprise Act applies to utilities serving populations of 5,001 or more. This Act stipulates conditions for financial management, staffing requirements, basic corporate governance and other measures for corporate financial restructuring. It stipulates the duty of local public enterprises to provide separate accounting for each enterprise and the principle of cost recovery.

Cost recovery mandates incomes to be applied to the costs other than those paid within general accounting and other special accounting of local public agencies. This is an absolute requirement for the continuous operation of the water supply business.

The Measurement Act stipulates measurement standards for ensuring proper execution of measurements, and key provisions for water meters, including definition of meters, accuracy requirements, types of meters and replacement period (every 8 years). The Act ensures accuracy of meters and appropriate billing.

The River Act stipulates that utilities must obtain a license for the use of water from a river from the River Administrator. It also stipulates the legislative requirements for building new intake facilities and dams, or removing old facilities in the river and surrounding area. It defines the coordination required of organizations having jurisdiction in the area.

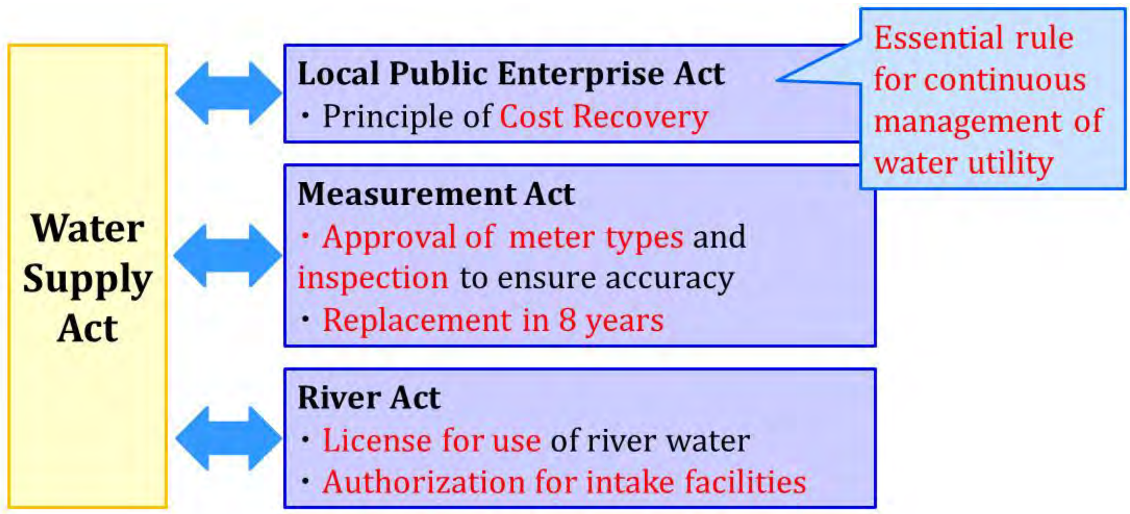


Figure 8. Water Supply Act and Other Relevant Laws

(4) Administrative Framework

> The Japanese central government directly supervises large utilities and oversees prefectural governments that supervise small utilities and requires them to report on the operation and facilities, and conduct on-site inspections. This ensures the compliance with the Water Supply Act and appropriate operation of the utilities.

The Water Supply Act falls under the jurisdiction of the Water Supply Division of MHLW, which approves utilities serving populations of more than 50,000. Prefectural authorities approve those serving populations of not exceeding 50,000. In the prefectural water supply administration, the public health center plays many crucial roles.

The Water Supply Act stipulates that the agency which deals with Approval (License) may give instruction, oversee report submission and conduct on-site inspection of facilities to verify compliance with specifications and management standards. Waterworks approved by prefectural governments are of small to medium sizes. They tend to lack human and technical resources. Engineers from the Health Center in each area can make regular visits and give instruction and supervision to ensure compliance. They also explain the technical information in the notifications issued by MHLW.

Column: Ministry of Health, Labour and Welfare, Prefectural Governments and Health Centers

MHLW issues public notices to large utilities and prefectural governments or mayor of the municipality (city designated by ordinance or core city). Prefectural governments or mayor of the municipality delivers the notices to the prefectural Health Center, to be passed on to every Small Scale Public Water Supply.

Health Centers support local residents in their health and sanitation matters. They are established under the Community Health Act by the prefecture.

The Community Health Act stipulates the roles of a Health Center as follows:

Article 6. Health Centers shall plan, coordinate and instruct in the following matters as well as conduct related activities:
(1) Matters concerning promotion of ideas on and improvement of community health;
(2) Matters concerning demographic statistics and other community health statistics;
(3) Matters concerning nutritional improvement and food hygiene;
(4) Matters concerning home, water, sewer and waste disposal, cleanup, and other environmental sanitation;

Health Centers provide services on matters concerning environmental sanitation (Paragraph 4), including acceptance of applications for waterworks, onsite inspections and instruction. The participation of the Health Centers in instructing utilities reflects the alignment of community health with water supply, as intended by the legal system.

The following chart shows the administration system for water supply in Japan:

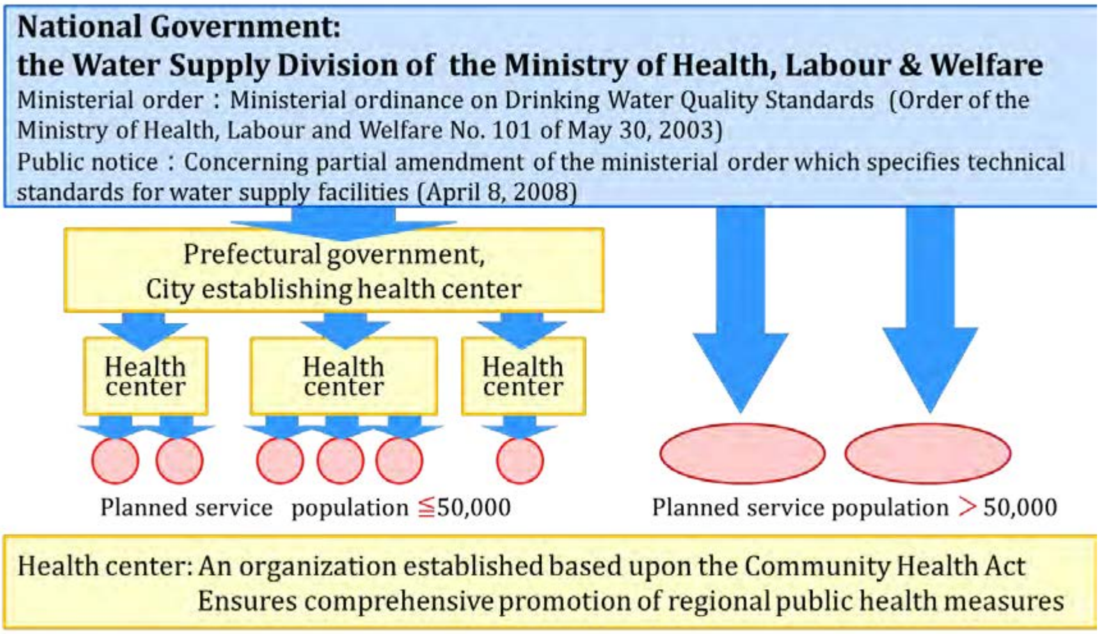


Figure 9. Japanese Administrative System for Water Supply

5. Challenges in Maintaining Universal Coverage

By actively promoting the water supply systems in rural areas, Japan achieved almost 100% coverage. However, small utilities have poor financial conditions and inadequate human resources and technical capabilities. For them to operate sustainably and replace aging facilities in the future, they must find ways to consolidate their operations.

During the high economic growth period, mayors of municipalities in rural areas promoted the development of the Small Scale Public Water Supply, as they were committed to water supply coverage as a priority and believed that it would be a great benefit to the residents. Establishing Small Scale Public Water Supply in rural areas was very effective in expanding the nationwide water supply coverage. However, this resulted in many small utilities scattered in remote mountainous areas. As shown in Figure 10, there were 8,667 utilities each serving populations of 500 or less in 2002.

It is very difficult for small utilities to maintain or renew aged facilities. Unlike urban utilities, their accounting system does not include depreciation costs and water tariff is not enough to pay depreciation costs. Their facilities age more rapidly due to the use of low-cost materials such as asbestos cement pipes. They also have difficulty raising funds. They face enormous challenges.

Small utilities have many weaknesses. Without adequate human resources, they depend on the *Water Supply Facilities Maintenance Manual* issued by Japan Water Works Association and training programs provided by local governments (e.g. public health centers). The situation could become worse with the shrinking work force.

It was necessary to strengthen the financial base and the human resources and expand the scale of operation. Ministry of Health, Labour and Welfare revised the Water Supply Act in 2001 to promote the merging of facilities. However, the progress of this initiative was very slow because it encountered a lot of difficulties. Quite a number of consolidations (utilities serving population less than 500) took place in 2005 (big merger of Heisei). Even so, there were still 6,254 of Small Scale Public Water Supply operating in 2012. Although the number of small utilities serving less than 500 customers declined drastically, there are still numerous compared to large utilities serving more than 5,001 customers.

As of 2015, there are 1,388 large to medium size facilities, supplying water to 119,670,000 people, and 5,890 small facilities, supplying water to 4,200,000 people. 96.6% of the population receives piped water from public utilities and 3.4% from their own wells or unregulated small systems, mainly in rural areas. In spite of the success in achieving universal access to water supply, serious challenges still remain.

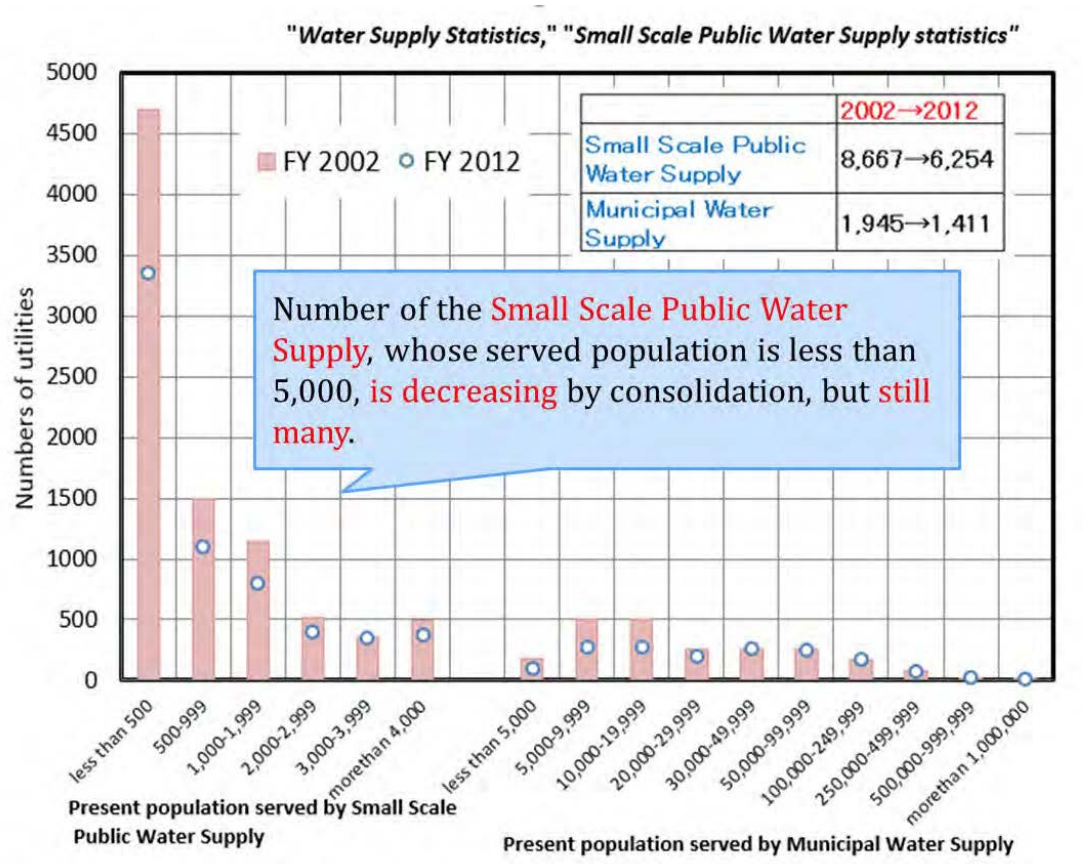


Figure 10. Number of Waterworks by Size (2002 – 2012)

Small utilities are considering various measures including outsourcing, seeking help from larger utilities and obtaining subsidies for facility renewal.

MHLW is promoting the following measures for all utilities:

- consolidate facilities in adjacent areas
- develop Water Supply Vision and master plan
- develop water safety plan for reliable and sustainable water supply
- manage assets to properly finance the timely replacement and maintenance of existing equipment and facilities

Table 3. Japanese Social Situations, Legal System and Waterworks Promotion

Year	Japanese social situations	Trends in laws and systems	Trends of water utility industry	Water Supply Coverage
1859	Yokohama Port opened			
1868	Meiji Government established			
1877	Cholera outbreaks in Yokohama/Nagasaki, spreading nationwide			
1879		Drinking Water Warning Act (Notification)		
1886				
1887			Yokohama City waterworks introduced	0～1%
1889		City systems/municipal systems put into effect		0～1%
1890		**The Waterworks Ordinance proclaimed**		0～1%
1894	Sino-Japanese War			0～1%
1895				1 ～2%
1896		Former River Act established		2～3%
1899			Tokyo City waterworks completed (Waterworks to spread nationwide thereafter)	2～3%
1904	Russo-Japanese War		Federation of Water Authorities (later version of Japan Water Works Association) established	2～3%
1905			Water quality testing methods/management/operation studied	4～5%
1914	World War I			12%
1918				18%
1923	Great Kanto Earthquake			19%
1934			Water Supply Equipment inspection system started (Japan Water Works Association)	28%
1937	Sino-Japanese War	Health Center Law (later version of Community Health Act)		30%
1941	World War II			30%
1945	End of war, GHQ occupation		Chlorination ensured	30%
1947	Constitution of Japan proclaimed	**Constitution of Japan proclaimed**	"Universal Water Supply Policy" targeted	28%
1950	Korean War broke out			26%

Year	Japanese social situations	Trends in laws and systems	Trends of water utility industry	Water Supply Coverage
1951		Measurement Act established	Water meter accuracy secured	27%
1952	US-Japan Status Treaty, end of occupation	Local Public Enterprise Act established	Small Scale Public Water Supply subsidy plan started	29%
1953	End of Korean War			31%
1954	High economic growth period		Waterworks subsidies abolished, specializing in Small Scale Public Water Supply subsidies	33%
1957		**Water Supply Act established**	The water supply is subject to the local municipal enterprise law Development of prefectural human resources/promotion of Small Scale Public Water Supply systems accelerated	36%
1964		River Act established		69%
1967			Waterworks water supply source development and facility improvement subsidies started	72%
1970	Pollution problems became visible	Water Pollution Control Act established		81%
1973	Oil shock			84%
1979	Second oil shock		Trihalomethane problems became visible	91%
1994		Act on Advancement of Raw Water Quality Management Projects established	Response to disinfection byproducts became necessary	95%
1995	Great Hanshin Earthquake			
2011	Great East Japan Earthquake			97%
2014		Water Cycle Act established		98%

* Water supply coverage rates up to 1955 estimated, the rest based on the water statistics

* The red character is a text entry

6. Lessons Learned

The following Japanese experience could be useful for other countries.

- **(Continuous Pressurized Water Supply)** Japan introduced the modern water supply systems to reduce the incidence of waterborne diseases including cholera. Water supply facilities were built to treat and deliver a continuous supply of safe drinking water through pressurized distribution networks to customers around the clock. The modern water supply is one of the important determinants of public health and healthy living environment in Japan.

- **(Water Supply Act)** Japanese government established the Waterworks Ordinance in 1890, and the Water Supply Act in 1957 (full revision of Waterworks Ordinance) to promote the establishment of water supply systems. These laws emphasize the technical aspects of the operations and focus on improving public health and the running of the water supply business for public good. The Water Supply Act defines water quality standards and facilities standards.

- **(Approval (License) of Water Utilities)** The Waterworks Ordinance instructs municipalities to construct water supply systems using public financing and requires waterworks to be approved by the national government (some by prefectural governor). The Approval (License) process ensures that all utilities have a certain level of technical competence, that facilities are designed with safety in mind and that the financial plans are sound. The master plan is required in the process of Approval (License).

- **(Universal Access)** Based on Article 25 of the Japanese Constitution, all citizens shall have the right to maintain the minimum standards of wholesome and cultured living. The national government has provided universal access to water, including in rural areas.

- **(Financing of Urban Utilities)** Urban waterworks cover their expenses for facility construction with income generated from tariffs and with funds from bond issues and equity capital. Some national subsidies were also used.

- **(Government Assistance for Rural Areas)** Utilities in rural areas required extra government assistance in terms of training and financial support. The active role played by local politicians made it possible to set up the Small Scale Public Water Supply in these areas as a high priority. Local residents worked on facilities construction, sometimes on a voluntary basis. All these contributed to achieve universal coverage of water supply including in rural areas.

- **(Enforcement of the Act)** The Japanese legal system has many detailed stipulations clearly spelled out in government ordinances, notices, and procedures, to show the water supply business how to abide by the relevant Acts including the Water Supply Act. The Act defines the administrative process for the development of water supply across the country, with different levels of government working together. Depending on the size of the utility, the national or the prefectural government instructs the utilities on compliance and carry out the required monitoring.

- **(Acts Relevant to the Water Supply Act)** The Measurement Act, which stipulates requirements to ensure the accuracy of water meters, thereby contributes to accurate billing. The Local Public Enterprise Act, which requires utilities to use specific business accounting systems, contributes to their sustainable financial operations.

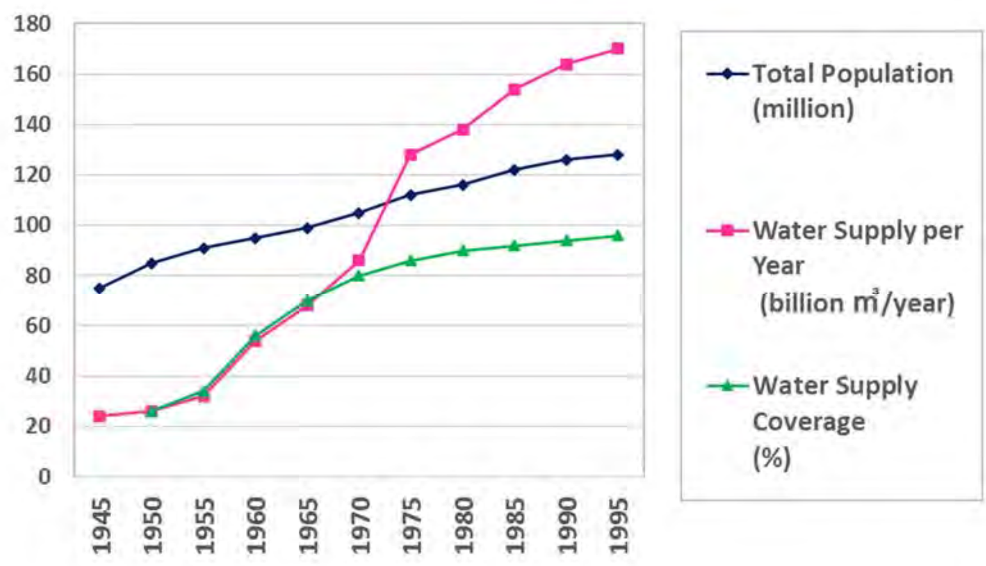
- **(Challenges of Rural Water Supply)** Waterworks in rural areas were developed using national subsidies. Their operational and financial situations tend to be weak. They maintain their technical capabilities with the help of the guidelines such as *Water Supply Facilities Maintenance Manual*, and obtain staff training conducted by local governments. Other issues such as the cost bearing for facility renewal, succession of techniques, and maintaining staff capability in a shrinking work force, are serious challenges for their long term sustainable operation.

Theme 2. Water Supply System: from Water Resources to Distribution

Contents

1. Introduction

The water supply system is the infrastructure for the intake, transmission, treatment, storage and distribution of drinking water for water users. Development of water supply systems dramatically increased the coverage of drinking water distribution in Japan since the 1950s.



Source: JWWA, *Water Supply Services Overview*, 6th edition (2015) p.21

Figure 1. Water Supply Volume in Japan

This module describes Japanese waterworks' experience in securing water resource, selecting water treatment methods which corresponds to quality of source water, designing water supply system and managing technical standards by addressing the following frequently asked questions by participants from developing countries:

Q1. How did Japanese water utilities choose water sources and maintain facilities for stable and economical safe water supply?

Q2. How did Japanese water utilities develop water resources to meet increasing demand? How did they manage the conflicts with other water use? How do they share the cost with other stakeholders in water resource development?

Q3. How water sources were developed for water supply in wide areas? How the Bulk Water Supply, which only treats and supplies water to utilities and does not supply water up to consumers, is managed?

Q4. Water sources were polluted by wastewater through economic activities. Then large water demand forced water utilities to take large amount of water from polluted water sources. How did Japan control pollution of water sources?

Q5. How did Japan overcome land subsidence caused by excessive groundwater use in response to growing economic activities?

Q6. How did Japanese water utilities develop water distribution pipelines? What are characteristics of water distribution networks in Japan?

Q7. Why does Japan emphasize water supply plans for facility constructions? How do Japanese water utilities steadily develop water supply facilities in required level? How master plans are made and utilized?

The following sections attempt to provide answers to these questions:

2. Water Sources and Treatment System (Q1)
3. Development of Surface Water (1), (2), (3) and (4) (Q2)
3. Development of Surface Water (5) (Q3)
4. Treatment Process (Q4)
5. Groundwater (Q5)
6. Distribution Systems (Q6)
7. Engineering Design and Master Plans (Q7)

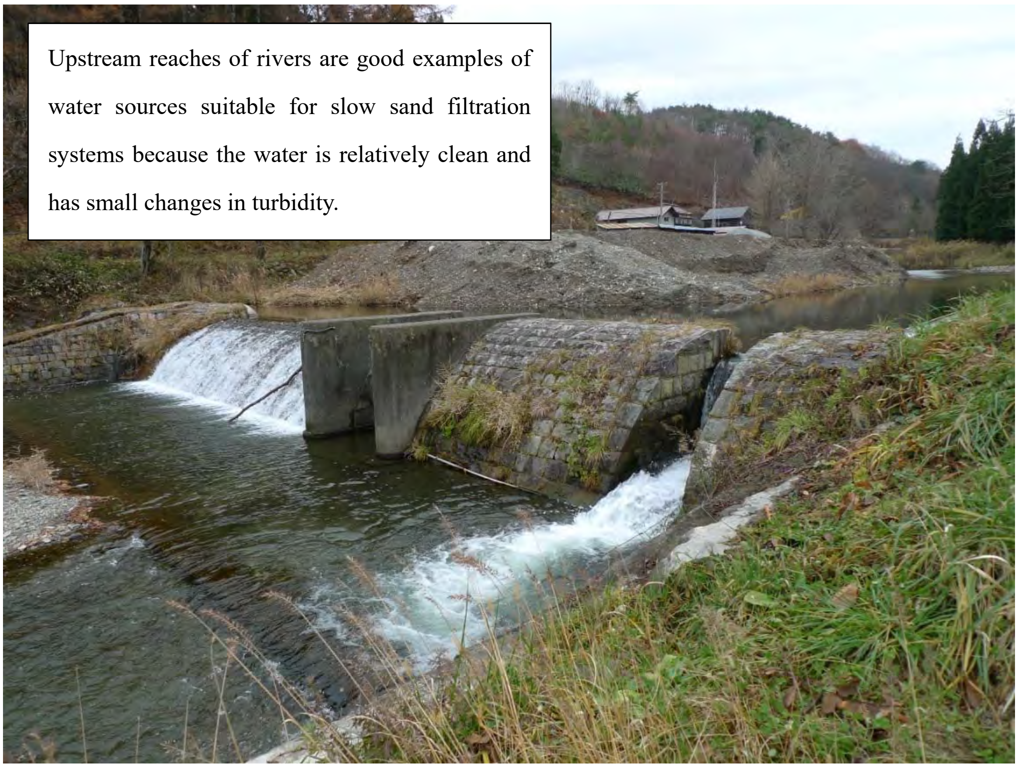
2. Water Sources and Treatment System

Water sources should be as clean as possible, taken from upstream areas without any pollutants. Small utilities can source good quality raw water to save on financial and technical resources for water treatment. Larger utilities do not always have the choice to start with unpolluted raw water because larger intakes are usually only available in downstream sections of rivers. Treatment processes are required to cope with the pollution load.

Ideally, water sources should be free from contaminants. The better water sources are usually in the upstream reaches of rivers, springs or groundwater. Before the high economic growth period, many utilities could use upstream surface water, spring water or groundwater and if necessary, treat the water with simple method such as slow sand filtration. Even today, small utilities (serving populations of 101 - 5,000) are still using this simple system if they can source good quality raw water, as they usually have insufficient technical capability to conduct advanced treatment processes.

Large utilities normally take their water close to urban areas from sources with substantial flow. They have to move their water sources downstream where large enough volume is available as the demand grows. These water sources are often polluted as human and industrial activities increase, and advanced treatment is required to cope with the pollution load. Urban development in the watershed raises the pollution risk to the water source and treatment plants have to deal with this risk. Rapid sand filtration is often used because it can treat a large amount of water with equipment that can be installed in a relatively small space.

During Japanese high economic growth period (from 1955 to 1973, the period while economic growth rate surpassed 10%), large water utilities shifted their water sources to downstream which is able to meet large demand. Rapid sand filtration came to often used because the process can treat large amounts of polluted water efficiently and can be combined with breakpoint chlorination. In addition, excessive pumping of groundwater caused land subsidence. For solving these problems due to increased demand of water by growing population, water utilities and other water users were turning to dam development. At present, about half of the raw water for waterworks is drawn from dam reservoirs.



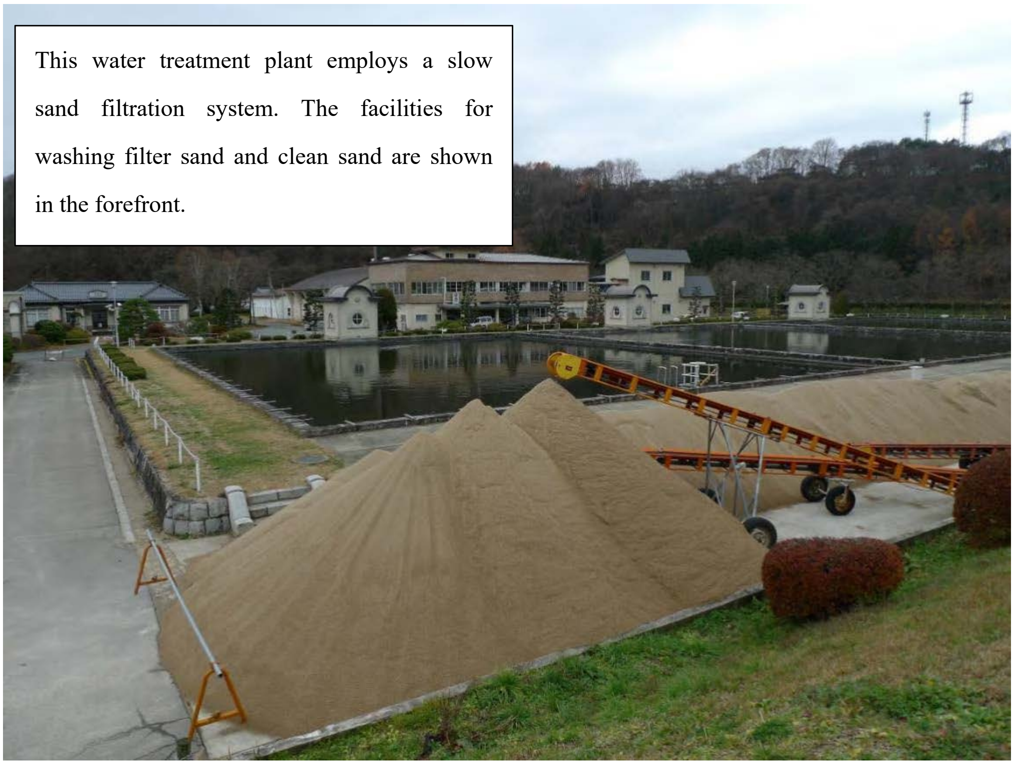


Photo 1. Water source and intake of the Yonai Water Treatment Plant in Morioka, Iwate prefecture. Unpolluted water from the upstream reaches of the river is taken and treated by slow sand filtration (November 23, 2010).

Photo 2. Kanamachi Water Treatment Plant, Bureau of Waterworks, Tokyo Metropolitan Government. It is equipped with advanced water treatment facilities which include rapid sand filtration, high-speed coagulation, flocculation and sedimentation reservoir. It also has power generation facilities, constructed using private financing (April 4, 2004).

Column: Environmental Water Quality Standards for Public Water Bodies

In Japan, utilities must provide information on annual changes in the quality of raw water when they apply for their operating Approval (License). This information is the basis for the selection of appropriate treatment methods. Before, the oversight authority instructed the utility to make modifications on water source if the raw water quality and treatment methods are not satisfactory.

Raw water is categorized by the treatment needed to render it potable and to meet the legislated quality standards. Above mentioned instructions on Approval (License) procedure were made based on the category of water source as follows;

Class 1: water requires simple processes such as filtration;

Class 2: water requires treatment with sedimentation and filtration; and

Class 3: water requires advanced methods such as pre-treatment combined with filtration.

Water environment standards identify target water quality for drinking water sources and promote water quality conservation in public water bodies. It is recognized that the conservation of water sources and their environment go hand in hand.

Table 1. Environmental Water Quality Standards for Public Water Bodies

(1) Rivers (excluding lakes)

Item Type	Water use	Standard Value				
		Hydrogen-ion concentration (pH)	Biochemical Oxygen Demand (BOD)	Suspended Solids (SS)	Dissolved Oxygen (DO)	Total Coliform
AA	Water supply class1, Conservation of natural environment, and uses listed in A-E	6.5≦ pH≦8.5	1mg/l≦	≦25mg/l	≧7.5mg/l	≦50 MPN/100mL
A	Water supply class2, fishery class1, bathing and uses listed in B-E	6.5≦ pH≦8.5	2mg/l≦	≦25mg/l	≧7.5mg/l	≦1,000 MPN/100mL
B	Water supply class3, fishery class2, and uses listed in C-E	6.5≦ pH≦8.5	3mg/l≦	≦25mg/l	≧5mg/l	≦5,000 MPN/100mL
C	Water supply class3, industrial water class1, and uses listed in D-E	6.5≦ pH≦8.5	5mg/l≦	≦50mg/l	≧5mg/l	-
D	Industrial water class2, agricultural water, and uses listed in E	6.5≦ pH≦8.0	8mg/l≦	≦100mg/l	≧2mg/l	-
E	Industrial water class3 and conservation of environment	6.5≦ pH≦8.0	10mg/l≦	Floating matter such as garbage should not be observed.	≧2mg/l	-

(2) Lakes (Natural lakes or artificial reservoirs with 10 million cubic meters of storage capacity and retention time of 4 days or more.)

Item class	Water use	Standard Value				
		Hydrogen-ion concentration (pH)	Chemical Oxygen Demand (COD)	Suspended Solids (SS)	Dissolved Oxygen (DO)	Total Coliform
AA	Water supply class1, fishery class1, conservation of natural environment, and uses listed in A-C	6.5≦ pH≦8.5	1mg/l≦	1mg/l≦	≧7.5mg/l	≦50 MPN/100mL
A	Water supply class2 and 3, fishery class2, bathing and uses listed in B-C	6.5≦ pH≦8.5	3mg/l≦	5mg/l≦	≧7.5mg/l	≦1,000 MPN/100mL
B	Fishery class3, industrial water class1, agricultural water, and uses listed in C	6.5≦ pH≦8.5	5mg/l≦	15mg/l≦	≧5mg/l	-
C	Industrial water class2 and conservation of environment	6.0≦ pH≦8.5	8mg/l≦	Floating matter such as garbage should not be observed.	≧2mg/l	-

Source: Extracted from Environmental Quality Standards for Water Pollution.

3. Development of Surface Water

(1) Water Rights

In Japan, water right is a special license for exclusive use of a designated amount of water for a certain purpose. It is legally designated with consideration of customary uses. It has been effective in reconciling conflicts among stakeholders.

Surface water is suitable for intake in large quantities; therefore it is an extremely important water source for large utilities. Utilities often compete with other large scale users, such as agriculture and power generation, for the same water source. Some kind of coordination and cooperation is required. The system of water rights and coordination among water users has been functioning to avoid conflicts and complicated or contentious situations especially in large rivers.

Since Japan developed mainly agriculture with many paddy fields before it was replaced with industry and has a history of conflicts over water use, the importance of coordinating water utilization was recognized early on. The River Act established in 1896 conceptualized the rights for utilization of water in rivers. By 1961, the concept of existing water rights was already in place.

As rivers in Japan are relatively short and most are already exploited to the fullest extent, dam construction is the next effective means to increase capacity to meet growing demand. Dams need to serve multiple purposes so that the enormous investment can be shared among the various users. Coordination and cost allocation is required among users such as utilities, farming communities, flood control organizations and hydropower suppliers. Government authorities from different sectors are often involved.

Certain rights to use surface water for agriculture were recognized before the River Act was established in 1896. These customary water rights present challenges in water resource development. The customary rights become vested interests and it requires construction of new dam with enormous investment to acquire new water rights other than the customary rights in some cases.

Photo 3. Shiroyama Dam and Lake Tsukui for the water resource development along the Sagami River (December 19, 2009).

Authorities responsible for not only water use but also flood control, transportation and environmental maintenance are involved in the coordination of water use. It takes time to build consensus among the stakeholders. Sometimes small steps have to be taken one at a time to resolve conflicting interests. Support and intervention from downstream water users to water source area were also effective to reach consensus.

Example: Coordination of Water Use through Comprehensive Development: Kagawa Canal in Shikoku Region

Kagawa Prefecture initiated the project to build the Kagawa Canal as part of the Comprehensive Development of the Yoshino River, which runs through Tokushima, Ehime and Kochi Prefectures. For a long time, Kagawa had wanted to build a canal to access water from the Yoshino River to ease its chronic water shortage. Tokushima was reluctant to divert its share of water to Kagawa even though it suffered from flooding. Kochi where a dam would be built did not give a positive answer. The negotiation among stakeholders from various administrative agencies and watersheds was complicated and difficult. The four prefectures went through the following process to arrive at a consensus and Kagawa Canal was built as part of the Comprehensive Development of the Yoshino River.

(i) In 1950 Ministry of Construction[1] led the negotiation because the four prefectures could not settle the issues by themselves.

(ii) The considerations were elevated above the prefectural level. Water use for flood control, food production and hydroelectric power were discussed, together with the development of the entire Shikoku area beyond each prefecture. Shikoku island is located apart from the main island. There was a concern shared by all 4 prefectures that the economic developments on the main island during the period of high economic growth, would pass them by, and the concern became a foundation of discussion for economic development of the area.

(iii) The Shikoku Region Development Promotion Act was formulated in 1960. The Shikoku Regional Development Council was established consisting of Diet members, representatives from administrative organizations, prefectural governors and academics. The Council decided on water allocation arrangements, cost allocation, and the operating agency (today's Japan Water Agency). The consensus for the Yoshino River Comprehensive Development Project was achieved and Sameura Dam, Ikeda Dam and Kagawa Canal were completed in 1975.

(iv) The Yoshino River Council was established to manage water utilization through comprehensive consultation. It operates on the principle that adjustments have to be made regularly to accommodate changes in social demand and balance resource utilization with environmental conservation.

[1] The Ministry of Construction was merged with the Ministry of Transport and two Agencies to form the Ministry of Land, Infrastructure, Transport in 2001.

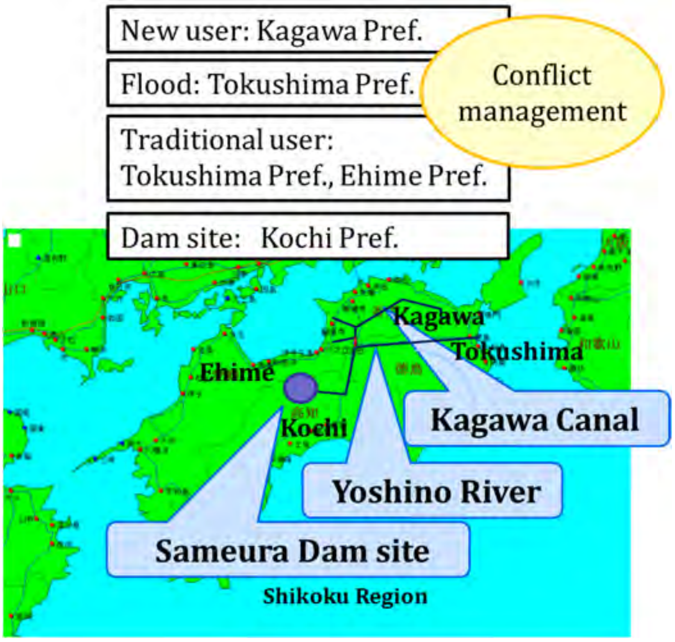


Figure 2. Kagawa Canal in Sikoku Region

(2) Development of Surface Water Source

In Japan, multipurpose dams were built to meet the increasing water demand under the Comprehensive River Development Projects conducted by the government, for water use, flood control and environment conservation. These projects enabled to reduce the cost burden for the utilities in securing the water sources.

The comprehensive river development was initiated by the Home Ministry[2] in the 1930s for comprehensive flood control, irrigation and power generation. The basic idea was to maximize the use of water resource by stocking variated river flow and to control the risk of flooding with dams and river improvement projects. River control projects began in 1937 following the examples of the Tennessee Valley Authority in the United States of America. After surveying the major rivers across the country, seven were selected for the first project. In 1951, the Comprehensive River Development Projects were implemented with taking over the initial projects and a series of legislation such as the Comprehensive National Land Development Act were developed in the same period.

These river developments focused on flood control, except for some cases such as the

[2] The Home Ministry was changed to the Ministry of Home Affairs in 1947.

Ogouchi Dam (completed in 1957) which was developed exclusively for water supply by the well-financed Tokyo Metropolis. Most utilities were not financially capable of building dams exclusively for water supply; therefore, multipurpose dams were developed together with other users.

When the Japanese economy began to grow rapidly, construction of multipurpose dams was the only mean to meet the growing needs in a financially feasible way by sharing construction costs among users. The Water Resources Development Public Corporation (now Japan Water Agency) the implementing agency of the projects, was established with the enforcement of the Act on Advancement of Water Resources Development in 1961. Utilities shared the cost for construction and O&M in these dam developments. The Water Resources Development Basic Plan (Full plan) was formulated exclusively for seven water systems where there was increasing demand. The Basic Plans looked at the integrated construction and management of the dams, water channels, and other related facilities. In this way, independent water related policies and projects such as flood control by the Ministry of Construction, irrigation by the Ministry of Agriculture and drinking water by the Ministry of Health and Welfare[3] were integrated and securing water source was promoted in the whole country. This approach had to find a compromise between two competing goals: storage space for flood control and storage space for securing adequate water resources. Flood control requires a reservoir that has enough empty storage capacity to cope with a one in a hundred-year flood event (50 to 200 years depending on the river system). Water supply requires a reservoir capacity that can store enough water to avoid shortage during a prolonged drought event that occurs about once every ten years. The final reservoir capacity had to be worked out to meet both goals, and compromises were also needed in deciding the optimal operational rules for the dam.

Users that benefit from the dam have to share the construction expenses in accordance with the Specified Multipurpose Dam Act or the Water Resources Development Public Corporation Development Act, as well as under the provisions of the Minister of Land, Infrastructure, Transport and Tourism or a governor of the prefecture. There were environmental and social impacts including involuntary resettlement due to dam construction. To keep dam investment under control, utilities made efforts on leakage reduction and increasing the efficiency of the distribution system to economize the usage of water. Utilities distributed free "water saving tap washer" which is replaced with usual washer in tap and it can reduce water flow compared to the normal one, to customers to advocate economy of water use and to lower water consumption. This PR activity contributes to save on future investment. In addition, the sewerage tariff system

[3] The Ministry of Health and Welfare was merged with the Ministry of Labour to form the Ministry of Health, Labour and Welfare in 2001.

which is calculated based on the amount of tap water consumed, raises consumer's awareness to save water and is the reason to purchase water saving devices, such as water saving toilets.

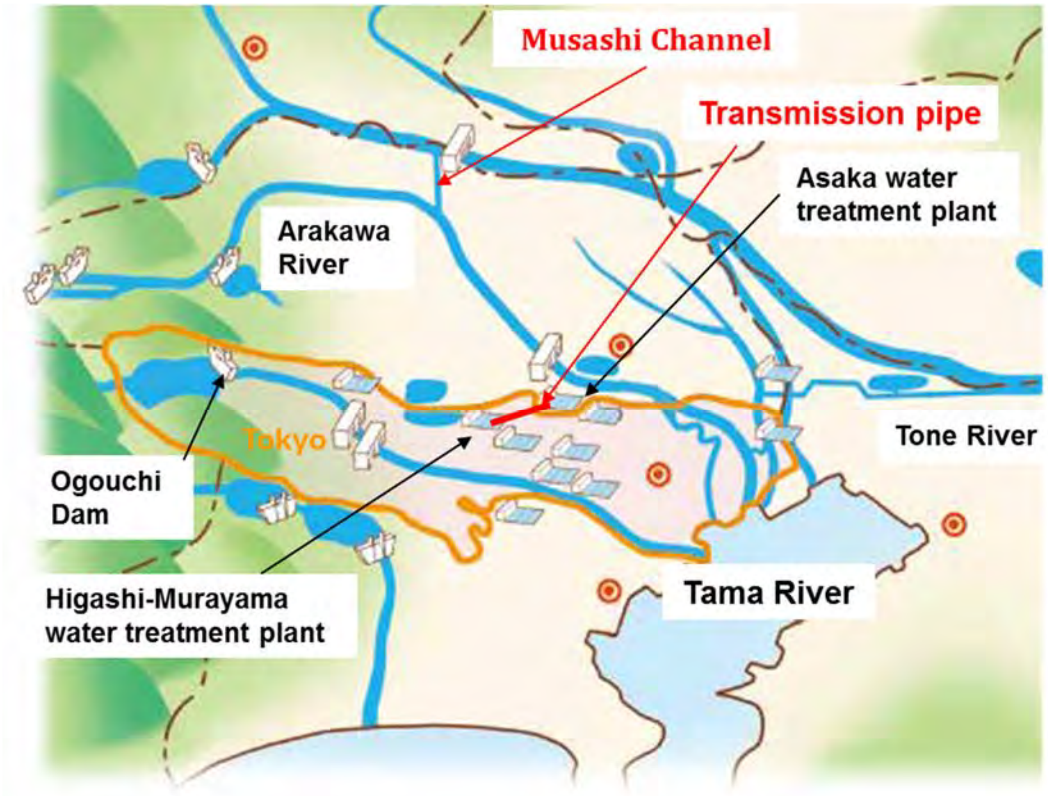
As the result of comprehensive water resource development and effective use of limited water resources, the frequency of intermittent supply and water use restrictions dropped significantly in many areas. As water demand declined after the 1990s, dam developments became contentious because of the huge investment and great environmental and social impacts. Some projects were stopped when the impacts became a concern. In addition, the share of dam maintenance cost based on the allocation of water rights became a serious financial burden for the utilities as water demand declines.

Example: Water source development by the Tokyo Metropolitan Government Bureau of Waterworks (Ogouchi Dam development and the drought during Tokyo Olympic Games)

A lot of damage was done by aerial attacks to the Tokyo Metropolitan Area during World War II. Water demand once had declined at the end of the war then increased significantly as the city recovered. Various types of water supply expansion projects supported by the government were carried out at a rapid pace after the war. The construction of Ogouchi Dam located in Tokyo, exclusively for drinking water supply for Tokyo Metropolitan Area, started in 1938, suspended by the war in 1943, was resumed and completed in 1957.

After the early 1960s, the Tokyo Metropolitan Area experienced high concentration of industries, population, and rapid expansion of flush toilets resulted in drastic increase in water demand. There were droughts every year and the most severe one was in 1964 when the Tokyo Olympic Games were held. In order to survive the crisis, Bureau of Waterworks, Tokyo Metropolitan Government tried to secure alternative water sources from surrounding prefectures. The arrangement was extremely difficult, however Higashi-Murayama water treatment plant was taking raw water from the Tone and Tama River systems and the Arakawa River. The Musashi Channel connecting the Tone and Arakawa Rivers was built in 1965. The Tone River system became the water source for Tokyo and solved the water shortage problem. (See Figure 3 and Photo 4)

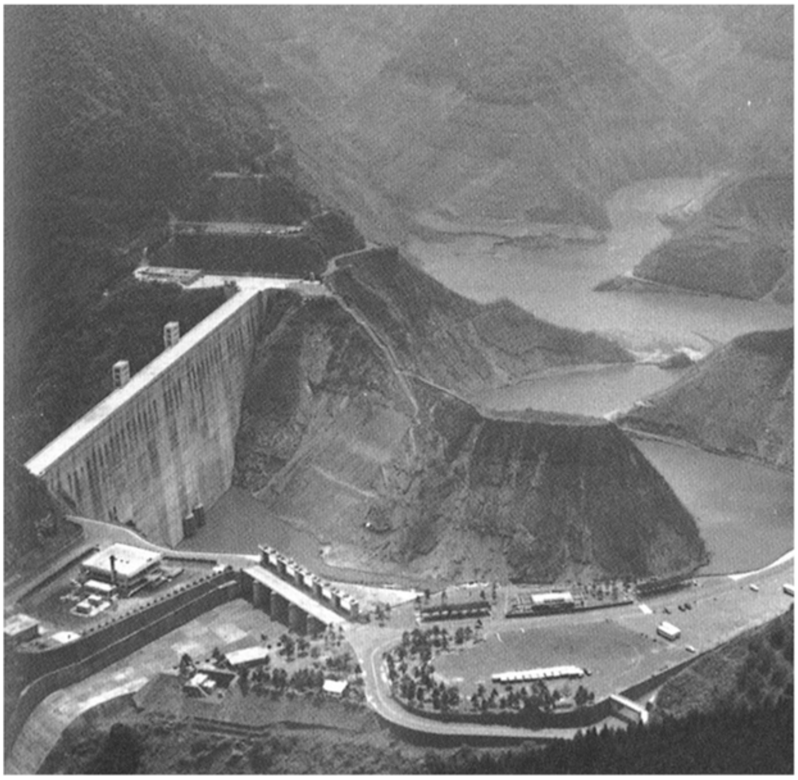
Tokyo shared a large amount of the cost for the multipurpose dam development led by the national government, and the cost was covered by public enterprise bonds. At one time, more than 60% of the revenue of the Bureau was applied to the repayment. Based on the experience, the Bureau sets the water tariff to cover water resource development and made effort to reduce water leakage.



Source: Bureau of Waterworks Tokyo Metropolitan Government
https://www.waterworks.metro.tokyo.jp/kids/study/images/study_13-14-15-16.pdf

Figure 3. Geographical Outlook of Tokyo Metropolitan and Its Water Sources

Photo 4. Tone Ozeki; Water intake facilities of the Musashi Channel (November 19, 2010).



Source: JICA, The Challenge of the Tokyo Waterworks, *Integrated Water Resource Management (A), Knowledge Co-Creation Program Textbook*.

Photo 5. Ogouchi Dam without Water during Drought

(3) Watershed Conservation

Good source water quality depends on sustained efforts to preserve the environment in the entire watershed. Japan has improved source water quality through wastewater effluent regulations, development of sewage treatment and the conservation of forests in the catchment area of the water source for a long period.

A clean water source is the starting point for securing safe drinking water. Therefore, watershed conservation is an important priority for the drinking water supply.

It is critical to regulate wastewater, including domestic, industrial and agricultural discharges containing pesticides and fertilizers, for preserving water quality, to manage the water source area properly and to be prepared for accidental water source contamination. Japan has long been engaged in various measures in this regard and these efforts are continuing today.

Effluent water quality standards for industries came into effect with the establishment of the Water Pollution Control Act in 1970. The Act contributed to reduction of total volume of discharged water, and significant improvement of water quality in the watershed. The Sewage Act was revised in the same year, with the added targets for watershed conservation. By the revision of the Act, wastewater treatment plants were newly constructed to reduce pollution load in household discharges. Two laws concerning water resources, the "Act on Special Measures concerning Water Quality Conservation at Water Resources Area in Order to Prevent the Specified Difficulties in Water Utilization" and the "Act on Advancement of Project for Quality Management of Raw Water" were established in 1994. Utilities are legally and directly involved in the protection of water sources under these laws.

Forests in the watershed are very crucial to the preservation of water source areas. Conservation of these forests is carried out continuously by specific efforts in each area. This is recognized in the Basic Act on Water Cycle established in 2014. The Act is expected to contribute to the systematic conservation of all stages of the hydrological cycle including groundwater.

Japanese government agencies are working hard to improve water quality even within their individual mandates. Dams are constructed in the upstream of rivers, wastewater treatment plants are constructed, industrial wastewater and domestic sewage are treated and reduced in the middle river basin, and various efforts to save water are taking place. These efforts together are bearing fruit; water quality has improved and the pollution risk reduced in the entire watershed.

Utilities are also making valuable contributions on early detection of accidents that can compromise water quality. They have hotlines for reporting on oil or chemical spills so that remedial actions can be taken immediately. They also work together on water safety plan to analyze and reduce risks in the entire system.

(4) Salt Water Intrusion

Estuary barrages prevent salt water intrusion at intakes in coastal areas.

It is easier to obtain large quantities of water from downstream sections of rivers. Sometimes it is the only option for utilities in coastal regions. However, when the intake is in an estuary there is the risk of saltwater intrusion.

Estuary barrages are set up to prevent saltwater intrusion and stabilize the flow at the intake.

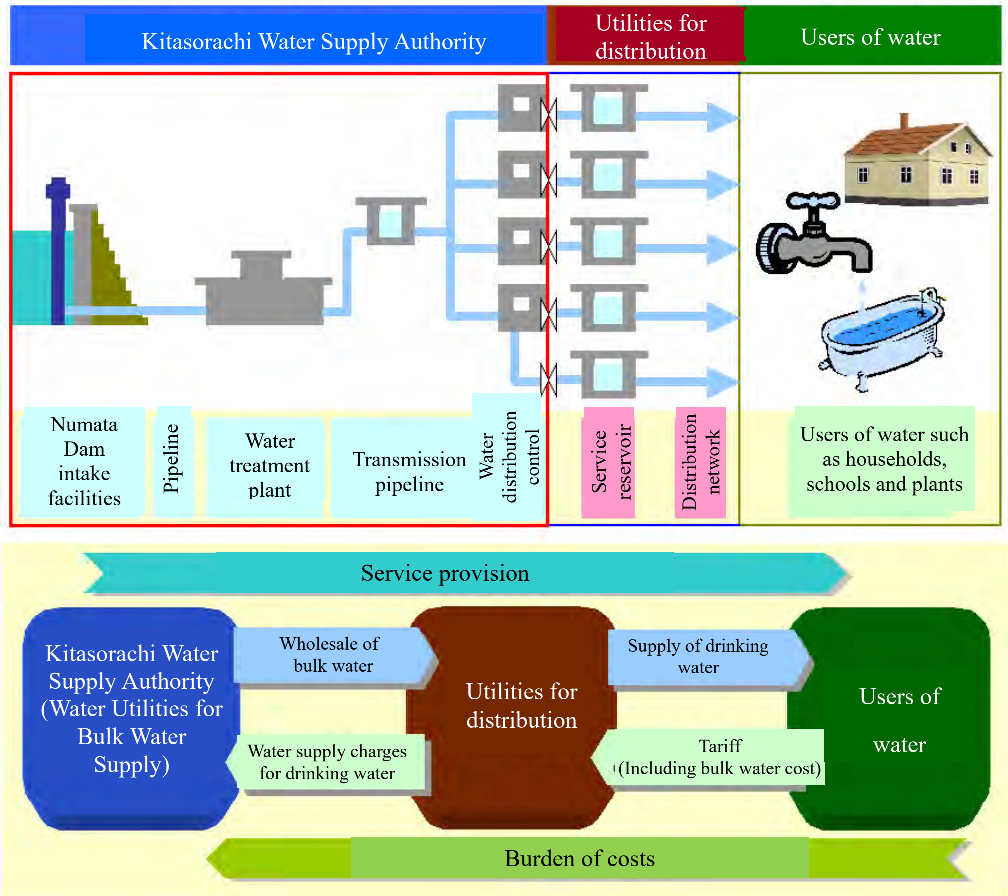
Since most of the urban utilities in Japan take water from downstream, estuary barrages are common in these areas. Discussions with the river administrator and coordination with maritime traffic and fisheries activities are necessary when installing such facilities.

Movable rubber dams or temporary dams are used in some places where other facilities are not suitable (such as Yura River in Kyoto and Imari City, Saga Prefecture).

(5) Bulk Water Supply

In Japan, utilities working together and/or a prefecture would take the lead to establish a Bulk Water Supply Authority for large scale water source development to secure water, to save huge investment costs for the utilities.

Each municipal government on its own was unable to cope with the expense of participating in a large dam project. Therefore, they jointly organized a Bulk Water Supply Authority to participate in dam development and secure their water as bulk supply. National subsidies pay for one half or one third of the expenses for the water resource development. Since public funds are used, the operators of the bulk water supply have to be public institutions, unlike in developing countries where sometimes private financing is involved. There are no private bulk water suppliers in Japan.



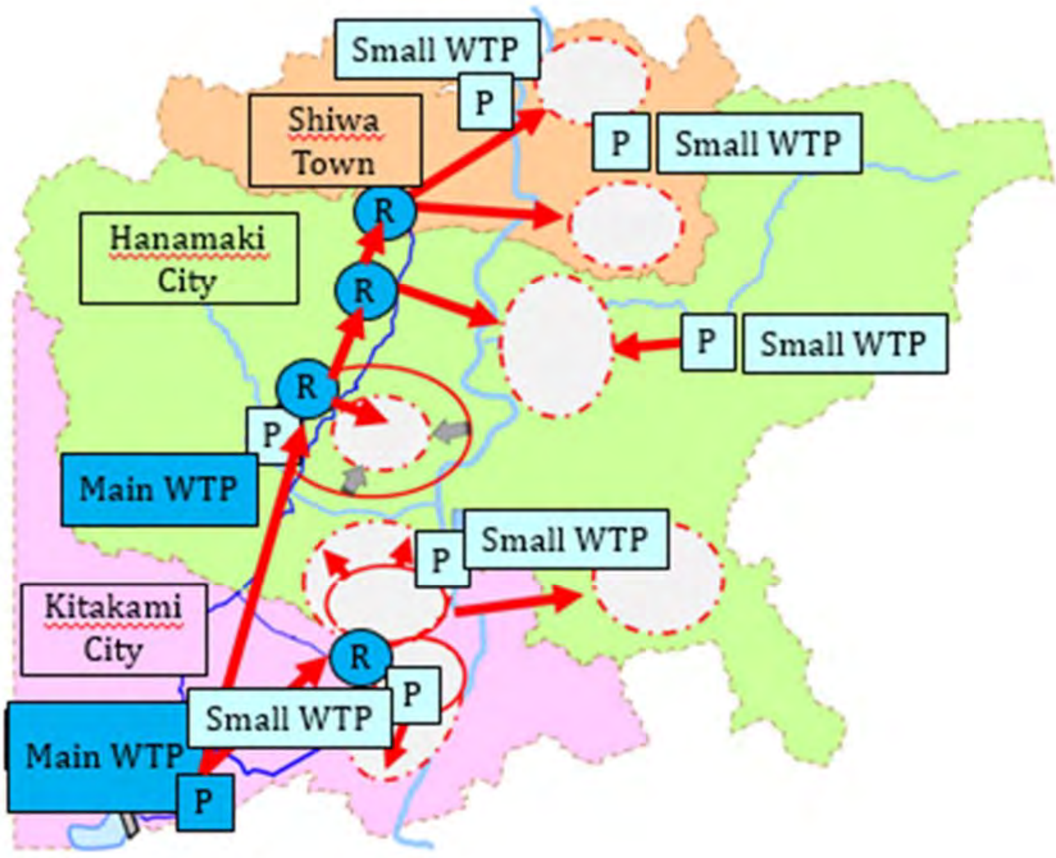
Source: Kitasorachi Water Supply Authority, *About tariff of Bulk Water Supply in Japan*, http://www.kitasorasui.or.jp/ryoukin.html

Figure 4. Bulk Water Supply and Water Tariff

Bulk water supply was initially started to improve management efficiency and the quality of service. Benefitting from economies of scale, participating utilities can deliver the water supply at a higher service level. It emulates the British system which consolidates operations for sustainability. However, the system is not practical when utilities have huge gaps in water source availability and are run independently by their own municipal governments as in Japan. Therefore, partial consolidation in terms of securing water resource and supplying bulk water was promoted. Bulk Water Supply Authorities were founded accordingly.

Bulk water supply improves the long-term management of the water source, stabilizes source water and cuts operational and maintenance costs. On the other hand, the distribution is not a part of this operation and does not benefit from these advantages. When the water demand does not increase as initially projected, the investment cost for the dam and water treatment plants becomes a financial burden to the entire organization. Small scale utilities could lose critical mass of their technical staff because of the segmentation of the operation. It is desirable to manage bulk water supply and distribution in an integrated way to avoid these pitfalls.

Regional collaboration of water utilities used to be initiated by the Bulk Water Supply Authorities in Japan. Recently, some water utilities, such as the Iwate Chubu Water Supply Authority, have been merged into one water utility through voluntary discussions among some municipalities, to review and revise their overall operation and distribution system to look for more efficiency in water source management and water supply service.



Source: JICA, Extensive Waterworks System in Iwate Central Region by vertical and horizontal integration, *Integrated Water Resource Management (A), Knowledge Co-Creation Program Textbook.*

Figure 5. An Example of Water Supply Integration

*Iwate Chubu Water Supply Authority is an example of the consolidation of utilities. The Authority closed and merged some facilities and selected the best water source. It also reduced risks of transmission pipeline accidents by the introduction of pipeline looping.

4. Treatment Process and Water Quality Control

(1) Chlorination

Access to safe drinking water is essential to public health. Utilities successfully use chlorination to control microorganisms in tap water to prevent the spread of waterborne diseases.

Safe drinking water is one of the most important factors in preventing outbreaks of waterborne diseases. Chlorination eliminates pathogenic microorganisms in drinking water to safe levels without requiring sophisticated skills or large energy input. It is an extremely important technology for developing countries.

In Japan in the early 1900s, waterborne diseases were spread by the water supply before disinfection was practiced. Yodobashi Water Treatment Plant of the Tokyo Metropolitan Government Bureau of Waterworks introduced chlorination for the first time in Japan in 1922. The practice was not widely adopted at that time and was only used when there were disease outbreaks.

The effectiveness of chlorination was recognized after World War II (WWII) when the hygienic status became poor. The General Headquarters at the Supreme Commander for the Allied Power (GHQ[4]) enforced and supported the practice by providing chlorine agent.

During the same period, soldiers returning from overseas after the war brought back dysentery which spread across the country. Believing that the epidemic was caused by water, there was opposition against the development of water supply. The Water Supply Act was enacted in 1958 and established drinking water standards. The Ordinance for Enforcement of the Water Supply Act made chlorination mandatory and promoted the public water supply as a safe measure. Outbreaks of waterborne diseases reduced dramatically, and the foundation of public health was established.

Flush toilets became commonly used even in rural areas and Johkasou (Japan's on-site treatment systems for domestic wastewater) were installed during high economic growth period. However, Johkasou treated only night soil and not grey water at that time. As population increased rapidly, this rudimentary wastewater treatment was insufficient and the discharge of highly polluted wastewater into the environment was contaminating surface water. There were

[4] GHQ is an agency established in Japan by the Allies to enforce the Potsdam Declaration at the end of the World War II on August 1945.

incidences of diarrhea, food poisoning and waterborne diseases mainly in areas without water supply system. Water supply in these areas was urgently needed to overcome public health concerns.

Disinfection by chlorination has contributed the drinking water supply but can be problematic. Chlorine can react with naturally occurring organic compounds and form disinfection by-products. It can also stimulate corrosion of water distribution facilities such as pipes.

Handling and storing of chlorine in the gas phase is dangerous because of its strong corrosive potential and can be fatal for the workers if it is inhaled. Therefore, sodium hypochlorite is generally used in Japan. Sodium hypochlorite should be stored below 20°C to reduce its rate of decomposition.

Customers may find the odor of residual chlorine in the tap water unpleasant. Residual chlorine in the water supply may produce carcinogenic by-products such as trihalomethanes, so the countermeasures are necessary.

In spite of the drawbacks, chlorination contributed to the significant decrease of waterborne diseases and infant mortality after WWII. There is no doubt that chlorination plays an important role to acquire safe water in Japan.

On the other hand, the legal requirement to chlorinate the water supply created an over-reliance on one particular disinfection method at the expense of other treatment processes. In 1996 there was an outbreak of cryptosporidium, whose oocyst was highly resistant to chlorine disinfection.

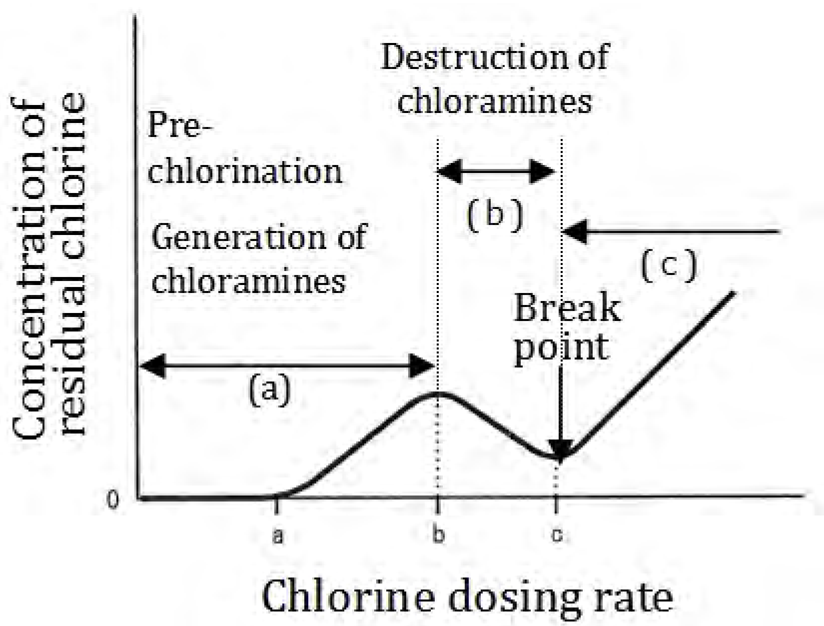
A research study around 2000 looked at alternative disinfection methods. Ultraviolet light and chlorine dioxide were introduced in the last couple of decades. However, their application is limited because chlorination is still the legal requirement for drinking water safety.

Column: Water Treatment Using Chlorine Prior to Filtration

While chlorine is mainly used for disinfection, it is also effective for the removal of algae and ammonia. When chlorine is injected in water containing ammonia, chlorine is consumed rapidly and chloramine is generated. The treatment method to inject chlorine at a higher dose to degrade chloramine and generate free chlorine is called break point chlorination. Due to the degradation of source water quality after the mid-1960s, large utilities adopted pre-chlorination to remove ammonia and algae.

Osaka City experienced a large consumption of oxygen in the slow sand filtration system because of the high concentration of ammonia in the source water. The city shifted to rapid sand filtration, break point chlorination and disinfection by chloramines.

Manganese can also cause water quality problem. Manganese can be eliminated almost completely through oxidation using chlorine and rapid sand filtration. The sand is coated with a layer of manganese dioxide.



Source: Ministry of the Environment, Government of Japan, *Testing Method Set by the Minister of the Environment Based on Item 2 of Article 5 of the Ordinance for Enforcement of the Act on Special Measures concerning Water Quality Conservation at Water Resources Area in Order to Prevent the Specified Difficulties in Water Utilization*, http://www.env.go.jp/hourei/05/000188.html

Figure 6. Break Point Chlorination

Column: Standards for chlorine concentration

The third clause of Article 17 of the Ordinance for Enforcement of the Water Supply Act establishes the following standards for chlorination:

Chlorination must achieve a residual concentration of free chlorine of ≥ 0.1 mg/l (0.4 mg/l in chloramines) for effective disinfection at the point of use. In case there is the risk of contamination by pathogenic organisms, large number of organisms or substances suggestive of pathogenic organisms, the residual free chlorine should be 0.2 mg/l or higher (1.5 mg/l or higher for chloramines) to eliminate the risk.

The injection dose of chlorine proposed by GHQ immediately after WWII was for residual chlorine at ≥ 2.0 mg/l. This was extremely high and was gradually reduced to the current standard as the quality of treated water improved.

The exceptionally high concentration of residual chlorine was proposed by the US Navy based on sanitation management in a developing country. This is a reminder that conditions in one country can be very different from another. Adopting a practice from another country must be carefully considered and adjustments may be necessary.

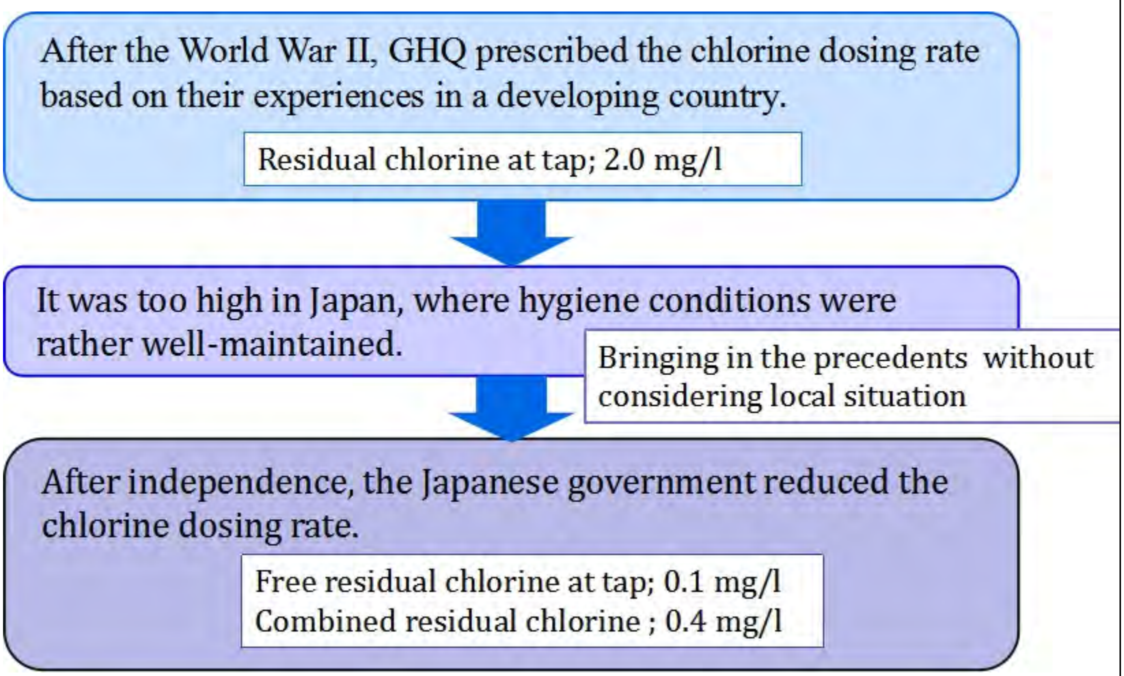


Figure7. Determining an Appropriate Standard for Residual Chlorine

(2) Selection of Treatment Process

Water may be treated differently in different places depending on the quality of the water that enters the treatment plant. Adaptation to environmental conditions, technical knowledge and training skilled workers are essential considerations in choosing the appropriate treatment processes and for managing their operations.

It is important to assess and characterize source water quality, identify the treatment options accordingly and finally select the appropriate treatment method.

Japanese utilities study the volume and quality of water sources to select the most appropriate intake point. Data collection over 5 or more years is conducted with considerations for seasonal variation throughout the year. Utilities also work with treatment facility construction companies to set up pilot facilities to evaluate treatment processes. They also monitor the effectiveness of the treatment processes up to a year after completion of plant construction, making adjustments if necessary to achieve optimal performance.

The quality of raw water has a direct impact on the smooth operation of the treatment processes. Water quality and temperature in dam reservoirs can be different at various depths. When it rains, turbid water can flow onto the reservoir surface. Depth adjustable intake facilities are a practical design solution for selecting less turbid water. Intakes should be located upstream of wastewater discharges and oil booms should be deployed around the intake for stable source water quality and water treatment.

Water treatment must be designed for local conditions and the technical capability that is available. Small utilities in rural communities with limited capabilities must start with a good water source to minimize treatment requirements. In addition, education and training of engineers are also important to understand the natural condition of the place of operation and to be able to select suitable treatment processes.

(3) Slow Sand Filtration

Slow sand filtration is an adequate treatment process if the raw water is relatively clean and stable but it requires a large area for the facilities.

Slow sand filtration uses biological treatment and is also known as the "Ecological

Purification System". It is different from the physical separation in rapid filtration. It is simple and requires little chemicals or electrical and mechanical equipment. It was the most commonly used treatment system when modern waterworks were introduced in Japan.

The basic processes of slow sand filtration system are removal of suspended solids by gravity in the sedimentation tank and sand filtration at slow velocity, around 4 – 5 m/day in Japanese standards. The filtration rate can be faster if the raw water turbidity and viscosity are low and the biological film is more active such as in tropical/subtropical areas. Miyakojima City Waterworks Bureau operates slow sand filters at 7 m/day, as it is located on the southern island in a subtropical area. When biological activity is not inhibited, the filter can remove not only suspended matters and bacteria but also a certain amount of ammonia nitrogen, odor, iron, manganese, synthetic detergent, and phenols.

Slow sand filters differ from all other filters in that they have a complex biological film that grows naturally on the surface of the sand filter. The surface biofilm is a gelatinous layer that provides the effective purification. The underlying sand and particles of foreign matter trapped on the surface of sand filter provides the support medium. Sludge is formed with organic substances and nutritious salts which are adsorbed into the suspended solids on the surface, as the water passes through the sand. Then, algae, soluble organic material and nutrient salt are trapped and adsorbed in the biofilm. The contaminants are metabolized by the bacteria, fungi and protozoa and these together form a filtration filter. This filter has functions of screening, absorption and biodegradation. In addition, the biofilm is effective for removal of odor. As it is principally biological treatment, the facility should be designed so that sunlight can reach the surface of biofilm and sufficient oxygen must be available. In operating the system, flow should be carefully controlled and inflow of toxic matters and mud should be minimized. A pre-filter can be used if the turbidity of the raw water is too high.

This method requires long treatment time, large area, and low turbidity in the water source. The treatment process has to be suspended periodically to scrape off the surface layer of sludge when the filtration resistance becomes high. Many utilities switched to rapid sand filtration when land acquisition became difficult because of urbanization. Other reasons for switching include pollution of raw water and increasing water demand.

But slow sand filtration system still has its advantages. In 2011, Public Enterprise Bureau of Shimane Prefecture constructed the Mijiro water treatment plant with slow sand filtration at 35,000 m^3/day.

Example: Yanagasaki Water Treatment Plant, Otsu City Public Enterprise Bureau

Otsu City Yanagasaki Water Treatment Plant, the principal water treatment plant of the city, was constructed in 1948. It has a 15,000 m^3/day slow sand filter. This was expanded to 27,000 m^3/day during 1960-1965. With growing water demand, a 30,000 m^3/day rapid sand filter was completed in 1973.

There is no complaint in the area served by the slow sand filtration system even though raw water from the Lake Biwa tends to cause odor because of water quality deterioration. Biological contact filtration was added to the rapid filtration system in 1998 to control odor.

Source: Otsu City Public Enterprise Bureau, Main water supply facilities

http://www.city.otsu.lg.jp/kigyo/about/water/1454032216393.html

Photo 6. Yanagasaki water treatment plant, Otsu City Public Enterprise Bureau

(4) Rapid Sand Filtration

The basic method for water treatment is solid-liquid separation, which removes turbidity from water. In the early days of construction of water supply systems in Japan, slow sand filtration was used for treatment of small volumes of relatively clean raw water. Coagulation, sedimentation, and rapid sand filtration became the mainstream treatment technology when demand increased.

The basic method for water treatment is solid-liquid separation, which removes turbidity from water.

In the past when utilities used groundwater or water from the upper watershed that had less turbidity, chlorination was often the only treatment required in Japan. Many utilities sourced from groundwater that have less turbidity and distribute it after chlorination.

It was common for the water utilities, which could intake surface water from upstream, to choose slow sand filtration process, because upstream water contained less turbidity.

As utilities required larger intakes to meet increasing demand, their intakes shifted downstream. Treatment processes were introduced to deal with more polluted and turbid water sources. These include coagulation, flocculation, sedimentation, and rapid sand filtration. Rapid sand filtration is a physical purification method that provides rapid and efficient removal of relatively large suspended particles. The factors for determining the treatment process of choice include: ability to treat fluctuating levels of turbidity; area available for setting up the treatment facility; and if the treatment process can work with break point chlorination for the removal of ammonia. The advanced water treatment systems are introduced for the urban areas where rivers are more polluted.

Example: Application of Rapid Sand Filtration for Lake Biwa Aqueduct

The rapid sand filtration together with coagulation, flocculation and sedimentation were introduced for the first time in Japan at the Keage Water Treatment Plant in Kyoto City in 1912. The Lake Biwa Aqueduct Projects [with the first aqueduct (1890) and the second aqueduct (1912)] were extremely ambitious projects which introduced various new challenges such as bulk water, canal, and power generation for the first electric trams in Japan. It was also the important turning point for the waterworks by being the first to use rapid sand filtration system.

Source: Waterworks Bureau, City of Kyoto http://www.city.kyoto.lg.jp/suido/page/0000158305.html

Photo 7. Keage Water Treatment Plant

Many large utilities use the coagulation-flocculation-sedimentation and rapid sand filtration process for various reasons:

- Land cost in major cities became high. It was also difficult to acquire a large land. That was why water treatment plants with slow sand filtration in Tokyo were mostly located outside the city. Rapid sand filtration requiring less space became the method of choice.
- Around 1960, river water had high turbidity and the river channels where affected by sedimentation. Extraction of construction materials from river beds also caused high turbidity. Rapid sand filtration is suitable for the removal of high turbidity. With the development of dams and the prohibition of gravel extraction, turbidity is now less of a problem.
- The Yodo River system experienced increased levels of ammonia in its source waters due to contamination in 1958. The large oxygen demand created anaerobic conditions in the slow sand filtration, causing iron and manganese to re-dissolve. Water turned red and black when chlorine was added. Break point chlorination was introduced to remove ammonia and odor when slow sand filtration no longer worked. Rapid sand filtration became the most common treatment technology. Developing countries may have to deal with similar situations when the pollution of water sources worsens.
- Coagulation-flocculation-sedimentation technology was regarded as the most advanced technology after WWII. The leading waterworks introduced the technology together with rapid sand filtration when water sources became more polluted. Other utilities adopted the technology to keep up with the advances.

The coagulation and sedimentation process has evolved through trials and errors. The following part explains about high-speed coagulation-sedimentation system, which has been less used as the water treatment methods change, and development of coagulants.

In the high-speed upflow type coagulation-sedimentation process, large flocks are formed efficiently with the presence of existing flocks in the source water. This makes the sedimentation process more effective in the sedimentation tank where the main water flow is upwards. This method was introduced in the 1950s because it is compact and it can treat a large quantity of water at relatively low cost. The operation of the high-speed process requires highly skilled workers compared to the horizontal flow sedimentation process. The high-speed process has lost some of its appeal after the introduction of inclined plate and tube-type settling equipment for horizontal flow sedimentation. At present, high-speed upflow coagulation sedimentation is rarely used, because more strict turbidity removal is needed for removal of cryptosporidium which is resistant to chlorination.

The choice of coagulants has changed with technology development. In Japan, polyaluminium chloride (PAC or PACl) developed around 1967, is effective over a broad pH range. This quickly replaced for aluminum sulfate, domestically and around the world. Organic polymer coagulants, often used overseas, are not popular in Japan because the safety of the product was not confirmed when it was introduced. Although its safety has now been proven, its use never picked up.

Example: Changes from Slow Sand Filtration to Rapid Sand Filtration in Osaka Municipal Waterworks

The water supply system of Osaka City was built in 1895. Its water source was the Yodo River. It was the fourth modern water supply system at that time after Yokohama, Hakodate and Nagasaki. 51,240m^3/day at 80l/capita/day was supplied without water treatment. To meet increasing demand, Kunijima water treatment plant (151,800m^3/day) with slow sand filtration was built in 1914. Water quality was very good (general bacterial concentration was less than 100 cfu /100 ml) and chlorination was not needed before WWII.

After WWII, chlorination was introduced. The destruction of upstream forest during the war caused landslides when there was heavy rainfall. High turbidity in the river became a problem. To solve this problem, Osaka Municipal Waterworks Bureau examined some types of coagulants and improved valves for dosing coagulants. Then, the problem was eased with the restoration of the upstream forest.

Around 1955, organic matters and ammonia in the water started to increase. Water intake was suspended when water suddenly turned black and there were fish die-offs in 1958. From 1960 to 1962, water quality worsened. At first, the mechanism of this situation was not clear but later turned to be that heavy rain had flushed out large amounts of anaerobic, decayed organic contamination from the bottom. At first, there were objections to introducing chemical treatment because all the filters at that time were slow sand systems. However, by 1958, small amounts of chlorine and aluminum sulfate were regularly injected into sedimentation tanks as a pre-treatment to slow sand filtration to stabilize the water quality.

10 mg/l of dissolved oxygen (DO) is required for the nitrification of 1 mg/l of ammonia. When ammonia nitrogen is high, nitrification occurs in the filtration layer and the oxygen becomes depleted, making the bottom of the filtration layer anaerobic. Under such conditions, the iron and manganese become reduced, ionized and re-eluted. The addition of chlorine produced ferrous oxide and manganese dioxide causing the red and black colored water.

In 1962, break point chlorination was introduced as a treatment prior to slow sand filtration, and solved the problem of the odor and taste, iron and manganese. Before this, chlorine in rapid sand filtration was only used for disinfection.

The elution of manganese and iron accumulated in the slow sand filtration tank can be an issue, when oxygen level dropped due to the rise of water temperature and worsening of water quality in summer. The city investigated and considered aerating the raw water. However, as it was unclear how the water quality may change, rapid sand filtration was used instead during 1969 to 1974, after discussions with the water and sewerage utilities. The system was introduced together with pre-chlorination to remove manganese and iron.

(5) Advanced Water Treatment

Serious pollution causes musty odor which is difficult to remove with conventional water treatment processes. Japan developed advanced water treatment systems that use a combination of technologies.

As the pollutant load increases, eutrophication occurs and the deterioration of water source quality accelerates. When ammonia and nitrogen loads become significant in the initial stage, break point chlorination and other treatments offer certain level of removal. As eutrophication continues and odor caused by algae becomes serious, it becomes difficult to treat water with conventional water treatment. Advanced water treatment technologies have been introduced, which combine processes such as activated carbon treatment (adsorption removal), ozone pre-treatment and biodegradation mainly for the treatment plants, which source in downstream river.

Column: Introduction of Advanced Water Treatment Technology

The Yodo River System faced pollution of water sources after the war. The increase of pollutant load in the Yodo River system was due to insufficient sewage treatment, characterized by the rise in ammonia concentration. Break point chlorination was used to remove the ammonia.

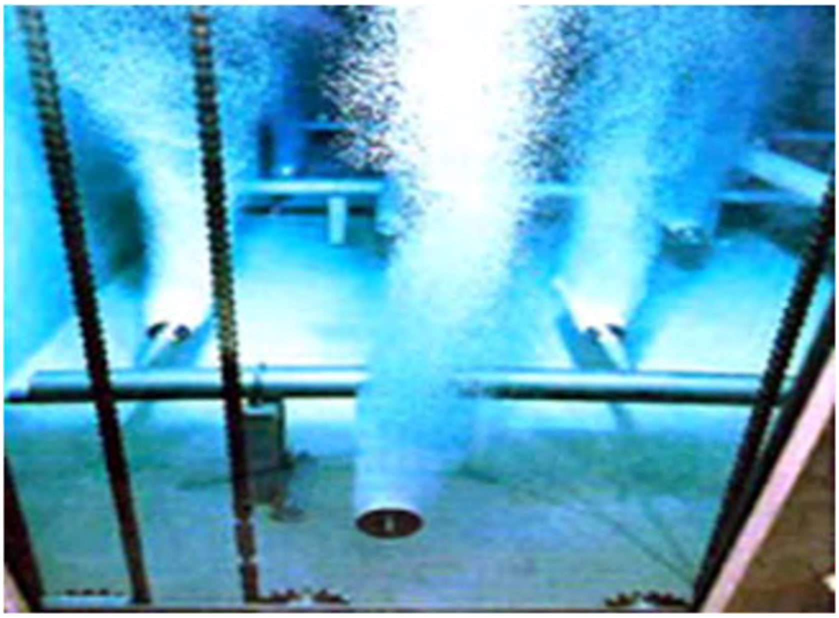
At that time, eutrophication of lakes became a serious problem in Japan, Biwa Lake, the source of the Yodo River System, was no exception. In 1971, algae bloom caused eutrophication in the river flew down all the way to the water intake. The moldy taste came from abnormal growth of algae, caused by eutrophication of the entire watershed. Break point chlorination alone could not treat it, and degradation or adsorption process had to be employed.

To tackle the problem, research was carried out on biological treatment and ozonation. In 1973, the first ozonation plant was built in Amagasaki City. Activated carbon was introduced and used in combination with ozonation to ensure complete removal of taste and odor.

In the Kanto region, the combination of ozonation and activated carbon treatment was introduced at the Kashiwai water treatment facility in Chiba Prefecture in 1980. These cases initiated the research on advanced treatment processes.

The high investment cost held back the use of advanced treatment processes at the beginning. However, as social concerns over carcinogenic by-products of chlorination emerged, utilities discussed applying advanced treatment processes only for drinking water and distributing the drinking water separately from water for other use. They also discussed about supplying bottled drinking water.

In the end, advanced water treatment was used because it was deemed important to reduce the organic substances in the water purification process to minimize by-products of chlorination. Nowadays, the comprehensive efforts in water resource conservation have stabilized water source quality. The advanced treatment methods considered earlier were attractive when at the time, it was difficult to know if the source water quality could be improved or not.



Source: Tokyo Metropolitan Government Bureau of Waterworks,

https://www.waterworks.metro.tokyo.jp/suigen/topic/13.html.

Photo 8. Ozone contact basin

Advanced water treatment improves odor and taste of the treated water and reduces the risks caused by organic substances. Safe and tasty water plays a critical role in winning the citizens' trust in the water supply.

(6) Membrane Filtration

Membrane filtration can be easily automated, thus requires less labor input. It is mainly introduced at small and medium utilities in Japan. It is assumed that application of the method will increase around the world.

The principle of membrane filtration is the removal of substances by a pressure driven membrance separation process. Coagulants are added as a pre-treatment in some cases. The advantages of membrane filtration technology include: requiring less space, little maintenance and manpower, easy to control, and automate. In Japan, they are ideal for mountainous areas, where the raw water has low turbidity but is contaminated with protozoa from wild animal excrement. On the other hand, no economy of scale can be expected as it is joining membrane modules.

Source: Waterworks Bureau, City of Kyoto

http://www.city.kyoto.lg.jp/suido/page/0000160981.html

Photo 9. Membrane filtration facilities,
Water supply system for Kuroda area in Kyoto City

There are different types of membrane filtration for water treatment: microfiltration (MF), ultrafiltration (UF), and reverse osmosis (RO). Microfiltration and ultrafiltration are physical separation of suspended matters. They are differentiated by the size of the pores of the membranes. Ultrafiltration uses smaller pores and can remove viruses, but requires higher pressure than microfiltration. Reverse osmosis is used for desalination.

In Japan, industry, government and academia collaborated in developing the next-generation of water supply technologies under the MAC21 (Membrane Aqua Century 21) research project (1994-1996). Establishing membrane filtration technologies was one of the projects implemented under the plan.

Desalination of seawater or brackish water is expected to increase around the world, because it has already defused especially in areas such as the Middle East where water resources are scarce, or where there are not many trained workers. If membrane filtration is broadly promoted and the cost comes down, this technology is expected to become one of the main options for water treatment in developing countries.

(7) Water Reuse

In Japan, reuse of treated wastewater for flushing toilets or for industrial purposes is widely employed. Water reuse can be an option for developing countries where water resources are scarce.

Water reuse is use of recycled water such as sewage water treated with advanced water treatment process.

Sewage water is treated and discharged to the watershed for natural purification and used again in a downstream basin. This type of "indirect reuse[5]" is common and widely used. On the other hand, the element technologies of treating sewage water for "direct reuse[6]," such as biological treatment and ozonation are already established and technically possible. However, it is not practical to achieve drinking water quality because of the high energy cost. There is also some non-acceptance by users because of cultural and religious constraints, so its use is still extremely limited on a global basis.

In Japan, "direct reuse" is not in place for drinking water purpose. Uses for industrial purposes and for toilet flushing are reasonable targets. Especially in regions where groundwater use is strictly regulated (e.g. Tokyo) because of land subsidence or where water resource is scarce (e.g. Fukuoka City), reusing water is enforced and proactively utilized as "middle water" (the water quality is in the middle of potable water and wastewater, not for drinking but can be used for other purposes).

Many countries experience extreme water shortage. In China for example, it is estimated that they require water for "indirect reuse" five times more than in Japan to meet the demand. Advanced water purification such as microfiltration (MF) / reverse osmosis (RO) membrane can be options in such cases. For water to be fed in boiler, treated water with RO could be of better choice than drinking water. In Japan, as there are relatively rich water resource, these options are considered to be extremely rare. But water shortage will force developing countries to explore various options.

(8) Wastewater Treatment

In Japan, utilities have to comply with the effluent regulations for discharging treated wastewater to public waters. Water treatment plants have processes to treat sludge from sedimentation facilities and backwash from filtration units. The treatment system usually consists of thickening, dewatering and drying processes. Wastewater is now rarely discharged to public waters. It is usually treated and reused.

Sludge is produced from suspended solids removed from raw water. Backwash from cleaning the filters is another source of waste from the water treatment process. In Japan, the water treatment plants which have a capacity larger than 10,000m^3/day, with sedimentation and filtration systems are regulated by the Water Pollution Control Act. They have to install a

5 An example of "indirect reuse" is taking treated wastewater, which was discharged into a river, as raw water.
6 An example of "direct reuse" is using wastewater from flush toilet for flushing again.

wastewater treatment system to meet standards for effluent discharges to surface waters.

First, the sludge concentration of wastewater is adjusted at the filter backwash clarifier or the gravity thickener, then turned into thicker sludge so to make the following dewatering process easy. The skimmed water can be sent back and used as raw water again, but the water quality should be tested carefully as it may contain concentrated dissolved matters which may have an impact to the treatment process.

The thickened sludge is dewatered mechanically or naturally. Mechanical methods include vacuum filtration, pressure filtration and centrifugal separation. Solar sludge drying beds utilize natural wind and/or sun for dewatering.

The dewatered sludge cake or water treatment generated soil, is used for landfill or for manufacturing cements, reclaiming playgrounds or producing agricultural compost.

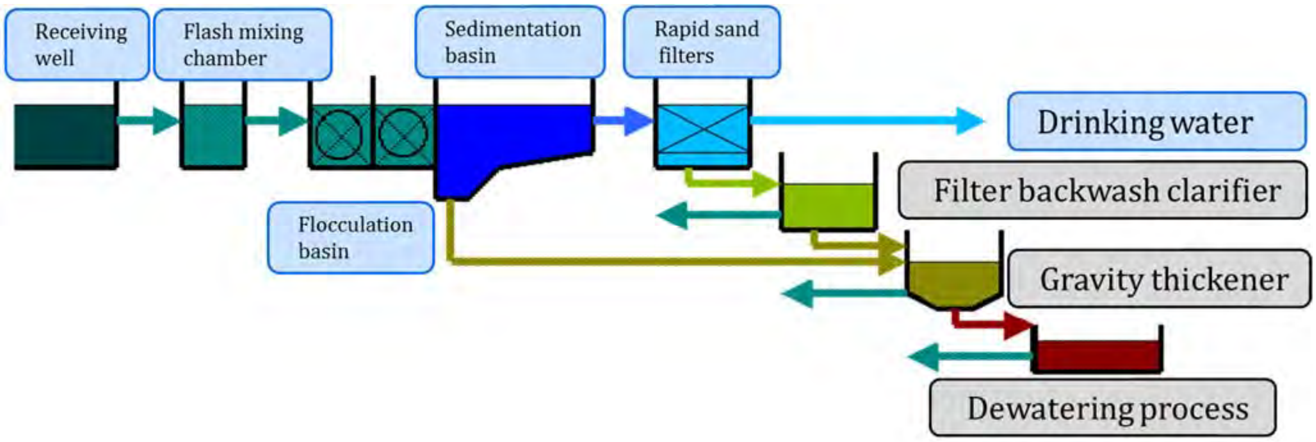


Figure 8. Wastewater Treatment System

5. Groundwater Use and Prevention of Land Subsidence

(1) Groundwater Use

Clean good quality groundwater is an excellent water source. However, quality of groundwater and the operation and maintenance requirements must be carefully assessed.

Japan has relatively abundant water resources, and spring water and groundwater has been utilized since ancient times. Many utilities, especially small scale ones use groundwater sources. But surface water has taken the place of groundwater in urban area which is located on alluvial plain, to avoid land subsidence.

There are wells that draw shallow groundwater and artesian wells that tap deep aquifers. Japan has developed unique techniques for digging deep wells without machines, radial collection well that extract shallow groundwater efficiently, and some excellent strainer and screen products for efficient intake from wells.

Photo 10 shows an example of rich groundwater as the source of drinking water. Photo 11 shows an example of traditional water grids, which is not a source for water supply utility, but is utilized as a community water source from springs for drinking, and other domestic purposes.

In many cases groundwater is an excellent water source. Kumamoto City and other many utilities distribute groundwater after only chlorination. However, in some cases, utilities have problems such as contamination from the surface of the ground, or pollution of iron and manganese. Some groundwater contains pollutants which may cause serious problems such as arsenic poisoning. Water quality testing before intake must be carried out to avoid utilization of such sources. In case there is no other water source, appropriate water treatment process should be adopted and water quality should be managed carefully.

In using groundwater as source, maintenance cost is required for well washing and monitoring for groundwater level. Well screens will be clogged up by changeover time.

Photo 10. Takizawa Village, Iwate Prefecture.
Ubayashiki Water Sources (December 2, 2010).

Photo 11. This spring water is currently used in Morioka City.
Traditional water grids which are separated for drinking, washing and other purposes from the upstream (November 23, 2010).

(2) Prevention of Land Subsidence

Some areas of Japan experienced serious land subsidence. This is under control mainly by introducing strict regulations for pumping groundwater and providing alternative sources by development of surface water and industrial water supply.

Land subsidence occurs naturally but can also be induced by human activities. The mechanism of land subsidence can be determined from hydrogeological surveys. It is important to determine the cause. If it is human-induced, measures must be taken to prevent its occurrence, such as: (1) investigate the hydrogeological features for clay layer which will cause consolidation and settlement; (2) monitor water level and pumping volume of every aquifer; and (3) avoid pumping more than the amount of natural recharge. Japan has a broad observation network and strong regulations to restrict over abstraction of groundwater. In establishing the regulations, efficiency and social acceptance are also considered by restricting pumping only large amount pumping from the layer which has the greatest impact on land subsidence.

In addition, it was important to develop alternative water source such as industrial water supply to reduce the reliance on groundwater. Land subsidence is well controlled by implementing these measures.

Column: Land Subsidence in Japan

Larger quantities of groundwater were extracted with the development of pumps and drilling technologies, causing land subsidence. Land subsidence was recognized for the first time during the survey after the Great Kanto earthquake in 1923. Similar findings were reported in Osaka and Nagoya. The problem was not much reported again until after the end of World War II (1945) as the pumping discharge of groundwater declined during the period. Land subsidence caused many social problems in eastern Tokyo, Osaka City and eastern Saitama Prefecture, etc. in the 1950s. Strengthened groundwater use regulations and development of alternative sources for industrial water has successfully prevented most land subsidence and the groundwater level recovered. Land subsidence is no longer a serious issue but still occurs in some areas.

6. Distribution Systems

In the early days, water distribution systems were developed as dendritic (tree) systems in a disorganized manner with little or no documentation of their locations and connecting points. Pipeline capacity was not clearly understood. The poor management became a serious problem when the system had to be expanded. Therefore, new pipelines were constructed to go around old networks and unitedly formed pipeline network in response to the expansion of urban area. This provided stable service with equal water pressure and fewer water stoppages.

After the 1970s, distribution networks become more sophisticated with the block system. The system allows the adjustment of water pressure in the distribution pipelines and flexible water supply operation. It is desirable to design the system from the earlier stage with future vision of developing the block system.

(1) Water Distribution System

Distribution systems such as service reservoirs, pumping stations and pipelines are very costly, adding up to 2/3 of the total investment of the water supply facilities. Therefore, planning with long-term vision and efficient design are very important.

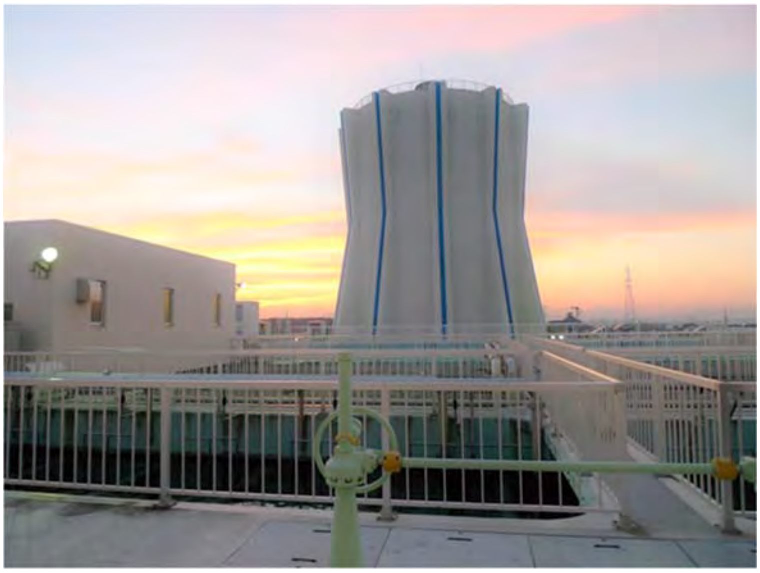


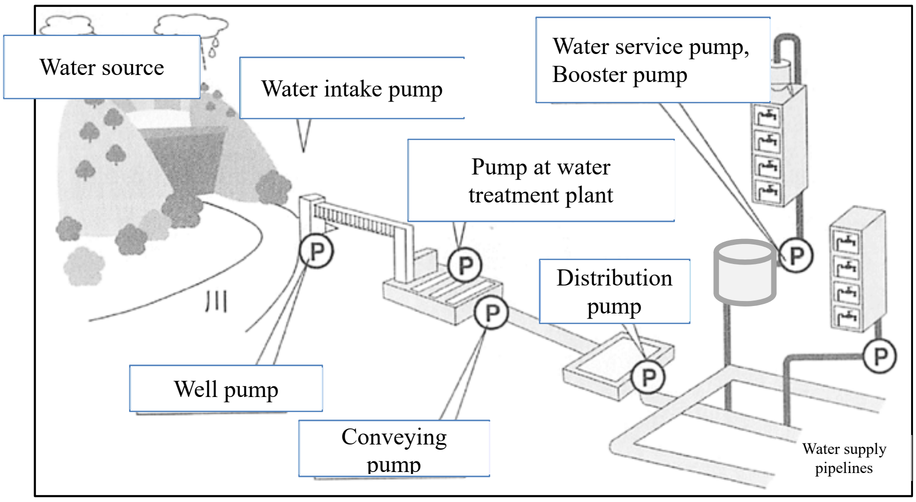
Photo 12. An elevated tank at the Hakusan Water Treatment Plant Hachinohe Region Water Supply Authority. (October 29, 2010).

Ideally, distribution reservoirs should be built on hillsides to take advantage of gravity. Otherwise pumping is required for flat areas.

For vast flat areas it is necessary to use elevated tanks with storage capacity that can provide the required water pressure in the distribution network. The facilities should also be earthquake resistant in Japan, making their construction rather expensive. Elevated tanks are less used nowadays, because pumping technology has been improved and the water supply system has been equipped with enough capacity of distribution reservoirs. Water distribution systems can now send water under pressure with constant pumping without serious problems.

Distribution tanks must be designed with careful estimation of long-term demand and the appropriate distribution system, since their water level ranges are fixed once they are built.

It is necessary to understand pumping technology and water hammer control to distribute large volume of water. Water hammer can cause serious damage to the distribution system. Therefore, surge tanks, pumps with flywheels and other surge prevention measures should be considered in the design phase.



Source: Water Partners Jp Co., Ltd., "Fundamental knowledge of water supply pumps", Water Solution and Technologies, No.15, 2012.

Figure 9. Example of Water Distribution System and the Use of Pumps

(2) Pipeline Configuration

Water distribution pipeline gradually evolved from the facility, which simply distributes water, to the system, which has the function of controlling water flow and pressure forming organic network and consisting with distribution blocks.

The requirement for water distribution pipelines has been evolved by 3 stages: (1) investment cost efficiency (the most effective diameter for dendritic (tree) system that pipes are arranged in a tree-like form), (2) operational efficiency (network systems which enables flexible operation and minimizes the impact of accidents), and (3) management efficiency (block system with remote monitoring and control called Supervisory Control And Data Acquisition, SCADA).

At first, distribution pipelines were constructed as simple dendritic system. This system is relatively inexpensive, and it is easy to locate leaks. However, as it follows a single route, water pressure fluctuates depending on the demand. In addition, service stoppage can be long as repairs must be done before service can be restored.

The concept of distribution network existed before the 1940s, but it became widespread after the 1960s when water supply was promoted and expanded. Houses were firstly constructed near main roads and rivers, and then spread into a wide area including hilly terrain. Network system was formed through interconnecting existing service areas with other pipelines when distribution capacity was expanded for the service areas spread widely. The other reason of introducing network system was limited capacity of tree system. In Japan, a fire-hydrant is required for every 2,500 habitants. The pipe sizes in a dendritic system were not enough to handle water for firefighting.

Other events that prompted the shift to better distribution networks include liquefaction observed after the Niigata earthquake in 1964, Fukuoka City drought in 1978, and water pressure problems in Sendai City and Kobe City with undulating landscape. Every utility had its own reason to introduce the block system.

With the cost of information technology declining rapidly, water distribution management can make use of remote monitoring and control (or SCADA) to regulate the water flow in pipelines and to detect leakage.

On the other hand, still many utilities do not have the sufficient management capacity to deal with pipeline information, such as pipe age, type, repair and accident records. Improvement of network management by further applying information technology will be implemented with mapping system, asset management based on assessment of soundness of network and smart meters.

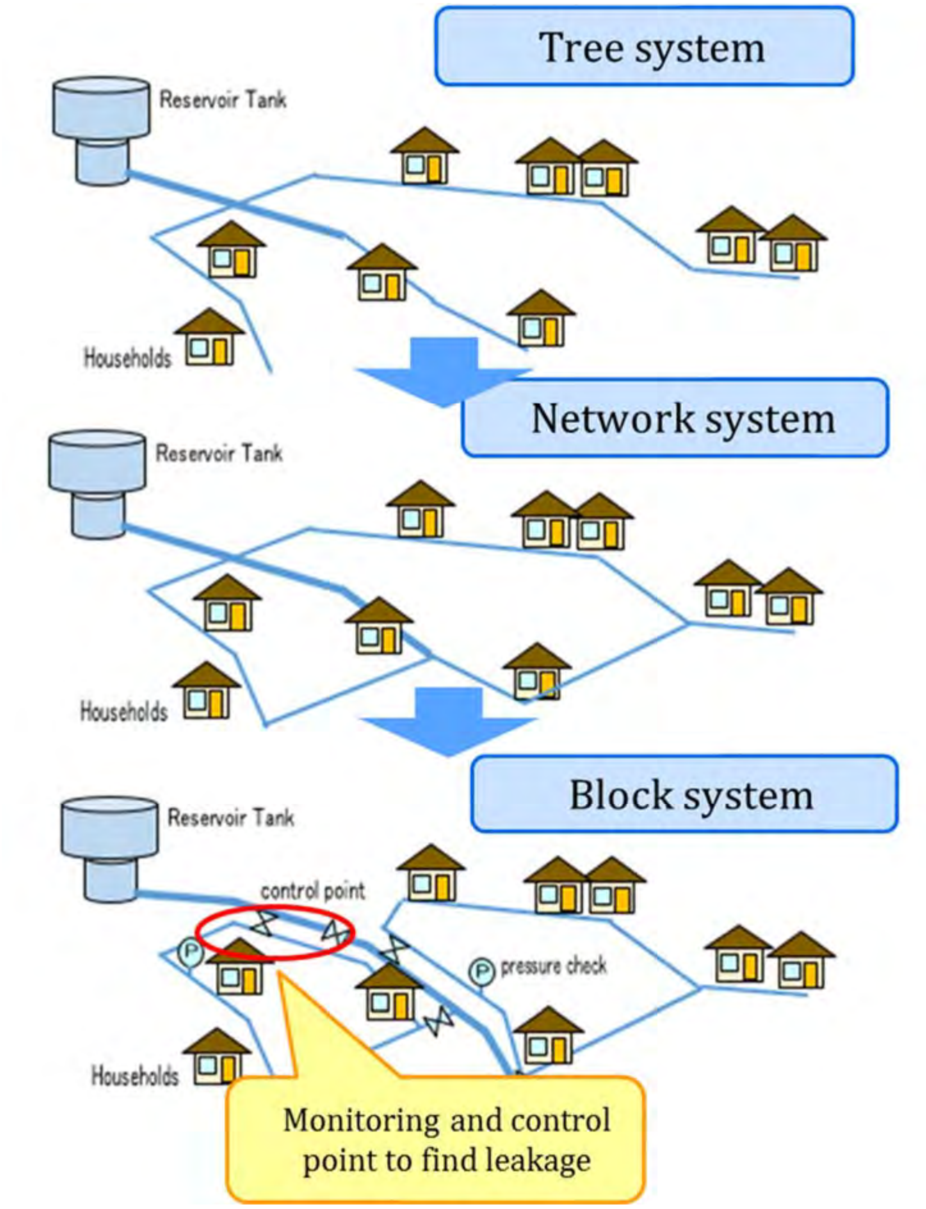


Figure 10. Dendritic System, Water Distribution Network and Block Distribution System

7. Engineering Design and Master Plans

(1) Importance of Engineering Design Standards

The core idea of water supply is to secure safe water supply by properly operating and maintaining facilities, which are properly designed and constructed. Standards for water supply facilities are specified in the Water Supply Act.

In Japan, engineers had frequently faced difficulties in designing water facilities when the network started to be established. Utilities needed to share their experiences with others. Japan Water Works Association (JWWA) played a central role in the initial development of the water supply systems. It became the repository of accumulated technical knowledge from its member utilities, and was instrumental in the preparation of the design criteria and facility standards.

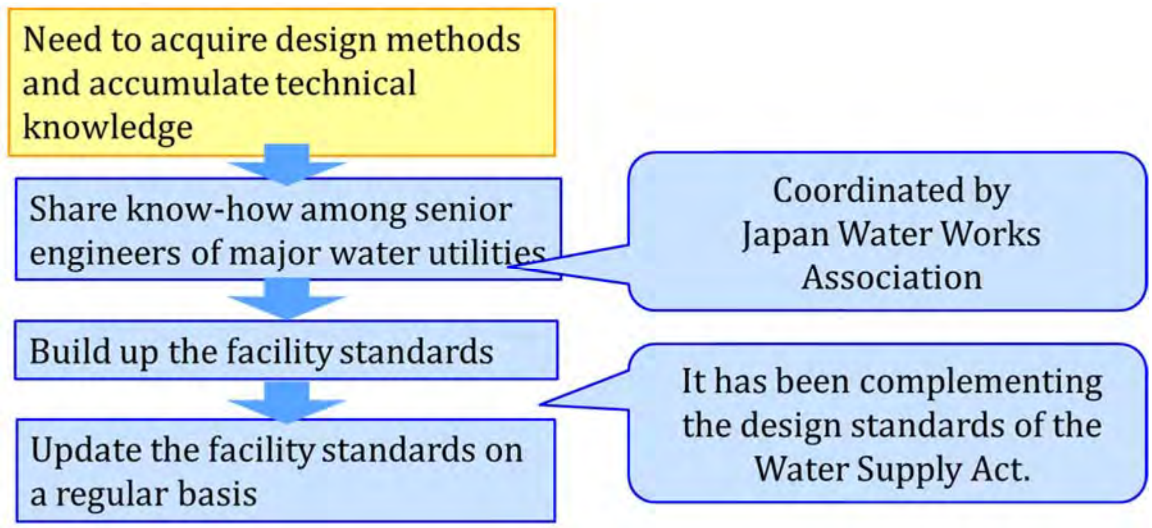


Figure 11. Engineering Design Development in Japan

(2) Updating Design Concepts

Design philosophy of water supply facilities should fit the social and physical environment of the country. As Japan is an earthquake prone country, the design of water supply facilities and equipment has been improved based on experience with past earthquakes.

In Japan, technical standards for public facilities originally focused on constructing substantial structures, which were earthquake resistance such as ability to withstand 5 intensity earthquakes (Japanese earthquake scale). However, after the Niigata earthquake in 1964, there were extensive liquefaction and severe damages to water supply pipelines. Since then, many technical studies were carried out on earthquake resistance of water pipelines. In 1973, the studies on preparedness for the Minami Kanto earthquake prompted the design of a chain-like structure with connectors that can flex with ground movements, leading to the standardization of earthquake-resistant pipelines.

Following the Hanshin-Awaji Earthquake in 1995, which occurred directly underneath a metropolis, various ingenious attempts were made to develop earthquake-proof water supply facilities. This experience brought improvement of seismic design based on classification of ground motions into two levels, and minimum amount of water to be stocked for drinking and firefighting even in water outages, then they became a part of the guidelines for earthquake countermeasures thereafter.

As a result of these efforts, not many water supply structures were damaged during the Great East Japan Earthquake in 2011 considering its intensity and multiple impacts from the tsunami. While the damages were as anticipated, the destruction of aged pipelines which were not earthquake resistant was quite extensive. It is very difficult to preserve the integrity of pipelines buried in the ground over a broad area. More discussion is still taking place to decide how to make pipelines earthquake-proof.

(3) Importance of Expansion with Proper Planning

The development of water supply requires enormous investment and funding is always limited. The master plan is a very useful tool for managing funds and forecasting revenue for expansion. In Japan, a master plan is required for obtaining the Approval (License) for operating the utility and for securing financial resources.

To expand the water supply coverage, it is necessary to broaden the distribution area. More facilities have to be built continuously. Public funds must be procured from governments, and revenue will cover the expense on facility expansion once operations started.

Investment in urban water supply in Japan has been funded by municipal bonds and investment, and subsidies from the national government.

A master plan is needed to secure the investments through an approval process involving the local assembly and also requiring the understanding and support of the residents. The master plan is also needed to gain national subsidies or funds.

The master plan is also critical for determining the cost recovery of the entire operation (from securing water sources, to treatment, transmission and distribution). In Japan, a water supply system was first developed in relatively small urban centers due to the financial constraints with establishing a complete set of facilities and management system including tariff collection to secure management foundation. Then it was gradually expanded to the surrounding areas. The planning and management of every expansion must be worked out in the master plans to ensure cost recovery and sustainable operations.

Development of urban water supply can be constrained by the scarcity of water sources and progress can only be made as water sources are allocated, in spite of demand pressures. Plans have to be reviewed frequently as water resource, urban planning as well as industrial development can change. Gradual expansions in accordance with demand growth and the concept of cost recovery to cover the construction cost by tariff revenue enabled continuous investment to maintain a sustainable water supply.

Rural utilities use their limited funds for renewal of facilities. The financial constraints force them to use inexpensive materials. They do not use the public enterprise accounting system and have to manage their operation with the assistance of the prefectural government. They are necessary for universal coverage but their sustainability is a big issue at present.

(4) Approval (License) System and Complementary Frameworks

The Water Supply Act stipulates that utilities must obtain Approval (License) to operate water supply systems. The approval process requires the submission of a master plan. In the early stage of expansion when utilities were not yet technically sophisticated, the approval process contributed to prevail appropriately designed water facilities.

The facility standards and the Approval (License) system specified in Article 6 of the Water Supply Act are important pillars in the development and management of the water supply systems. The Approval (License) process clearly states that utilities serving populations of over 50,000 have to be approved by the Ministry of Health, Labour and Welfare, and those serving populations of less than 50,000 by prefectural governments.

The application must provide information on demand projections, facility plan and fiscal plan (including proposed tariff structures), i.e. the preparation of a master plan is always required. The application for Approval (License) for small scale utilities is also used to determine eligibility for national subsidies.

Each prefectural government had special divisions in charge of Small Scale Public Water Supply, with staff devoted to the design and approval process. There was not enough technical expertise to manage the responsibilities even with personnel transfers of engineers from a construction division to a public health division. Later, affiliated organization and private companies were contracted for planning and designing, but their workforce was insufficient to meet the demand of Small Scale Public Water Supply at that time.

Small utilities prepare their plans based on the assumption that they have limited human resources and that they must seek good quality water sources. They also have to secure the services of local businesses for the repair of water supply pipelines. The Plumbing Constructor's Association was established in various regions as a result of this development.

The Approval (License) process is very effective for small scale utilities which have insufficient technical ability to maintain good quality of the service. It is essential that developing countries take the initiative to develop their own plans and not just follow proposals led by donors.

It is noted that Approval (License) is required only for new or expansion projects. Since Japan has achieved nationwide coverage, this process is taking place less frequently. Therefore, the national government urges water supply utilities to prepare Water Supply Vision and Water Safety Plan, and implement asset management, by introducing guidelines and tools for them, emphasizing operation and maintenance and facility renewal. Water Supply Vision defines the method to assess utilities and their challenges, forecast future business environment, determine future vision for local waterworks, set operational targets, monitor performance and conduct reviews.

Utilities have to prepare annual management plans (annual budget), based on the Local Public

Enterprise Act. The local assembly has to scrutinize and approve these plans, as a means to validate the efficient and effective operation of the water supply business. These plans and their monitoring complement the Approval (License) system, which is effective for the era of construction and expansion and not for the era of operation and maintenance.

8. Lessons Learned

The following Japanese experience could be useful for other countries.

- **(Selection of Water Source)** It is ideal if pristine water sources can be used for drinking water supply. This is especially important for small- and medium-scale utilities that are in short of human resources and technical capabilities.
- **(Surface Water Development)** The water rights system and Comprehensive River Development are effective for developing water resources. It requires cooperation of stakeholders, negotiations and sometimes conflict management. Dam construction is expensive, so that municipalities needed to get together and work with other users and river authorities on multipurpose dam construction. They also organized to secure bulk water supply.
- **(Chlorination)** Chlorination contributed a lot to the supply of safe drinking water. However, it has some disadvantages including: production of disinfection by-products, formation and corrosion of equipment.
- **(Rapid Sand Filtration)** The coagulation, flocculation, sedimentation and rapid sand filtration process is often used to treat highly polluted raw water. The choice depends on the quality of the raw water and water demand. Many utilities use this method to treat large volumes of polluted water especially in urban area, which usually located at downstream.
- **(Dealing with Source Water Deterioration)** Japan developed technologies and new approaches to deal with challenges of water source pollution and drought. These include advanced water treatment, membrane filtration and wastewater reuse. Although new technology development requires large investments, it can produce high quality waters to win public support for the water supply.
- **(Prevention of Land Subsidence)** Japan faced serious land subsidence due to over-pumping of groundwater in some regions. This problem is under control by strictly regulating groundwater abstraction, providing alternative water sources, and monitoring ground and groundwater levels.
- **(Transmission and Distribution Systems)** The investment for transmission and distribution systems accounts for two thirds of the total investment cost of the water supply system, so that it is important to plan and construct distribution reservoir, pumps and pipelines efficiently based on the long-term plans. Japan has taken advantage of its

hilly terrain to build gravity flow systems to save money and energy and for easy control of water distribution.

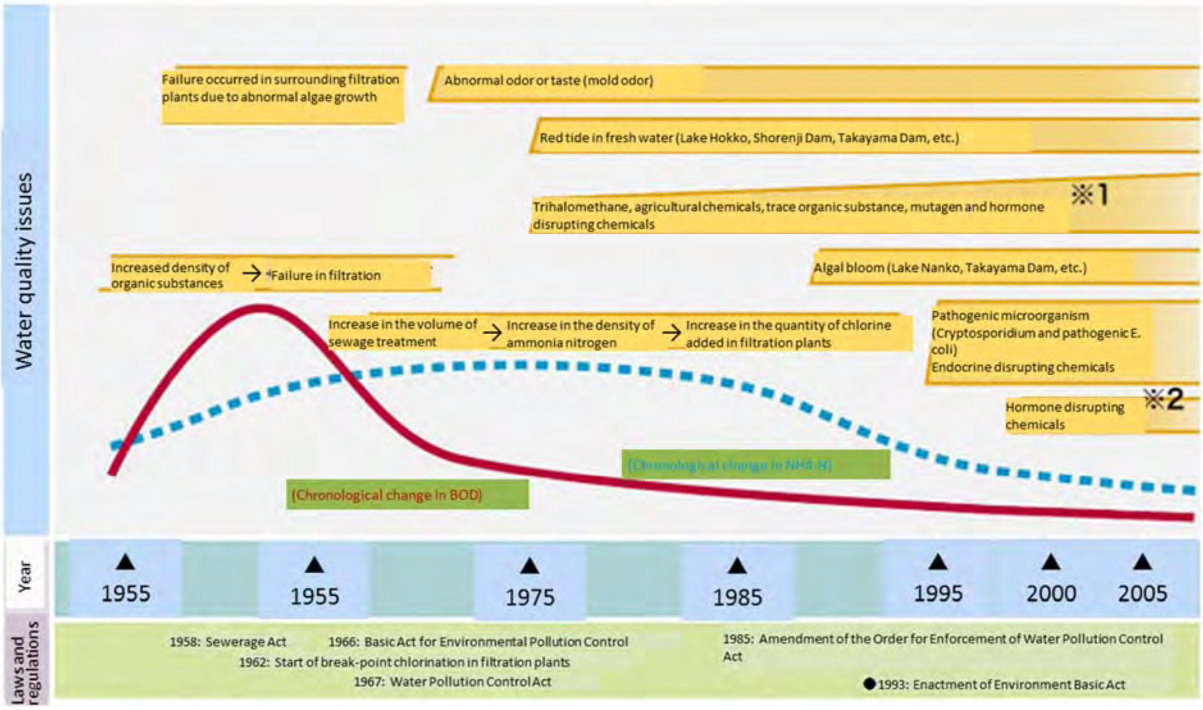
- **(Block Distribution System)** Distribution pipelines have evolved from dendritic systems, to network and block distribution systems as cities expand. The advanced designs provide better control of water distribution and minimize supply disruptions.
- **(Master Planning)** Japan expanded its water supply systems by well-planned and stepwise expansion to keep pace with population growth and water demand. This approach is effective for sound financial management of the utilities. Formulation of a master plan, which includes long-term projection of demographic and social changes, is effective in developing water supply system and improving water supply coverage.
- **(Approval(License) System)** The Water Supply Act stipulates the requirement for Approval (License) of utility operations, adherence to facility standards and appointment of a qualified technical administrator. These requirements set the high standard for water supply quality and sound business management. In addition, the national government is encouraging the preparation of Water Vision and Water Safety Plan to ensure technical stability of utilities. The preparation of annual business plans, which include budget plan based on the Local Public Enterprise Act, and the approval by the local assembly ensure sound business management.

Theme 3. Water Quality Management

Contents

1. Introduction

Japan has one of the safest water supplies in the world. Water quality management has been an important public health focus ever since the first modern waterworks started in Yokohama City in 1887. Utilities successfully dealt with every water quality change at water sources and have accumulated valuable experience in this field. This module explains the basic principles and importance of water quality management in water supply systems in Japan.



*1 Polychlorinated biphenyl (PCB) typically from wastes

*2 Priority chemical substances in SPEED '98 specified by the Environment Agency.

Source: Yodogawa River office, Ministry of Land, Infrastructure, Transport and Tourism, *Historical transition of water quality problem*, https://www.yodogawa.kkr.mlit.go.jp/know/data/problem/02/a.html

Figure 1. Water Quality Issues of Yodo River, a Source of Drinking Water for Osaka

Japanese utilities have a vast pool of knowledge and experience in water quality management and this module will answer following questions frequently asked from the participants of water supply training courses:

Q1. What measures were implemented to reduce the incidence of waterborne diseases such as cholera, which affected Japanese society in the past?

Q2. Why Japan could implement long-lasting water quality management?

Q3. What are the requirements for compliance with water quality standards for water utilities in Japan?

Q4. How has the good quality equipment required for water quality management been procured in Japan?

Q5. How has Japan dealt with the serious problems caused by deterioration of source water quality?

The following sections attempt to provide answers to these questions:

2. Importance of Water Quality Management (1) and (2) (Q1)
2. Importance of Water Quality Management (3) (Q2)
2. Importance of Water Quality Management (4) and 3. Drinking Water Quality Standards and its Compliance (1), (2) and 4. Drinking Water Quality Testing (1), (2) and (3) (Q3)
5. Standards for Water Supply Materials and Equipment for (Q4)
6. Preventing Deterioration of Source Water Quality for (Q5)

2. Importance of Water Quality Management

(1) History and Background on Water Quality Management

Safe drinking water is of utmost importance to public health. The Water Supply Act stipulates "water quality standards," "securement of appropriate water supply facilities" and "proper water quality management" to ensure that utilities appropriately manage secure and stable water supply from source through consumer.

The management of water quality begins from the water source through treatment and distribution to the taps of the customers.

Japan has been focusing on epidemiological safety in establishing modern water supply. The World Health Organization (WHO) defines safe drinking water as water that "does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages." The Water Supply Act established in Japan in 1957, stipulates detailed standards for the quality of drinking water and declaring that water quality management is essential for the water supply.

The Ministry of Health, Labour and Welfare (MHLW) developed the New Water Supply Vision in March 2013. Chapter 5 of the document on "Targeted Outcomes" states that "the ideal goal is to provide safe water supply by securing the best quality of raw water, treating the water appropriately, maintaining water quality in the pipelines and service connections and taking measures to secure proper hygiene of water wells so that all citizens can drink safe water anytime, anywhere." This clearly defines the concept of safe water and water quality management.

The Water Supply Act has a number of provisions concerning water quality. Article 4 on water quality standards specifies the requirements for "clean" water and the measures that should be taken to ensure proper operation and management of water supply facilities.

Article 5 sets out the Water Supply Facility Standards. Article 12 deals with supervision of construction work by a qualified engineer. Article 13 specifies the inspection of facilities and water quality testing required before commencement of operation. Article 16 states the structure and materials of service connection facilities shall be in accordance with the standards.

Article 19 specifies that a technical administrator must be appointed at each utility. Article 20 states the requirement for periodical and temporally water quality testing. Article 21 states the mandatory health checkup of workers. Article 22 lists disinfection and other necessary measures required for sanitary purposes. Article 23 defines the provisions on emergency suspension of water supply when health concerns arise.

These legislative requirements intend to safeguard public health by enforcing appropriate water quality management measures in every facet of the water supply system, from raw water intake to delivery at the taps.

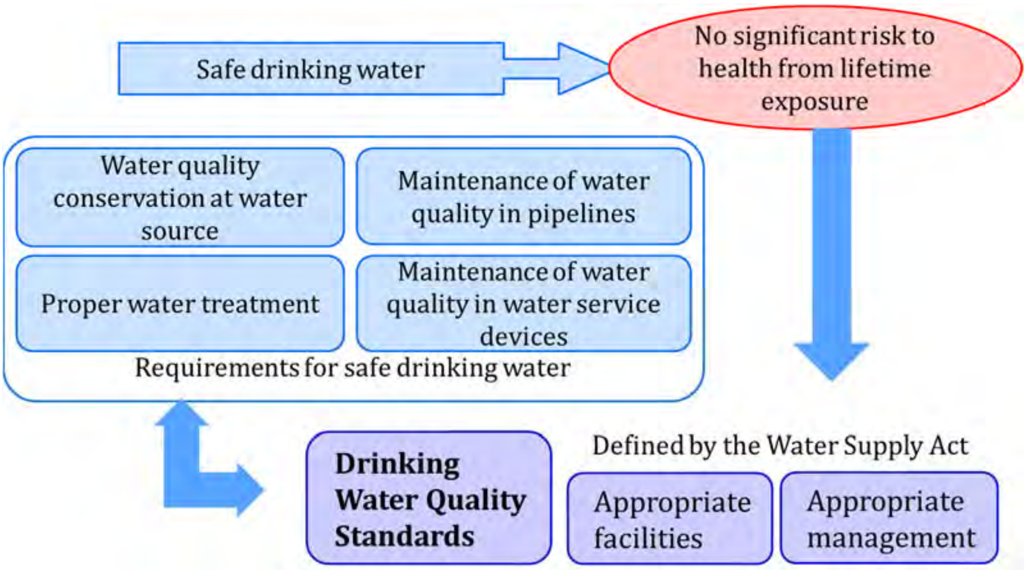


Figure 2. Concept of Water Quality Management

The Waterworks Ordinance (1890) clearly recognized that water supply development improves public health. The Health Department of the Home Ministry[1] was in charge of water supply at that time. In 1893, the responsibility was divided into two parts with the Health Bureau looking after the public health aspects, and the Engineering Bureau taking care of technical matters. In 1938, the Ministry of Health and Welfare[2] was established and its Public Health Bureau took over the public health portfolio. The technical responsibilities were eventually moved to the Ministry of Construction[3] after World War II (WW II). Over this long history and the changes in responsible authorities, the concern with water quality has always been managed from the perspective of public health.

After WW II, General Headquarters of the Supreme Commander for the Allied Powers (GHQ) ordered thorough chlorination of water as part of the treatment process. In addition, public health engineering was introduced in the National Institute of Public Health and staff of

[1] The Home Ministry was changed into the Ministry of Home Affairs in 1947, then it was merged into the Ministry of Internal Affairs and Communications in 2001.
[2] The Ministry of Health and Welfare was merged with the Ministry of Labour to form the Ministry of Health, Labour and Welfare in 2001.
[3] The Ministry of Construction was merged with the Ministry of Transport and two Agencies to form the Ministry of Land, Infrastructure, Transport in 2001.

water utilities and prefectures were trained on water quality management. In 1957, the Cabinet gave the Ministry of Health and Welfare the sole administrative responsibility for water supply. The Water Supply Act was enacted in the same year specifying a number of requirements regarding water quality management.

Column: Article 18 of the Water Supply Act

Article 18 of the Water Supply Act stipulates that customers have the right to request a utility to inspect service connection facilities and test water quality. This right entrenched in the Waterworks Ordinance demonstrates Japan’s commitment to water safety and public health.

In other words, the Act enacts the aim of water supply to contribute public health and indicates water quality standards, as it put great emphasis on the epidemiological safety of drinking water. Moreover, with the provision of the right to request water inspection by customer, the Water Supply Act require that utilities, even as public monopolies, must discharge their responsibilities to their customer with vigilance and provide the enforcement mechanisms to ensure that the water supply is safe and reliable at all times.

Safe water is guaranteed by law in Japan as summarized above.

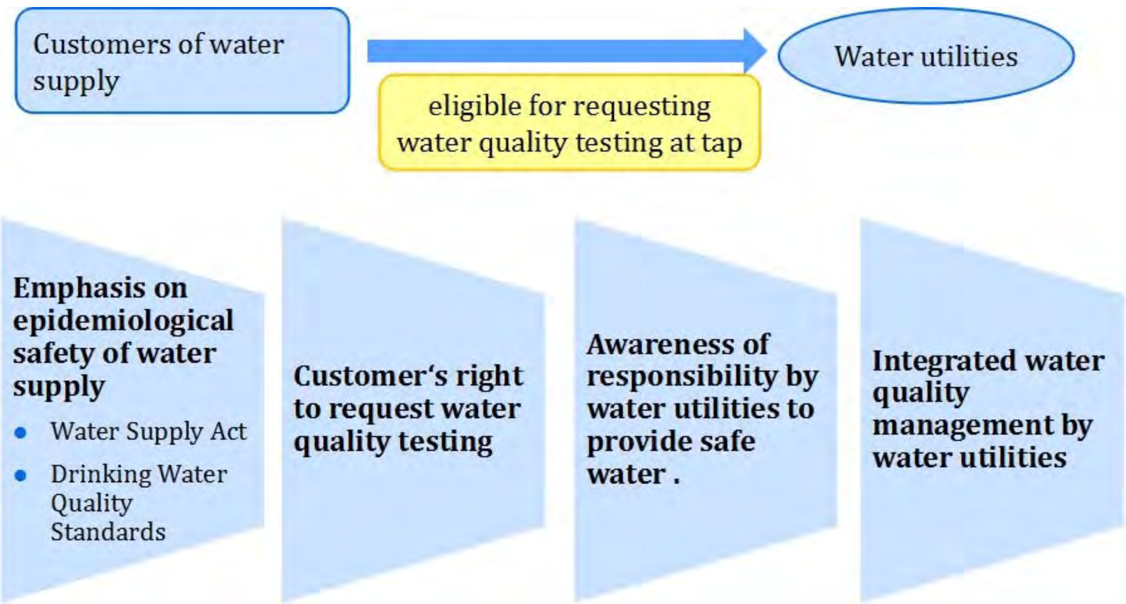


Figure 3. Implications of Article 18 of the Water Supply Act

(2) Water Quality Management System

Water quality is monitored at the water source, treatment plant, distribution reservoir and customers’ taps.

In Japan, water quality is checked at the water source, each water treatment process, distribution reservoir and customers’ taps.

Water quality can be affected by environmental conditions and human activities. The effects can be acute or long lasting. Water quality changes must be tracked and the causes and effects of the changes must be investigated. The parameters, which influence water treatment (such as turbidity and electrical conductivity) are automatically measured. Comprehensive water quality testing at the water source is conducted at least once a year even for groundwater, the source which is considered to be stable.

Water quality management in the treatment plant monitors the efficiency of the treatment to optimize the quantity of chemical injections and produce safe drinking water that will comply with water quality standards. Turbidity, pH, electrical conductivity and temperature are measured by automated instruments. Comprehensive testing is conducted about once a month.

At the distribution reservoir, turbidity, color, residual chlorine and pH are monitored by automated instruments for any water quality deterioration, and changes of air temperature and retention time. There are additional dosing facilities to inject more chlorine if the residual chlorine decreases because of change in temperature.

The purpose of water quality management on taps is monitoring the suitability for water quality standards. Water quality at customers’ taps is tested for residual chlorine, color and turbidity every day and tested once a month or once every three months for other items. Recently, automated measuring instruments have now replaced manual tests in some areas.

Since 2000, the Ministry of Health, Labour and Welfare (MHLW) conducts annual survey on proficiency testing to assess laboratory performance and verify the accuracy and reliability of test results of the registered water quality testing organizations. A total of 441 organizations were assessed in 2015. These are grouped as follows:

・Water quality testing organizations registered by the Minister of Health, Labour and Welfare (212 entities)
・Water utilities’ testing organizations who showed willingness to participate to the survey (175 entities)

・Local governments' laboratories who showed willingness to participate to the survey (54 entities)

The result of the survey with each organization's assessment and ranking in the proficiency testing is published. MHLW investigates the cause of any deficiency and recommends improvement for those with low result in statistical value ranging from 1.4 to 8.3%.

MHLW reviews historical water quality data when they revise water quality standards and waterworks management policies. Process data are also tracked and used as feedback for management of water source, treatment plant and distribution and supply departments within the utility. These data are utilized for water resource conservation, adjusting treatment processes and developing preventive measures for accidents.

(3) Costs of Water Quality Management

> Water quality management requires significant financial commitment which must be clearly stated in the utility's financial plan. Small-scale water supply systems can save on water quality management by starting with good quality water sources.

Water quality management requires significant financial commitment, e.g. costs for coagulant and electricity, testing, adjusting the treatment processes, equipment for water quality analysis and human resources development.

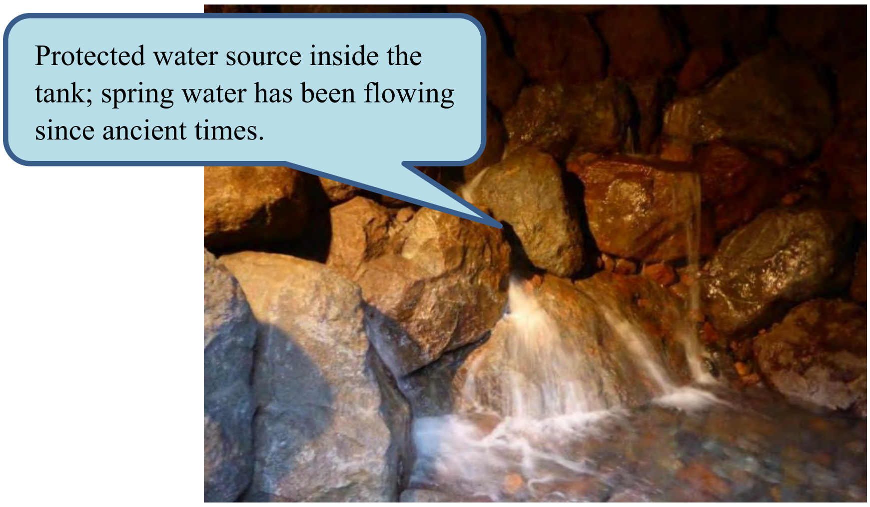
Figure 4. Costs Related to Water Quality Management

Utilities’ financial plans must include carefully considered costs for water quality management. These are then verified and approved by the supervising authority. This means that utilities need to estimate the costs accurately from the planning stage and ensure that the costs are recovered from the water tariffs. With limited revenue base and human resources, small-scale water supply systems start with good quality water sources and easily operated facilities to reduce treatment costs.

Column: Small-Scale Water Supply System Using a Water Source of Good Quality

If the source is surface water, a treatment process is essential. The treatment process and maintenance can be easy if groundwater or spring water of good quality can be used and care is taken not to contaminate the water source.

Using good quality springs as water source is acceptable for residents because they have been using such water sources since ancient times.



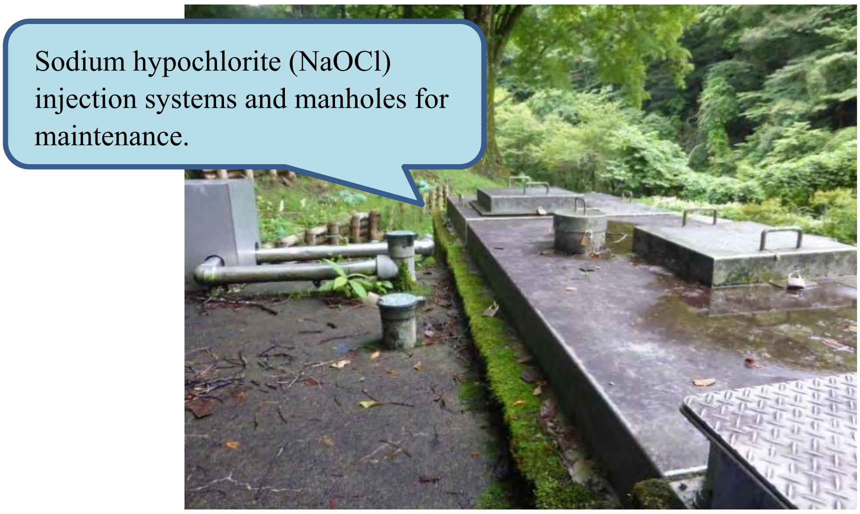


Photo 1. One of the Water sources in Hakone Town (September 18, 2015)

(4) Clarify Responsible Person for Water Quality Management

To appropriately manage water quality, a water utility needs to appoint a Technical Administrator. In addition, national and prefectural governments have administration systems to check water quality management. Small-scale utilities are supported by the administration systems.

Article 19 of the Water Supply Act requires that utilities appoint a Technical Administrator responsible for technical aspects of water supply management. The administrator has to inspect the facilities for compliance with the facility standards, test water quality, implement public health measures and suspend water supply if necessary.

A qualified administrator must have relevant formal training and adequate experience. The training course for qualification of Technical Administrators is offered by the Japan Water Works Association and completion of the course can compensate for lack of relevant experience (Article 19, Paragraph 3 of the Water Supply Act, Article 6 of the Order for the Act and Article 14 of the Ordinance for Enforcement of the Act). Water utilities appoint a Technical Administrator among those who are qualified.

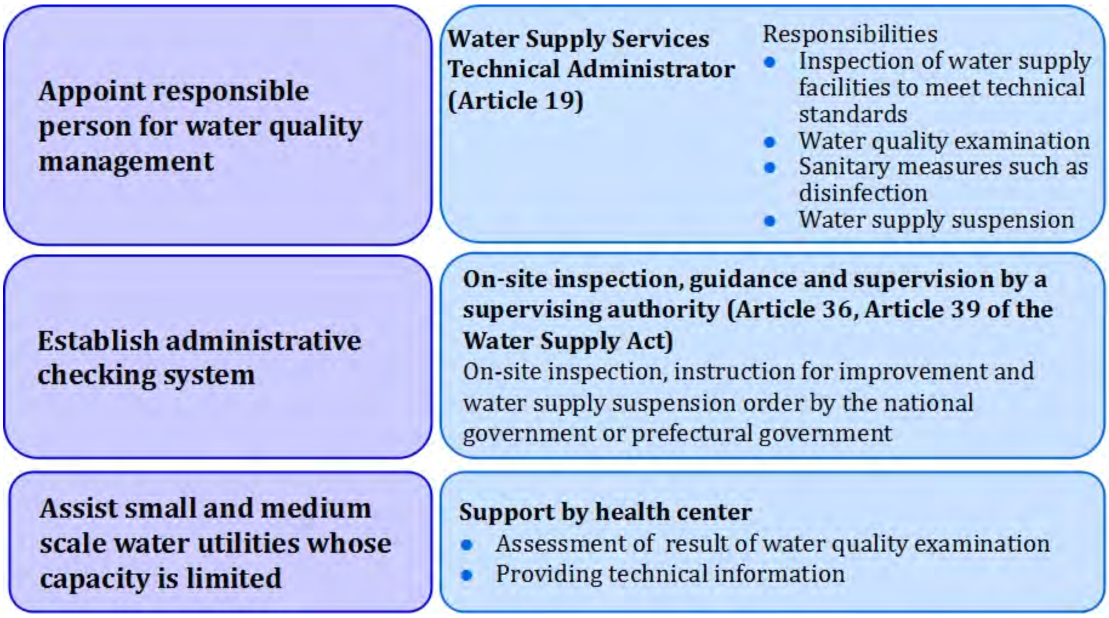


Figure 5. Framework for Water Quality Management

Site inspections by the Ministry of Health, Labour and Welfare (MHLW) and verification of the results of water quality testing by a prefectural health center are key steps in the overall management of water quality. If a water utility is judged to be not operating appropriately including its water quality management, it can be order to make improvements based on Article 36 of the Act. Water supply operations can be suspended based on Article 37.

The prefectural health center evaluates the results of water quality tests and provides technical advice on water quality. It plays an important role especially for small and medium scale utilities that do not have adequate technical expertise.

The key aspects to bear in mind when designing the water quality management system are: 1) clearly identify who is responsible for water quality management; 2) establish a system to verify that water quality is meeting the standards required by law; and 3) provide support for small and medium scale utilities to compensate for their inadequate expertise.

3. Drinking Water Quality Standards and its Compliance

(1) Formulation of Drinking Water Quality Standards

In Japan, water quality standards are established to be compatible with social demands (risk management level), natural environment and availability of testing instruments, while the focus is always on safety of drinking water. There is close to 100% compliance from Japanese utilities.

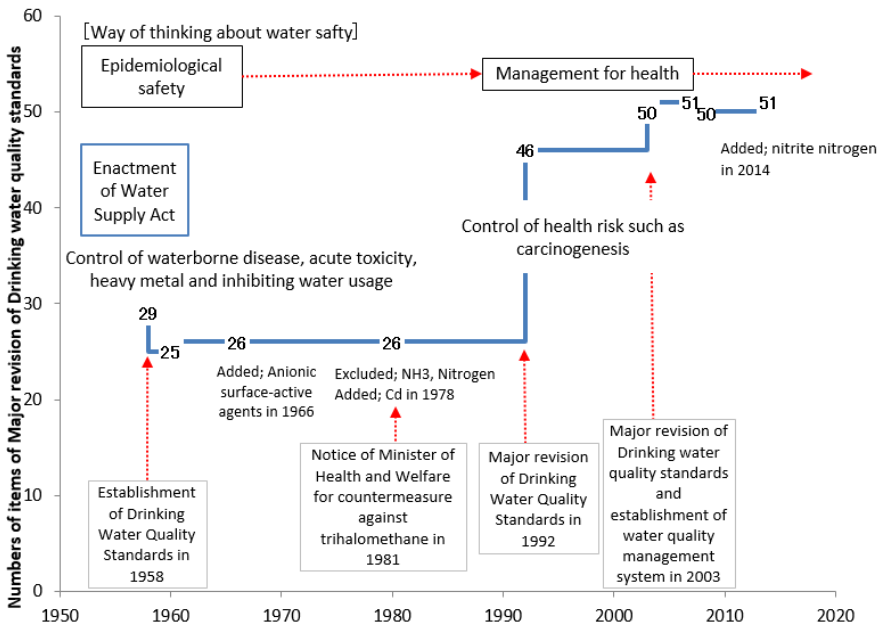
There are no international standards for drinking water quality. Many countries, including Japan, set their national standards based on their own environment and considerations. Countries without legislative or administrative frameworks for such standards usually follow WHO guidelines.

Japan has been establishing water quality standards with focus on safety, and to be suitable for its situation. The compliance of the water quality standards is almost 100%.

Article 4 of the Water Supply Act of Japan, stipulates the drinking water quality standards and Article 5 stipulates the facility standards required to achieve the desired water quality. The water quality standards in the first Water Supply Act stipulated two types of parameters in drinking water; that obviously cause health risks and that may pose nuisances in daily use such as odor, taste and color. Water quality standards are designed to protect the health of the most vulnerable members of society by setting the maximum acceptable concentrations of harmful substances determined on a scientific basis. The acceptable daily intake of contaminants is multiplied by a safety factor to avoid any possible health hazard. The maximum acceptable concentrations of non-health related qualities can vary depending on the local circumstances. For example, the *WHO Guidelines for Drinking Water Quality* specify the pH range of 6.5 to 8.5. Japanese standards set a lower range between 5.8 and 8.6 because the country has a lot of volcanoes and some of its water sources have this level of acidity. Very few countries adopt pH as low as 5.8 which can be highly corrosive.

Japanese standard for manganese has been 0.05 mg/l since 1992. The WHO guideline value has changed over time; it was 0.4 mg/l, then lowered to 0.1 mg/l in the second edition (1993) and "no guideline value" in the third edition. Manganese often reacts with residual chlorine to form manganese oxide which forms a black coating on pipes. Even concentrations of manganese < 0.05 mg/l may cause black precipitate which sloughs off turning the water black. 0.01 mg/l is determined as "Complementary Items to Set the Targets for Water Quality Management," which is items to be paid attention for water quality management other than the water quality standards’ value in order to ensure the safety of drinking water for the future.

The Water Supply Act was enacted in 1957 with replacing Waterworks Ordinances. Following that, the Ministerial Ordinance on Water Quality Standards was enacted in 1958. After three minor revisions that added and deleted some parameters, the Drinking Water Quality Standards (existing 26 parameters) underwent a major revision in 1992 (figure 6).



Source: Material prepared by Koichi Ogasawara

Figure 6. Changes to Drinking Water Quality Standards in Japan

To respond to newly recognized contaminants and disinfection by-products, the national government and relevant institutions issued notifications with interim indicators and testing methods, such as the following:

- 1981: Acceptable limits for and the measures to reduce trihalomethanes, which have carcinogenic properties.
- 1984: Provisional water quality standards for and measures to reduce trichloroethylene, tetrachloroethylene and trichloroethane, which are contaminants in groundwater, originated from organic solvents from high-tech plants.
- 1990: Provisional drinking water quality standards concerning agricultural chemicals used on golf courses.

The national government and relevant institutions have issued these notices every time when the items cause health problems had detected. These notifications provide additional protection against contaminants not covered by the standards in Article 4 of the Water Supply Act, thus ensuring the quality of the drinking water at all times.

Before the major revision in 1992, the water quality concerns were mainly focused on the control of waterborne diseases, inhibitory substances, chemicals with acute toxicity, heavy metals and the aesthetic parameters. The significant changes made in 1992 reflect the new concern for long-term health risks from carcinogens. The revision resulted in a set of water quality standards with 29 parameters which address health concerns and 17 parameters related to aesthetic characteristics of drinking water, which turned into 20 parameters as of 2016. Trihalomethanes, volatile organochlorine compounds, selenium and major agricultural chemicals used on golf courses, dealt interim with under former notification, were incorporated into the health standards at that time.

These transitions were due to the shift on public health issues at times. First, successful control of waterborne diseases was achieved, while the medical treatment against acute toxic matters improved. These resulted lengthening of lifetime in Japanese society, and the public concern shifted to focus on more timely problems; increased mortality by cancer. Therefore, it has been needed to strengthen water quality management to control carcinogenic agents.

Meanwhile, WHO issued the second edition of *the Guidelines for Drinking Water Quality* in 1993. The Japanese government while respecting the WHO Guidelines, reconciled these with the country's own natural environments and social characteristics. Japan focused on disinfection byproducts other than trihalomethane such as haloacetic acid, so the standard values for them were set. The Japanese standard values were set based on large number of testing data of water sources and treated water. If the testing data had been low enough compared to those of WHO guideline values, such items were omitted from the list of Japanese standards. After 10 years of careful review, the Japanese water quality standards were revised in 2003.

(2) Notifications about Drinking Water Quality

> Prefectural health centers and local authorities are important players in disseminating information on drinking water quality and changes to water quality standards.

Water quality standards concerning 25 - 26 parameters were established since 1958 until 1992. Additions and deletions of these parameters are announced through notifications as circumstances change. Utilities are informed of the changes by prefectural health centers and relevant local authorities. At times of major revisions such as those in 1992 and 2003, guidance and training sessions were organized to help utilities fully understand the changes. The dissemination of information on water quality as well as guidance and supervision of water utilities have been effective.

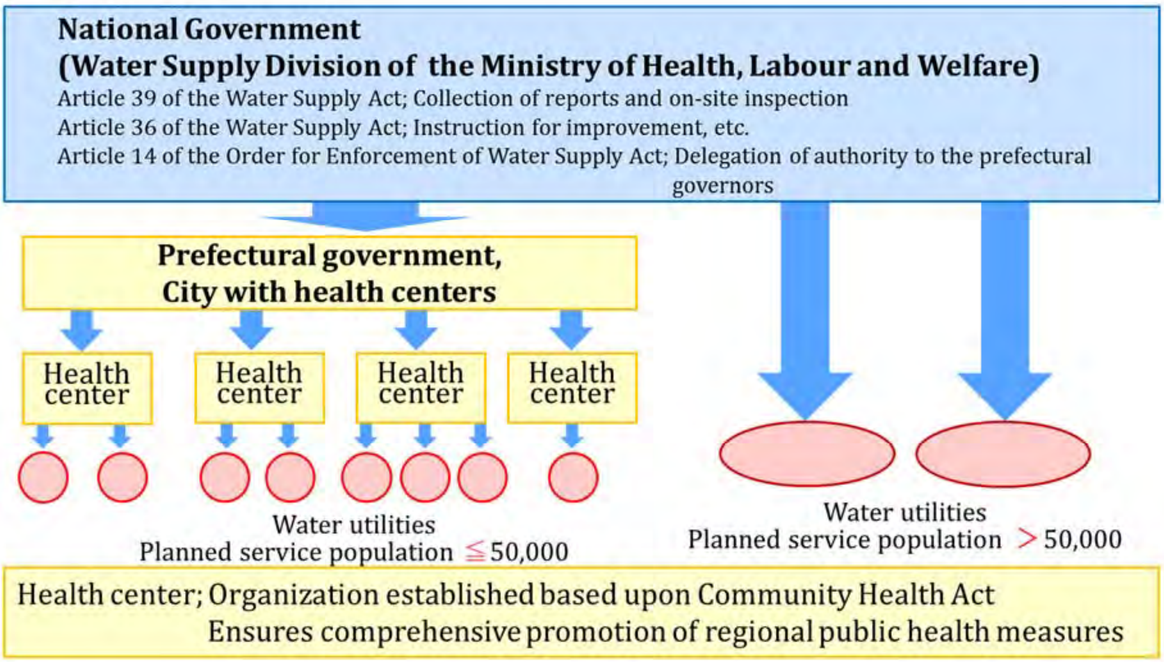


Figure 7. Administrative Framework for Water Supply

4. Drinking Water Quality Testing

(1) Water Quality Parameters and Analytical Methods

> The number of water quality standard parameters has increased from time to time to reflect social concerns and availability of analytical methods. Design of water quality standards requires viability of analytical methods.

Japanese water quality standards are revised by the following procedure: (i) Committee on Living Environment and Water Supply, Health Science Council of the Ministry of Health, Labour and Welfare (MHLW) sets some parameters and values based on WHO *Guidelines for Drinking Water Quality* and research papers on health effect surveys; (ii) some large utilities conduct continuous surveys of source water and purified water; (iii) the Committee submits the report, and new parameters are added when 1/10 of the values set by the Committee are observed at the survey; (iv) MHLW amends the water quality standards based on the report of the Committee together with the analytical methods. The measurements should have an accuracy within 1/10 of the standard.

Drinking water quality parameters measured in the early days involved the use of comparatively simple instruments and microbial tests. When new parameters were added they required more advanced instruments such as absorption spectrophotometers (the chemical reaction in a sample is measured by light spectrum) and mass spectrometers. Some parameters were omitted because they were rarely detected (1,1-Dichloroethene in 2004). A comparison of the instruments used today and in 1978 is shown in Table 1.

As shown in Table 1, the number of substances that must be tested increased significantly since 1978. In 1978, the absorption spectrophotometer and atomic absorption spectrophotometer were the main measuring devices. While technology has improved tremendously by 2003, gas chromatography (GC) and liquid chromatography (LC) have become more sophisticated and mass spectrometer (the mass of a molecular or ion are detected and the measurement value is obtained as mass spectrum, MS) are more widely available. GC/MS and LC/MS are now often used in water quality testing. Water quality standards are revised as more harmful substances, such as carcinogens, are observed in the water supply. As new standards are added, it is necessary to have the appropriate technologies available for their testing.

In summary, Japan originally set the drinking water quality standards to prevent waterborne diseases and acute toxicity caused by chemical substances and heavy metals. Absorption spectrophotometers and atomic absorption spectrophotometers were the main instruments in those days. When carcinogens and chronic toxicity became serious concerns, advanced technologies such as mass spectrometers were needed and became widely used.

Table 1. Instruments Used for the Measurement of Parameters in Drinking Water Quality Standard

Current water quality testing methods		**water quality testing methods in 1978**	
Main instruments	**Parameters: 51 in total**	**Main instruments**	**Parameters: 26 in total**
Sensory analysis	Taste, Odor	Sensory analysis	Taste, Odor
Incubator	Standard plate count, *E. Coli*	Incubator	Standard plate count, E. Coli
		Titration (Burette)	Cl^-, Ca^+, Mg, Organic substances (Potassium permanganate consumption)
Analytical balance	Total residue	Analytical balance	Total residue
pH meter with glass electrode	pH Value	pH meter with glass electrode	pH Value
Absorption spectrophotometer	Non-ionic surfactant, Color, Turbidity	Absorption spectrophotometer	As, Cr^{6+}, CN^-, NO_3^-, NO_2^-, F, Fe, Anionic surfactant, Phenols, Color, Turbidity, Organic phosphorus
Atomic absorption photometer	Hg	Atomic absorption photometer	Cd, Hg, Pb, Zn, Cu, Mn
TOC analyzer	TOC		
Flameless atomic absorption photometer	Cd, Se, Pb, Cr^{6+}, Zn, Al, Fe, Cu, Na, Mn, Ca^+, Mg		
Ion chromatography	NO_3^-, NO_2^-, CN, F, B, Chloric acid, Bromic acid, Na, Cl^-		
Inductively-coupled plasma emission analyzer (ICP)	Cd, Pb, Cr^{6+}, Zn, Al, Fe, Cu, Na, Mn, Ca^+, Mg		
Inductively-coupled plasma mass spectrometer (ICP-MS)	Cd, Se, Pb, Cr^{6+}, Zn, Al, Fe, Cu, Na, Mn, Ca^+, Mg		
Gas chromatography-mass spectrometer (GC-MS)	Carbon tetrachloride, 1,4-dioxane, 1,2-Dichloroethylene, Dichloromethane, Tetrachloroethylene, Trichloroethylene, Benzene, Chloroacetic acid, Chloroform, Dichloroacetic acid, Dibromochloromethane, Total trihalomethane, Trichloroacetic acid, Dibromochloromethane, Bromoform, Formaldehyde, Geosmin, 2-Methylisoborneol, Phenols		
Liquid chromatography	Anionic surfactant		
Liquid chromatography-mass spectrometer (LC-MS)	Chloroacetic acid, Dichloroacetic acid, Trichloroacetic acid, Formaldehyde, Phenols		

Note: Some of the parameters can be measured by different kind of instruments.

The setting of water quality standards has to reconcile with priority concerns in the society and what can be measured with available technologies. Furthermore, it is necessary to evaluate priorities of society for introducing the items which involve high level technology to measure.

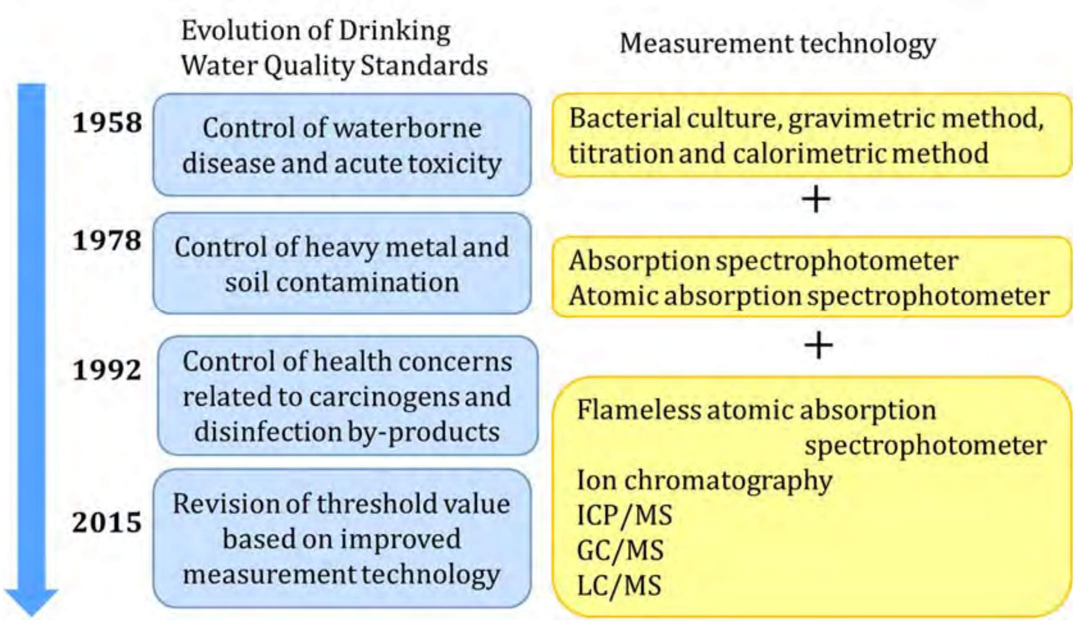


Figure 8. Water Quality Standards and Measurement Techniques

Photo 2. Gas Chromatography-Mass Spectrometer
(at the National Institute of Public Health)

(2) Responsibility for Water Quality Testing

Utilities are responsible for routine testing to demonstrate that quality of the supplied water meets the legislated standards. Small and medium scale utilities do not have in-house expertise and rely on health centers to fulfill this responsibility. When utilities and health centers could not pay for expensive instruments for the increasing number of parameters to be tested, nationally-registered private facilities began to conduct the testing.

Small and medium scale utilities often do not have the facilities and technical capability to conduct all the required water quality testing; this was a problem even in 1978 when the list of substances to be tested was relatively modest compared to today. Considering the situation, in 1957, the government proposed to the Diet that: 1. utilities may identify a technical personnel in charge among them and share the responsibility; and 2. health centers could include water quality testing as one of their services. This system worked and health centers and utilities were reporting deterioration in water quality to administrative authorities. However by 1992 the health centers could no longer afford to continue the testing service, as the number of parameters was increasing significantly, and more expensive instruments such as mass spectrometers were required to test for tracing chemical substances such as organochlorine compounds. As the result, number of nationally-registered private facilities began to carry out the more sophisticated tests, as well as sample pick up and other related services. MHLW supervises these private testing facilities and the registration must be renewed every three years. MHLW conducts proficiency tests by sending out blind samples periodically to check the reliability of the test procedures and to ensure that improvements are made if required.

Today, the utilities, which have their own testing facilities and technical personnel, are roughly limited to those who are serving more than 300,000 people. Most utilities including medium size ones are outsourcing this task. The outsourcing however does not diminish the important responsibility that each utility has in the daily measurement of residual chlorine and the development of an annual water quality monitoring plan. Determining water safety and ensuring the quality of the water supply still remain a primary responsibility.

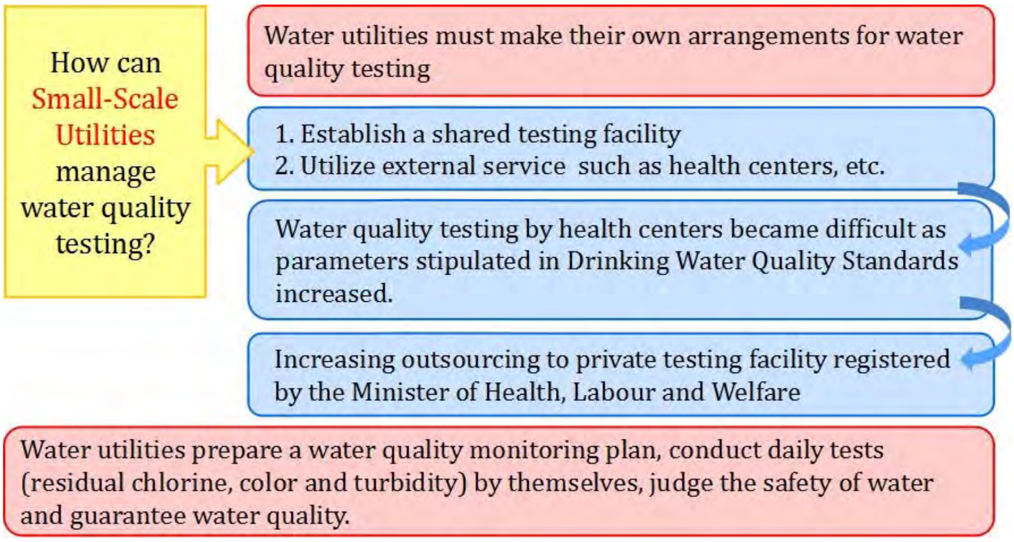


Figure 9. Responsibility of Utilities for Drinking Water Quality Testing

(3) Administrative Framework for Water Quality Testing

Utilities have to prepare annual water quality testing plan as required by Ordinance for Enforcement of the Water Supply Act. The testing plan and test results are reviewed by national and prefectural governments and health centers.

The drinking water quality standards revised in 2003 stipulate that utilities must prepare an Annual Water Quality Examination Plan (AWQEP), containing the following information:

1. The conditions to be considered in preparing AWQEP (i.e. expected water quality throughout the supply system from raw water to customer's tap, factors contributing to the presence of contaminants and the priority of the substances to be tested) 2. Daily and regular tests to be performed (i.e. substances and items to be monitored, sampling locations and number of tests to be conducted; justification for reducing the frequency of tests required in the Ordinance for Enforcement of Water Supply Act) 3. Items omitted from regular testing and justification for the omission.

(i.e. reason for not testing certain items required to be tested according to the Ordinance for Enforcement of Water Supply Act)

4. Occasions of ad-hoc testing

(i.e. state the need to conduct non-scheduled testing and the substances to be measured)

5. Outsourcing plan

(i.e. specify in detail the tests to be outsourced to local government agencies or organizations registered by the Minister of Health, Labour and Welfare)

6. Other items to be considered in water quality testing

(i.e. evaluation of test results, review of the AWQEP, accuracy and reliability of the tests and liaison with the parties concerned)

Authorities which give Approval (License) can conduct on-site inspections, check the AWQEP, the results of the tests or obtain the information in a report in accordance with Article 39 of Water Supply Act and Article 14 of the Order for Enforcement of Water Supply Act, as shown in Figure 7. If any deviation is detected, the authority shall order improvements to be made based on Article 36 of Water Supply Act.

Column: Water Quality Management Personnel

Drinking water quality management involves many workers at treatment plants, technical staff conducting water quality testing, workers in charge of monitoring tap water quality, and administrators who supervise these steps.

The Bureau of Waterworks, Tokyo Metropolitan Government, the largest water utility in Japan, has 3,794 employees (as of March 2015). Water quality management employees account for 24.6% (933) of the entire staff complement: 98 in the Purification Division, 65 in the Water Quality Management Center, 121 in the Water Resources Administration Office and the Reservoir Management Offices, 398 in the 3 Purification Management Offices, 260 in the 6 Purification Plants. This is a much larger work force than that of the utilities in rural areas. It is difficult for other utilities to assign as many employees as Tokyo to the water quality management as they need to allocate more people to water distribution. The water utilities in rural areas make effort to achieve the standards' value which is applied equally nationwide.

These workers are aware of the direct impact that drinking water has on public health. They work hard to supply high quality water and are proud to be part of this service. When they explain the work to students visiting the water treatment plant as a part of school education, they are reminded of their mission and are motivated to do their best.

Other personnel supporting water quality management are maintenance staff of the water facility manufacturers, administrative officers who distribute information concerning water quality and check compliance.

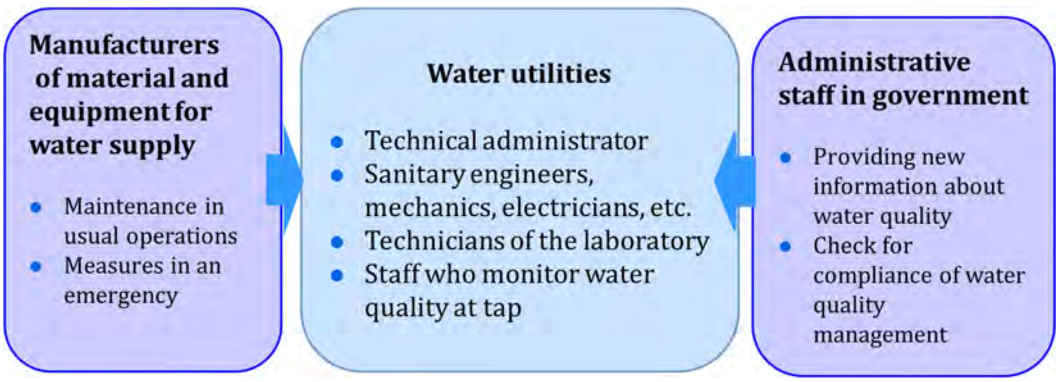


Figure 10. Water Quality Management Personnel

5. Standards for Water Supply Materials and Equipment

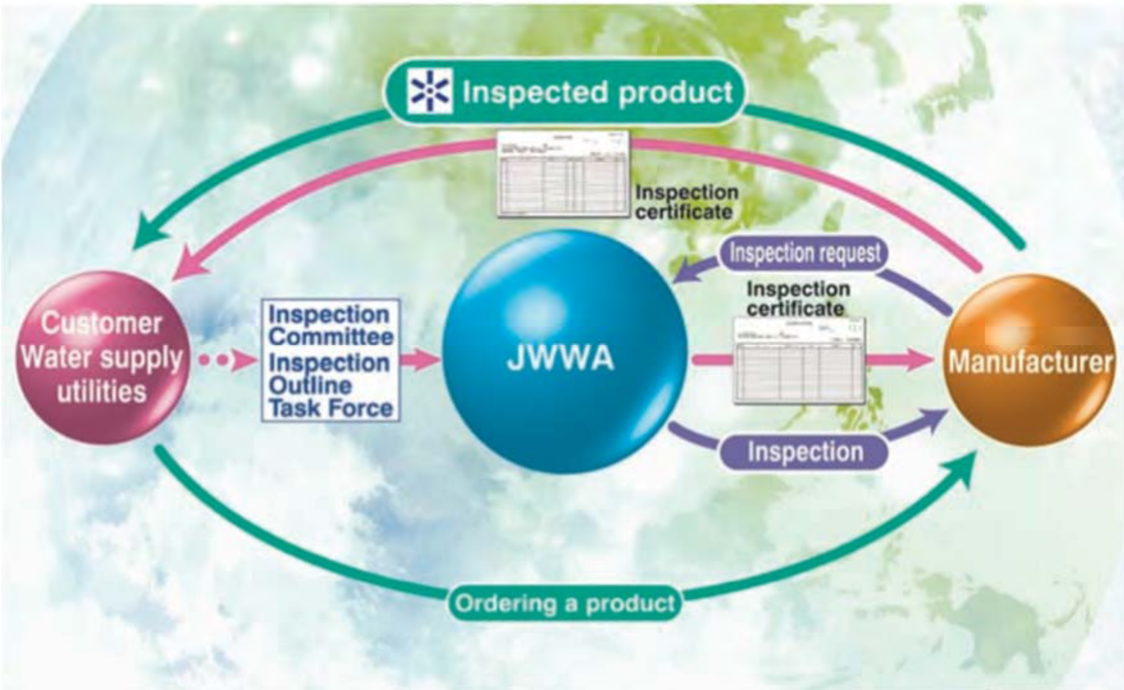
Water quality management should be conducted at the water source, throughout the treatment processes, distribution networks and up to the customers’ taps. Materials and equipment used in the water supply systems must meet specified standards and this is very important for water quality management. The Japan Water Works Association inspects, certifies and registers products to ensure that they are in compliance with quality standards.

Drinking water must be clean and safe from the time it leaves the treatment plant to when it reaches the customer’s home. The quality of materials and equipment of the distribution system are important for maintaining water quality.

In Japan, there are quality standards for materials and equipment used in the water supply system. Products that comply with the standards are certified. The Federation of Water Authorities, the predecessor of the Japan Water Works Association (JWWA), developed the first set of standards for cast iron pipes in 1914. These were later revised and expanded.

Each utility used to visit manufacturing facilities separately to check for product compliance. JWWA took over the task on behalf of its members in 1935 for cost reduction of utilities and efficiency of inspection. In 1997, the certification system was revised to evaluate performance and function to simplify the complex process of approving service connection facilities’ model and ease some of the restrictions.

New standards and inspection methods have to be established as new materials and equipment are being developed and used in the water supply systems. JWWA ensures that strict and fair inspections are conducted in accordance with the Water Supply Act.



Source: Japan Water Works Association, "*Profile Public Interest Incorporated Association Japan Water Works Association*," http://www.jwwa.or.jp/jigyou/kaigai_file/JwwaProfile2015.pdf

Figure 11. Inspection System for Water Supply Materials and Equipment

Standards for materials and quality of water supply devices, such as faucets, and chemicals such as disinfectants, are specified in the Ordinance of Ministry of Health, Labour and Welfare. Product characteristics such as pressure resistance, degree of dissolution and volume of impurities in chlorine and other chemicals are required to meet specified standards. On requests from manufacturers, JWWA's Quality Certification Center evaluates, certifies and registers the products, before they go on sale and put qualified stamps on.

Utilities nationwide use the registered and certified materials and equipment because of the reliability offered by the registration and certification system. As a result, Japanese water supply facilities are able to keep a high quality of service. Usage of the standardized materials and equipment is significantly meaningful for water supply.

6. Preventing Deterioration of Source Water Quality

(1) Deterioration of Source Water Quality

As the economy grew in Japan, the inflow load increased in accordance with the rapid population growth. Water sources had been polluted by agricultural chemicals and industrial wastewater. Therefore, water source conservation, sewage treatment and industrial wastewater treatment were needed.

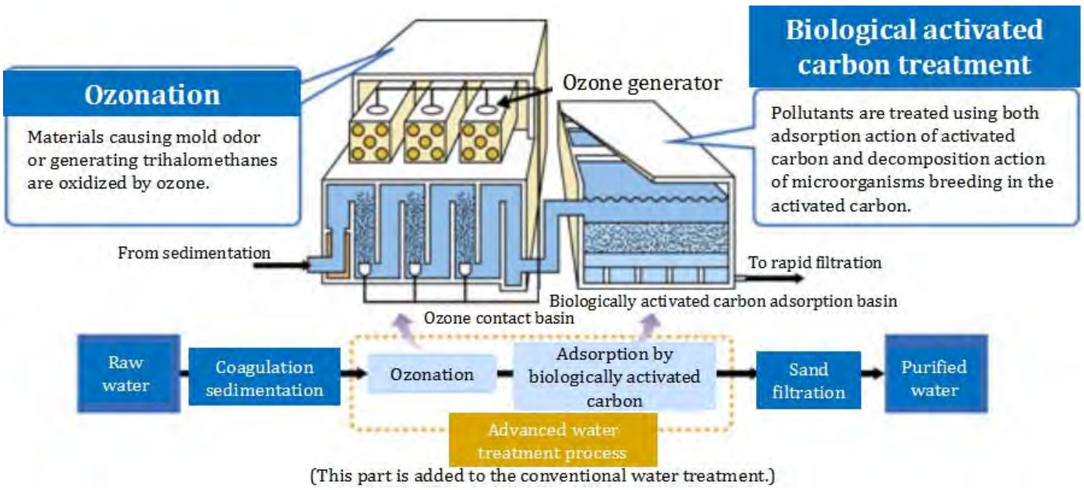
During the period of high economic growth in the 1960s, wastewater from factories caused serious contamination of the sources for drinking water. There were increased incidents of pollution related illnesses. Unpleasant odor and taste due to eutrophication in dams and lakes became a social issue. In 1970, the Water Pollution Control Act together with the Act on Entrepreneurs' Bearing of the Cost of Public Pollution Control Works, were enacted to protect the quality of the water sources against contamination by industrial wastewater.

Source: Website of Kasumigaura River Office, http://www.ktr.mlit.go.jp/kasumi/kasumi00026.html

Photo 3. Float for Collecting Blue-Green Algae (often encountered from 1960s to 1970s)

Regulations on wastewater from factories were strengthened in the 1970s and Japan's anti-pollution measures were deemed "successful for the most part" by the Organization for Economic Co-operation and Development (OECD) in 1978. Since the late 1970s, domestic wastewater became more of an issue than industrial wastewater because economic growth turned sluggish.

Untreated domestic wastewater was discharged into rivers because sewage system development was not catching up with the rapid population growth. The nitrogen and phosphorus it contains caused eutrophication and harmful algal bloom. Odor also became a big problem. The Ministry of Environment and the Ministry of Construction promoted the combined Johkasou, Japanese on-site advanced treatment systems for domestic wastewater including excrement and grey water, and sewage system and the quality of river water improved significantly. However, water quality was not improved in some lakes and ponds, because the pollutants settled as sedimentation and flowed up when the water temperature rose. Some utilities moved their intake facilities upstream or introduced advanced water treatment systems to deal with the situation. Japanese government established subsidies for the advanced water treatments in 1988.



Source: Website of the Bureau of Waterworks, Tokyo Metropolitan Government

https://www.waterworks.metro.tokyo.jp/suigen/kodojosui.html

Figure 12. Example of Advanced Water Treatment

There were no water quality standards for odorous chemicals such as geosmin and 2-methylisoborneol before eutrophication became an issue. While the odor and taste may be unpleasant, the water remains safe to drink. Initially utilities were reluctant to invest in expensive advanced treatments to deal with these problems. Today, utilities are skilled in advanced treatment processes to produce safe, odor free and good tasting drinking water.

There is a limit to cope with excessive pollutant loads discharged to water source and worsened quality of water source only with development of treatment facilities. Measures to prevent pollutants from getting into the water sources in the first place are needed. These include river flow improvement with erosion control works, river bank protection and forestation of catchment area and sewerage system improvements.

It is evident that utilities must take measures to maintain the quality of water sources. Especially for lakes that receive industrial and domestic sewage, pollutants can result in proliferation of blue green algae and aquatic plants and in turn, eutrophication and deterioration of water quality that put increasing burden on the treatment processes. Utilities must engage in environmental protection activities such as forestation of catchment area and lake conservation, and convince customers and residents in catchment area of the importance of these activities.

Example: Treatment System to the Chiba Prefectural Waterworks

Chiba Prefecture, a suburb of Tokyo saw a big increase in population. At that time, untreated domestic wastewater was discharged into Imba-numa (a large lake), the water source of the Chiba Prefectural Waterworks.

Eutrophication in the lake caused huge algae blooms. Water had a bad taste and odor. In 1970, activated carbon was used at the intake to adsorb the odorous compounds in the transmission pipelines and then allowed to settle out at the treatment plant.

However, this method did not solve the root problems. Chiba Prefectural Waterworks organized an experts committee in 1973 to investigate and demonstrate the use of advanced treatment. Then the Chiba Prefectural Waterworks introduced ozone with powdered activated carbon injection in 1976, and ozone with granular activated carbon in 1980.

Example: Moving Intake Facilities to Upstream

The Abukuma River (length: 239 km; basin: 5,390 km^2) is the second longest river in the Tohoku region in Fukushima Prefecture (Northeast of the main island). Northern urban area of the prefecture had nuisances with water quality deterioration and droughts of Abukuma River.

Fukushima City and surrounding towns joined the national government's Surikamigawa Dam Project, upstream of the Surikami River (part of the Abukuma River system). These municipalities established the Bulk Water Authority using water from the Surikamigawa Dam.

Fukushima Water Supply Authority was established in 1985 to supply 149,920 m^3/day (latest plan: 231,570 m^3/day) for 3 cities including Fukushima City and 3 towns. The Surikamigawa Dam was completed in 2005 and the Fukushima Water Supply Authority started to implement full-scale supply in 2007.

Fukushima Waterworks Bureau had to use activated carbon to treat the water from Abukuma River. After switching to the bulk water from Fukushima Water Supply Authority, it no longer required the activated carbon treatment and also reduced the level of chlorination. The chlorine odor on taps decreased. The Waterworks succeeded to distribute quality drinking water to users by using water further upriver.

Source: Surikamigawa Dam and Reservoir Management Office http://www.thr.mlit.go.jp/surikami/

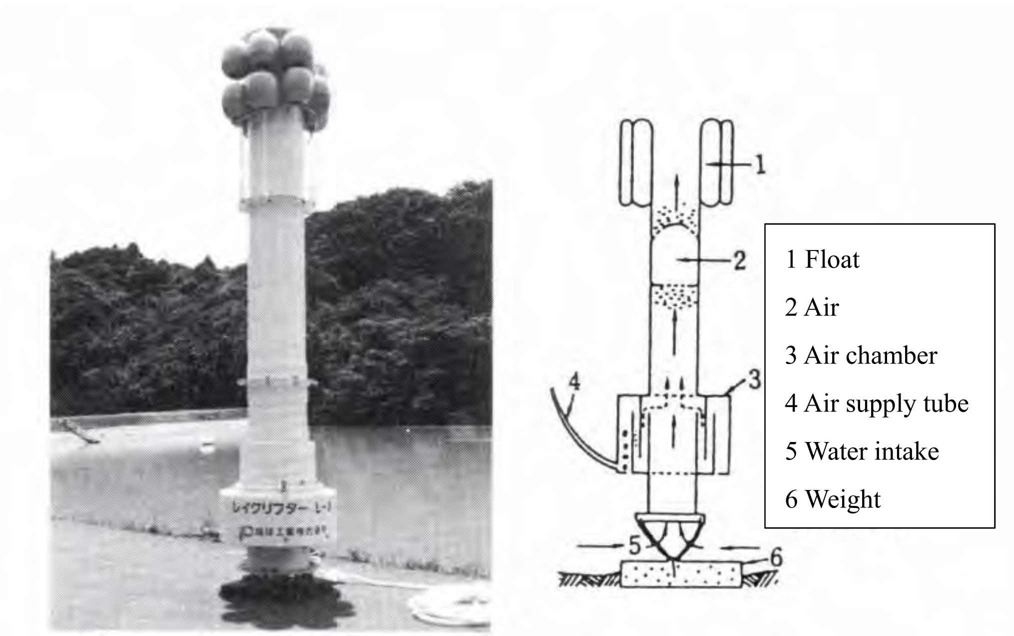
Photo 4. Surikamigawa Dam

Eutrophication problems can be solved by removing blue-green algae, by purifying inflowing rivers (utilizing vegetation or soil to purify river water), or circulating lake water artificially (using air lifting towers or aeration systems). Purification carried out by phytoremediation is a biological treatment method using plant-based systems and microbiological processes to eliminate contaminants in nature by utilizing a natural ecosystem (absorbing and collecting nitrogen and phosphorus by the extremely fast growing water hyacinth).

When water supply systems expanded rapidly, most of the efforts were devoted to the construction of facilities and development of sewage systems tended to be of a lower priority. Source water quality issues were not well understood and problems were dealt with on an ad hoc basis. It is preferable to prevent deterioration of water quality, understand the impact of effluent treatment on water supply and develop the required infrastructure. Developing countries located in the tropics and subtropics typically have more serious eutrophication problems in their reservoirs and lakes. The warm climate and heavy rainfall mean more nutrients are washed from the soil into the water and resulting in higher biological activities.

Column: Artificial Circulation of Lake Water

Artificial circulation, mixing of deeper and upper layers of the reservoir, can prevent eutrophication. This method prevents oxygen depletion at the deep layers caused by dead phytoplankton/algae decay. This involves an upper layer aeration and circulation, deeper layer aeration and aero-hydraulic guns.



Source: Sadao KOJIMA, *Artificial circulation of lake water as a counter-measure to eutrofication; It's principle and results*, Japanese Journal of Water Treatment Biology Vol. 24 (1988) No. 1, p.9-23. https://www.jstage.jst.go.jp/article/jswtb1964/24/1/24_1_9/_pdf

Figure 13. Schematic of the Aero-Hydraulic Gun

(2) Conservation of Water Catchment Forests

Some utilities practice forest conservation upstream of the water sources as a strategy to preserve the water quality for the entire watershed.

Many utilities conduct water resource conservation upstream of their water sources. Under the Forest Act, forests located upstream of water sources are designated as "reserve forests" and tree cutting or development projects are prohibited since a long time ago. In some cases, utilities take more proactive measures by owning the forests and taking care of the trees with volunteers. In 1910 the Tokyo Metropolitan Government started the management of a water catchment forest that recharges the water source in Okutama. Yokohama City also purchased a forest on a mountain outside the prefecture in 1916. Many utilities in Fukuoka, Okayama, Kofu, Morioka city and Kagawa Prefecture followed suit.

Table 2. Examples of Catchment Forest Conservation by Some Utilities

Water utility	Location	Area
Tokyo Metropolis	Upstream of Tama River (Okutama machi and part of Yamanashi Prefecture), started in 1910 as the first attempt	23,000 ha
Yokohama City (Kanagawa Prefecture)	Upstream of Doshi River (Yamanashi Prefecture), located outside Kanagawa prefecture	2,873 ha
Kagawa Prefecture	Upstream of Yoshino River (Kochi Prefecture) Subsidy for tree thinning	–

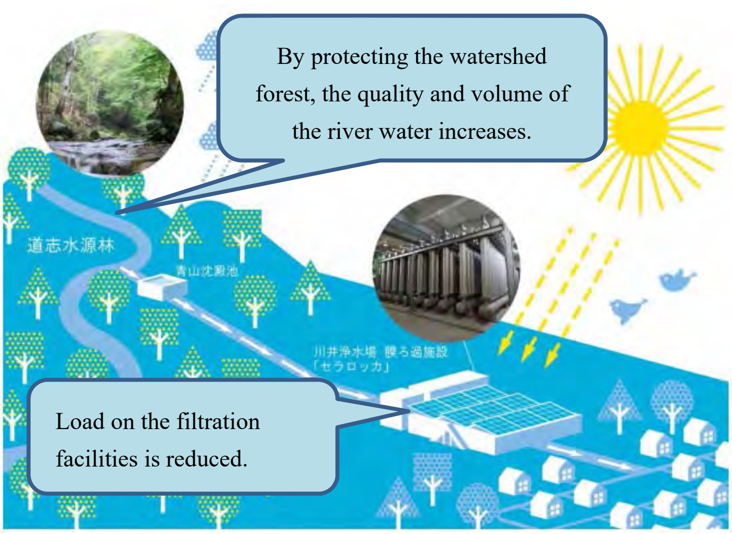
Example: Watershed Forest in Doshi

The Yokohama City water supply system was established in 1887, and the water intake was moved to Doshi River, a tributary of the Sagami River, in 1897. Yokohama City procured publicly-owned forest from Yamanashi Prefecture in 1916 and implemented conservation projects to protect the water source. The forest is designated as the Yokohama City Doshi Watershed Forest (Doshi Forest). Doshi Forest is located in Doshi Village, south east of Yamanashi Prefecture, upstream of the Doshi River.

The forest accounts for 36% of the area of the village. Yokohama City established the Doshi Forest Fund. Donations and sales of bottled water from this water source support the conservation activities by citizen volunteers.

Source: Yokohama Waterworks Bureau, *Doshi Watershed Forest*, http://www.city.yokohama.lg.jp/suidou/kyoku/torikumi/suigen-hozen/suigenkanyourin-sub-wind.html

Figure 14. Doshi Watershed Forest



Source: Water Works Bureau, City of Yokohama, *The Eleventh Plan for Doshi Watershed Forest*, http://www.city.yokohama.lg.jp/suidou/kyoku/torikumi/suigen-hozen/pdf/doushisuigenrinpuran.pdf

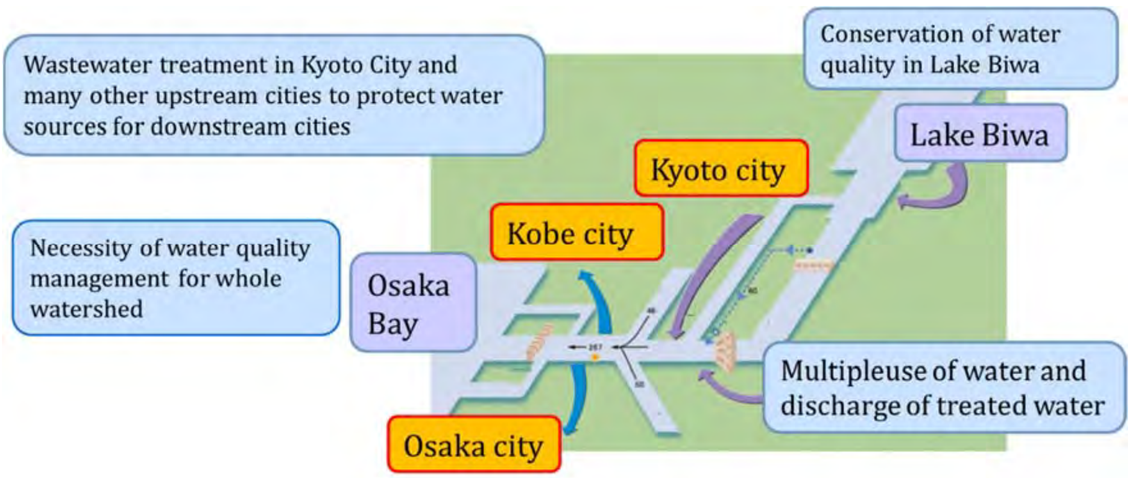
Figure 15. Schematic of a Forest Recharging a Water Source

(3) Legislative Framework for Protection of Water Source Quality

Promoting water quality management over an entire watershed is difficult in Japan. The different laws implicated are under the jurisdiction of various authorities. Improvement of the situation and source water quality are expected as a result of better coordination among utilities and prefectures and establishment of the Basic Act on Water Cycle.

The Water Supply Act stipulates the management of water supply systems by municipalities. This comes from the fact that small scale water management had been done based on historically formed communities. Communities traditionally used spring water and groundwater as water sources in many parts of Japan. Gradually these developed into small water supply systems.

However, after water usage expanded, this management model is no efficient or effective when water quality management evolved to focusing efforts on the entire watershed. To secure as much as quality river water continuously for waterworks, integrated water management with consideration of entire watershed should have been undertaken.



Source : Yodogawa River Office, http://www.yodogawa.kkr.mlit.go.jp/know/data/use/

Figure 16. Water Quality Management from the Perspective of River Usage and the Entire Water System of Yodo River

Efforts are made to coordinate various legislative frameworks (Water Pollution Control Act-related regulations, various legal systems and institutional frameworks) and technical efforts (installation of sewage system and Johkasou).

Currently, the River Act and sewage systems are under the control of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The Ministry of the Environment takes care of water environment of lakes and rivers, the Ministry of Economy, Trade and Industry (METI), industrial water intake and the Ministry of Agriculture, Forestry and Fisheries (MAFF), agricultural water. Water supply and sanitation administration should be implemented with the coordination of authorities dealing with the environment and construction.

In 1994, the Law concerning the Promotion of Projects to Preserve Water Quality in Drinking Water was introduced by MHLW; and the Law concerning Special Measures for the Preservation of Water Quality in Headwaters Areas for the Purpose of Preventing Specific Trouble in the Drinking Water Supply was introduced by the Ministry of the Environment.

The purpose of the Law concerning the Promotion of Projects to Preserve Water Quality in Drinking Water is to “ensure the supply of safe drinking water of good quality and contribute to the improvement of public health and living environment by taking measures to promote the implementation of programs that contribute to the protection of the quality of source water for public water supply.” Under this Act, if a utility makes a request to the prefecture that controls the water source catchment area, the prefecture can request the upstream prefecture as well as the river administrator to establish a plan to enhance programs for water quality conservation in response to their needs. It means that a mechanism, where a request can be made via a prefecture from downstream to upstream and from utilities to river administrators, is established by Law. This framework is based on watershed management. The effectiveness of this framework is still unclear because requests have been made only for areas directly upstream and rivers in the same prefecture since the Act was enacted.

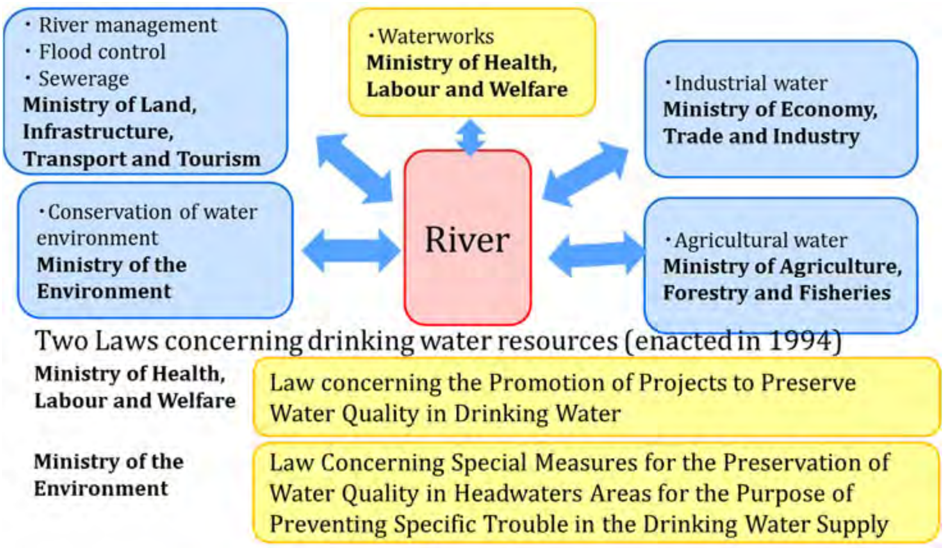


Figure 17. Status of River Management

The Basic Act on Water Cycle was established in 2014, which is expected to facilitate the consideration of the entire watershed in water quality management. It takes a considerable time to coordinate administrative systems of various ministries and to arrive at some consensus.

Column: Establishment of the Basic Act on Water Cycle and the Way Forward

Until the Basic Act on Water Cycle was promulgated, there was no national comprehensive policy to address principles and directions regarding water issues, to conserve and protect water resource. The responsibilities reside with different authorities: river and sewage systems are controlled by MLIT, industrial water by METI, agricultural water by MAFF and drinking water by MHLW. There were not enough frameworks, such as integrated control of all aspects of the water cycle, systems and plans for community-driven water resource conservation in each watershed, and legislation on groundwater use.

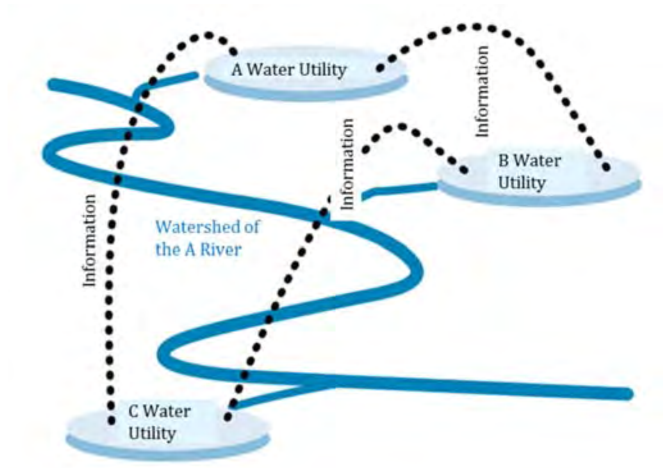
In the midst of growing social interest in water issues including the possibility of global water shortage, the National Commission on Water System Reform was established in June 2008. The Commission was made up of academic experts, citizens, and Diet members from all parties. It pointed out the dysfunction of an administrative framework with ministries operating in isolation, the need to break down the silos and called for the integrated promotion of water administration and the establishment of a basic law.

The bill for the Basic Act on Water Cycle was introduced and enacted in 2014.

A special characteristic of the Law is the setting up of the cabinet office that cuts across multiple ministries for integrated and comprehensive discussion and implementation of top-level policies dealing with every stage of the water cycle. The cabinet office is headed by the Prime Minister and composed of the chief cabinet secretary and ministers. This integrated team will tackle water issues which involve many sectors and jurisdictions.

The Water Cycle Basic Plan was established in 2015, and will be reviewed every five years.

Groundwater abstraction continues to be a concern in many parts of Japan and there are restrictions with very stringent targets set in the Industrial Water Act and the Building Water Act, designed to prevent land subsidence. The Water Cycle Basic Plan should make it clear what concrete measures the national government would take and it is hoped that effective plans could be developed.



Source: Fukushima Prefecture, "*Vision for the Daily-life Water in Fukushima*," (2006), p.61

Figure 18. Concept of Watershed Monitoring

(4) Practical Measures against Water Source Pollution

In Japan, cooperation among utilities in different prefectures is credited for solving an accident when chemicals were discharged from a factory located upstream of several water treatment plants and generated harmful disinfection byproducts.

In May 2012, a factory discharged hexamethylenetetramine into upstream of the Tone river, which flows Kanto Region. Formaldehyde was produced as a by-product and detected when several treatment plants downriver chlorinated the water. The formaldehyde level almost reached the maximum concentration allowed by the water quality standards.

This case attracted lots of public attention. Several utilities had to stop their water supply at one point. The prefectures affected immediately announced the situation and the Ministry of Health, Labour and Welfare (MHLW) investigated and published a report on the incident and the public notice "Concerning enhancement of countermeasures against water source pollution" was issued in March 2013 to prevent future accidents.

The incident shows the necessity of cooperation and information sharing among utilities in the same watershed. Associations made up of utilities in the same watershed had been formed: the Tonegawa/Arakawa Watershed Water Utility Association, the Kisogawa Watershed Water Utility Association and the Toyokawa/Yahagigawa Watershed Water Utility Association against Water Pollution. These associations share information on their website as well as work together on improvements. Watersheds which do not have formal associations rely on informal systems. Environmental departments of utilities would report incidents to water supply department of the prefecture which in turn shares the information with utilities downriver.

MHLW requires each utility to develop a water safety plan. The plan must describe the measures to be taken in response to change in water quality. It is essential to detect the change at the earliest possible stage. Therefore, sharing water quality information with utilities in the same watershed is important.

Example: Impact of Contamination Accident Upstream on Utilities Downstream

"Formaldehyde incident at Tone River"

On May 15, 2012, formaldehyde at 0.045 mg/l was detected in the treated water during routine testing conducted by the Enterprise Bureau of Saitama Prefecture. The concentration approached the allowable limit of 0.08 mg/l for drinking water. Tests were carried out more frequently and the incident was investigated. Nearby utilities informed by Saitama prefecture started to strengthen their monitoring. Exposure above the maximum allowable limit of 0.08 mg/l causes irritation to the airways.

Activated carbon was used in many plants to absorb the formaldehyde and its precursors and the chlorine treatment process was adjusted, both had limited impact. The plants which do not have ozone and biological activated carbon treatment processes, shifted the water source to ground water, utilized stored water for emergencies, or got water from utilities in other watersheds.

On May 19, some water treatment plants stopped supplying water when the concentration of formaldehyde approached the allowable limit for an extended period. Water supply was resumed in all plants on May 20.

The study by the National Institute of Health Sciences revealed that the formaldehyde was generated by the hexamethylenetetramine in the source water, based on the water quality analysis and correlation of formation potential of formaldehyde in raw water.

The investigation followed by the incident revealed that from May 10 to 19 neutralized plating waste solution containing hexamethylenetetramine was discharged by a waste disposal company to the drainage system which runs into the Tone River system.

Table 3. Damage Caused by Formaldehyde Incident of May 19, 2012

Victim utilities	Venues	Business type	Countermeasure	Damage
A	Ibaraki Prefecture	waterworks	Injection of Activated Carbon and change of volume of chlorine	No suspension of water supply
B	Gunma Prefecture	Water Utilities for Bulk Water Supply	Suspension and limitation of transmission, etc.	No suspension of water supply
C	Saitama Prefecture	Water Utilities for Bulk Water Supply	Suspension of intake and transmission	No suspension of water supply
D	Chiba Prefecture	Water Utilities for Bulk Water Supply	Suspension of transmission	No suspension of water supply
E	Chiba Prefecture	waterworks	Suspension of intake and distribution	suspension of water supply in whole service area
F	Chiba Prefecture	waterworks	Suspension of intake from Water Utilities for Bulk Water Supply	suspension of water supply in whole service area
G	Chiba Prefecture	waterworks	Suspension of intake from Water Utilities for Bulk Water Supply	suspension of water supply in whole service area
H	Chiba Prefecture	waterworks	Suspension of intake from Water Utilities for Bulk Water Supply	suspension of water supply in part of service area
I	Chiba Prefecture	waterworks	Suspension of intake from Water Utilities for Bulk Water Supply	suspension of water supply in part of service area
J	Tokyo Metropolis	waterworks	Suspension of intake and distribution only in suffered plant	No suspension of water supply by changing of distribution pipelines

7. Lessons Learned

The following Japanese experience could be useful for other countries.

- **(From Source to Taps)** Water quality management is considered as a whole of management procedures to meet the water quality standards of tap water throughout from the water source. The national government and water utilities have been actively involved in periodical review of water quality standards, improvement of water quality testing methods, monitoring by administrative organizations, quality control of materials and equipment, and human resource development.

- **(Public Health)** Japan has been focusing on epidemiological safety of modern water supply because it experienced outbreak of waterborne diseases. Water quality management is critical to utilities' ability to supply safe drinking water; which is very important to public health.

- **(Monitoring)** Water quality is monitored at the water source, treatment plant, distribution reservoir up to the customers' taps. Automated systems have been introduced in place of manual tests for daily testing of residual chlorine, color and turbidity. It is important to utilize the data accumulated for water resource conservation, water treatment and emergency response to accidental contamination of source water quality.

- **(Cost of Water Quality Management)** Utilities have made sustained efforts in water quality management by securing the necessary budget in their business plan. This is based on the recognition that water quality management requires certain costs for chemicals, electricity and many other expenses.

- **(Starting with a Good Quality Water Source)** Small-scale utilities with limited technical capability and funding have utilized a good quality water source and have installed facilities to simplify and economize the treatment process.

- **(Designing Water Quality Management System)** In designing water quality management system, it should comply with the legal requirements prescribed by the relevant acts and regulations. These include: (1) designating a responsible officer for water quality management; (2) having national or local government oversight and (3) supporting small and medium scale utilities with limited capacity.

- **(Setting Water Quality Standards)** The aim of setting drinking water quality standards is the protection of public health from toxic substances and bacteria, and the parameters of our health concern. Water quality standards for contaminants suspected to cause long term health risks (such as cancer), are revised as a result of new knowledge, public concerns, and availability of measurement instruments. It was important to establish the standards considering qualities of water resources and drinking water, the technical levels of water quality testing and measurement instruments in the country.

- **(Standards for Materials and Equipment)** It is important that utilities use certified materials and equipment. Article 5 of the Water Supply Act stipulates performance standards for pipes, equipment and facilities. Standards for structure and materials are specified in the Ordinance of Ministry of Health, Labour and Welfare. The inspection and certification services of Japan Water Works Association for materials and equipment play an important role in maintaining the high quality of such products. It is essential that water supply systems utilize standardized materials and equipment.

- **(Protecting Water Sources)** Utilities use advanced treatment processes to deal with odor caused by quality deterioration of water sources. Advanced treatments were introduced but they are expensive. Therefore, government authorities take water resource conservation measures such as construction of sewage facilities, regulation of industrial wastewater, enhancement of information sharing among surface water users, awareness-raising activities, and conservation of water catchment forests. At present, as the water demand saturated and stabled, it became important to conduct water resource conservation with stakeholders around watershed while seeking for cleaner water source, for example, by moving intake facilities to upstream.

- **(Cooperation in Watershed)** Utilities in the same watershed cooperate, share information and take prompt action together in case of incidents of pollution. The formal mechanisms for cooperation and coordination greatly facilitate information sharing and water quality management. In this regard, the development of a comprehensive water safety plan is promoted by the national government in Japan.

Theme 4. Operation and Maintenance of Facilities

Contents

1. Introduction

When water supply facilities were being built across the country during the period of rapid expansion, establishing new systems was the priority. The operation and maintenance aspects did not get the necessary attention and budget. Over the years, the water supply industry had to deal with many operational issues, emergency situations and serious disease outbreaks. The lessons learned, especially in the recognition of the importance of maintenance, gradually transformed the utilities to ones that provide a stable supply of safe drinking water to the Japanese population.

Figure 1. Steps toward Good Practices in Maintenance

As conceptualized in Figure 2, corrective maintenance (which implies "run it till it breaks," or maintenance carried out after failure detection) may seem to have an economic advantage in the short term, it has disadvantages compared to preventive maintenance according to the experiences of Japanese water utilities:

- It is less efficient and more expensive in the long term.
- Accidents will undermine users' trust in the water utilities.

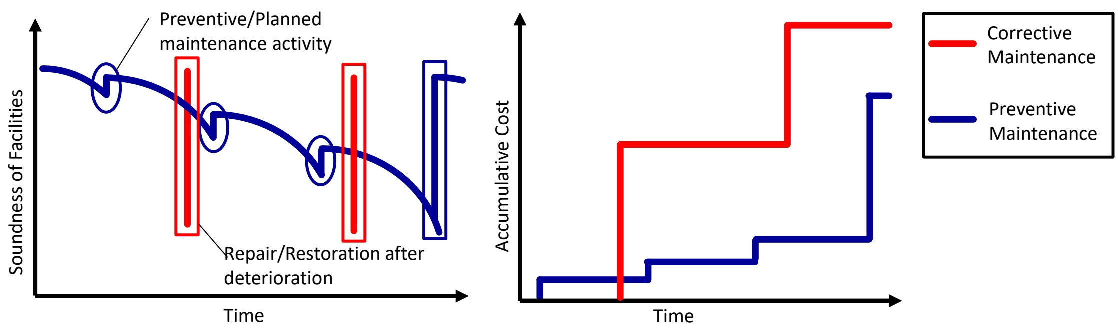


Figure 2. Conceptual Graph of "Corrective Maintenance" and "Preventive Maintenance"

Preventive maintenance either Time-Based Maintenance (TBM) or Condition-Based Maintenance (CBM) is preferable. Its implementation relies on good record keeping and best practices in information sharing.

This module intends to answer to following frequently asked questions from participants of the water supply training courses from developing countries.

Q1. As a result, new facilities often receive higher priority than maintenance, in terms of budget and staffing. How did Japanese utilities achieve good practices in maintenance in spite of these challenges?

Q2. The sharing of information among water utilities is not easy because they are managed at the local level. Another difficulty is that the number of engineers or senior technical personnel, who would benefit from liaising with their counterparts, is limited at any one facility. How do Japanese utilities manage to share the knowledge on maintenance and benefit from each other's experience?

Q3. Developing best practices for maintenance is critical to an efficient operation and for continuous improvement. How can best practices be retained in spite of staff turnover? What is Japan's approach to sharing best practices within a utility and across the water supply sector?

The following sections attempt to provide answers to these questions:

2. Importance of Maintenance (Q1)
3. Laws and Institutional Framework (Q2) and (Q3)
4. Best Practices in Japan (Q3)

2. Importance of Maintenance

When water supply expansion was the priority, operation and maintenance (O&M) was not sufficiently implemented. Attention was paid to O&M only when serious disease outbreaks or accidents occurred. Efforts were made to enhance water safety and avoid supply interruptions with increasing regulations on water quality standards, and to operate facilities efficiently in response to sustained pressure to reduce the numbers of staff.

Today, water supply systems in Japan are very well operated and maintained. It is safe to drink water from the tap anywhere, even in the countryside. There are national guidelines on operation and maintenance and standard operational procedures (SOPs) at the facility level to keep facilities in good condition. These achievements are the result of years of steadfast efforts.

Before the end of World War II in 1945, water supply systems were prevalent only in urban areas. After the 1950s, small rural water supply systems for up to 5,000 people were installed rapidly across the country. Water supply coverage increased significantly from 25.2% in 1950 to 80.8% in 1970. Today's good practices in maintenance have been achieved through on-going efforts to reduce incidences of waterborne diseases including the following:

- Repeated notices from central and prefectural governments on improvement of operation and maintenance.
- Efforts made by utilities to improve their operation and maintenance.

Outbreaks of waterborne diseases (such as dysentery, typhoid fever) were attributed to inadequate disinfection, equipment failures, cross connections, and negative pressure in water supply pipelines. Accidents caused by aging distribution networks were highly publicized. Cross connections presented the opportunity to the utilities to focus on the quality of construction and maintenance after the construction.

Table 1. Disease Outbreaks and Related Maintenance Issues

Item	Triggering events	Issues and causes
Water Treatment Facility	Poor disinfection (waterborne diseases spread by water supply)	No standard manuals nor operational procedures for O&M
	Malfunction of facility and failure of water treatment	
Pipelines	Contamination due to negative pressure (waterborne diseases spread by water supply)	No precise information nor drawings on aged pipelines
	Secondary disaster due to burst pipes	
	Public complaint of rusty/turbid water	
	Dysentery caused by cross connection	Quality control for installation of water service connections

(1) Disease Outbreaks

Outbreaks of waterborne diseases attributed to inadequate maintenance, frequently occurred during the expansion of water supply facilities in Japan. The improvement of maintenance practices supported by national guidelines (*Water Supply Facilities Maintenance Manual*), and the notices from Ministry of Health and Welfare (MHW) to strengthen supervisions and inspections helped prevent disease outbreaks associated with the water supply system.

Water supply coverage was rapidly expanded in Japan to reduce incidence of waterborne diseases. However, according to the surveys by the Ministry of Health and Welfare[1] during 1950-1961, 42% of disease outbreaks were caused by inadequate disinfection and 27% by contamination from back-siphonage of polluted water during interruptions. The Ministry of Health and Welfare recognized that inadequate maintenance was the underlying cause of disease outbreaks and published the *Water Supply Facilities Maintenance Manual* in 1953 to address this problem to prefectural government bodies.

In 1961 the Ministry of Health and Welfare announced the emphasis on proper O&M of water supply facilities, including improvement of disinfection facilities. Regular inspection of facilities was also put in place. Guidance on how to meet the legislative requirements for O&M was provided to the utilities by prefectural agencies and Health Centers. These efforts helped to reduce the incidence of waterborne outbreaks by 1970s.

[1] The Ministry of Health and Welfare was merged with the Ministry of Labour to form the Ministry of Health, Labour and Welfare in 2001.

Column: Guidelines for Water Supply Facilities

The *Water Supply Facilities Maintenance Manual* was first published by the Ministry of Health and Welfare in 1953, aimed at preventing disease outbreaks by ensuring proper operation and maintenance of facilities. After the Water Supply Act was established in 1956, the first revision was published in 1959.

The manual has been revised approximately every 10 years depending on socio-environmental conditions (such as water contamination, increase and decrease of water demands) and technical innovations (such as advanced water purification). The fifth and the latest revision (2006), considers future challenges in achieving sustainability in the water supply business, such as decline in population and water demand, and the need for infrastructure renewal.

Table 2. Revision History of *Water Supply Facilities Maintenance Manual*

Year	Version	Contents of Revision
1953	original	Measures to prevent spread of water borne diseases
1959	1st Revision	Description of maintenance for processes such as purification, transmission and distribution.
1970	2nd Revision	Description of - Water quality management in each facility - Latest instrumentations - Measures to prevent rusty water from water supply pipes
1982	3rd Revision	- Added description of new technologies, such as advanced treatment, etc. - Description of regional management - Description of management of employee health and safety, earthquake and drought
1998	4th Revision	- Risk management and information processing techniques - Latest information such as seawater desalination, cryptosporidium
2006	5th Revision	- Changes in business environment such as tightening water quality standards, managing risk of accidents or disasters, environmental conservation, popularization of information processing, third party consignment. - Maintenance in small- and medium-scale utilities - Added best practices based on the results of questionnaire survey to the water supply utilities

Currently, water supply utilities of Japan are facing many serious issues such as (1) decrease of revenue due to population decline, (2) loss of the technical capabilities due to retirement of a generation of skilled technical staff, and (3) natural disasters such as the Great East Japan

Earthquake of 2011. It is necessary to conduct proper operation and maintenance, rehabilitation and renewal of the facilities to supply safe and secure water. The priority tasks are as follows:

- To prepare manuals and standard operation procedures to maintain the skill and know-how in the organization especially when many workers will be retiring in the near future.
- To prepare for disasters restructuring water supply system in order not to cause malfunction of water supply system.
- To strengthen risk management from source to tap based on the Water Safety Plan.
- To establish long-term rehabilitation-renewal plan using asset management as well as to ensure there is adequate financial sources.
- Prolong asset life cycle by carrying out early detection and repair based on planned maintenance.
- Maintenance of new processes such as membrane filtration.

The manual will be revised to address the current needs.

(2) Cross Connections

In 1960s, serious accidents caused by cross connections occurred. Water supply pipes were connected by mistake to industrial or irrigation pipes. The resulting health problems were well publicized and accelerated implementation of measures for prevention.

Cross connection is fault connection that water supply pipes are connected to pipes for other purpose such as for irrigation, industrial supply or drainage. In the 1960s, rapid expansion of water supply facilities resulted in cases of poor construction practices. There were cross connections with industrial and irrigation pipes in various places in Japan. The seriousness of these problems propelled the national government to strengthen the measures to avoid cross connections. Measures were taken on strengthening construction supervision, accurate recording of construction activities and water quality testing after construction, in all the water supply utilities in Japan.

Example: Cross Connection Accidents in Yokohama and the Counteractions

In 1969, an outbreak of dysentery in a kindergarten in Yokohama was reported. Based on speculation that the dysentery was caused by contaminated tap water, water quality tests were conducted. The result did not show any residual chlorine in the tap water. It was found that a water supply pipeline was cross connected with an industrial water supply pipeline. Later, it was determined that the cross connection was not the cause of the outbreak. Nevertheless, the notion that people including kindergarten children had been drinking industrial water for a long time, caught the attention of the citizens and the Yokohama Waterworks Bureau.

The kindergarten's service pipe was originally connected to a 200 mm distribution pipe. Subsequently, the distribution pipe was relocated 13 times over a 9 year period from 1959. During this period an industrial water pipe of 200 mm was laid near the distribution pipe. In 1968 during the installation of a sewer line some pipes had to be relocated urgently. Workers did not consult the drawings properly. The service pipe was mistakenly connected to the industrial water pipe. Fortunately, the water source of the industrial and the drinking water supply were common and they did almost the same water treatment because the industrial water supply systems had just started off their business and supplied water almost the same quality as the drinking water. Furthermore, the amount of industrial water used was small. Therefore, the cross connection did not cause apparent problems and was not discovered for a long time.

After the incidence, the Ministry of Health and Welfare issued the "Notice of the strengthening of construction supervision of water supply facilities, and comprehensive facility and water quality management" in 1969. It announced the requirement that construction of water supply pipelines must be supervised by qualified personnel. The notice also required complete and accurate recording and reporting of construction activities, proper record keeping of drawings, water quality testing including that of residual chlorine after the construction.

The Yokohama Waterworks Bureau reviewed its operations and construction supervisions to make further improvements. First, the Bureau strengthened planning for emergency repairs and constructions especially when these must be scheduled at night and during holidays. An assistant to the technical supervisor was designated for construction management and supervision. It took 12 years from 1971 and 725 million yen to complete detailed pipeline drawings for sharing correct information. Corrections were made and all information was confirmed to be accurate on the drawings. In 1971, the Bureau assigned a mobile unit for water quality testing, making it possible to respond more quickly to enquiries from citizens and reports on unusual conditions of water sources.

(3) Burst Pipes

Burst pipes, water pressure drop, turbid water often occurred throughout the country in the past. Control measures included planned replacement of aged pipes, use of better pipe materials, improved installation method and sharing information on maintenance. Assistance from national government promoted implementation of these measures.

Pipe breaks lead to pressure drop or contamination due to negative pressure. A major pipe break can cause prolonged supply interruption, serious traffic problems, sink-holes and flooding that have enormous impact on daily lives. The accidents are usually caused by aged pipes, improper installation, or natural disasters. Japanese utilities have taken measures such as planned replacement of aged pipes, improving installation method, enhance earthquake-resistant.

Example: Burst Pipe in Osaka City and the Counteractions

In Osaka City, 70 bursts of 15 main distribution pipes happened for 100 years (1895－1994). The most pipe bursts happened from around 1937. These pipes were usually made of cast iron with coal tar lining and laid from 1933 to 1943. Rust aggregates formed immediately after the installation. The pipes' mechanical strength was rapidly reduced due to graphitization of the cast iron, narrowing of pipe diameter and corrosion from the outside. All these factors contributed to pipe failure.

In the 1951 accident, a fountain of water erupted from a burst 1,500 mm diameter pipe, caused flooding, sagging roads and traffic chaos. 120 houses sustained damages. Water stoppage affected a broad area, while the surrounding area experienced low water pressure. The damage and repairs were costly and time consuming. Subsequently Osaka City implemented a program to strengthen pipes with the use of reinforcing bands, however, it was not a satisfactory solution. Slip-lining systems were intensively introduced to replace old pipes to reduce the number of pipeline accidents.

Column: Japan Water Works Association's Role in Information Sharing

Japan Water Works Association (JWWA) is an umbrella organization for the water supply utilities. JWWA has various committees and convenes meetings to share information among the utilities. In 2008, JWWA published a book on accidents in the water supply sector (*Casebook of Water Supply Accidents for Practical Use: Prevention of Accidents and Transfer of Techniques*), which promotes prevention measures and lessons learned.

JWWA holds annual meetings to discuss the issues of water supply including the practical operation and maintenance issues brought forward by operators. The participants are employees of water utilities, researchers from universities, research institutions and private corporations. The first annual meeting was held in 1950. Since then the meeting topics have expanded from 4 to 11 sectors, covering water supply administration, planning, water sources/intake, purification, transmission and distribution of water, service pipes, machinery, electricity, instruments, water quality, risk management, and disaster preparedness.

The focus on expansion of water supply to nationwide coverage resulted in insufficient attention paid to maintenance of facilities. However, utilities learned from serious accidents, and made efforts to enhance water quality and prevent water stoppage caused by an accident. The national government and prefectural governments also guided and supported the utilities. These approaches from various stakeholders were effective to forge the awareness of importance of the maintenance.

Column: Appropriate management for pipelines and reduction of leakage

Pipelines installed before the World War II were rapidly deteriorating in the 1950s, because of poor quality materials and damage during the war. Increasingly heavy traffic accelerated the deterioration. Leakage rates were 30% in major cities such as Tokyo and Osaka. In 1960 the Ministry of Health and Welfare issued an instruction to prevent leakage.

In 1970 the Ministry of Health and Welfare also issued an instruction on preventive measures for rusty water caused by aged pipes. Subsequent efforts by the utilities in repairs and replacement of the distribution networks brought the ineffective water rate (leakage and miscellaneous loss) down to 16.4% in average in 1980.

Table 3. Events Related Leakage Control in Japan

1945	End of World War II (pipeline damage by war)
September 1946	*Water Leakage Prevention Guidelines* (Ministry of Health and Welfare, Japan Water Works Association)
1950s	Aged pipelines installed before the war and deterioration of pipes of poor material manufactured during the war.
1960	Revision of *the Water Leakage Prevention Guideline* (Water Leakage Prevention Committee, Bureau of Waterworks, Tokyo Metropolitan Government)
1960	Notice of the Ministry of Health and Welfare: on water leakage prevention measures
Around 1970	Media reports on rusty water causing public concern.
1970	Notice of the Ministry of Health and Welfare: on pipeline repair and replacement to prevent leakage and removal of rusting pipes.
1977	*Guidelines for Water Leakage Preventive Measures*

Source: The editorial committee of the One Hundred Year History of Modern Water Supply, "*One Hundred Year History of Modern Water Supply*," Nihon Suido Shimbunsha, 1988.

3. Laws and Institutional Framework

The Water Supply Act regulates maintenance of water supply systems. Facility standards and guidelines for design and maintenance are established and compliance by the all water supply utilities is required. This assures the required level of quality of facilities and maintenance practice across the country.

Article 5 of the Water Supply Act (facility standards) stipulates that "in determining the location and arrangement of water supply facilities, the construction, the operation and the maintenance shall be economic and ease as much as possible. Reliability of the water supply shall also be considered."

Article 19 stipulates that a Technical Administrator of waterworks must be assigned to ascertain conformity to the standards. The *Design Criteria for Water Supply Facilities* was prepared with strict adherence to the facility standards of the Water Supply Act. Application to operate a water supply system is scrutinized against the design criteria before approval. The *Water Supply Facilities Maintenance Manual* is provided as the guidance on operation and maintenance.

Facility standards are important to operation and maintenance. The design and construction division and the maintenance division must fulfil the same objective of supplying water continuously under sustained pressure. The facility standards help to determine the facility design and establish maintenance procedures. Both divisions work together to share the knowledge obtained from maintenance activities and use the information to solve future problems.

Water Supply Act

"Article 5: Standards for waterworks facilities and guidelines for design and maintenance

Waterworks shall be provided with a part or all of facilities such as water intake, water storage, raw water transmission, water purification, water transmission, and water distribution in line with raw water quality and flow rate, topographic conditions, and configuration of the waterworks. Each facility shall conform to the following requirements:

5. The water transmission shall be equipped with pumps, pipelines, and others to convey required amount of purified water.

6. The water distribution shall be equipped with reservoirs, pumps, pipelines, and others to convey required amount of purified water with more than a certain pressure.

2 In determining the location and arrangement of water supply facilities, the construction, the operation and the maintenance shall be economic and ease as much as possible. Reliability of the water supply shall also be considered.

3 Structures and materials of the waterworks shall be sufficiently durable to water pressure, earth pressure, seismic loads, and other loads without contamination and leakage of water.

4. Best Practices in Japan

Effective maintenance of water supply systems are characterized by (1) preventive maintenance, (2) application of construction standards and using high quality materials by standardization, (3) adherence to national guidance, (4) information sharing among the utilities, and (5) standardization of procedures and preparation of manuals which are repositories of cumulated knowledge and skills. Asset management is promoted for a useful tool for planning facility replacement with respect to the financial capability of the utility.

In this chapter, the best practices in the utilities in Japan and the principles and ideas behind the practices are introduced. In the past, the most common approach to maintenance was to repair a failure when it occurs. As the utilities gain more experience with accidents and understanding of leakage prevention, there is a gradual shift to preventive maintenance. Pipeline maintenance is not easy because of the extensiveness of the networks and the fact that they are buried in the ground. The preventive maintenance for pipeline, however, is the most important idea for reducing non-revenue water (NRW); the preventive maintenance largely contributes to low NRW of the utilities in Japan. In this context, this textbook largely focuses on the maintenance of pipelines.

Maintenance practices are guided by: (1) regulations and instructions issued by the central and prefectural governments (top-down); and (2) accumulation and sharing of experiences and know-how (bottom-up). The Japan Water Works Association (JWWA) plays an important role in both top down and bottom up processes.

Revenue of water utilities in Japan is declining because of shrinking population. Asset management has been used by many water supply utilities to ensure that maintenance is conducted effectively. Utilities must (1) project population growth and water demand, and know the condition of the facilities; and (2) ensure proper financing for sustainable operation.

(1) Corrective and Preventive Maintenance

In the past leakage and breakdown of equipment was repaired or replaced when the problem was discovered (corrective maintenance). This is not conducive to sustainable and reliable operation. Therefore, preventive maintenance with planned inspections and facility renewal has been introduced by many utilities to prevent failures.

In the past, water supply pipelines were replaced as a corrective measure when leakage occurred or rusty water was reported. Many utilities recognized the advantages of preventive maintenance and began to conduct planned renewal of facilities. Cast iron, asbestos, and lead pipes were systematically replaced. The toxic nature of pipe materials, such as lead and asbestos, was also an incentive for replacement. The national government provides subsidies for scheduled replacement of aged or asbestos pipes. Utilities also set the priority for the replacement of mechanical and electrical equipment that have short service life or ones that would cause serious damage to the supply system if failure occurs.

Asset management is very effective in managing facility renewal by considering the service life and setting priority according to financial constraints.

(2) Maintenance in Water Treatment Plant

The *Design Criteria for Water Supply Facilities* and the *Water Supply Facilities Maintenance Manual* published by JWWA contributed to the standardization of maintenance practices in water treatment plants in the whole country. Maintenance of mechanical and electrical equipment began to be contracted out to private enterprises, and the practice gradually extended to all other operations.

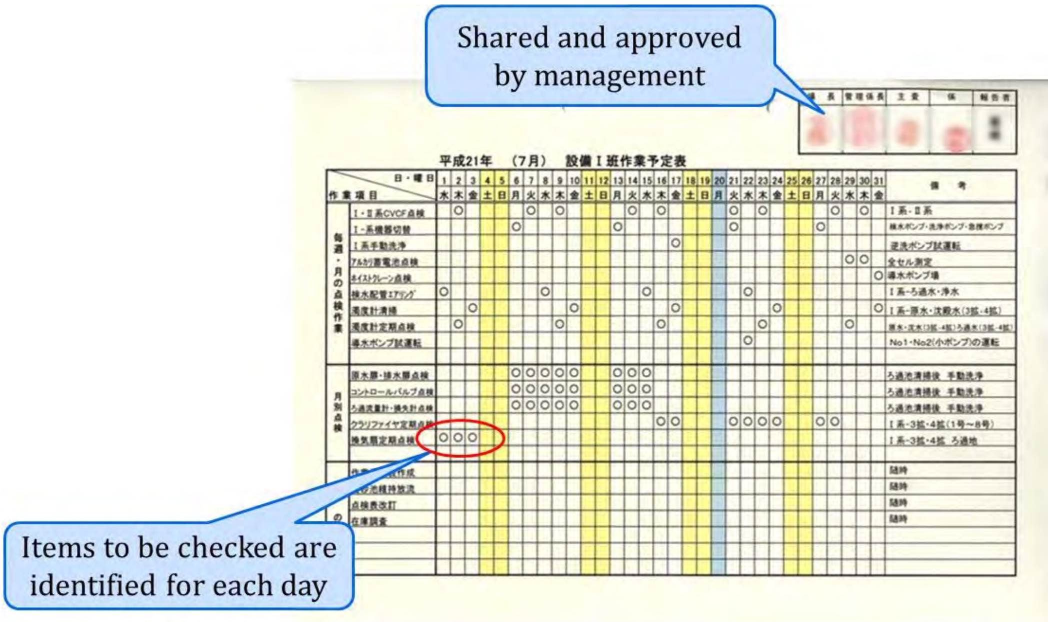
Operation and maintenance of treatment plants require fundamental knowledge of water purification methods and ability to manage all aspects of the operations, including administration, procurement, and maintenance. The design criteria, maintenance manual and on the job training facilitates the transfer of knowledge among treatment plant operators. The guideline and the maintenance manual were compiled based on cumulated knowledge and experience of many utilities in different natural and social situations. These resource materials are used by all of the utilities across the country and institutions of higher education, and professional associations. The national government promotes their use for developing and improving facilities maintenance. Treatment plant operators follow the maintenance manual to prepare their plants' own operation and maintenance manuals, to record operational data, and to perform regular inspections.

Utilities may not have the expertise for the maintenance of special equipment. The vendor may have to deal with the repairs or provide training to utility staff to do so. For an instance, there are many cases that they established relationships based on mutual trust; when there is a problem in equipment, the water supply utilities just called them and they rushed to help them immediately. The sellers also took part in some part of the water supply utilities' work such as operation, maintenance, and regular inspection and maintained the equipment.

There is increasingly outsourcing of maintenance activities because of gradual loss of skilled workers through attrition, a cost saving measure and a measure to increase efficiency by public-private partnerships.

Example: Maintenance of Water Treatment Plant and Consignment

Sapporo City Waterworks Bureau has five water treatment plants in its service area and consigns the operation and maintenance of two plants and inspection of another two to the Sapporo Water Service Association, a general incorporated association. The consignee prepares a work plan and conducts regular inspection as shown by Photo 1.



Source: JICA Training Course Material prepared by Sapporo City Waterworks Bureau (JICA Sapporo, 2015)

Photo 1. Regular Inspection Schedule

Other water utilities usually consign maintenance to private operators. Most of the consignments are outsourcing of individual operations such as meter reading or maintenance of a particular set of equipment. The utility still has the legal responsibility for the out-sourced operation, as stipulated in the Water Supply Act. In recent years, other types of consignment such as; (1) management of technical matters including responsibility stipulated in the Act as "third party consignment"; and (2) design, construction, operation and maintenance as "design build operate (DBO)" are gradually increasing. The utility has the responsibility to monitor the performance of the consignee. The utility publishes the performance evaluation in accordance with the *Draft Manual for Evaluation of Performance of Consigned Maintenance Works for Waterworks Facilities* prepared by JWWA, and audit their facilities properly.

An appropriate amount of chemicals and spare parts must be available for performing daily operations and for urgent situations such as earthquake disaster. Utilities rely on daily inspections to manage their inventory. In the past, utilities had to manage procurement by tracking carefully the movement of items on its inventory. Utilities can now procure required materials and equipment on short notice because of the highly developed logistics of the suppliers.

(3) Pipeline Maintenance

1) Transmission and Distribution Pipe Materials and Maintenance

Materials for pipelines were mostly imported in the early days since the facilities were designed by foreign engineers. Domestic production started when there was public demand to use domestic products. The technology and manufacturing bases were gradually established through trial productions and usage. Domestic products took over the market partly through the establishment of national standards by JWWA.

Materials for pipelines were mostly imported in the early days and were expensive. The general public and policy makers began to demand transition to domestic products. The transition was not successful in the initial stage, because the domestic manufacturing industry was underdeveloped. In the second half of the 1890s, modern water supply system was gradually spreading to major cities in Japan. Development and improvement of water supply materials and equipment intensified. Domestic products gradually became more broadly used. Manufacturing technology also improved by standardized specifications.

At present, ductile iron pipe (DIP), steel pipe, un-plasticized polyvinyl chloride pipe (uPVC), polyethylene pipe (HDPE) are manufactured in Japan. The choice of material depends on ground conditions, purpose and available budget.

Example: Transition of Pipe Materials

Most of the utilities have used various kinds of materials and technologies for pipelines along with the innovations for preventing leakages and corrosion. This Example introduces the history and transition of the materials of pipes and appurtenant technologies.

The water supply system in Kyoto City was established in 1912. Gray cast iron pipes were used like other cities. After a serious pipe burst in 1923 and an earthquake which hit the other part of the country in the same year, deeper underground installation and thicker pipe walls were proposed. Although these were not adopted because of financial concerns, strengthening of pipelines was a serious concern even at that time.

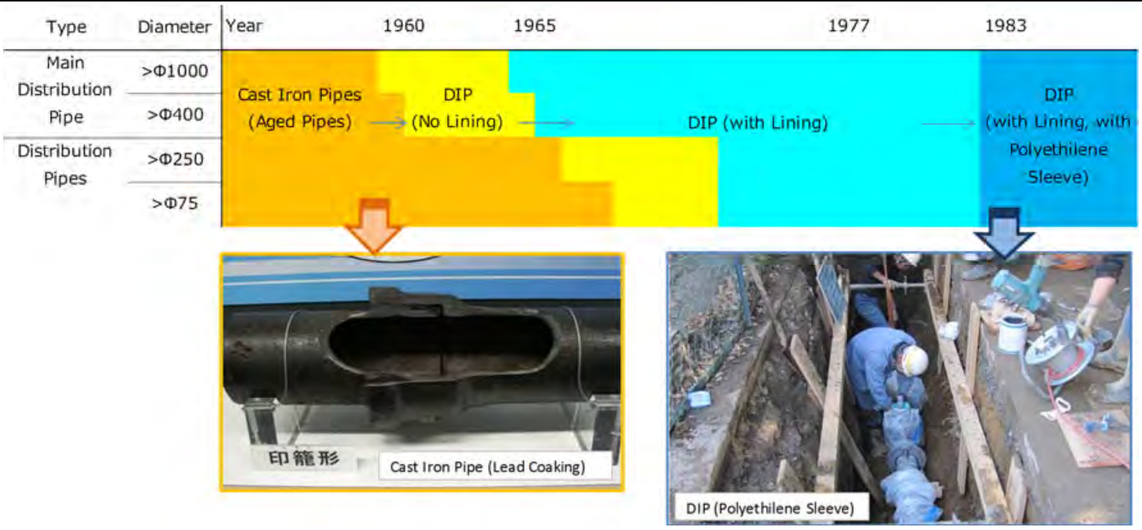
High grade cast iron began to replace gray cast iron as the material of choice, but it was difficult to procure at the time. Utilities turned to asbestos cement pipe as an inexpensive option.

During the 1940s to 1950s, leakage prevention measures for distribution pipes were implemented and significantly increased accounted-for-water by more than 20 percent.

The Kyoto, Osaka and Kobe cities petitioned the General Headquarters of the Allied Forces (GHQ) to lower the required content of residual chlorine (0.4 ppm) which caused steel pipes to rust prematurely by 5 years. Around this time, ductile cast iron pipe from the United States of America (USA) started to be used in Japan. Kyoto City started to use this material from 1959.

During the 1960s, asbestos pipes were used extensively, but the use ended in 1968 due to their rapid deterioration. Thereafter, existing pipe materials were changed to (1) ductile cast iron; (2) ductile cast iron wrapped in polyethylene sleeves for corrosion protection; and (3) earthquake resistant joints.

Bureau of Waterworks, Tokyo Metropolitan Government (BWTMG) started using ductile iron pipes in water distribution networks since 1960. Some new technologies apply an inner lining or polyethylene sleeve to prevent corrosion. The aging cast iron pipes are being replaced at about 300 km to 400 km per year. With a total of 24,000 km distribution pipes, all the water distribution pipes will be replaced in 60 to 80 years.



Source: Training materials for JICA Technical Cooperation Projects

Sources of Photo: (Left) Water Partners Jp Co., Ltd. (Right) Japan Ductile Pipe Association

Figure 3. History of Pipe Materials in BWTMG

2) Materials and Maintenance for Service Connections

Lead, galvanized steel, and copper were commonly used for pipes in the past. Lead pipe was replaced by uPVC pipe etc. because of health concerns caused by the elution of lead. The Water Supply Act stipulates the material and structure for water supply facilities (facility standards).

In 2004, JWWA published the "*Guidelines for Maintenance of Service Connection Facilities*" stipulating the responsibilities to be fulfilled by parties including the national government and users.

Lead and copper were used to manufacture service pipes because of their workability. Lead pipes had to be replaced when the toxicity of lead was understood. Currently, commonly used pipe materials are stainless steel, uPVC, and polyethylene.

Utilities sometimes face difficulty for managing and replacing service pipes because some part of the facilities are the asset of the customers, on contrary to the transmission and distribution pipelines which is owned by utilities. Accidents such as cross connections can be caused by the lack of maintenance and supervision. Manufacturers, certification bodies, utilities, and construction companies, supposedly had lower awareness to maintenance for service connections and could all do more to prevent accidents. Many leakages also occur in service pipes and customers can do more for their maintenance. JWWA prepared the "*Guidelines for*

Maintenance of Service Connection Facilities" in 2004. The guideline clearly describes the problems with maintenance and management of the service connections and the responsibilities of the national government, the water utility, the contractor, and the customer.

The specifications for pipe materials have been developed by JWWA which reflect the input from utilities and the manufacturing industry. JWWA also established an inspection system which helped utilities to procure high quality materials and contributed the development of the water industries. It is important to establish standards for materials and equipment to ensure their quality.

Column: Restrictions on Usage of Lead Pipes in Japan

The regulations on lead pipes were issued in a notification of "public health measures concerning service pipes" in response to a report of a water supply and sanitation committee of Ministry of Health and Welfare in 1989. The highlights of the notification are as follows:

(a) New service pipes must be lead free
(b) Replacement pipes must be lead free
(c) pH must be maintained at a high level in the water supply to suppress lead elution
(d) The public is advised to run water for a while after turning the tap on and use this water for purposes other than drinking or food preparation.

Based on the latest scientific evidence and drinking water quality standards of the World Health Organization (WHO), acceptable limit for lead was changed from 0.1 mg/l to 0.05 mg/l (December 1992), and again to 0.01 mg/l (March 2002).

Notifications and amendments to the water quality standards accelerated the replacement of lead pipes in Japan, but not as much as expected. Utilities tend to give the priority to upgrading the seismic resistance of water pipes. There is also no incentive to deal with the service pipes which are the property of the consumer. There are still many lead pipes remaining in the distribution systems of small- and medium-scale utilities (around 4 million connections in 2010). In 2012, the Ministry of Health, Labor and Welfare issued the "*Guidance for Lead Pipe Replacement*" outlining the technology, policy, and required efforts for each water utility.

Lead pollution in tap water in Flint, Michigan State in USA, which occurred in January 2016, reaffirmed the seriousness of the toxicity of lead.

3) Mapping of Distribution Networks

Digital GIS mapping systems have replaced paper records of distribution networks making it easier for information sharing within the utility and with other related infrastructure agencies to facilitate the communication.

Digital mapping integrated with database systems capture a vast array of information on the distribution network on one single platform. It makes the monitoring of pipeline conditions, locating operational problems and planning repairs and replacements much more efficient.

Traditionally pipeline information was kept as paper drawings and on ledgers, and sometimes saved in microfilms for portability. The information can be lost during disasters, as in the tsunami caused by Great East Japan Earthquake in 2011. It is also more difficult to share the information and data, compared to doing so electronically. Utilities started to transfer their pipeline data to electronic systems. These databases are also useful for hydrological calculations and for asset management.

Whether in paper or electronic format, information held by individual staff should be shared for more efficient management of water distribution, and construction planning to minimize water supply disruption. Sharing of information is the basis for proper pipeline management.

It is also important to update drawings in a timely manner after construction or rehabilitation. Most water utilities in Japan either have a specialized department for this purpose or the task is outsourced.

Example: Tokyo Metropolitan Government; Road Infrastructure Coordination Council

All utilities (water supply, sewer, gas, electricity and telecommunication) must replace their distribution networks from time to time. This should be planned to coincide with their maintenance and repair, to save money on road resurfacing, minimize traffic disruption, and prevent damage to other underground utilities. Committees with representation from implicated service sectors, shares their multi-year infrastructure construction plans and coordinate the work plan.

At the Tokyo Metropolitan Government, the Bureau of Construction organizes meetings of the road infrastructure coordination council several times a year. The council members include the Bureau of Construction of Tokyo, Ministry of Land, Infrastructure, Transport and Tourism, Police Department, Metropolitan Expressway Co., Ltd., Bureau of Waterworks, Bureau of Sewerage, Bureau of Transportation, Nippon Telegraph and Telephone Corporation (NTT), Tokyo Electric Power Company, Tokyo Gas, Tokyo Metro and Japan Railway Company (JR). The council is divided into working groups for coordination, maintenance, and improvement. The coordination working group engages in the coordination of road works and shortening the construction work period.

(4) Construction Quality Management

Construction quality control is essential for improved maintenance and long service life of the facilities. In Japan, it is required by law that construction must be implemented under the supervision of a qualified engineer. Contractors for service connections must be registered and certified as stipulated in the Water Supply Act; this is a quality control measure.

Article 12 of the Water Supply Act stipulates that qualified engineers must supervise the construction of service connections. During the period of high economic growth, many projects were implemented at the same time resulting in poor construction and errors such as cross connections. Contamination of water distribution pipes because of poor quality equipment and construction practices were also reported. As its measures, The Ministry of Health and Welfare set the standards for construction and required that contractors installing service connections be qualified and registered. These approaches are one of the good examples of the measures for improving the construction quality; there are many approaches such as laws, administrative orders and reforms of implementing methods.

Column: Designated Prequalified Contractors and the Registration System for the Contractors for Service Connection

In the beginning, the construction of service connections was mostly carried out by utility workers. Most utilities preferred to maintain close control of new construction and repairs because of the public health responsibility. There was always a concern that unqualified contractors might use inappropriate materials or construction practices. However, there were some exceptions. In the early years of water supply in Yokohama, Tokyo and Osaka, customers were allowed to use their own materials and labor for the construction of service connections as long as they obtained approval from the utility and passed inspection. In response to an increase in the construction of water supply facilities after WWII and multiple natural disasters, many cities began introducing a system of "designated prequalified contractors” for service connections. The system ensured that only qualified contractors approved by the utility could work on service connections. This ensures standards for the design, material selection and construction are met. This requirement also succeeded in reducing leakage. The system also improved the response time to emergency repairs because the standardized construction made it easier to establish the operating procedures for the repair work.

After the system of designated prequalified contractors became widespread, the Japan Plumbing Constructor's Association was established in 1960. Amongst its many activities the association also organizes member companies for disaster recovery in affected areas.

In recent years, most utilities outsource repair and installation because of their shrinking workforce. The revision of the Water Supply Act in 1996 standardized the requirements for designated prequalified contractors. It sets the registration system for the contractors for service connections and introduced unified qualification. Engineers supervising installation of service connections are required to be qualified in accordance with the Water Supply Act.

5. Lessons Learned

The following Japanese experience could be useful for other countries.

- **(Preventive Maintenance)** In the expansion phase of water supply facilities, inadequate facility maintenance sometimes caused disease outbreaks. Utilities improved their maintenance activities to avoid water quality deterioration and supply interruptions. Development of legal frameworks and national guidelines followed immediately after serious accidents, and changed maintenance practices across the country. Preventive maintenance is greatly facilitated by the national facility standards and is very effective in lowering the life cycle cost of the facilities.

- **(Guidelines and Standards)** Good maintenance practices are supported by legislation and strengthened supervision by national and prefectural governments. The Japan Water Works Association (JWWA) prepared the *Design Criteria for Water Supply Facilities* and *Water Supply Facilities Maintenance Manual*. Utilities across the country share their knowledge in these publications, and train their workers based on these standards.

- **(Concepts and Tools)** (1) Preventive maintenance, (2) standards for materials/equipment quality and construction quality, (3) guidelines, and (4) information sharing, contribute to improved operation and maintenance. New tools, such as digital mapping and asset management are very valuable in systematic rehabilitation of water facilities.

- **(Maintenance of Water Treatment Plant)** Utilities share knowledge by preparing operation manuals. The workers can be trained according to a standardized set of procedures. The accumulated knowledge and specialized skills can be shared with other utilities at annual meetings of JWWA. Maintenance practices for safe and stable supply were established as a result of the struggle to transform the personal knowledges which were exclusively owned by skilled staff to collective knowledges which could share with all staff. The collective knowledge realized well planned and organized maintenance activities. Recently, maintenance is outsourced to private companies in most water treatment plants. It is important to properly monitor the performance of the private companies. The maintenance evaluation manual prepared by JWWA is very useful for this purpose. The selection of suppliers for spare parts and chemicals and inventory control are also important.

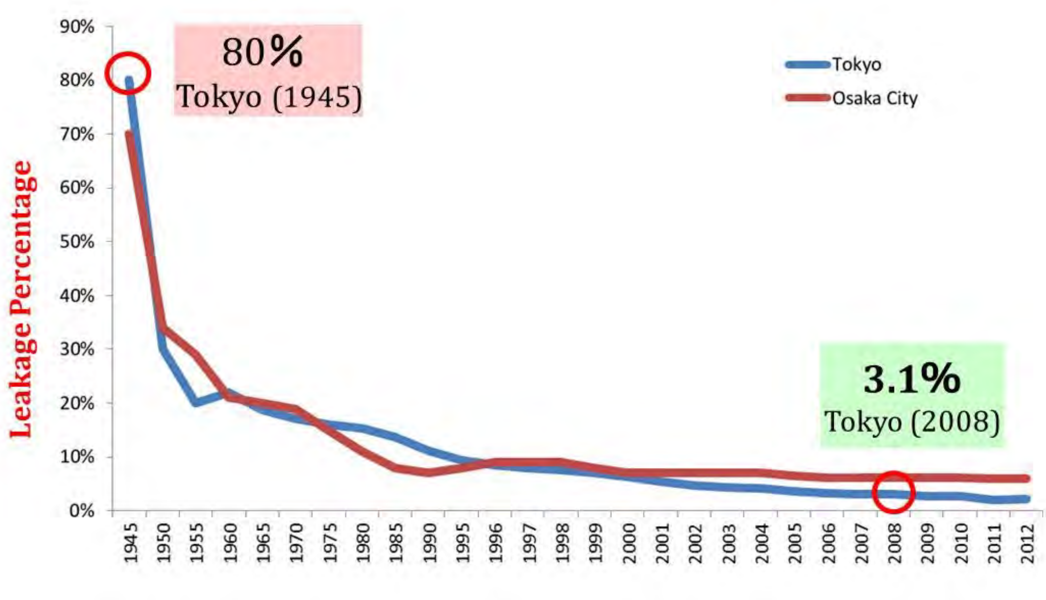
- **(Quality Control)** In the past, accidents were attributed to poor quality pipe materials and poor construction. Now there are more robust pipe materials and construction quality has improved. Manufacturers are developing better technologies. At the same time the establishment of standards and inspection system by JWWA contributes to setting an acceptable level of quality across the country. Construction quality also improved with the registration system for the contractors for service connections as required by the Water Supply Act. Information on pipelines after construction and repairs should be properly recorded and shared within the water utility. Good pipe materials, control of construction quality and information sharing help utilities to comprehend their own systems and improve their maintenance practices. Both the public and private sectors contributed to improved quality control.

Theme 5. Reducing Non-Revenue Water

Contents

1. Introduction

The average water leakage rate of the water supply systems of the utilities in Japan in 2014 was only 4.69 %. This was not the case many years ago. Major cities in Japan suffered from high leakage rate after World War II (WW II). Tokyo, the capital city, had a leakage rate of 80 %. With persistent efforts, this was eventually brought down to 3 % in 2008.



Source: Modified from Bureau of Waterworks, Tokyo Metropolitan Government and Osaka Municipal Waterworks Bureau

Figure 1. Improvement in the Water Leakage Rate of Tokyo and Osaka City

This module describes Japanese experience in reducing non-revenue water and provides examples of effective control measures and will answer questions frequently asked by the participants of water supply training courses.

Q1. How did Japan reduce leakage from 80% to 3% in some large cities?

Q2. What are the effective measures for reducing Non-Revenue Water (NRW)?

Column: Definition of Non-Revenue Water (NRW) and Leakage

Japanese utilities use the water balance table system developed by Japan Water Works Association (JWWA) which is slightly different from that of the International Water Association (IWA) used by many utilities all over the world (Figure 2a). Many of them use "effective water rate" instead of "NRW rate" as the target performance indicator (Figure 2b). The effective water rate is made up of water consumption by customers, water used during the water treatment process, and unbilled consumption for public use. The "in-effective rate" is leakage and minor adjustments to customer billing such as discounts for the poor, or leakage or water quality deficiencies. Utilities are mainly looking at leakage for NRW reduction.

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
	Water Losses	Unbilled Authorized Consumption	Unbilled Metered Consumption	**Non-Revenue Water (NRW)**
			Unbilled Unmetered Consumption	
		Apparent (Commercial) Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Systematic Data Handling Errors	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

Figure 2a. Water Balance Table of IWA

Supplied Water	Effective water	Revenue Water	Billed Water	Revenue Water
			Bulk Sales/Emergency	
		Effective Non-Revenue Water	Consumption by Utilities	**Non-Revenue Water (NRW)**
			Customer Metering Inaccuracies (Apparent/Commercial Losses)	
	Ineffective water	Adjustment (discounted customer billing for poor services caused by leakage or water quality deficiencies)		
		Real Losses (Ineffective Non-Revenue Water)	Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

Figure 2b. Water Balance Table in Japan

2. Status of Non-Revenue Water

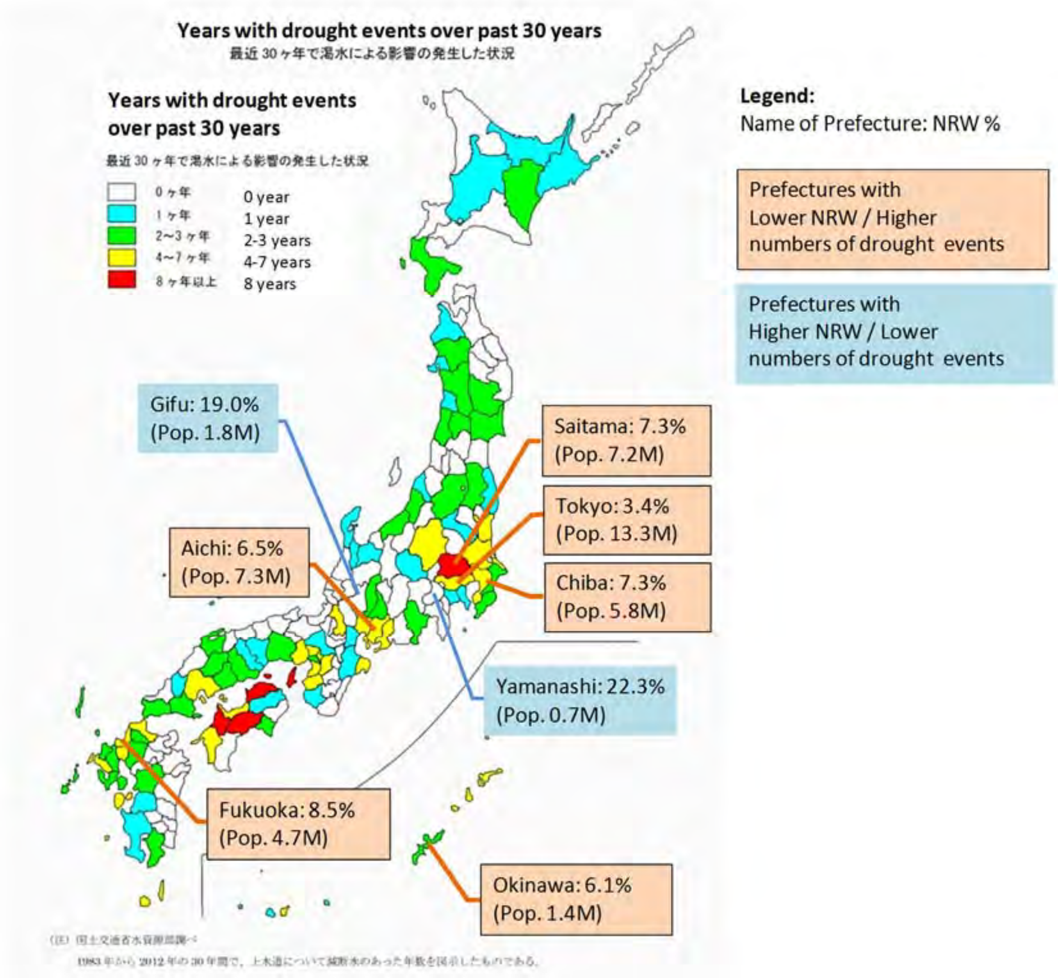
(1) Non-Revenue Water Rates across the Country

The average NRW rate in Japan was only about 9.82% in 2013 and the rate in Tokyo metropolitan area is less than 4%. However, the rates vary depending on the location, conditions of water demands, limited water sources and drought conditions.

NRW rates range widely in Japan. The Tokyo metropolitan area has a rate of < 4% and the rate for Okinawa, Aichi, Osaka, and Fukuoka is less than 9% (Figure 3). Where population density is low and distribution pipe length per connection relatively long, the rate exceeds 30%. Mountainous areas with abundant good water resources tend to have non-revenue water rate of > 20%, as in Yamanashi, doubling the national average of 9.82%. Social and natural conditions seem to have considerably impact on non-revenue water.

The areas with very low non-revenue water rates appear to be: (1) major metropolitan areas where population density, water demand and cost of water resource development are very high (e.g. Tokyo, Aichi, Osaka); (2) areas with limited water resources that often experience drought conditions (e.g. Okinawa, Fukuoka). This suggests that the availability of water resources affects the NRW rate. Not all utilities have low NRW, they mainly maintain NRW at an acceptable level.

As a benchmark for performance, the 2004 “Water Vision” published by the Ministry of Health, Labour and Welfare sets the effective water rate target of > 98% (≒ 2% leakage) for large-scale water utilities, and > 95% (≒ 5% leakage) for small- and medium-scale water utilities. This is quite low but the utilities are making their best effort to achieve the target leakage rates.



Source: Statistics on Water Supply (2014), the Ministry of Land, Infrastructure, Transport and Tourism website

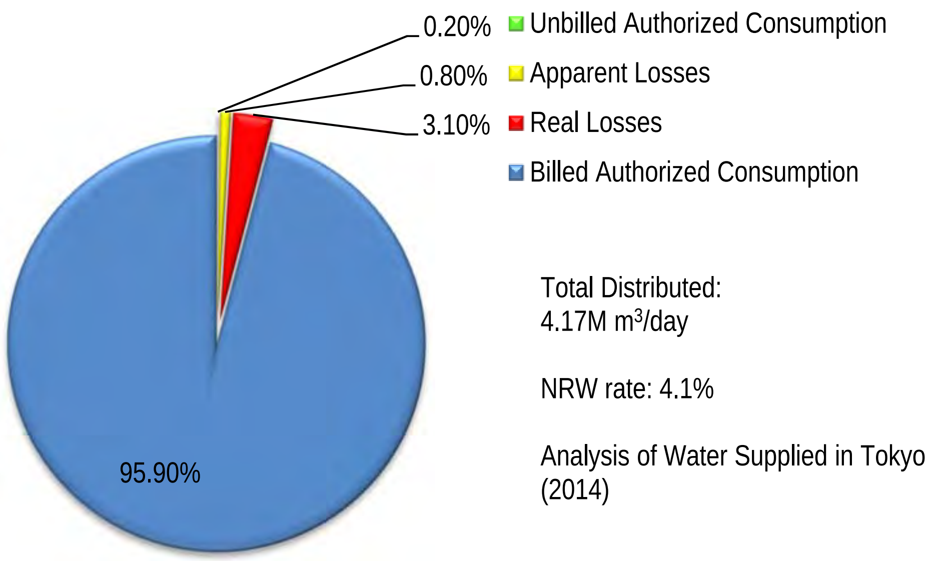
(Years with drought events over past 30 years)

Figure 3. Differences in Non-revenue Water Rates in Japan (by Prefecture)

(2) Components of Non-Revenue Water

Leakage from water service pipes (real losses) and metering inaccuracy (commercial or apparent losses) are the major components of non-revenue water in Japan. There are very few illegal connections. Control measures to reduce leakage are of top priority.

Figure 4 shows the rates of revenue and non-revenue water, and the components of non-revenue water in Bureau of Waterworks, Tokyo Metropolitan Government (BWTMG**)**. The largest component of non-revenue water is real losses which consist of leakage and the second is metering inaccuracy, also known as "commercial losses." These two components made up the overwhelming majority of the losses and illegal connections do not show up on the statistical figures because the cases are few. Other water utilities in Japan have similar non-revenue water composition. The utilities are committed to reduce in-effective water and implement control measures to reduce leakage.



Source: Materials by Shozo Yamazaki

Figure 4. Apparent and Real Losses in Water Supply in Tokyo

3. Causes and Control Measures for Non-Revenue Water

(1) Importance of Reducing Non-Revenue Water

NRW is a waste of resources and an unnecessary economic loss, taken seriously by management. Furthermore, contamination of the water supply can occur through leakage points and associated pressure reduction in the pipelines. National notices were issued to emphasize the need for water leakage control. Utilities form networks to develop and implement measures.

Non-Revenue consists of unbilled consumption and water losses which is “water not generating revenue”. Therefore, it affects the financial viability of utilities through lost revenues and increased operational costs. The major causes of commercial or apparent losses are mal-functioning or broken meters, meter reading errors, and illegal connections. If these problems are left unaddressed, the utility would lose the customers’ trust and with the flat rate system this can reduce the likelihood of customers taking water conservation seriously.

Real losses mostly from aging or rusting pipes and drop in water pressure in distribution networks can result in the degradation of water quality. This can affect customer satisfaction and willingness to pay. Utilities cannot afford to waste scarce resources through leakage, given the high cost of water resources development and the risk of having to impose water restriction in the event of water shortage.

NRW affects the performance of the supply system and financial conditions of the utilities. Utilities across the country have dealt with NRW successfully with the help of JWWA since they could communicate with one another how to get to it utilizing the network. Repeatedly issued national notices also accelerated the measures by disseminating the importance of NRW. The timely publication of technical documents such as the *Water Supply Facilities Maintenance Manual* and *Guidelines for Water Leakage Prevention* which contains specific methods for leakage prevention has been very helpful for the utilities.

(2) Causes and Preventive Measures for Leakage

Measurement of water flow in distribution networks is the crucial first step in the investigation of non-revenue water. Construction quality, leakage detection and repair, good quality equipment, are required to control real loss (leakage). Minimizing metering errors is also essential.

It is necessary to measure water flow in distribution networks when investigating the causes of non-revenue water. A pilot project in a selected distribution block can be carried out to obtain the base line values for water flow and the night time minimum flow. Then the leakage location can be confirmed and the leak repaired, or if necessary water meters can be installed or replaced, or illegal connections removed. Monitoring the water flow after the implementation of control measures, would indicate if the problems have been corrected.

Table 1. Water Leakage Control

Category	Item	Measures
Basic measures	Preparation for leakage prevention	Arrangement of financial and human resources
		Preparation of documents (Drawings of pipe network, distribution blocks, etc.)
		Information management system for pipe network
		Arrangement of areas and measuring devices
	Survey on current conditions	Analysis of water supply and leakage, measurement of water pressure
		Analysis of leakage and its causes
	Research and development of pipe materials	Materials for distribution and service pipes, joints and attachments
	Technological development	Measurement of leakage, investigation of underground pipes
Symptomatic measures	Responsive work	Immediate repair of visible leakage
	Planned work	Early detection and repair of leakage detected underground
Preventive measures	Water supply plan	Planning in consideration of leakage prevention
	Water network analysis and evaluation	Water pressure, aging pipes and joint types, etc.
	Design and construction	Earthquake resistance, durability, anti-corrosion characteristics, water tightness
	Replacement of aging pipes	Replacement of distribution pipes and service pipes (including material upgrade)
	Improvement of structures of water service devices	Integration of road-crossing pipes
	Pipe protection	Installation of meters to places closer to public-private border
		Devices for anti-corrosion and leakage prevention, strengthening of pipe bend
	Proper treatment of out-of-service pipes	Clearance of old pipes at interconnecting part
		Management of water service devices
	Patrol	Supervision to avoid damages by companies carrying construction near water supply facilities
	Adjustment of water pressure	Arrangement of distribution area, installation of pressure reducing valves

Source: JWWA "*Guidelines for Water Leakage Prevention*"

Measures against real losses include proper installation and high quality material, leakage detection and repair, and quality control of water supply equipment. Minimizing metering errors would reduce commercial losses.

1) Proper installation and high quality materials

Making the pipe connections in the distribution networks must be carried out with proper technical know-how and high quality material. Looking back the history in Japan, pipe technologies largely contributed to the leakage reduction. Until the 1950s, most of the pipelines were gray cast iron pipe with lead-caulked bell-spigot joints which used the hemp yarn and lead for making the connection. This type of pipeline has low ductility and flexibility and the joints can become loose causing leakage problems. In the 1960s, utilities began to use T-type push-on joints and A-type mechanical joints with rubber seals. K-type mechanical joint which uses rounded rubber joint to improve the water tightness was introduced later; this is the technology developed in Japan and has been used until today. Advanced pipe joining technology also contributed to leakage prevention. In addition to technological improvements, utilities also have strengthened construction supervision such as using a detailed check-list to ascertain uniform construction quality.

House connections are also one of the most important causes of leakages. Nowadays in Japan, most water leaks are found on house connections. To ensure proper installation the supervisory personnel would check that (1) the soil cover is not too thin, because the pipe wall can be damaged if there is lack of protection from external pressure or by construction material left in the ground unintentionally; (2) there is adequate service branch connections, and (3) the pipe material can withstand surrounding conditions. Construction qualities of house connections are quite important because these problems, especially for (1) and (2), could be solely prevented by quality control of the construction.

The official certification system, the establishment of the Plumbing Constructor's Association and the registration system of plumbing constructors, all help to ensure that the installation of the pipelines is carried out properly and competently. Utilities have a good archival system for drawings of pipe installations prepared for house connections. This enables them to respond quickly to reported problems and minimize leakage.

2) Detection and repair

The detection for and repair of water leaks have been carried out routinely so that the utilities stay on top of any potential problems. Most leaks found on water service pipes and could be detected by listening for leaking sounds around water meters and at service connections.

Measuring night time minimum flow at distribution blocks helps to pinpoint areas that are vulnerable to leakage, and identify priority areas for detection and repair. 24-hour water supply and well-controlled water pressure makes it easier to locate water leaks. Persistent effort and well-trained staff are essential for conducting the daily routine which can involve night inspections.

3) Good quality water service devices

The quality of water service devices are assured by a) laws and regulations, b) technical standards, and certification and inspection by a third party organization, and c) the use of high quality materials.

a) Laws and regulations

Structural design and materials of water service devices and a registration system for the contractors installing service connections, are prescribed in the Water Supply Act (Article 16). More detailed specifications can be found in the ministerial ordinance by the Ministry of Health, Labour and Welfare (MHLW).

b) Technical standards, certification and inspection by the third party organizations

In Japan, most of the water supply equipment is manufactured domestically. The equipment has to comply with the Japanese Industrial Standard (JIS) and JWWA standards. JWWA also performs certification and inspection.

c) Pipe materials

Pipe materials such as lead and galvanized steel, commonly used in Japan, lack earthquake resistance and are vulnerable to corrosion causing leakage. Elution of lead or rusting of steel pipes affects the quality of potable water. Bureau of Waterworks, Tokyo Metropolitan Government is switching to stainless steel for water service pipes. Yokohama City uses three types of pipe material: PVC lined steel, stainless steel and dual-layer polyethylene.

d) Metering errors (commercial or apparent loss)

In Japan, the Measurement Law prescribes the required accuracy and replacement period for water meters. These requirements contribute to maintaining the required level of accuracy. The water meter is protected in a box and is on loan to the customer by the water utility. It cannot be arbitrarily removed or intentionally destroyed. Meters must be installed properly and appropriately maintained to reduce NRW.

Column: Illegal connections

Illegal connections are rare in Japan. Deeply buried pipeline and continuous flow (24-hour water supply) with appropriate water pressure makes it difficult for untrained persons to install unauthorized connections. In addition, customers usually have high ethical standards. Some water utilities made strong efforts to persuade illegally connected households to apply for the service legally. Illegal connections can be detected from the changes in consumption pattern shown in the meter logs. Therefore, the metering system is very important for the detection of illegal connections.

Phnom Penh Water Supply Authority is widely known for its success with administrative improvement. They reduced NRW from over 70% to 6% in 2011. They identified illegal connections and leakage using distribution flow monitoring, introduced by Japanese experts in JICA technical cooperation projects. Electromagnetic flow meters were installed in each distribution block. On one occasion, water theft was caught by a patrol unit following up on suspicious high water flow recorded during the night. PPWSA’s reforms and successes are credited to the leadership shown by the utilities and the technical capabilities acquired from technical cooperation with Japan.

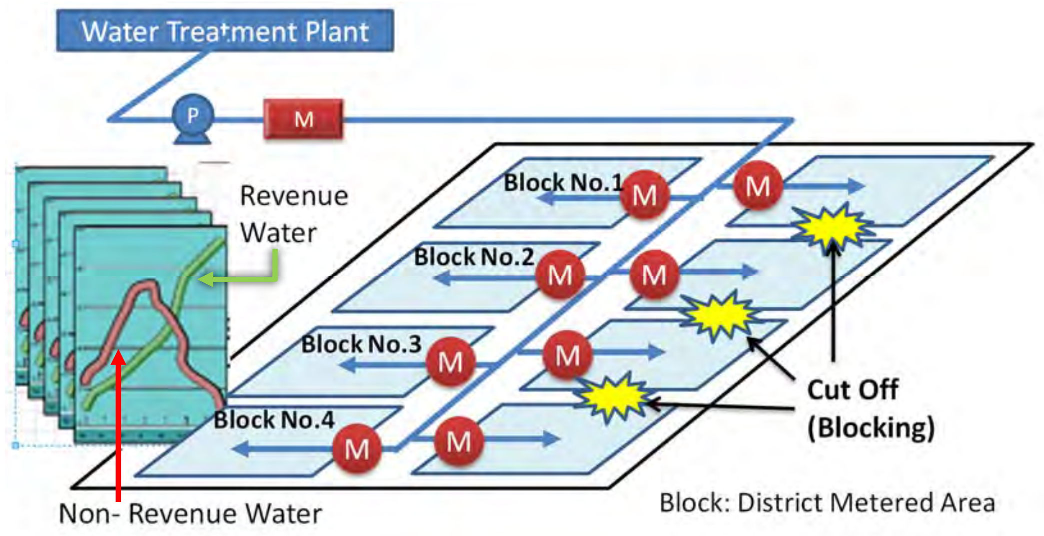


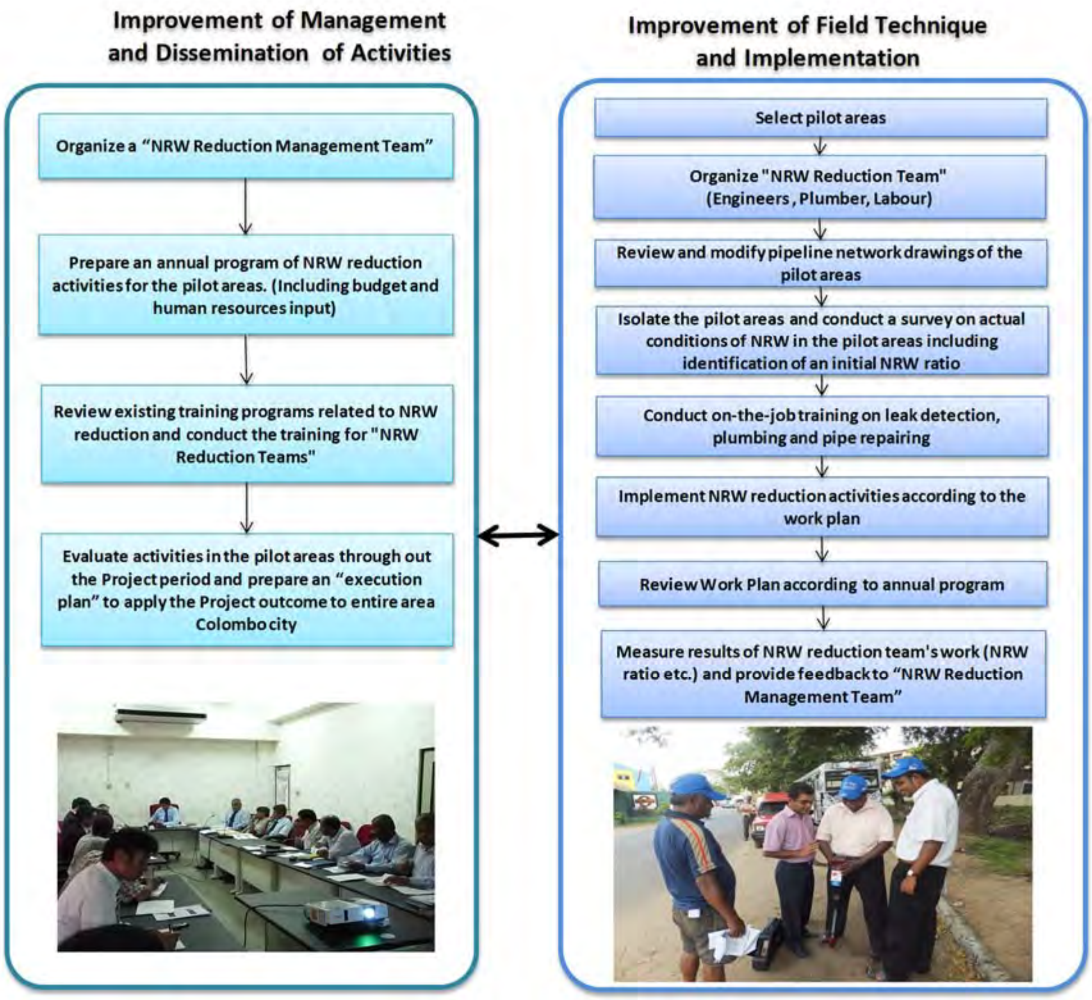
Figure 5. Distribution Monitoring System by PPWSA under Technical Cooperation with Water and Sewer Bureau, City of Kitakyushu

Column: JICA projects

JICA implemented several non-revenue water projects in developing countries and shared the experience and know-how of Japanese water utilities.

These projects emphasized: (1) identification of a responsible or lead department/division; (2) setting realistic and achievable goals; (3) employing quantitative indicators and monitoring to assess the effectiveness of preventive measures; (4) developing arms-length process for monitoring and assessing results; (5) preparing action plans for non-revenue water reduction; (6) offering incentives for improvements, bestowing rewards based on performance and (7) learning techniques by implementation of pilot project.

In the "Capacity Development Project for Non-Revenue Water (NRW) Reduction in Colombo City", JICA experts started with building the management and technical teams. The latter was given technical training. The management team received assistance with the preparation of the annual program, including budgeting, procurement and human resource plan. The experts also facilitated the development of the strategic plan for sustainable operation, including cost-benefit analysis of NRW reduction activities. The project included a training program in Tokyo. NRW reduction was not introduced as a short-term exercise but was emphasized as a core activity to be carried out consistently in an on-going basis.



Source: Project Completion Report: The Capacity Development Project for Non-Revenue Water (NRW) Reduction in Colombo City (JICA)

Figure 6. Outline of the Capacity Development Project for NRW Reduction in Colombo City (JICA Project)

4. Leakage Control

In Japan, commercial or apparent losses due to illegal connections and metering errors had been small compared to real losses from leakage. In the post war era, water utilities had to reduce leakage in their water supply systems to conserve scarce resources as it faced a rapid increase in water demand and suffered severe droughts.

Commercial or apparent losses due to illegal connections and metering errors are small compared to real losses from leakage. Leakage inflates the water utility's production costs and stresses water resources since they represent water that is extracted and treated, yet never reaches beneficial use. Water utilities, which have to bear high costs for water resources development or to suffer from water scarcity, tend to mount more vigorous efforts in tackling leakage. This accounts for their success in keeping the non-revenue water rate low. Other utilities with high non-revenue water also need to focus on reducing leakage as a means to limit the waste of water resources and curb lost revenue.

(1) Metering

Excessive consumption by customers paying flat rate tariffs has been widely recognized among Japanese utilities. Tariff setting based on meter consumption is widely used in Japan because the utilities are aware of its importance for reducing waste. The Measurement Act outlines the term of validity, accuracy, periodic inspection, replacement cycle and use of certified water meters. This highly developed metering practice contributes to low commercial losses thereby allowing utilities to more easily identify and effectively reduce leakage.

The Measurement Act specifies the terms of validity and accuracy of water meters, the requirement for the use of certified water meters, their periodic inspection and replacement. This has been very effective in contributing to the control of commercial losses.

Nagoya City had to manage a surge of water demand in the second half of the 1910s. Its open water supply based on a flat rate encouraged indiscriminant water use. From 1921 to 1924, 30,000 water meters were installed. Metering and volumetric tariffs were introduced, with other cities following suit. The use of water meters, hence the demand, brought improvements to the manufacturing of the product. The first made-in-Japan water meter was manufactured in 1913. By 1926, the share of national products in the water meter market expanded to 42% in Osaka City and 35% in Tokyo. Product inspection and certification for water meters was established in

1928 and the recommended replacement cycle was six years (revised to eight years in 1944). In addition, a licensing system was introduced for meter manufacturers. These developments contributed to the quality assurance of Japanese water meters even in the early days of modern water supply system development in the country. The importance of metering and metering accuracy is well recognized in major cities, therefore commercial or apparent loss due to metering error is usually low.

"Make your kitchen better: A household that values water prospers. A household that wastes water suffers."

Source: Nagoya City Waterworks and Sewerage Bureau

Photo 1. A Poster to Promote Water-Conservation (1912 - 1926)

(2) WWII Destruction and Post War Recovery

Major cities in Japan suffered from high leakage from the destruction caused by aerial attacks during WW II. Intensive restoration efforts supported by national subsidies helped to rapidly rebuild major water supply infrastructure.

Water supply infrastructures of major cities such as Tokyo, Hiroshima, Osaka and Nagoya, were badly damaged by aerial attacks during the war. Water distribution networks in Osaka reported a leakage rate greater than 70%. In 1945, the national government subsidized half of the restoration costs of water supply systems and implementation of leakage prevention measures; and one third of the costs for installation of distribution networks in the following year. Osaka City mended broken water taps with non-stop water flows and repaired or replaced distribution pipes and reduced the leakage rate to 30% in 10 years.

Column: Water supply reconstruction after the war

After WW II, the Japanese economy and major infrastructures were devastated. Water supply facilities were in a state of disrepair. There was a lack of manpower and shortage of materials, making the reconstruction very difficult.

According to the survey of 90 cities by JWWA, 53% of the water service pipes were destroyed (1.67 million out of a total of 3.13 million connections). 16.8% of the water supply facilities were damaged with an estimated cost of replacement or repair reaching 366 million yen. Lead pipes were the most seriously damaged because they were easily destroyed by fire.

A rapid recovery of water supply facilities was needed to restore good public health conditions in the cities. In 1945 the national government provided subsidies to cover half of the restoration costs and for measures to control leakage. In 1946, national subsidies covered one third of the cost for the installation of water distribution pipes.

The first task of the water utilities was to remove broken water taps to stop the continuous flow of water. This activity alone achieved a significant improvement in a short period.

The water supply capacity of the utilities was greatly increased just by reducing leakage. The increased capacity allowed the utilities to cope with the population growth around 1950. Population returned to the level of the pre-war period and the water demand barely exceeded the capacity of water supply facilities. By the mid-1950s, with the continuous rise of the urban population, water supply capacity could no longer meet the demand. Water utilities started to expand supply capacity and develop water resources. The number of water supply facilities increased from 357 to 485 between 1945 and 1955. The water supply coverage rose from 26% to 32%.

Source: Ministry of Internal Affairs and Communications

Photo 2. Situation After WWII (Ichinomiya City, Aichi Prefecture)

(3) Water Demand Increase and Water Shortage

Water demand driven up by rapid economic growth together with severe water shortage brought the country together to address the urgent need for leakage reduction.

Rapid post-war economic development and population growth drove the water demand in urban areas up by 10% annually between 1955 and 1975. Surface water resources were developed extensively to meet the demand. Severe drought conditions made the situation worse. Water restrictions were imposed over a wide area in Tokyo from 1961 to 1965 (during the Tokyo Olympic Games in 1964). National media suggested grave concerns for the future of the country. A nationwide water shortage occurred in 1973 and more water supply restrictions followed (Table 2). A call for water conservation began to spread in the Tokyo area. Leakage prevention was recognized as an effective alternative to the development of new water resources. The history of water shortages gave the impetus to leakage prevention across the country.

Destruction in WWII, demand increase and water shortages were severe mostly in larger cities such as Tokyo, Osaka Fukuoka but it was widely broadcasted throughout the country. Therefore, all utilities are well aware of the priority and importance of leakage reduction.

Table 2. Severe Drought Events and Long Periods of Water Restrictions from 1960 to 1975

1961～65	4-year long water supply restriction and drought in Tokyo
1964	More than 8-month water supply restriction in Nagasaki
1967	Water supply restriction in 278 water utilities west of Kanto region
1973	Water supply restriction in 393 cities due to water shortage

Source: Bureau of Waterworks Tokyo, Metropolitan Government website

Photo 3. Emergency Water Supply During Severe Drought from 1961 to 1964

(4) National Policy for Leakage Control

The national government issued notices to promote leakage control. JWWA prepared the guidelines for leakage prevention. A nationwide effort was underway to implement leakage prevention activities.

Water utilities carried out leakage prevention measures, while the Japanese government and JWWA played a crucial role in promoting the initiative throughout the country. The Ministry of Health and Welfare (MHW)[1] tasked JWWA to prepare the "*Water Leakage Prevention Guidelines*," and announced the "*Measures to prevent leakage in water supply systems*" in 1950.

The leakage control initiative was launched across the country. For example, the Bureau of

[1] The Ministry of Health and Welfare was merged with the Ministry of Labour to form the Ministry of Health, Labour and Welfare in 2001.

Waterworks, Tokyo Metropolitan Government took the following measures:

1950 -1958	Leakage detective survey and repairs
1959-1965	Replacement of old deteriorated distribution pipes
1966-1979	Introduction of DCIP as well as preventive maintenance works by well-trained technicians and establishment of dedicated research department
1980-	Continuation of the above and completion of service pipe replacement

The leakage rate was reduced from 17.2% (NRW 27.9%) in 1970 to 10.2% (NRW 14.6%) in 1990. Similar efforts at other utilities also reduced the average NRW rate from 26.0% to 14.3% for the same period.

In 1990, MHW decided to strengthen leakage prevention. Utilities with less than 90% effective water rate were instructed to implement further leakage prevention to raise their effective water rate to 90% as soon as possible. Utilities with an effective water rate ≥ 90% had to set a higher target (such as 95%) and continue to work on systematic leakage prevention. The 2004 "Water Supply Vision" published by MHW prescribes the target effective water rate of > 98% for large-scale water utilities, and > 95% for small- and medium-scale water utilities.

Column: Improvement in living standard and soaring water demand

There was a significant increase in water demand during the post-war period of rapid economic growth. Increase in purchasing power and improved living standard led to increased domestic water use. Water consuming household fixtures such as washing machines, private baths, and flush toilets became common items in Japan from 1955 to 1975, while the family size dropped from 4.68 in 1955 to 3.35 in 1975.

Water consumption per capita per day grew rapidly from 194 liters in 1960, to 216 liters in 1965 and 302 liters in 1975; an increase of 1.5 times from 1955 to 1975. Served population increased by 2.5 times in 15 years, from 39.68 million people in 1960, to 68.24 million people in 1965 and 98.4 million people in 1975. The amount of water supplied more than tripled in 20 years.

5. Best Practices at the Bureau of Waterworks, Tokyo Metropolitan Government

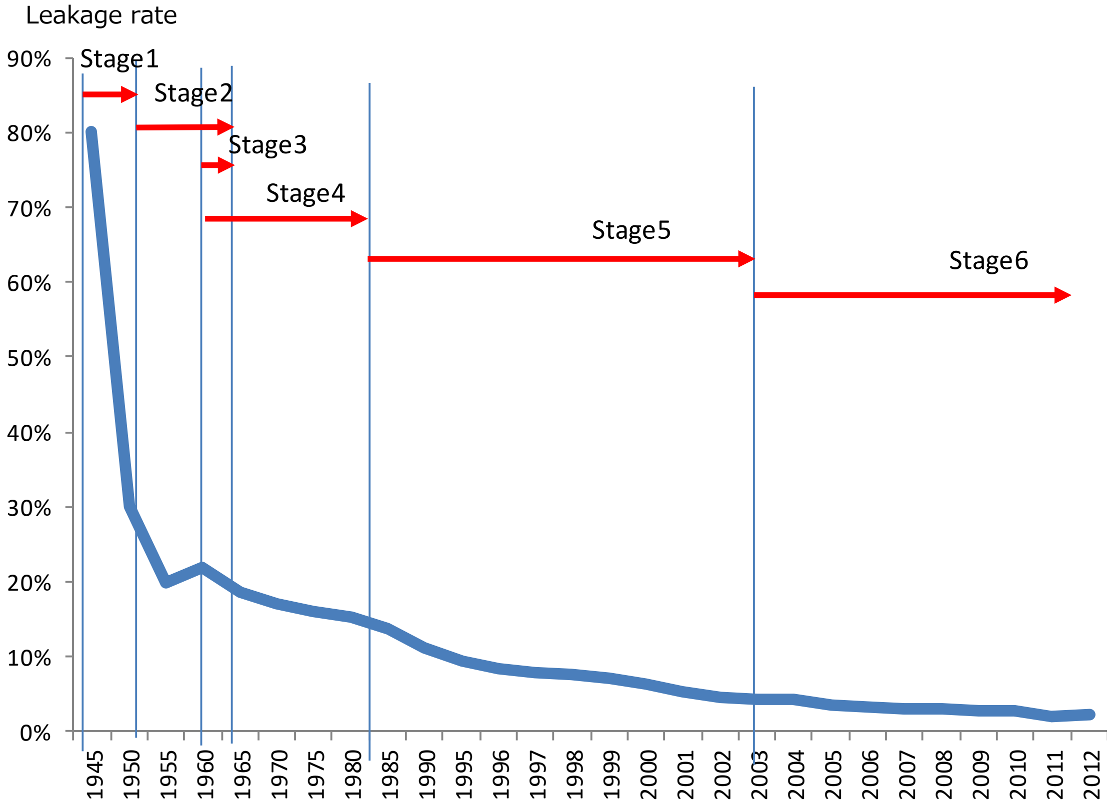
The important factors that contribute to leakage reduction include: early detection and repair of leaks, selective measurement, better pipe materials, and systematic replacement of aging pipelines.

(1) Progressive Approach to Leakage Management

In the early days when leakage rate was high, repairs were made when water was visible on the surface of the ground from leaks. Utilities gradually shifted to early detection and then to systematic pipe replacement together with the use of better pipe materials.

BWTMG lowered its leakage rate from 80% in 1945 to 3.1% by 2008. The improvements came about gradually. During the first few years (Stage 1) by fixing the leaks detected above ground with intensive input of manpower and building repair teams, the leakage rate was reduced to approximately 30%. In the next phase (Stage 2) the effort shifted to sub-surface leak detection using high quality water leak detectors, establishment of distribution blocks, and preparing accurate pipe network drawings. The leakage rate was further reduced to 20% by 1955. By this time the need for pipeline repairs became overwhelming. When a leak was repaired in one area, another would be found somewhere else. The leakage rate went up. The decision was made in the 1960s to replace aging pipes with ductile iron pipes instead of traditional cast iron pipes (Stage 3), bringing the leakage rate to < 20%. The activities for leakage prevention, pipe replacement, adoption of advanced technologies and staff training were accelerated. By 1979, the leakage rate was reduced to 15.5% (Stage 4). Then stainless steel became the material of choice for water service pipes, because of its strength and corrosion resistance. At that time more than 95 percent of water leaks were on service pipes (Stage 5). When the leakage rate fell below 5%, the emphasis was shifted from detection and repair to the more cost effective measure of systematic pipe replacement (Stage 6).

The progression the BWTMG went through in tackling leakage in the water supply system is typical for most water utilities in Japan.



Stage	Leakage ratio	Leakage control work	Method
1	>30%	Decrease aboveground visible leakage	Intensive repair activities
2	30%-20%	Decrease underground leakage	Zoning, accurate piping maps, training & utilizing good quality equipment for detection
3	25%-20%	Prevent recurrence of leakage	Increase in leakage control work, starting replacement of deteriorated pipes, use of DCIP
4	20%-12%	Carry out thorough leakage control work	Revision of working method & acceleration of pipe replacement work
5	12%-5%	Improve service pipes	Introduction of stainless steel service pipes which are strong and durable
6	<5%	Maintain low NRW	Systematic pipe replacement and leakage control work based on cost and benefit analysis

Source: Materials by Shozo Yamazaki

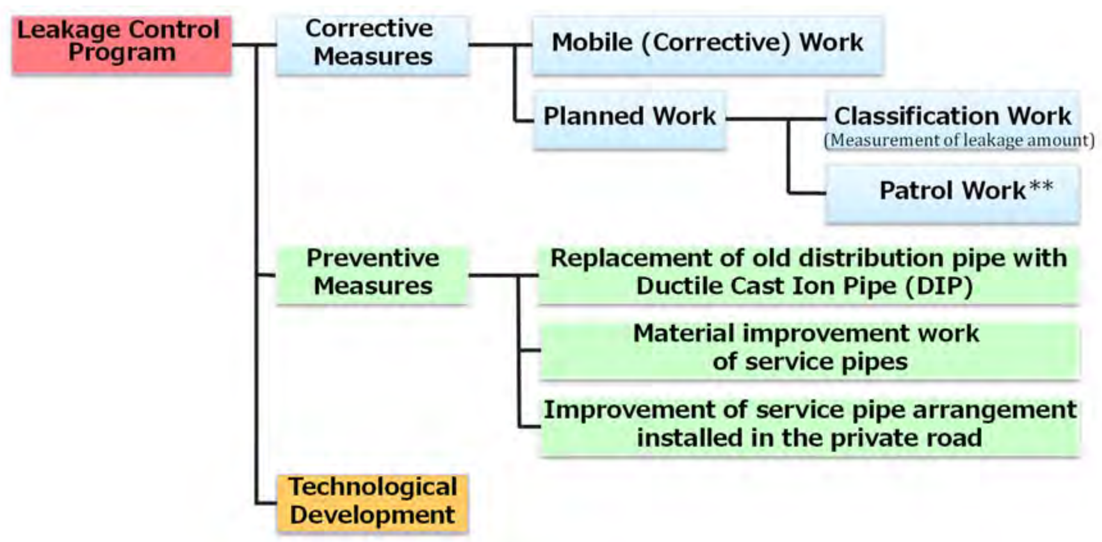
Figure 7. BWTMG Leakage Control Experience

(2) Early Detection and Repair: Planned and Corrective Maintenance

In Tokyo, fixing leaks detected or reported above ground makes up a large number of leakage control activities. However, 60% of leakage reduction is achieved by planned systematic leakage investigation. Both corrective and preventive measures are necessary to reduce leakage.

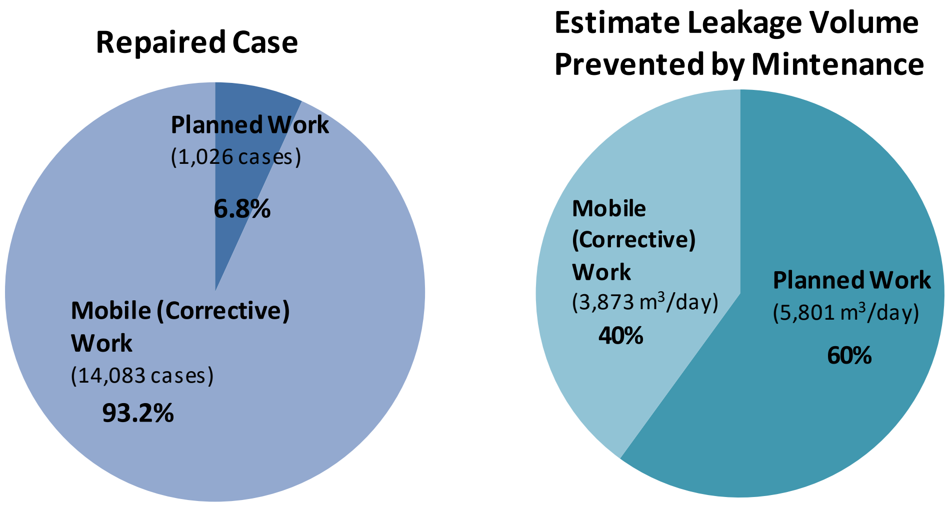
BWTMG has a 24-hour service to respond to customer calls about leakage as well as city-wide site inspections looking for signs of leakage. 93% of the repairs are carried out in response to leakage detected above ground. BWTMG also carries out scheduled inspections of each distribution block for leakage, which accounts for the balance (7%) of the leakage repairs. While reactive and planned preventive maintenance are both necessary for leakage control, an estimated 60% of the leakage reduction is credited to the latter.

Planned preventive maintenance can deal with below ground leakage at an earlier stage, significantly reducing the delay between the start of the leak and its repair.



Source: Training materials for JICA Technical Cooperation Projects

Figure 8. Leakage Prevention Measures



Source: Training materials for JICA Technical Cooperation Projects

Figure 9. BWTMG Corrective and Planned Maintenance for Water Leakage

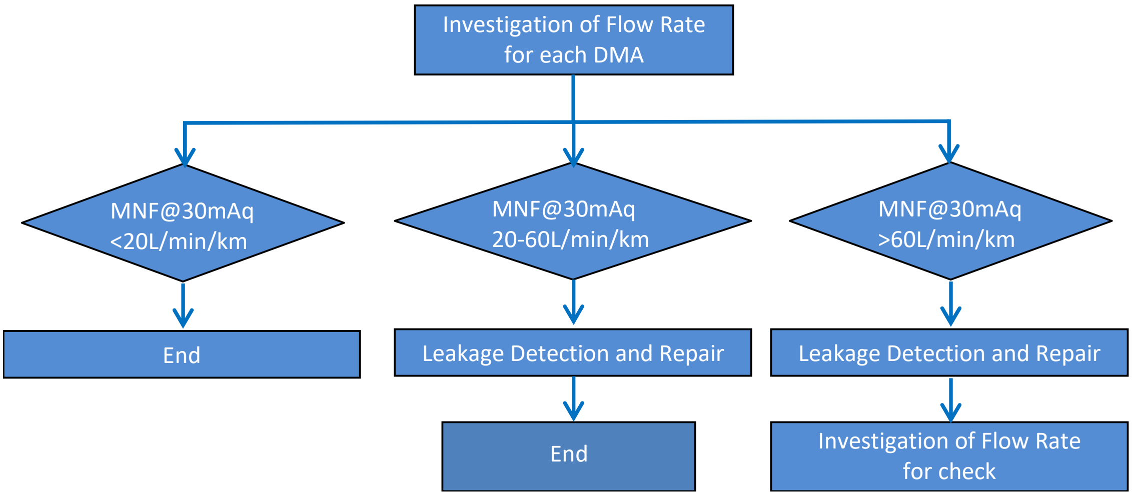
(3) Selective Measurement

Monitoring of night flows in distribution blocks is an effective tool for identifying water loss. The average minimum night flow data is used to determine the priority areas for leakage detection.

Most of the water supply networks in Japan are designed as block distribution systems. A network is divided into small manageable distribution blocks.

A BWTMG distribution block has about 1,100 households. Each distribution block is hydraulically isolated as the flow can be measured in each block at night time (minimal consumption) by a mobile meter installed in a concrete block chamber. Water loss is calculated from the minimum night flow.

BWTMG successfully conducted selective measurements from 1978 to 2005 to detect and repair leaks not visible on the surface. Distribution blocks are screened based on minimum night flow as shown in Figure 10. Selected distribution blocks are then targeted for leakage reduction activities.

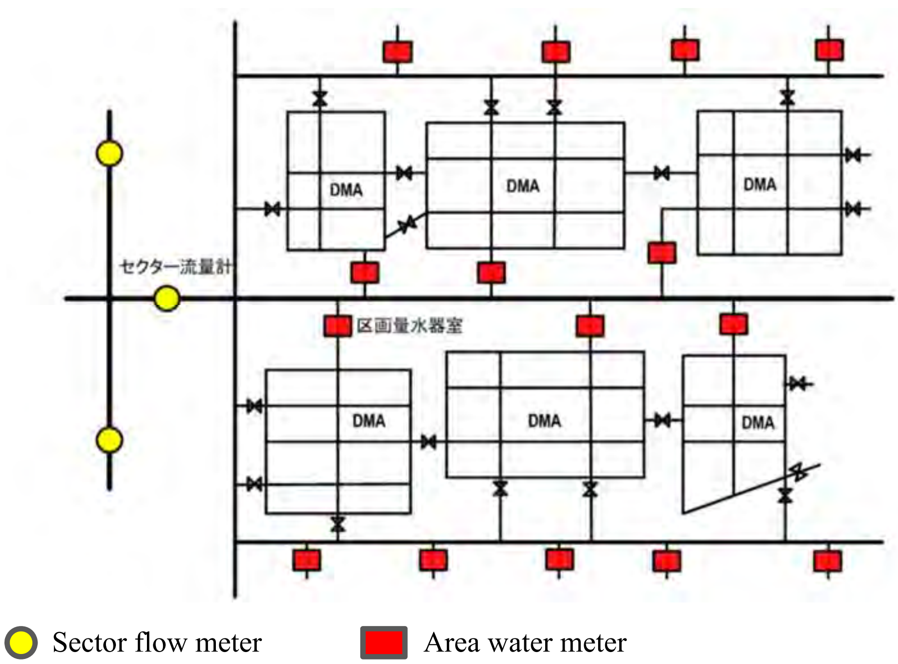


Note: MNF (Minimum Night Flow), mAq (meter Aqua≒0.1MPa)

If MNF is greater than 20 L/min/km at 30 mAq by investigation as part of routine planned work, implement more detailed leakage detection and repair work. Then measure again to check the impact of repairs.

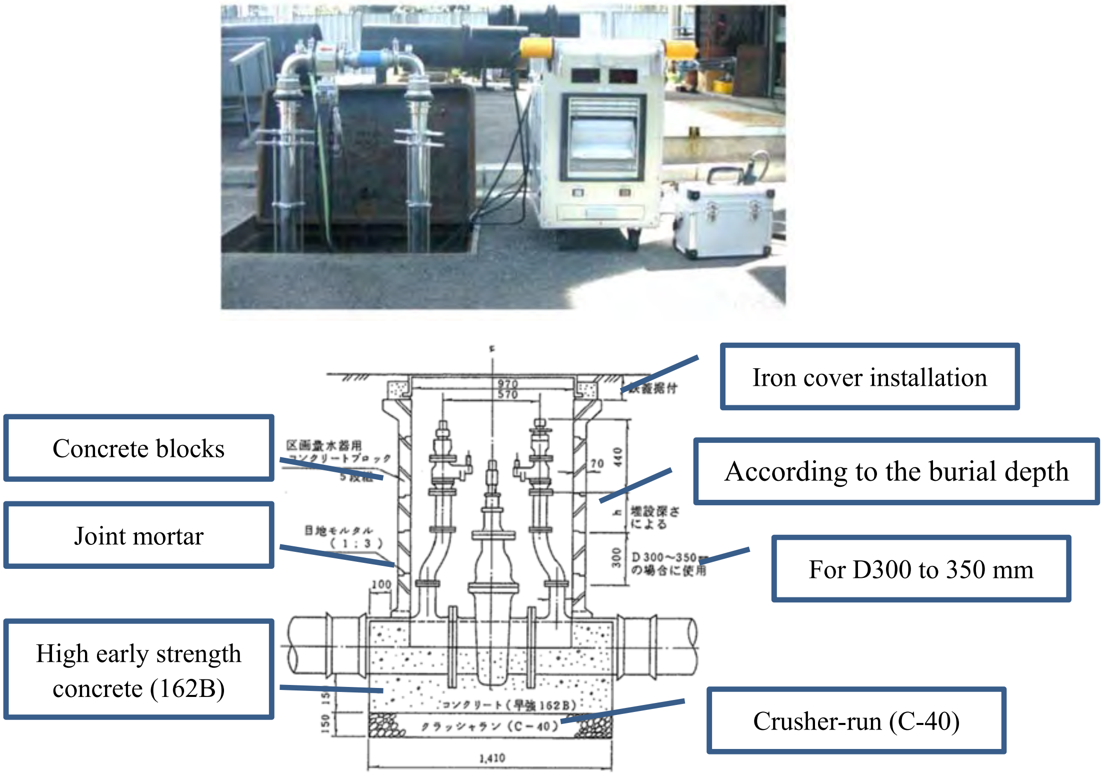
Source: Training materials for JICA Technical Cooperation Projects

Figure 10. Selective Measurement



Source: Training materials for JICA Technical Cooperation Projects

Figure 11. Conceptual Design of Distribution Blocks in BWTMG



Source: Training materials for JICA Technical Cooperation Projects

Figure 12. Mobile Block Meter for Measurement of Minimum Night Flow

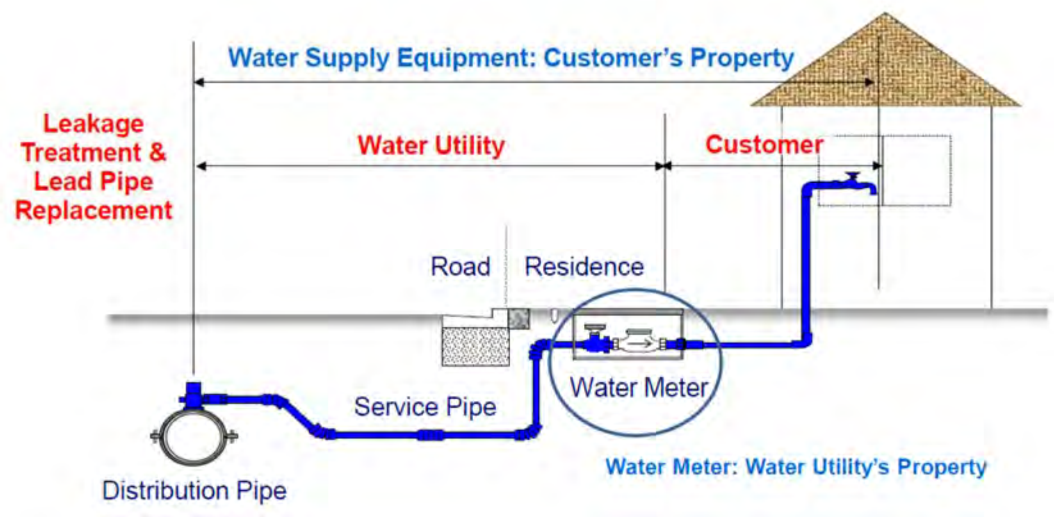
(4) Better Pipe Materials

Most water leaks occur at water service pipes. BWTMG significantly reduced leakage by switching to stainless steel pipes, which have high durability.

97.5% of the leakage experienced by BWTMG occurred at service pipes. On the other hand, there are fewer leakage from distribution pipes in Japan because utilities have implemented planned renewal of them. BWTMG customers are responsible for installation and replacement of water service pipes. Since replacement of these pipes is crucial to reducing leakage, BWTMG takes the initiative to do so instead of leaving it to the customers. Labor cost is usually higher than material cost. It is therefore more cost effective to use stainless steel (SUS316) pipes which have a longer service life and require less frequent replacement. BWTMG has a committee with members from the Water Service Devices Division in the Sales Department and various other departments to study and standardize the pipe materials. The committee visits pipe manufacturers, and inspected the materials at the test center. Stainless steel pipes have the additional advantage of being earthquake resistance.

There is a historical background why BWTMG adopted stainless steel for service pipes. Nowadays, there are other reliable and inexpensive options of pipe materials such as HDPE (PE100). PE100 is a relatively new material put into use after 1989. Some utilities hesitate to adopt HDPE because of reports of breakage and peeling of inner lining. In other words, such inexpensive options are not available in 1980s when BWTMG determined their measures. Therefore, looking at the cost effectiveness in their life cycle and better leakage prevention, BWTMG adopted stainless steel for its service pipes.

Utilities work together and with private companies to establish the causes of leakages and implement effective measures. They cooperate and coordinate on various issues in the process, such as setting priorities, budgetary appropriation, and confirmation on availability of materials and work experience and capability of local contractors. Their joint efforts are very effective and always produce remarkable results.



Source: JWWA

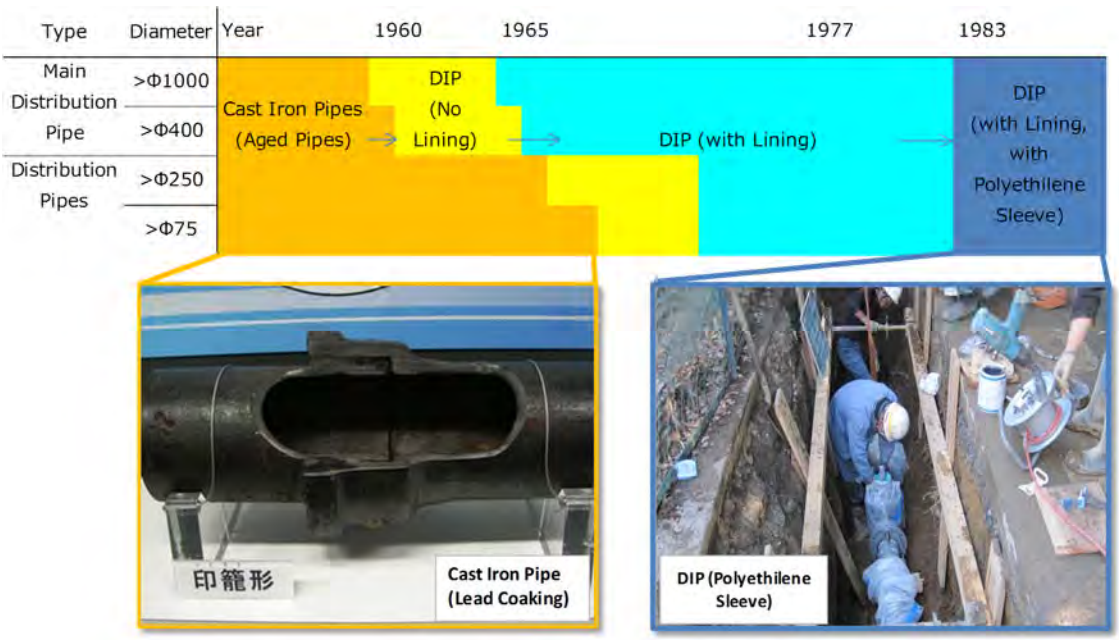
Figure 13. Responsibility of the Customer vs that of Utility at House Connections

(5) Systematic Pipe Replacement

Many leaks were found in aging pipes, installed based on old standards. BWTMG has been continuously and systematically replacing old pipes, with pipes made of better materials developed by manufacturers.

Asbestos cement pipes with low durability were commonly used from 1950s to 1970s. There were many technical innovations from the 1950s to 1970s during the period of significant expansion of water supply systems. Most water distribution pipes in Japan are ductile cast iron, steel or polyethylene.

BWTMG started using ductile iron pipes in water distribution networks since 1960. Some new methods applied gradually; an inner lining and polyethylene sleeve to prevent corrosion, and seismic resistant joint. The aging cast iron pipes are being replaced at about 300 to 400 km per year. With a total of 24,000 km distribution pipes, all water distribution pipes will be replaced in 60 to 80 years.



Source: Training materials for JICA Technical Cooperation Projects
Sources of Photo: (Left) Water Partners Jp Co., Ltd. (Right) Japan Ductile Pipe Association

Figure 14. Replacement of Cast Iron Pipe

6. Lessons Learned

The following Japanese experience could be useful for other countries.

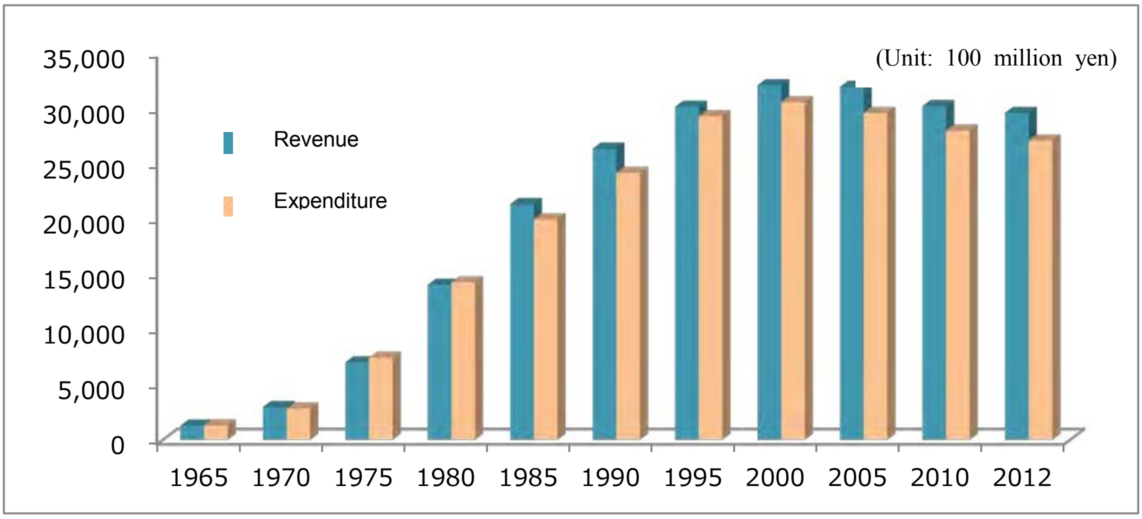
- **(Need for Leakage Prevention)** Water supply systems in Japan's major cities, such as Tokyo or Osaka, suffered from high leakage after WW II. Today the leakage rate is as low as 3% in Tokyo. Japan has historically used the water leakage rate rather than the non-revenue water rate in managing water supply system efficiency. Japanese water utilities recognize the importance of leakage control and prevention because of their experience with infrastructure destruction during the war, severe droughts, and water restrictions.
- **(Leakage Control for Reducing NRW)** The major cause of NRW in Japan is leakage. Utilities have dramatically improved NRW by reducing leakages. Utilities in Japan could identify the major cause of NRW because most of water supply was metered. It is important to install meters and analyze water flow, locate leaks and develop control measures. This requires a coordinated effort among various work units within the utility.
- **(Accuracy of Meters)** The Measurement Act requires replacement of water meters every 8 years and utilities are obliged to keep them in good working order under the Water Supply Act. Metering errors can be kept to a minimum with a strong legislative framework.
- **(Progressive Leakage Control)** An active leakage control program can start with improved response to repairing visible leaks. Then the activities can shift to early detection of leaks not yet visible above ground, and eventually to systematic planned replacement of aging pipes. Planned pipeline replacement and improved pipe materials is very effective for NRW reduction.

Theme 6. Financial Management: Finance and Tariffs

Contents

1. Introduction

Up till the 1980s, Japanese water utilities as a whole were running slight budget deficits while they promoted rapid development of the water supply systems (see Figure 1). Since then water tariffs, which are the main source of revenue, cover all expenditures, including interest payments, repayment of long-term loans for facilities construction, operation and maintenance costs, and administrative expenses.



Source: Based on information from JWWA, "*The Outline of Water Supply*," 1st ed. 1986, and 6th ed. 2015.

Figure 1. Change in Total Revenue and Expenditure of Water Utilities in Japan

This module describes the experience of Japanese waterworks management by addressing the following frequently asked questions from participants of the water supply training courses:

Q1. How did Japanese water utilities raise a large amount of funds for water supply development?

Q2. Have Japanese water utilities been able to achieve cost recovery?

Q3. How do Japanese water utilities determine water tariffs? What are the criteria?

Q4. How do Japanese water utilities serve low-income group?

Q5. How do Japanese water utilities achieve almost 100% billing collection?

The following sections attempt to provide answers to these questions:

2. Financing Water Supply Development (Q1 and Q2)
3. Setting Water Tariff (Q3)
4. Considerations for Low-Income Group (Q4)
5. Billing and Collection (Q5)

2. Financing Water Supply Development

In Japan, the first modern water supply system was established in Yokohama in 1887. After that, water supply systems were gradually developed in other port cities, major urban centers and provincial towns. Municipal bonds (public enterprise bonds) and government subsidies were main financial sources for the construction of these facilities. Japanese utilities used government subsidies and municipal bonds to finance water supply development projects, and successfully raised the water supply network coverage (population served/total population) from 26.2% in the 1950s to 80% in the 1970s and 90% in the 1980s.

Construction of water supply systems is expensive. Municipal bonds has been normally used to finance these developments. In the early 1900s, Tokyo, Yokohama, Osaka, Kobe, Nagoya and Kyoto issued municipal bonds at overseas markets such as those in London and Paris (Photo 1 and 2) for the development of urban infrastructure including water supply facilities, because it was difficult to raise funds in Japan at that time. Later funding also came from the domestic capital markets. Government subsidies were another important financial resource.

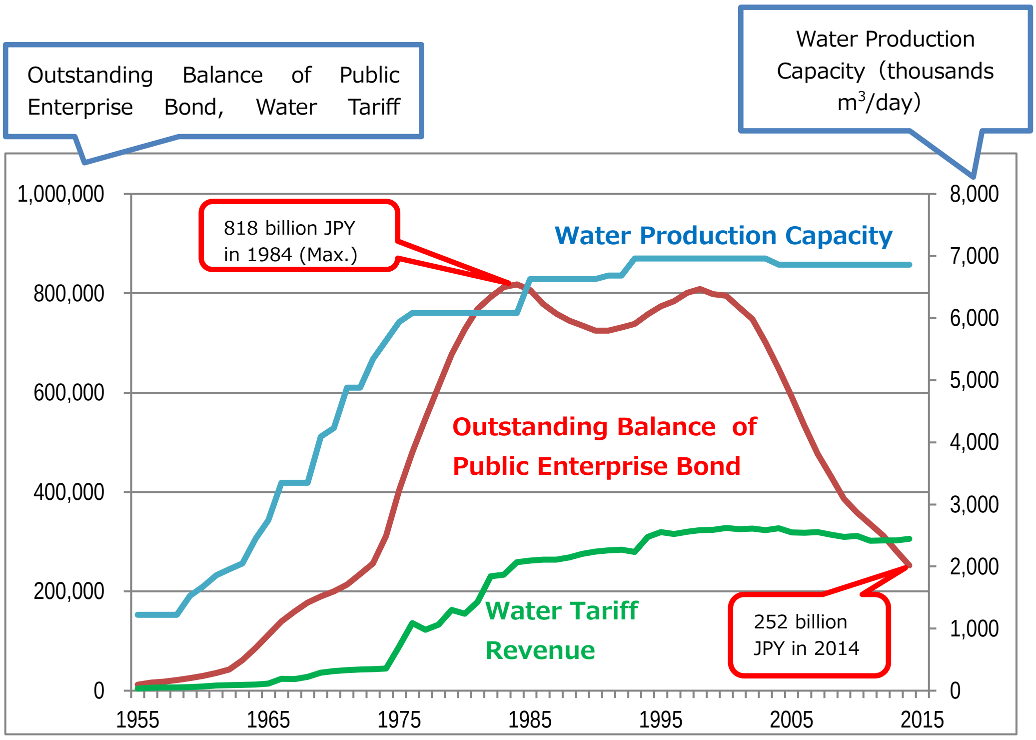
Source: Nagoya City, "*Nagoya City History in Taisho and Showa Period*," 1955.

Photo 1. Sterling bond issued by Nagoya City in 1909

Source: Kyoto City Waterworks Bureau

Photo 2. French franc bond issued by Kyoto in 1909

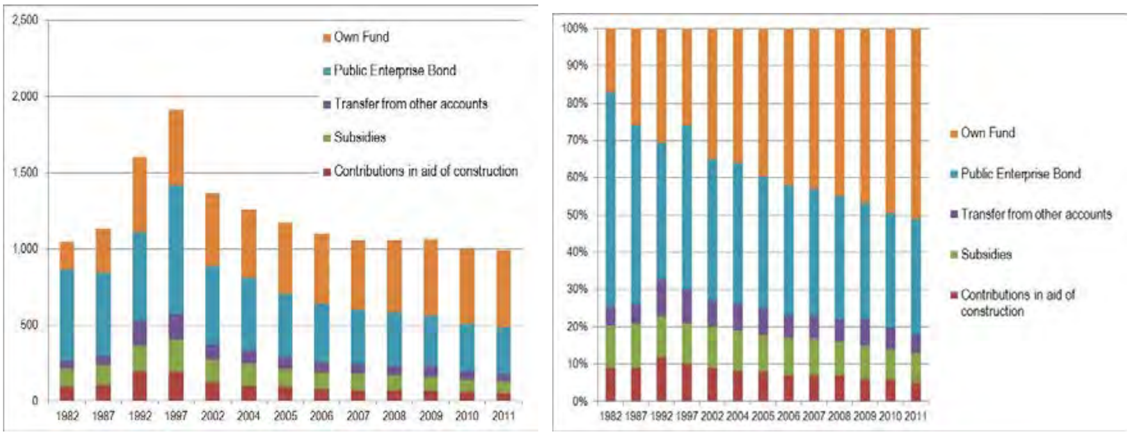
Figure 2 shows the changes in the outstanding balance of public enterprise bonds, principal and interest payment, water tariff revenue and production capacity of the Bureau of Waterworks, Tokyo Metropolitan Government. The outstanding balance of bonds and water tariff revenue increased as facilities were expanded to serve the growing population. The outstanding balance was gradually decreasing after expansion of facilities.



Source: Based on data from Bureau of Waterworks, Tokyo Metropolitan Government, *Annual Report*.

Figure 2. Changes in Outstanding Balance of Public Enterprise Bonds, Water Tariff Revenue and Water Production Capacity of the Bureau of Waterworks, Tokyo Metropolitan Government

By 1960 public enterprise bonds accounted for about 90% of major financial resources for water supply development, but the percentage gradually decreased since then. Investment in the construction of water supply facilities peaked around 1997 and then began to decline, as shown in Figure 3. Funding shifted from reliance on bonds and government subsidies to internal sources, reflecting the transition from construction to operating and maintaining established facilities.



Source: Based on information from Ministry of Internal Affairs and Communications, *Issues on Public Financial Plan: Appendix*, 2013, http://www.soumu.go.jp/main_content/000266902.pdf

Figure 3. Financial Sources for Construction of Water Supply Facilities in Japan
Left: Amounts by Fiscal Years (Billion JPY),
Right: Components of Financial Sources by Fiscal Years

Financed by public enterprise bonds and government subsidies, water supply coverage ratio increased from 26.2% in 1950 to 80% in the 1970s and 91.5% in the 1980s. Other financial sources for facility construction include “transfers from other accounts” and “contributions in aid of construction.” “Transfers from other accounts” are allocations mainly from general accounts to cover part of the repayment of principal and interest on outstanding debts and redemption of bonds issued. This means moving general accounts expenditure to special accounts income. This approach strengthens the foundations of waterworks management and reduces the liability of capital costs. The Ministry of Internal Affairs and Communications (MIC) notifies local governments of “transfer standards” - the rules of expense allocation every fiscal year, and water utilities are required to comply with these rules. “Contributions in aid of construction” refers to payments by developers for extensions of the water supply system to new housing developments, etc.

(1) Municipal Bonds (Public Enterprise Bonds)

Municipal bonds are long-term debt securities issued by local governments. The national government purchased municipal bonds using funds secured through postal savings, national pensions with favorable financial conditions. Proceeds from bond issues were normally used to finance infrastructure needs during periods of high economic growth, such as construction of water supply facilities. The municipal bonds allow the high costs of water supply facilities to be shared equitably over several generations.

Municipal bonds are long-term debt securities issued by local governments. They are repaid over 25 to 30 years. The legal basis for municipal bonds are stipulated in Article 45 of the Water Supply Act (Special Subsidies from the national government) and Article 5 of the Local Government Finance Act (Expenditures for which municipal bonds may be issued).

Municipal bonds issued to finance the construction and improvement of facilities managed by local public enterprises, are called public enterprise bonds[1]. Their principal and interest are basically paid by revenue of the public enterprises. During the period of high economic growth (1955–1973), a huge amount of public enterprise bonds were issued for investments in water supply facilities. Over 70% of the municipal bonds issued in 1964 and 1965 were bought by public funds such as postal savings, employees' pensions, national pensions, and postal life insurance funds. Currently only 40% of bond owners are public entities and the owner of 60% are private entities.

For large major capital projects, utilities normally use long-term debt to spread the cost of the project over the useful life of the facilities to be repaid from future revenue from users of the system. This keeps the annual revenue requirements low and ensures that existing customers are not paying 100% of the initial cost of facilities to be used by future customers.

Water supply facilities have a long service life. The development of these facilities benefits current residents as well as future generations. Therefore, it is reasonable to share the liability of facility construction with future beneficiaries by long-term repayment of the debt over the life of the facilities. This is characteristic not only of municipal bonds, but also of long-term loans from aid agencies or public financial institutions.

The Minister of Internal Affairs and Communications or the prefectural governor must be consulted on municipal bond issues. Projects to be financed must demonstrate engineering and

[1] It is also called as local public enterprise revenue bonds or revenue bonds.

financial feasibility to obtain agreement or permission to proceed. The involvement of higher level government guarantees the financial resources for bond redemption and eliminates the need for assessing the local governments' financial soundness and simplifies the issuance process. Utilities are deemed creditworthy being public institutions that have sound fiscal management and operate on self-supporting accounting system.

(2) Subsidies for Urban Water Supply Developments

Subsidies for urban water supply were provided to increase access to safe drinking water in Japan from 1988 to 1954. They were abolished when the water coverage ratio reached 50%. The subsidy system was restored to achieve specific policies such as water resources development in response to rapid water demand during periods of high economic growth (from late 1960s to 1970s), and has been utilized since then.

Although water utilities in Japan strive for cost recovery, subsidies are needed to promote water supply development as shown in Table 1. When using subsidies, the national government sets clear targets and invests according to well defined policy goals such as increasing access to safe drinking water and securing water resources.

At first, the national government granted subsidies only to three prefectures (Tokyo, Osaka, and Kyoto) and five port cities (Hakodate, Yokohama, Niigata, Kobe and Nagasaki) to cover one-third of the construction costs of water supply facilities. The big cities received the subsidies which covered one-fourth of their construction costs. Subsidies also paid for postwar reconstruction of water supply facilities. These subsidies for urban water supply developments were abolished in 1954. When the water supply coverage reached about 50%, urban centers were expected to finance further expansion by issuing public enterprise bonds, and assistance was directed to Small Scale Public Water Supply serving populations of 101 to 5,000.

The subsidy system was restored in 1967 when water demand increased rapidly because of the surge in urbanization, together with increasing concentration of industries in urban centers. Furthermore, the cost of water supply services increased with the need to pursue new water sources in remote areas because urban water resources were contaminated. The decision was made to use subsidies to develop water resources and consolidate facilities.

Table 1. Historical Changes in Subsidy System for Urban Water Supply Facilities

Period	Target	Rate of grant	Purpose
1888~ 1900~	Three prefectures (Tokyo, Osaka, and Kyoto), and five port cities (Hakodate, Yokohama, Niigata, Kobe, and Nagasaki) Others	1/3 1/4	Improve public health and reduce infectious diseases in major cities and port cities.
1907～	All major cities	1/4	Increase access to piped water.
After World War II ～1954			Post war reconstruction.
1954～1966	Abolishment of subsidies for urban water supply	When the urban water supply coverage reached 50%, subsidies were abolished. Municipal bonds were used to finance the expansion of waterworks in urban areas. Government subsidies were shifted to Small Scale Public Water Supply system development in rural areas.	
1967	Restoration of subsidy system for water resources development, facility development, and for consolidation of water utilities	1/2 or 1/3, 1/4	The financial liability was growing as utilities responded to complex and rapid changes in social conditions such as increase of water demand caused by concentration of population and industries in urban areas, increased water pollution, and the pursuit of water sources in remote areas. The subsidy system was restored based on the decision that it was not appropriate to have water utilities alone shoulder the increased costs.
1978～2009	Development of laboratories	1/4	Improve water quality testing in small- and medium-scale waterworks.
1988~	Development of advanced water treatment facilities	1/3, 1/4	Solve issues of odor and taste of drinking water associated with increased pollution of suburban rivers.
1990～1996	Rehabilitation of old deteriorated pipelines	1/3, 1/4	Promote rehabilitation and replacement of deteriorated pipelines.
1997	Reinforcement of earthquake preparedness	1/2 or 1/3, 1/4	Develop earthquake resistant pipes and water supply locations during emergencies. (Introduced following the Great Hanshin and Awaji Earthquake)
2010～	Development of automatic monitoring system for water sources	1/4	Improve monitoring system shared by some water utilities for efficient water sources management and reduction of management costs.
* Other than above, there are subsidies related to responses to disasters.			

Source: Based on JWWA, "*History of Water Supply in Japan*," JWWA, 1967.
and other materials by the Ministry of Health, Labour and Welfare (MHLW)

(3) Subsidies for Small Scale Public Water Supply

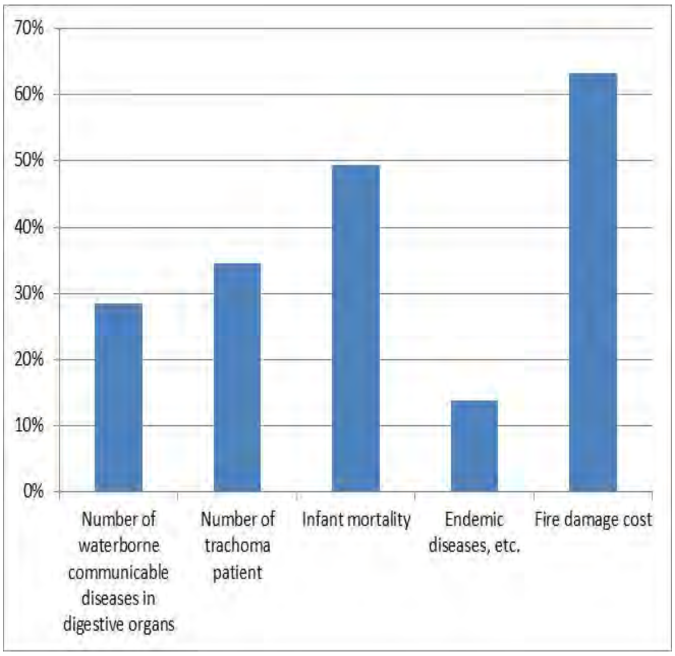
Subsides for the Small Scale Public Water Supply played a significant role in promoting access to piped water in rural areas. The nationwide coverage of water supply service substantially reduced waterborne diseases and infant mortality.

The subsidy system for Small Scale Public Water Supply (serving population between 101 and 5,000, as defined by the Water Supply Act) was established in 1952. The main objectives of the subsidies are to reduce waterborne diseases and relieve women's burden in fetching water for the family.

The Water Supply Division of the Ministry of Health, and Welfare (MHW) [2] persuaded the finance division of MHW to establish the subsidy to improve access to safe water in rural areas, citing the benefits of reduction of disease episodes. The compelling argument was made that the costs of improving water supply would be offset by economic benefits such as a reduction in health care costs.

In 1952 when the subsidy system was established, Small Scale Public Water Supply systems in about 180 areas were newly constructed across the country. After 1952, about 500 new systems were developed every year, resulting in nationwide coverage of water supply services.

In 1957, MHW reported on the outcomes of water supply facilities



Source: The editorial committee of the One Hundred Year History of Modern Water Supply, "*One Hundred Year History of Modern Water Supply*," Nihon Suido Shimbunsha, 1988.

Figure 4. Reduced Incidence of Diseases and Infant Mortality, etc.

(Information presented by the Water Supply Division of MHW in 1957. 100% represents the level that existed before construction.)

[2] The Ministry of Health and Welfare was merged with the Ministry of Labour to form the Ministry of Health, Labour and Welfare in 2001.

development. As shown in Figure 4, the incidence of infectious diseases, infant mortality and damage from fires, were significantly reduced in the 5 years after the promotion of the Small Scale Public Water Supply compared to the 5 year period before. The National Diet discussed the need for waterworks and accelerated water supply development throughout Japan.

Rural population is small. The cost per person for the water supply system is comparatively higher than for large cities. For some projects, rural residents eager to improve living conditions volunteered to work on the construction of facilities and raised funds by selling common forest trees of their community.

Source: Susumu Hani, the film "*Water in Our Life*," 1952

Photo 3. Voluntary Construction Work by Villagers

(4) Private Sector Financing

In Japan, the water supply business used to be financed by municipalities. In recent years, the use of private financing is increasing, supported by relevant laws and guidelines.

The water supply business in Japan is managed by municipalities as stipulated in the Water Supply Act. Recent slow economic growth and fiscal deficits are forcing governments to look for more efficiency and better management of public enterprises. The Act on Promotion of

Private Finance Initiative (PFI Act) was enacted in 1999, to improve public infrastructure through the utilization of private funds, engineering capabilities and management expertise. This approach is based on the belief that the involvement of the private sector would lead to efficient accumulation of social capital and improve delivery of affordable goods and services.

PFI is an approach to improve efficiency in construction, operation, maintenance and management of public infrastructure utilizing private finance, engineering skills and management knowledge. It is regarded as a type of PPP (Public Private Partnership), with the participation of the private sector in the provision of public services.

Private companies are involved in the design, construction, operation and maintenance phases of multi-year undertakings in PFI projects. The process leading to signing such contracts with private companies, are complicated, having to deal with technical, legal and financial aspects for project implementation. MHLW developed the “Guidelines for Introduction of PFI in Water Supply Project” to facilitate this process. Local governments also have been developing their own guidelines.

In utilization of private sector financing, it is necessary to have a strong legal framework and robust regulations to ensure that the public sector has the authority to pursue such projects as well as allow the private sector to mitigate unnecessary risks. It is also important for the parties to “comply with the requirements in the signed contract”. The detailed project plan would lay out the allocation of benefits and risks.

Table 2. PFI Projects for Water Treatment Plants

No	Place (Name of Prefecture)	Contracting Authority	Contract Year (FY)	Contract Type	Target Facility
1	Tokyo	Bureau of Waterworks, Tokyo Metropolitan Government	1999	BOO: Build Own Operate	New power generation facilities for Kanamachi Water Treatment Plant (1,600,000 m^3/day)
2	Tokyo	Bureau of Waterworks, Tokyo Metropolitan Government	2001	BOO: Build Own Operate	New facilities for power generation, chemical feeding, sludge treatment for Asaka Water Treatment Plant and Misono Water Treatment Plant (total capacity 2,000,000 m^3/day)
3	Kanagawa	Enterprise department Kanagawa Prefecture	2003	BTO: Build Transfer and Operate	Renewal of a sludge treatment facility for Samukawa Water Treatment Plant (750,000m^3/day)
4	Saitama	Enterprise department Saitama Prefecture	2004	BTO: Build Transfer and Operate	Renewal of facilities for power generation and sludge treatment for Okubo Water Treatment Plant (1,300,000m^3/day)
5	Chiba	Waterworks Bureau Chiba Prefecture	2004	BTO: Build Transfer and Operate	New sludge treatment facility for Nogikunosato Water Treatment Plant (60,000m^3/day)
6	Aichi	Enterprise department, Aichi Prefecture	2005	BTO: Build Transfer and Operate	Renewal of sludge treatment facilities for four water treatment plants (total capacity 664,000m^3/day)
7	Kanagawa	Yokohama City	2008	BTO: Build Transfer and Operate	Renewal of Kawai Water Treatment Plant (171,000m^3/day)
8	Chiba	Waterworks Bureau Chiba Prefecture	2009	BTO: Build Transfer and Operate	Renewal of a sludge treatment facility for Hokuso Water Treatment Plant (127,000 m^3/day)
9	Hokkaido	Yubari City	2010	BTO: Build Transfer and Operate	Renewal of two water treatment plants (total capacity 7,200 m^3/day)
10	Aichi	Enterprise department Aichi Prefecture	2010	BTO: Build Transfer and Operate	Renewal of sludge treatment facilities for six water treatment plants (total capacity 1,005,400 m^3/day)
11	Aichi	Okazaki City	2012	BTM: Build Transfer Maintenance	Renewal of a rapid sand filtration facility in Otogawa Water Treatment Plant (68,395m^3/day)

Source: JWWA, *Leading Cases of PFI*, http://www.jwwa.or.jp/wide-ppp/coop/coop_case/coop_pfi/

3. Water Tariff Setting

Water tariffs in Japan are decided based on financial, economic and environmental criteria deliberated by local assemblies. Water is essential to life, careful discussions are required when considering tariff increases. In Japan, tariffs are set based on the conditions defined by the legal framework including the Water Supply Act: (1) utilities must maintain financial discipline, using fully distributed cost method and self-supporting accounting system; (2) charges must be fair and simple to understand for the customers; (3) utilities must have efficient management and make continuous efforts to rationalize their operations (e.g. streamlining operations, effective allocation of the fixed number of employees, cost reduction associated with outsourcing, successful collection of unpaid water bills, good asset management, and reduction of non-revenue water); (4) affordability especially for low-income households while ensuring that they have access to an amount of safe water supply considered minimal for residential sanitary requirements; and (5) proper information disclosure to obtain the understanding and support of the citizens, and always emphasize good public relations and customer service. Furthermore, the *Water Tariff Setting Manual* is playing a significant role.

(1) Self-Supporting Accounting System and Fully Distributed Cost Method

The water supply business in Japan is managed on the principle of user-pay and cost recovery using the self-supporting accounting system. The public enterprise accounting system allows the accounting for depreciation costs and calculation of tariffs based on the fully distributed cost method.

The water supply business is managed by revenue from water tariffs using the self-supporting accounting system and public enterprise accounting system. Utilities finance and maintain all aspects of the water supply system, including replacement of infrastructure, using income generated from fees charged to customers. The accounting system must rely on sound asset management that can properly deal with the value of fixed assets (water supply facilities) and their replacement capital over the long-term. The fully distributed cost method enables proper setting of tariff structure, which leads to systematic investments based on asset management.

At the beginning of modern waterworks in Japan, utilities used to be managed by special accounts which were separate from the general accounts of municipalities, but the accounting system focused mainly on cash flow. It was difficult to understand the actual efficiency and effectiveness of the management. In 1952, when the public enterprise accounting system was introduced under the Local Public Enterprise Act (See Figure 5), the accounting system switched from cash to accrual basis, and the double-entry bookkeeping method was adopted (See Figure 6). Under this system, the same amounts are entered into debits and credits under the account entries for assets, liabilities, capital, expenses, or revenues. This method has the advantage of allowing simultaneous calculations of assets, profits and losses. Depreciation of an asset is entered as a debit in the income statement and also credited to the Accumulated Depreciation account on the balance sheet until the asset is disposed of. The annual depreciation expense component provides for the recovery of the utility's capital investment over the anticipated useful life of the depreciable assets. The funds from the inclusion of this expense were available for use as a source of capital for replacement, improvement, or expansion of its system.

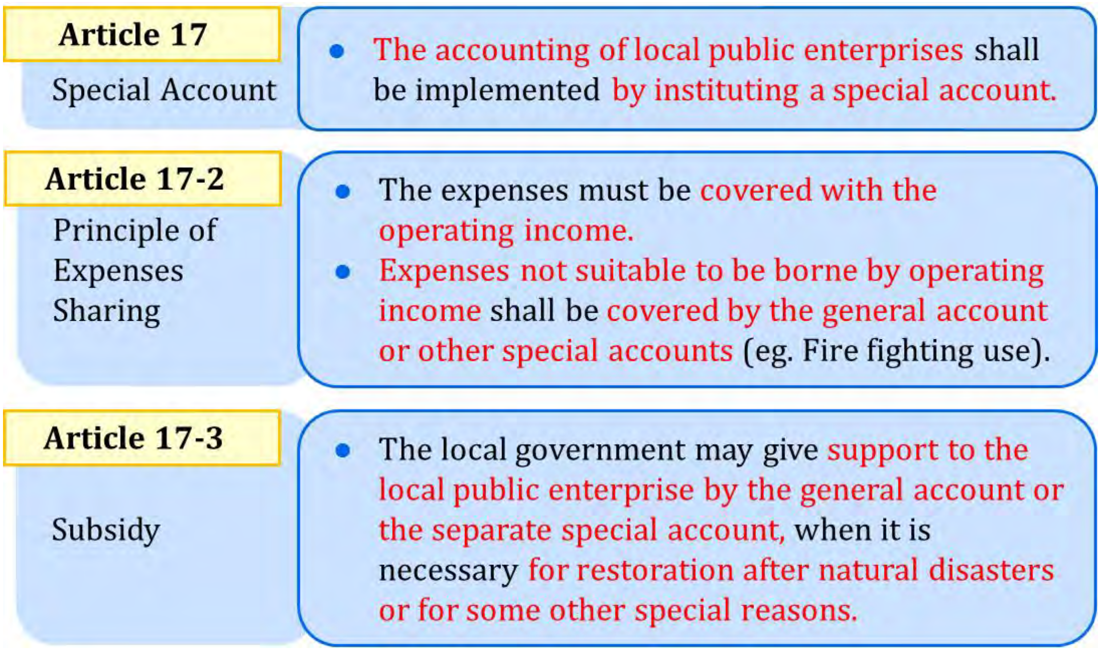


Figure 5. Local Public Enterprise Act (Article 17)

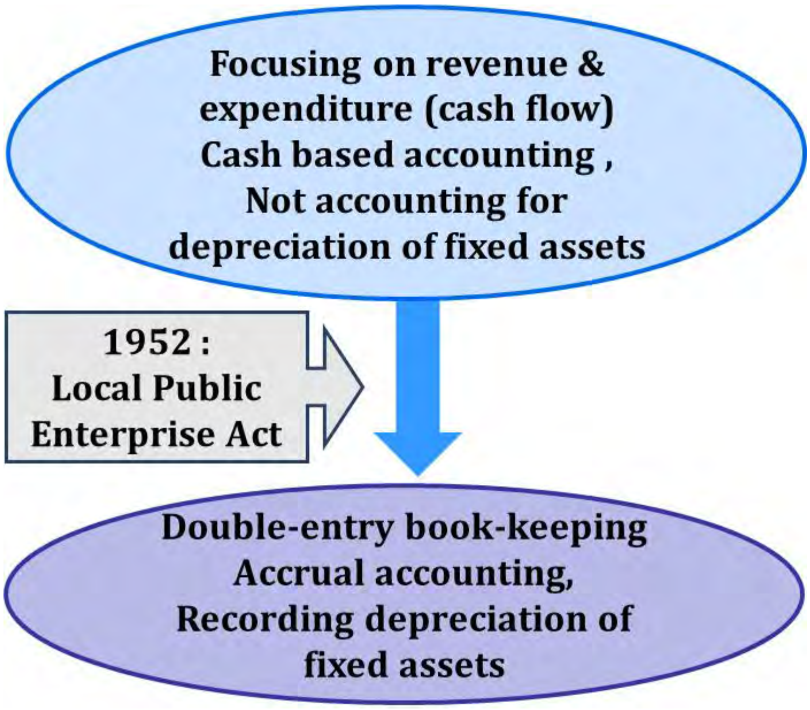


Figure 6. Change in Accounting System Related to Water Supply Business

(2) *Water Tariff Setting Manual*

The *Water Tariff Setting Manual* was prepared by Japan Water Works Association (JWWA), with the input from water utilities. It lays out the principles to be considered for water tariff setting. Water utilities calculate appropriate level of tariffs based on the standardized methodology.

Up till the late 1960s, each water utility established its own tariff system to cover the costs for water supply services. The government did not allow price hikes to counter soaring inflation in the postwar years (after 1945). Maintenance and construction costs were increasing because of the expansion of water supply facilities. Many utilities faced financial problems. In 1967, JWWA consulted with the utilities and prepared the *Water Tariff Setting Manual* so that utilities could make the best effort to generate sufficient revenue to ensure proper operation and maintenance, development and perpetuation of the water supply systems, and maintain the utilities' financial integrity.

The *Water Tariff Setting Manual* specifies that tariffs should be calculated so that the total revenue estimated for the period of three to five years would match the total costs. The total costs are the aggregate of operating expenses (personnel costs, chemical costs, energy costs, repair costs, wholesale water costs, depreciation costs, capital consumption costs and other maintenance expenses) and capital costs (interest costs and capital maintenance costs). The tariff structure is designed by allocating these costs to each customer group based on the estimated total revenue from the tariffs. The total costs are broken down into customer costs (costs incurred from meter reading, door to door collection, and meters, which would be incurred regardless of the amount of water used), fixed costs and variable costs. The customer costs and a part of the fixed costs are allocated to the minimum rate, while the rest of the fixed costs and variable costs are allocated to the volumetric rate (See Figure 7). In the process of these allocations, special measures can be taken to reduce the burdens for some domestic water users as described in “4. Consideration for Low-Income Group.”

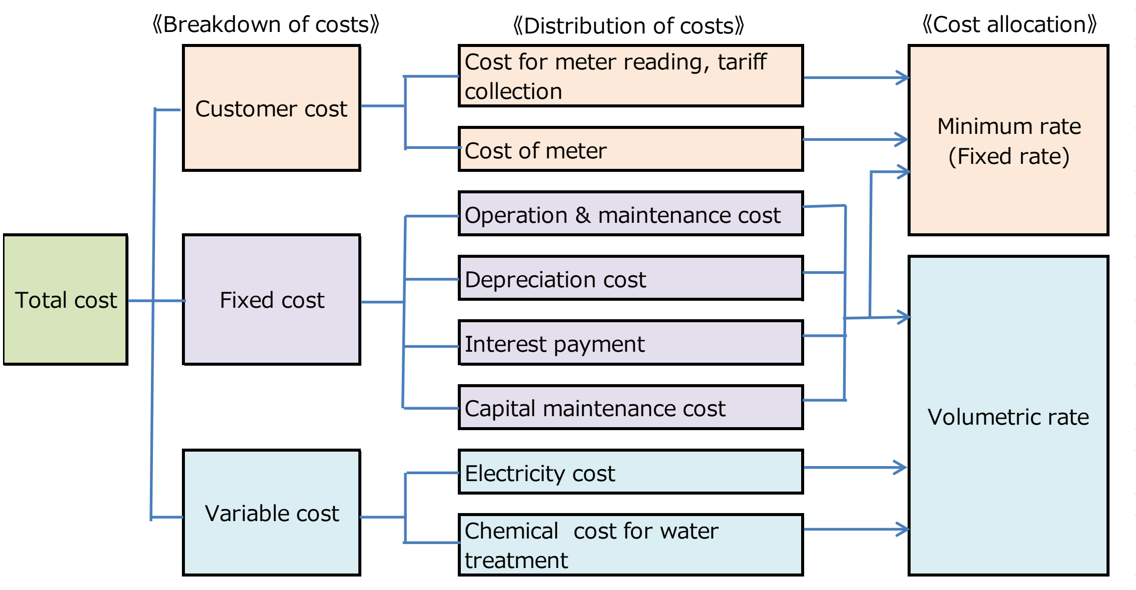


Figure 7. Calculation Steps and Cost Components for Water Tariffs

(3) Fairness and Clear Definition

When modern water supply was established in Japan, water tariffs were set based on the ability to pay. Metering was applied to very limited areas and a flat-rate system was generally adopted. With the expansion of metering, water tariffs were collected according to the amount of water used, and wasteful use was reduced. Water tariff structures continued to be improved using clear definitions to make them easier to understand.

Since the range of benefits (beneficiaries) and the degree (the amount of water used) are identified, the principle of beneficiary payment has been introduced into the water tariff system in Japan. It means that customers pay tariffs according to the amount of water used based on the principle of fairness.

The first water supply system in Yokohama (in 1897) was designed by a British engineer (Henry Spencer Palmer). Under the British influence, water tariffs were based on customers' ability to pay. Customers assumed to have the same ability were required to pay the tariffs according to the amount of water used. In some part of foreign settlements, customers paid minimum and volumetric rates. However, most of the water tariffs were based on the flat-rate system, and differential tariffs were set according to the number of family members and domestic animals such as horses and cattle (See Table 3).

Public taps were provided for low-income households, and monthly flat-rate charges were based on the number of households. The charges for public taps were significantly lower than private taps. Therefore, customers preferred to use public taps, and the utilities were not collecting the expected revenues. Monthly flat-rate charges were roughly decided based on the number of household' members and were estimated less than actual use. Therefore, even if a large amount of water was used, the revenue did not cover the expenses for delivering the service. By reference to the water tariff system in Yokohama, many refinements were made by other water utilities.

Table 3. Water Tariff Schedule of the First Modern Water Supply in Yokohama (1887)

Category		Rate	Current value (estimate)
General use for Japanese	Flat rate - base	Less than 10 people: 1 JPY/month	2,593 JPY/month
	Flat rate-increment	0.6 JPY for each additional 10 persons	1,556 JPY
	Volumetric rate	Less than 6,000 gallon: 1 JPY/month	Less than 27.3m^3: 2,593 JPY/month
	Volumetric rate	Less than 50,000 gallon: 0.16 JPY per 1,000 gallon	Less than 227.5m$^{3:}$ 415 JPY/ 4.55m^3
	Volumetric rate	More than 50,000 gallon: 0.1 JPY per 1,000 gallon	More than 227.5m^3 : 259JPY/4.55m^3
	Vessel	0.4 JPY per 1,000 gallon	1,037 JPY/4.55m^3
	Horse	1.5 JPY/year	3,890 JPY /year
	Cattles	1 JPY /year	2,593 JPY /year
	Dog-cart	1.5 JPY /year	3,890 JPY /year
	Four-wheeled carriage	2.25 JPY /year	6,483 JPY /year
	Lavatory use	0.3 JPY per 1,000 gallon	778 JPY / 4.55m^3
	Special use	0.35 JPY per 1,000 gallon	908 JPY/4.55m^3
	Public tap	0.9 JPY/month per tap for up to 6 households	2,334 JPY/month
	Public tap	1.5 JPY/month per tap for up to 12 households	3,890 JPY /month
	Public tap	0.5 JPY/month increases in each 6 households (in case of more than 13 households)	1,297 JPY/month
	Special Public tap	0.15 JPY/month	389 JPY/month
Foreign settlement	Flat rate	Annual house rental fee 300 JPY or less : 18 JPY/year	Annual house rental fee 778,000 JPY or less: 46,675 JPY/year
	Flat rate	Annual house rental fee 301-600 JPY : 6% of the rental fee	Annual house rental fee 778,001 JPY-1,555,000 JPY: 6% of the rental fee
	Flat rate	Annual house rental fee 601 JPY or more: 5% of the rental fee	Annual house rental fee1,555,000 JPY or more : 5% of the rental fee
	Volumetric rate	Less than 20,000 gallon: 1.6 JPY/month	Less than 91m^3: 4,149 JPY/month
	Volumetric rate	20,000 - 150,000 gallon: 0.24 JPY/1,000 gallon	91 to 683m^3 : 622 JPY /4.55m^3
	Volumetric rate	More than 150,000 gallon: 0.15 JPY/1,000 gallon	More than 683m^3: 389 JPY / 4.55m^3
	Vessel	0.4 JPY per 1,000 gallon	1,037 JPY / 4.55m^3
	Fountain	0.35 JPY per 1,000 gallon	908 JPY / 4.55m^3
	Sprinkling	0.35 JPY per 1,000 gallon	908 JPY/ 4.55m^3
	Flush lavatory use	0.3 JPY per 1,000 gallon	778 JPY /4.55m^3
	Horse	1.5 JPY/year	3,890 JPY / year
	Dog-cart	1.5 JPY/year	3,890 JPY / year
	Four-wheeled carriage	2.25JPY/year	5,834 JPY / year

*1UK gallon≒4.55 liter

Source: Based on the editorial committee of the One Hundred Year History of Policy and Administration for Water Supply, “*One Hundred Year History of Policy and Administration for Water Supply*,” Ministry of Health and Welfare, 1990.

During the 1920s and 1930s, water rates charged to different classes of customers such as domestic, industrial/commercial, official or public bath house use, were gradually established. At the same time, in order to prevent wasteful use associated with the flat-rate system and to obtain appropriate revenue, more utilities adopted the volumetric system for households as well. After World War I, many cities began to introduce the decreasing-block rates to stimulate demand for large users and industries such as electric power stations and marine vessel construction companies in order to promote the development of industries. This is a schedule of rates applicable to blocks of increasing usage in which the usage in each succeeding block is charged at a lower unit rate than in the previous blocks.

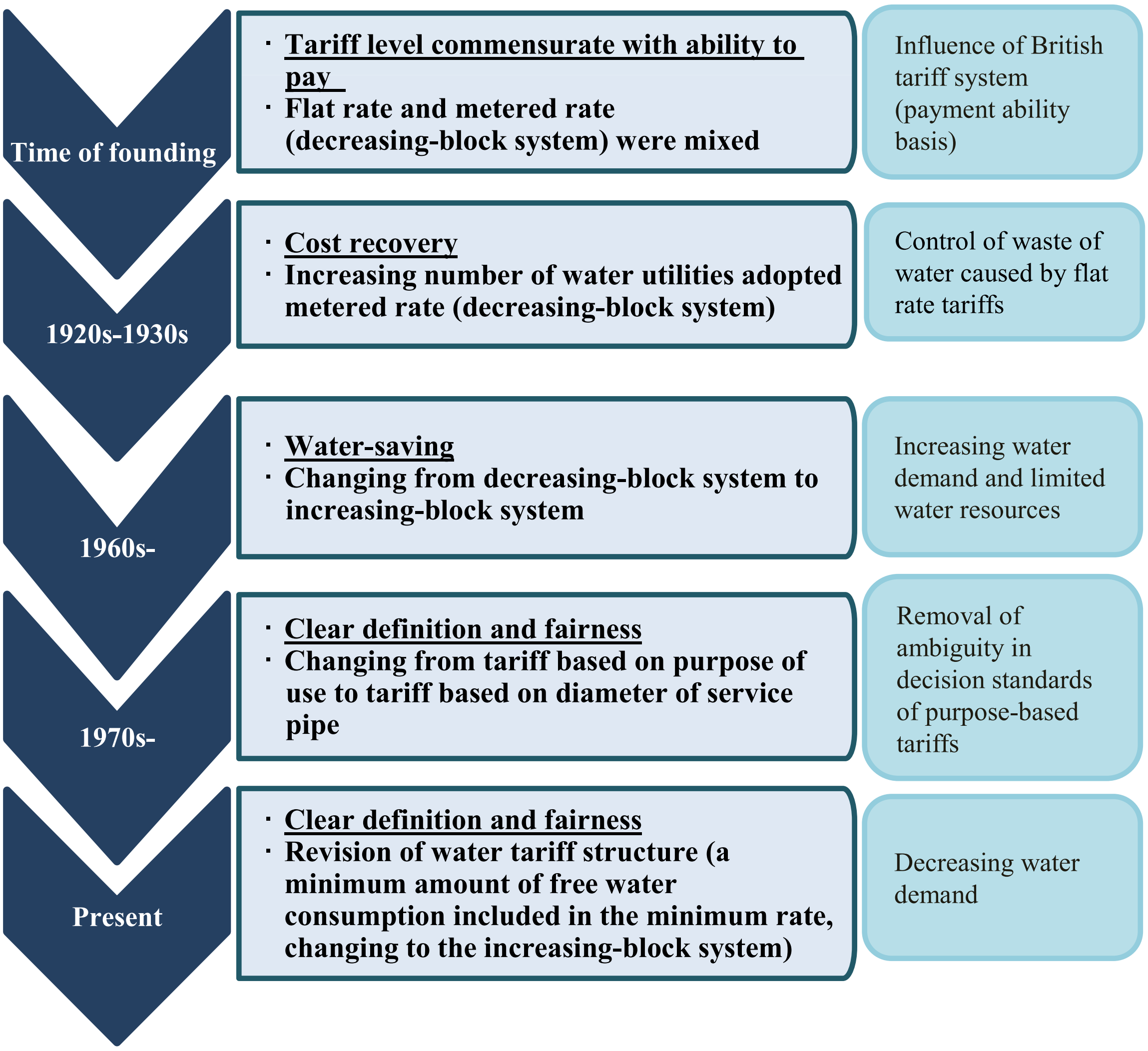


Figure 8. Changes in Water Tariff Structure in Japan

After World War II and during the period of high economic growth, the water demand sharply increased because of industrial development, population growth, and changes in lifestyle (installation of bath tubs in each house, conversion to flush toilets, etc.). Although water resource development and construction of new facilities were promoted, water supply services were unable to keep up with the demand. In order to control the amount of water use, utilities introduced an increasing-block rate around 1960. This is a schedule of rates applicable to blocks of increasing usage in which the usage in each succeeding block is charged at a higher unit rate than in the previous blocks.

Until the 1960s, the purpose-based tariff system had been widely adopted based on the concept of ability to pay. However, facing criticism for subjective and perceived arbitrary classification of customers such as domestic, industrial, and commercial, utilities were shifting to classification according to pipe size.

Column: Lawsuit in Osaka which Challenged the Fairness of the Purpose-Based Tariff System Contributed to the Shift to the Pipe Size Based Classification

Customer categories in Osaka City were classified under three types of use: “general”, “special”, and “public bath.” “General use” applied to buildings, department stores, factories and ordinary households. Inexpensive restaurants and inns were classified under “special use”. In 1967 a restaurant in Osaka filed a lawsuit challenging the fairness of this classification, claiming that the “special use” classification imposed unreasonably expensive, discriminatory, and unjustifiable tariffs, compared to those of general use. Osaka City won the case. The court ruled that the classification was reasonable based on public welfare. Nevertheless, many utilities switched to pipe-size-based classification which is more objective and eliminates the confusion associated with eligibility for each category. At the same time, the Water Tariff Setting Manual deemed that water tariffs based on pipe sizes are appropriate, although there is no direct association with the Osaka case.

It is important to design a tariff structure based on clear classifications, which is easy to understand for everyone.

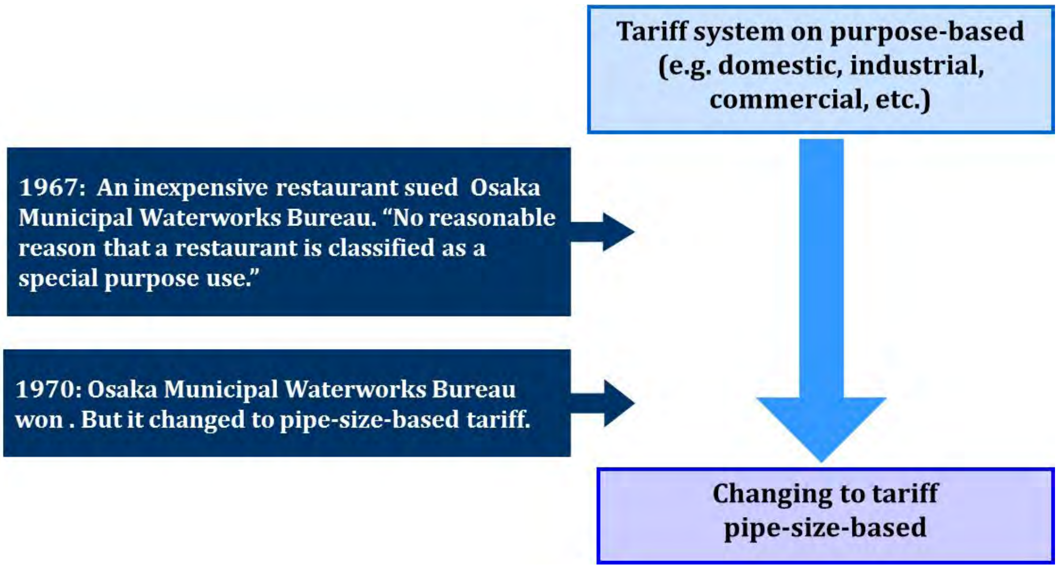


Figure 9. Setting of Water Tariffs Shifted from Purpose-Based to Pipe-Size-Based

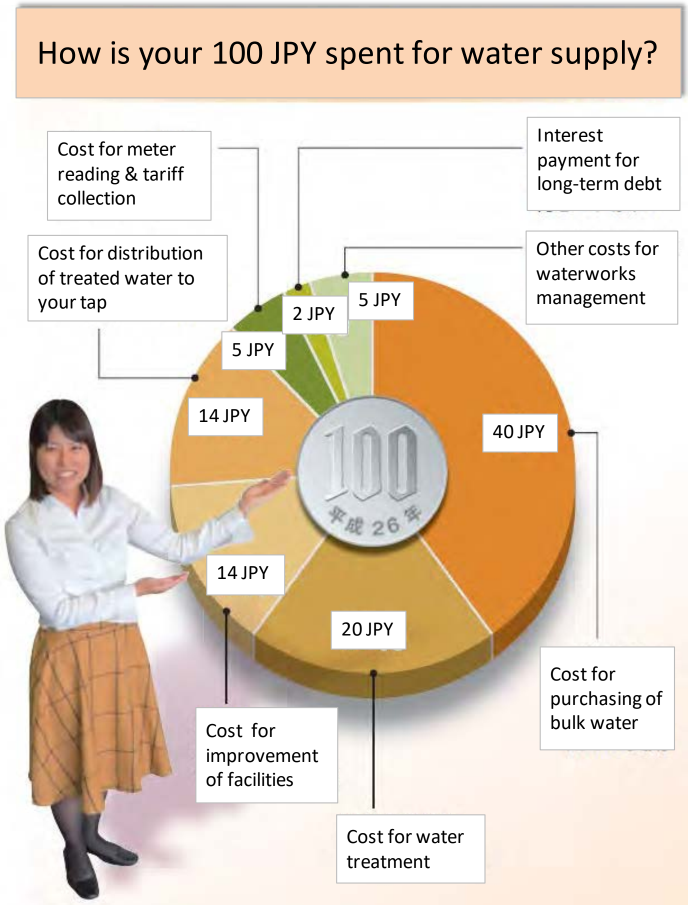
Two-part tariffs consisting of the minimum and volumetric rates are generally used in Japan. Some utilities still use purpose-based classification, but most have adopted pipe size-based system.

In recent years, water demand has declined with lower population growth and the advent of water-saving devices. More water utilities have examined the moderate amount of minimum volume (a certain amount of water included in the minimum rate for the purpose of encouraging water usage necessary for a daily life and public health) and the rate of each block in the increasing-block system.

(4) Transparency & Accountability, Public Relations

Japanese water utilities are fulfilling their accountability and promoting customer awareness by disclosing the details of the costs based on which the tariffs are set and other relevant management information.

In setting water tariffs, it is important to disclose the utility's financial information to gain the public's understanding of its business environment. Japanese utilities routinely disclose clear and detailed information on personnel costs, repair costs, electric power expenses, etc. to fulfill their accountability to the customers, and improve their understanding of the business (Figure 10). Delivering service of sustained high quality (safe and stable water supply, prompt responses to customers' enquiries) also fosters the customers' understanding of the need for tariff increases.



Source: Kawanishi Water and Sewer Bureau, *Water Supply and Sewerage in Kawanishi: Secure for Drinking, Comfortable for Using*, 2015, http://www.kawanishi-water.jp/ikkrwebBrowse/material/files/group/2/h27-12-1.pdf

Figure 10. Breakdown of Costs for Every 100 JPY of Water Tariff

Collection of charges for utilization of public facilities is stipulated under the Local Autonomy Act (Article 225) and the Local Finance Act (Article 24) in Japan. Utilities as public facilities that serve the local residents, are legally allowed to collect tariffs. By the same token, they are required to explain clearly to the residents about the management of the service. Residents on their part should be interested in and be supportive of the business.

(5) Efficient Management

Water tariff levels must be based on reasonable costs incurred under efficient management. Utilities are expected to make continuous efforts to rationalize and streamline their operations.

The Water Supply Act and the Public Enterprise Act require that utilities manage the water supply business efficiently so that costs can be covered by revenue generated from water tariffs set at affordable rates. Utilities are making continuous efforts to rationalize and to streamline their operations, specifically, with reduction of non-revenue water, more efficient administrative processes, re-allocation of personnel after facility upgrades and outsourcing of operation and maintenance. In recent years, construction costs are dropping because new technologies are shortening the construction period. Involvement of the private sector through PFI projects also contributes to further cost savings.

Example: Promotion of Efficiency in Osaka Municipal Waterworks Bureau

Osaka Municipal Waterworks Bureau faced very severe financial conditions when water demand decreased significantly from 1973 to 1980. A committee was established to find cost savings through more efficient management including personnel cost reduction in 1980. For 3 years (1980-1983) the workforce was down-sized through attrition. In 1984 shift assignments in treatment plants and distribution reservoirs were under review. Staff were re-assigned when water treatment plants acquired better equipment (1987 and 1993-1994) and again in 1990-1991 when online system and data processing of meter reading records were introduced. By 1988-1990, only half of the retired staff was replaced. The number of meter readings was reviewed in 1992, and work related to accounts and water tariffs was integrated in 1994.

Source：Osaka Municipal Waterworks Bureau, "*One Hundred Year History of Water Supply in Osaka City*," Osaka Municipal Waterworks Bureau, 1996.

Photo 4. Equipment Introduced for Online System in Osaka City

4. Consideration for the Low-Income Group

(1) Minimum Volume and Cross Subsidy in Water Tariff Structure

In Japan, the affordability of water for low-income households is considered when designing water tariffs. The minimum rate includes a minimum volume. Many water utilities use cross-subsidies.

Article 1 of the Water Supply Act stipulates the "supply of clean, abundant and affordable water" to all residents. Water tariffs have to be set at a level that is affordable to customers including low-income households. By including a minimum volume in the minimum rate and allowing for cross-subsidies, low-income households are assured adequate water supply for their daily needs at an affordable rate.

The minimum rate paid by customers regardless of the amount of water used, should cover fixed costs incurred by the water supply system. To achieve this, the minimum rate would be extremely high. The cross-subsidy system allows the low-income users to pay the minimum rate (which includes a minimum volume of water) while charging users of larger quantities higher rates to make up the difference. Many water utilities adopted 5 - 10 m^3 as the amount considered minimal for public health requirements.

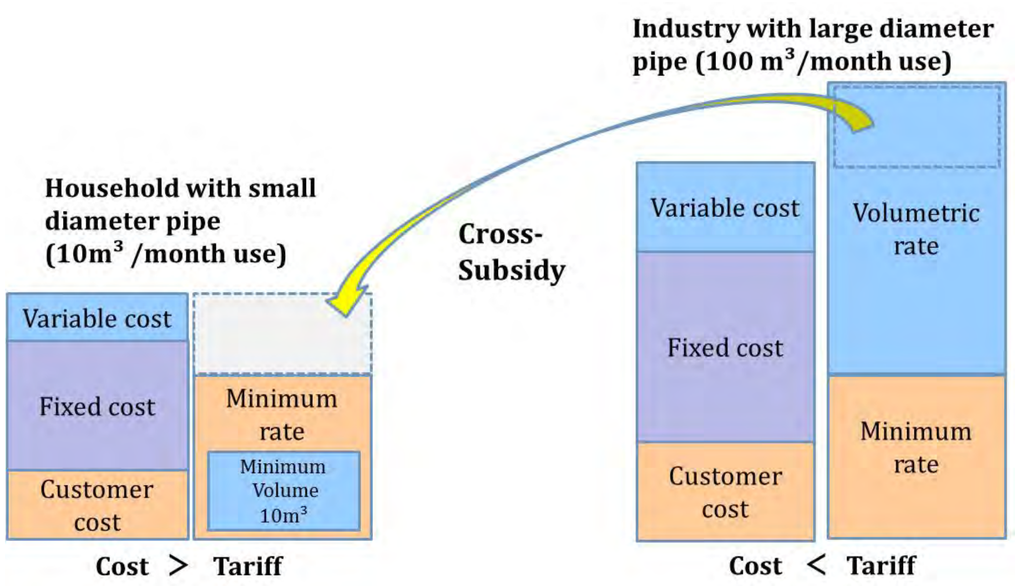
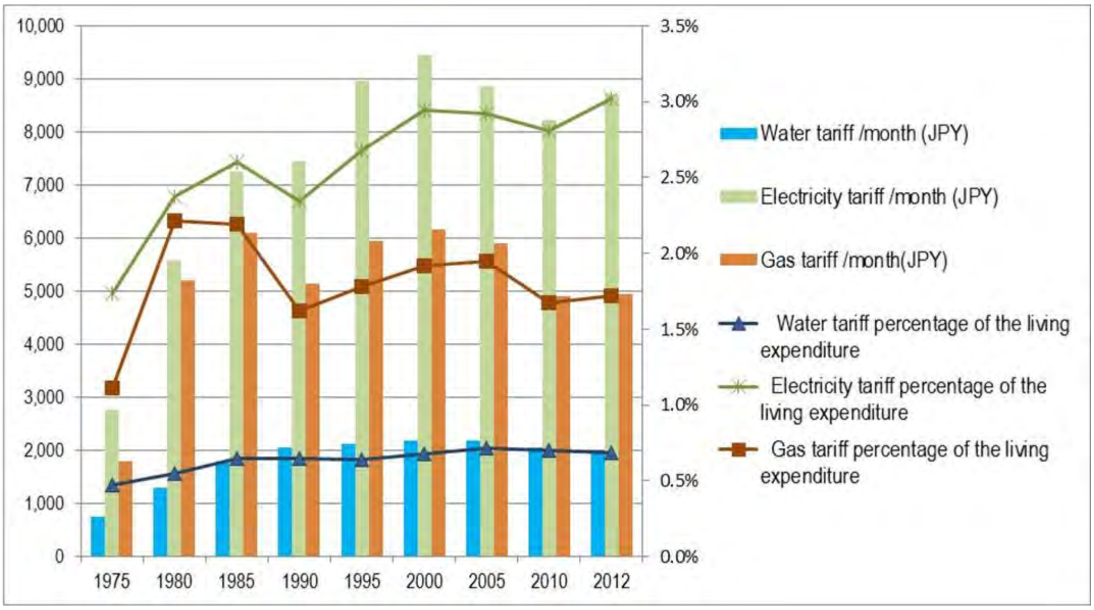


Figure 11. Diagram of Minimum Charge and Cross-Subsidy Concept

Column: Proportion of water tariffs as part of living expense

Figure 12 shows the proportion of water, electricity and gas tariffs as parts of monthly living expenses over the last 3 decades. Compared to tariffs for electricity and gas, water charges at 0.7% of monthly living expenses can be said to be affordable.



Source: Created from the data of JWWA, *“The outline of water supply,“* 6th ed. 2015.

Figure 12. Water, Electric, and Gas Tariffs to Average Monthly Living Expenditures

(2) Water Tariff Exemption

Some water utilities introduce reduction and/or exemption measures in water tariffs by clarifying the definition of low-income households.

Some water utilities introduce reduction and/or exemption measures to accommodate low-income households or persons on welfare, as stipulated in ordinances of the local government, as a part of the welfare policy. Local governments usually compensate the utilities for the lost revenue, using funds from their general accounts.

Example: Rules for Exemption from Minimum Charge in Water Tariffs in Tokyo

Recipient qualification:

- A household who receives public assistance, such as livelihood assistance, education allowance, home allowance, medical allowance or nursing-care allowance under the Public Assistance Act.
- A household who receives "childcare allowance" or "special child-rearing allowance" (persons with a child aged 18 or under in one-parent families below the income line, and parents with a child aged 20 or under with a physical or mental disability, below the income line).

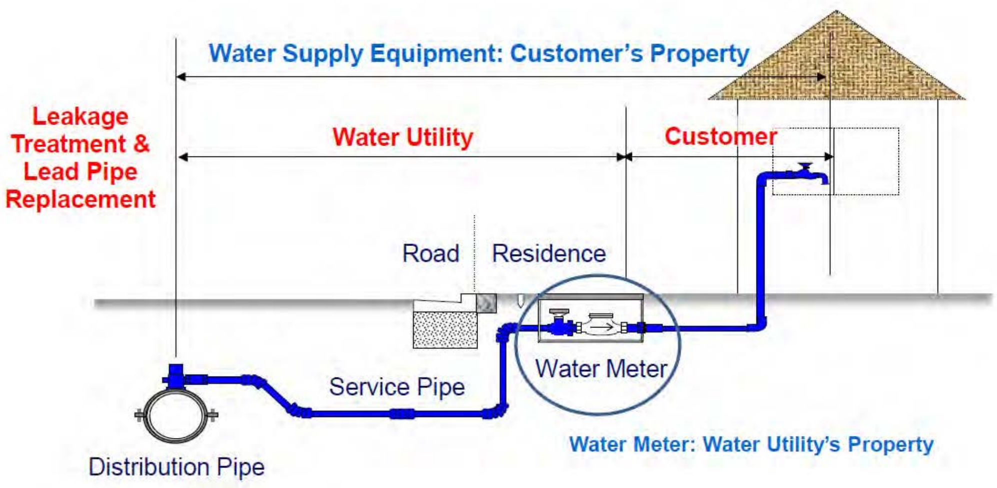
Reduced and exempted:

- Total of the minimum and volumetric charges up to 10 m^3 per month.

(3) Water Meter Policy & Connection Charge

In Japan, water meters are owned by the utilities and leased to customers. Customers are prohibited from breaking and removing water meters without permission. Costs associated with connecting to the water supply system are paid by customers. At the early stage of the modern water supply system, monthly installments and a fund for house connections were set up to help customers pay the connection charges.

Figure 13 illustrates the typical customer service connection. A customer owns and pays for the service connection equipment from the distribution pipe to the tap (excluding the water meter). The meter is on loan from the utility. The utility is responsible for maintenance of the service pipe and water meter. Customers are prohibited from tampering with or removing water meters.



Source: JWWA

Figure 13. Typical Water System Components

In Osaka, when the water supply system was firstly built, a fund was set up to help with the payments of house connections in order to promote the use of the service. Residents could pay the connection charges by monthly installments. Initially, it was 10 month installments, but this was later changed to 60 months. These initiatives were successful in encouraging house connections for the people unable to cover the connection charge in a single payment.

In rural areas where Small Scale Public Water Supply were developed, villagers relied on their own savings by putting away small amounts every day, to pay for house connections. For example, villagers set targets such as saving the price of one egg each day or saving money that they would have spent on drinks, and put that towards water supply that would relieve their hardship in fetching water.

5. Billing and Collection

In Japan, the water bill collection rate was improved by changing the interval between billings, how the charges were collected, and by enforcing collection of unpaid bills. Incentives offered to meter readers and tariff collectors also helped.

In the early days, water tariffs were collected the same way as taxes. Payments were usually made three to six times per year. The onus was on the customer to pay at the water utility. The collection rate was low. A customer might move away without informing the authorities, and there would be no way to track down outstanding payments. Urban residents inevitably had many expenses to deal with around paydays. Paying the water bill payment three to six times per year did not always make it to the top of the list. Water utilities began to shift to door to door collection to improve the collection rate.

The collection rate was further improved when payment by bank transfer was introduced. This became even more convenient when customers can pay the water charges at convenience stores which are open 24 hours a day, 7 days a week.

Each utility has guidelines and dedicated units for dealing with unpaid water bills. Customers would be reminded to pay the outstanding charges and advised of penalties such as suspension of water supply, according to clearly stated procedures. One water utility set up a special week to collect unpaid tariffs from delinquent accounts and implemented supply stoppage when final reminders are ignored. However, in cases of non-payment due to special circumstances such as illness or unemployment, etc., water supply connection is usually maintained at the discretion of the executive managing director of the utility. When one-time payment of water tariff is difficult, many utilities accept payment by installments.

In meter reading and bill collection, a performance based incentive system which tied wages to number of meters read and collected payments, improved collection rate. In the past, some meter readers skipped actual readings, and estimated volume used. Managers had to carry out spot checks, set standard procedures for meter reading, and provide training.

More than 90% of the utilities outsource meter reading, while providing internal and external training for staff in charge of billing and collection. Japan Water Works Association offers training programs on billing and collection.

Example: Changes in Water Bill Collection and Handling of Unpaid Tariffs in Osaka Municipal Waterworks Bureau

When Osaka Municipal Waterworks Bureau completed the installation of water meters in 1910, customers paid their water bills on a quarterly basis. From 1926 to 1931, only 30% of the customers actually did so. The Bureau implemented various measures, but only managed to collect 95 to 96 % by the end of the settlement period. With monthly door to door collection, the rate reached 99.9% in four years, and 100% after nine years.

Payment by account transfers was introduced in 1966. The overall efficiency actually declined when both methods (account transfer and door-to-door collection) were used at the same time. Door-to-door collection was abolished in 1975 when most households have no one at home during the day. Family groups consisting of two parents and their children increased, and both of parents went out to work. The unpaid amount went up. The payment method shifted to account transfers, and the transaction was expanded to more financial institutions.

In 1993, convenience stores started to handle water tariff payments, so that customers could pay during holidays and after hours. Tariff collectors were replaced by dedicated personnel assigned to manage receipt of payments and settle unpaid bills. A manual on settlement of unpaid bills was prepared.

Table 4. Changes in Billing and Collection in Osaka Municipal Waterworks Bureau

Period	Collection system	Remarks
1910 - 1930	Quarterly payment by customers	(Issue) Only 30% customers paid water bills by due date. Bureau used various procedures to secure payments, and was able to collect 95% of tariffs. The office could lose track of customers if change of address was not reported.
1931	Introduction of monthly door to door collection	(Result) 99.9% collection rate was achieved in four years after the introduction, and 100% in nine years.
1966	Introduction of bank account transfers	(Result) More customers shifted to account transfers every year, helping improve the efficiency and reduced the need for cash handling.
		(Issue) The overall collection rate declined when account transfer and door to door collection were both in use at the same time. More households had no one home during daytime, because family groups consisting of two parents and their children increased and both of parents went out to work. The unpaid amount went up.
1975	Door to door collection system was abolished	Tariff collectors were replaced by dedicated personnel assigned to receive and manage payments and settle unpaid bills. A manual on settlement of bills was prepared to set standard procedures for resolving overdue accounts.
	Gradual promotion of account transfers, and expansion of financial institutions handling them	
1993	Start of handling payment in convenience stores, payments can be made during holidays and at night	

Source: Base on Osaka Municipal Waterworks Bureau, "*One Hundred Year History of Water Supply in Osaka City*," Osaka Municipal Waterworks Bureau, 1996.

Example: Challenges and Solutions Concerning Meter Reading and Door to Door Collection System in the Bureau of Waterworks, Tokyo Metropolitan Government

When the door to door collection system was adopted in Tokyo, meter reading and receipt of payment were carried out by separate sets of workers to avoid unlawful handling of the transactions. The problems facing collectors included customers often not able to pay at the time, or collectors not willing to accommodate customers' request to come after office hours. The collection rate was not good. In order to improve the collection rate, the Bureau hired workers with more interpersonal experience and introduced incentives that tied compensation to performance (number of visits and payments collected). The Bureau also introduced on the job training for collectors and replaced analogue meters with digital ones for more accurate readings.

Even though the Bureau provided meter readers with generous benefits such as allowance per customer, daily travel expenses and transfer to office work after four years, it was difficult to hire and retain enough meter readers. Eventually meter reading was outsourced.

The collection procedure for unpaid water bills in the Bureau of Waterworks, Tokyo Metropolitan Government is shown in Figure 14. The customer is sent a reminder, followed by an advisory letter, and the notice of disconnection, and eventually the water supply is disconnected. The process is well-publicized, which also contributed to the decrease in unpaid tariffs.

The bill collection rate of the Bureau of Waterworks of Tokyo Metropolitan Government is 99.9%.

1st day	Meter reading
	↓
1st day	Transmitting metering data (& tariff calculation)
	↓
4th day	Issuing of Bills
(10 days)	↓
14th day	Deadline of Payment
	↓
28th day	Issuing of Reminder Letter
(7 days)	↓
35th day	Designated Deadline
	↓
74-97th	Issuing of Advance notice of disconnection
(7 days)	↓
81-104th	Deadline
	↓
-	Issuing of Disconnection Enforcement
	↓
-	Disconnection

Source: Training Materials prepared by Nihon Suido Consultants Co., Ltd.

Figure 14. Bill Collection Procedures for Nonpayment – the Bureau of Waterworks, Tokyo Metropolitan Government

Meters are housed in boxes and replaced every eight years as stipulated under the Measurement Act. They should be in good working order to ensure that the readings are accurate.

6. Lessons Learned

The following Japanese experience could be useful for other countries.

- **(Financial Sources for Water Supply Development)** Water supply facilities were developed using public enterprise bonds and subsidies. Utilities borrowed large sums at low interest rates and long repayment periods from public financial sources. Subsidies based on well-defined policy goals were granted. This government financial assistance contributed greatly to achieving universal access to water supply service. Public enterprise bonds are an effective and fair way to share the liability of the construction costs among existing and future customers. It is important to have a financial plan showing that water tariffs can generate enough revenue to cover debt repayment and demonstrate financial soundness.

- **(Subsidies for Nationwide Water Supply Coverage)** Although it is desirable to cover all expenses with the revenue from water tariffs, subsidies were required to achieve nationwide water supply coverage and develop water resources in Japan. Especially, in rural areas with small populations, it has been difficult to cover the construction costs of the facilities with tariffs alone. Rural water supply was developed by subsidies and contribution from villagers.

- **(Tariff Setting)** In Japan, water tariffs are set based on the following policies and principles: (1) utilities use the fully distributed cost method and self-supporting accounting system, (2) financial liability for construction of facilities is shared equitably and there is absolute clarity in how tariffs are set, (3) efficient management of the utilities, (4) affordability, and (5) adequate information disclosure. It is important to have the appropriate legal framework and standardized procedures to guide the tariff setting process. Utilities make continuous efforts towards efficient management and information disclosure so that customers clearly understand and support the water supply business.

- **(Affordability)** To support all households including low-income groups, water tariffs are made affordable by including a minimum volume in the minimum charge and implementing cross-subsidies. Exemption and reduced tariff systems are established as a welfare policy of the local government. The qualification targets for low-income groups are clearly defined by ordinances. Customers could pay by installments for costly new connections and were encouraged to save money systematically for the payments.

- **(Increasing Bill Collection Rate)** Japanese water utilities have achieved a bill collection rate of nearly 100% by shifting to a payment system that is convenient for customers. It is important to find the easiest way for customers to pay depending on the financial services available. There are clear procedures for following up on unpaid bills and applying penalties as required. Training for meter readers and tariff collectors together with performance based incentives could also help raise collection rates. Installation of meters at all customers and keeping meter accuracy, have also contributed to high collection rates.

Theme 7. Institutional Management: Governance, Human Resources Development, Consolidation of Water Utilities, Public-Private Partnerships

Contents

1. Introduction

Water utilities in Japan are managed at the local level under national government oversight. The Ministry of Health, Labour and Welfare regulates and supervises the technical aspects of the water supply services based on the Water Supply Act. The Ministry of Internal Affairs and Communications is the competent authority for local government administrative and management practices according to the Local Public Enterprise Act.

In the framework of such regulation and supervision, water utilities manage their organization including human resources development.

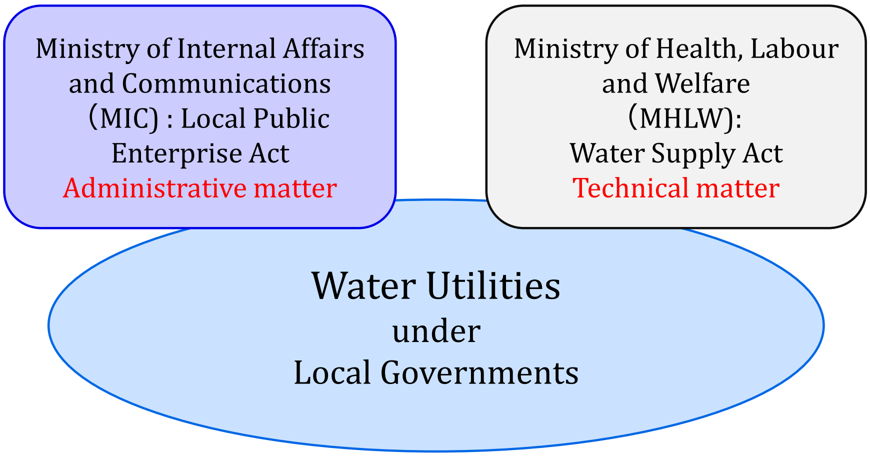


Figure 1. Water Supply Administration (relevant laws and authorities)

This module describes the governance structure and management practices of Japanese water utilities under this administrative structure (Figure 1) by explaining the following questions frequently asked from the participants of water supply training courses.

Q1. What is the governance of Japan's water utilities? Who and how are they supervised as a "public enterprise"?

Q2. Why do Japan's water utilities emphasize business planning? What are the contents business plans?

Q3. How do Japan's water utilities develop capacities of human resources? How to train engineers when a lot of human resources were needed during the expansion of water supply system?

Q4. Do small- and medium-scale water supply utilities have any problems with finance and human resources? If they have problems, how do they attempt to overcome the problems?

Q5. How does Japan promote public-private partnerships in the field of water supply? How to deal with issues such as ensuring safety, public benefit, etc. in public-private partnership?

The following sections attempt to provide answers to these questions:

2. Governance (Q1)
3. Business plans and PDCA Cycle (Q2)
4. Human Resources Development (Q3)
5. Consolidation of small- and medium-scale water utilities and regional collaboration (Q4)
6. Private-Public Partnership (Q5)

2. Governance

(1) Responsibilities of the National Government, Water Utilities and Citizens

The Water Supply Act of Japan specifies the responsibilities of the national government, water utilities and citizens. A water utility is obligated to establish the water supply contracts and disclose them to the public.

Article 2 of the Water Supply Act of Japan lays out clearly the responsibilities of each party as follows: (1) the national government shall prepare and promote basic and comprehensive policies on water resources and water supply development, and provide technical and financial support to water utilities; (2) water utilities shall proceed with phased water supply development and appropriate and efficient management; and (3) the citizens shall respect the national and local (water utilities') policies and ensure proper and reasonable use of water.

Figure 2. Responsibilities of the National and Local Governments (water utilities) and Citizens in the Water Supply Business

A water utility is obliged to establish contracts with its customers for the services set forth in the water supply rules. The information on water tariffs, allocation of expenses for installation of service connections and supply conditions has to be disclosed to the public in the water supply contracts.

(2) Executive Managing Director

The water supply business (excluding Small Scale Public Water Supply) is managed and operated under the Local Public Enterprise Act. A water utility is independent from local general administrative organizations. The executive managing director has the authority and responsibility for the operations of the utility. The annual management plan and annual budget has to be approved by local assembly as a check on the proper management of the utility.

Water utilities in Japan must comply with the Local Public Enterprise Act in their management practices and business operations. Application of the Act for Small Scale Public Water Supply is determined by the ordinance of the local government. The Local Public Enterprise Act also covers other sectors such as power, gas and transportation. These public enterprises are required to serve the public good as well as run an economically sound business.

The Local Public Enterprise Act requires that an executive managing director[1] of a local public enterprise be under the guidance and supervision of the head of the local government (the mayor). He/she is appointed by the mayor for 4-year renewable terms, based on the individual's competence in management. He/she cannot be dismissed against his/her will except as otherwise provided by the Act. The mayor has the right to "provide necessary directions to the executive managing director about the execution of an operation which may have a critical influence on the welfare of the residents." The mayor does not provide general guidance and supervision. The mayor can only provide "direction on a limited scope", even if invoked as an exception. The executive managing director manages the utility efficiently and effectively on his/her own initiative. His/her authority is strengthened by the separation of the water supply business from other local administrative organizations. The executive managing director appoints and dismisses staff, establishes divisions for clerical duties and sets management rules. The mayor, not the executive managing director, adjusts budgets and proposes various bills. Salary scale is based on performance, cost of living, and should be comparable to employees in similar public and private enterprises.

The annual management plan (annual budget) has to be approved by local assembly as a check on the proper management of the utility.

As Japanese water utilities are managed at arm length from the municipal government, they improve the capabilities of their staff by managing their own human resources development according to their needs, and reward staff for their performance.

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[1] It is also called "a director general" in water utilities.

Example: Staff Recruitment at the Bureau of Waterworks, Tokyo Metropolitan Government (BWTMG)

There are two types of employees in a water utility in Japan: general staff and laborers for simple tasks. They have different compensation packages. General staff has to pass a civil service examination administered by the local government. Laborers are recruited based on the criteria of the water utility (at present there are very few such recruitments).

BWTMG used to hire its own workforce, recruiting laborers through local acquaintances or connections. In some cases, children of the farmer who lived in the expropriated land were employed for the construction of the new facility. Performance based incentives were available for meter readers and water tariff collectors.

BWTMG was able to improve its operation by giving incentives to meter readers and bill collectors according to the number of meters read and money collected.

(3) Technical Administrator

The Water Supply Act requires that a Technical Administrator be in charge of the operations of a water utility.

Article 19 of the Water Supply Act sets the requirement for a qualified Technical Administrator. The Technical Administrator must have a combination of formal education, training for qualification and practical experience in the water supply field.

The Technical Administrator is responsible for (1) inspecting whether or not water supply facilities meet facilities standards, (2) conducting water quality inspection and facility inspection when main water supply facilities are constructed, expanded and/or alternated, (3) conducting inspection to check if the structure and material of service connections meet standards, (4) periodical and extra water quality testing, (5) worker health checkups, (6) sanitary measures including disinfection with regard to management and operation of water supply facilities, and (7) emergency suspension of water supply, etc.

The success of water supply management in Japan can be attributed to both qualified Technical Administrators who are responsible for operations and executive managing directors who have the authority for institutional management.

(4) Checks & Balances and Interdepartmental Cooperation

Checks and balances are set in place in water utilities to reduce mistakes, prevent improper behavior or avoid concentration of power and foster cooperation. Utilities also establish and utilize task forces to address challenges and work together across organizations.

Checks and balances are important because decisions made in one department can affect other operations. Water utilities have reduced mistakes and prevented improper behavior by having a check-and-balance system within the organization. When dealing with specific challenges, task forces can be established by bringing together efforts across related sections.

Example: The Bureau of Waterworks, Tokyo Metropolitan Government

Meter reading and bill collection were assigned to separate units so that workers could not exploit their professional position for personal benefits. Other examples were separation of bill collection from accounting, and planning from field operations. During the period of high economic growth, the planning department proposed facility expansions and the finance department should balance these against other expenses in order to maintain the overall financial viability of the organization. Departments were required to understand each other's situation, accommodate and adjust to one another's needs. It took several rounds of discussion with involved parties to resolve an issue and the process would start over again for the next issue. The process was disclosed and forged cohesiveness and strong teamwork, and aligns competing interests to serve the ultimate common goals. The business has been operated in an effective manner by using the PDCA cycle.

BWTMG dealt with water leakage problems by having staff from related departments work together to come up with the practical measures.

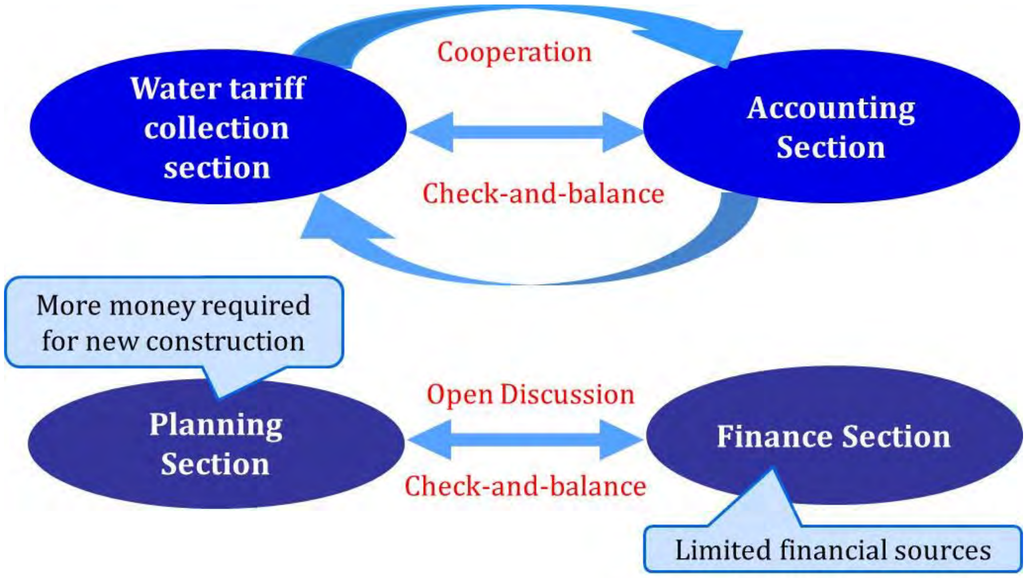


Figure 3. Concept of Check and Balance between Sections

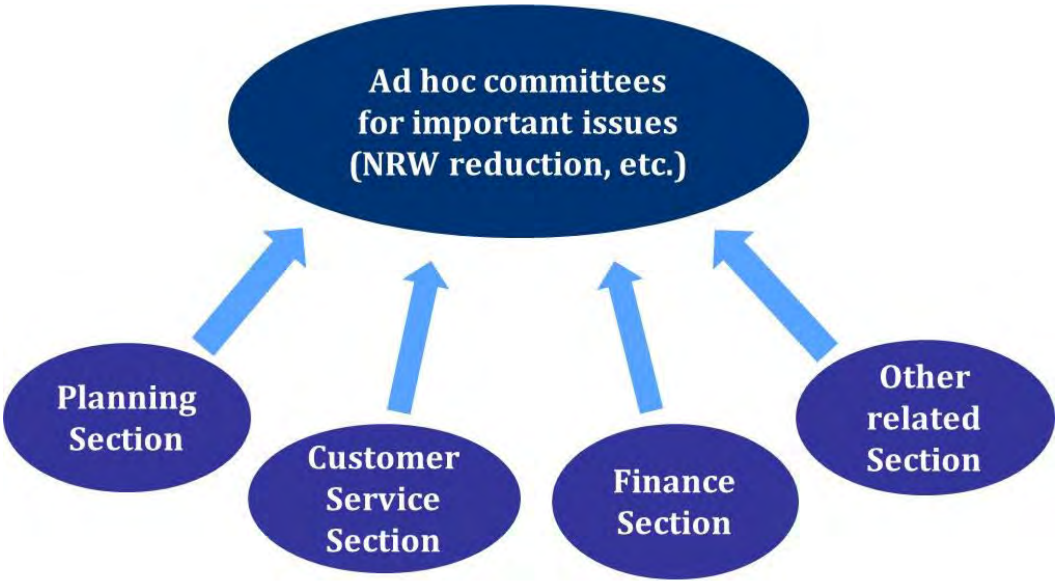


Figure 4. Concept of Ad hoc Committees for Dealing with Important Issues

(5) Advisory Committee

An advisory committee is a local government's auxiliary body that provides information and advice to assist the utility on governance issues such as policy development, financial problems, and decision making on matters of importance.

The advisory committee is an affiliated organization that conducts reviews, deliberations, and investigations on behalf of the local government. The composition and number of members in the committee is prescribed by local ordinance. Generally the committee is comprised of representatives from academia, business sector, citizen's groups and individuals selected from the public. They are tasked by the mayor or the executive managing director of the utility to report on consultations on important matters such as operation and management policy, or financial issues.

An advisory committee provides the opportunity for the utility to: (1) explain its operations, disclose details to demonstrate transparency and accountability; (2) secure objective external advice; (3) tap into expertise not available internally; and (4) engage the customers and the public to better understand their needs and secure their participation.

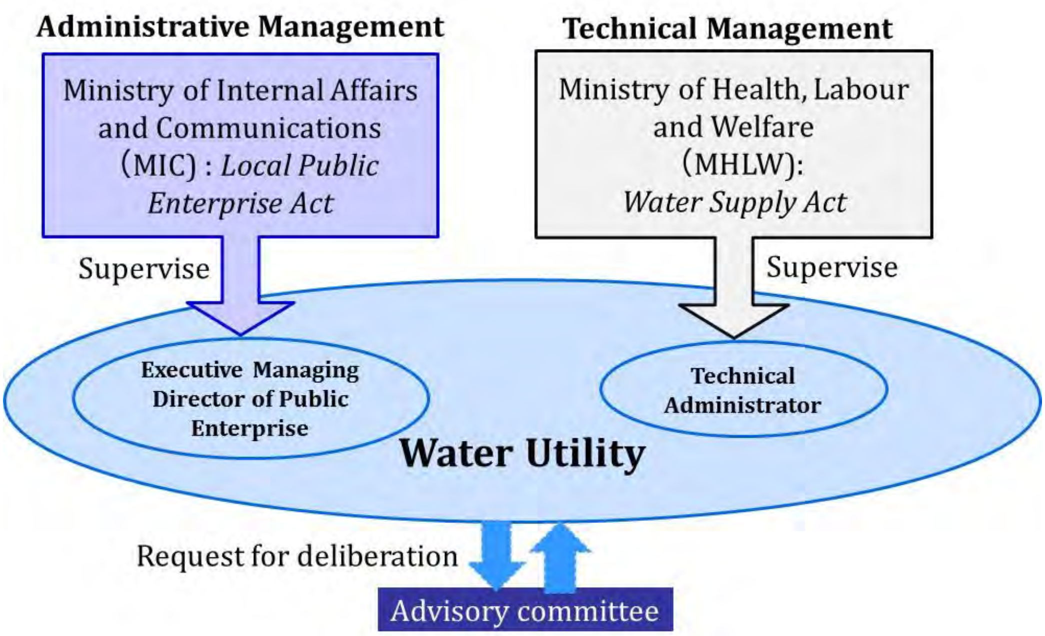


Figure 5. Concept of Governance of a Water Utility

3. Business Plans and PDCA Cycle

During the period when construction and expansion of water supply systems were required, water utilities constructed their facilities based on master plans. Currently, operation and maintenance is their main concern. The focus has shifted to improving the existing status by engaging in careful analyses and developing long term visions. PDCA (plan-do-check-act) is the iterative four step management method used to control and continually improve the processes and services in the water supply business.

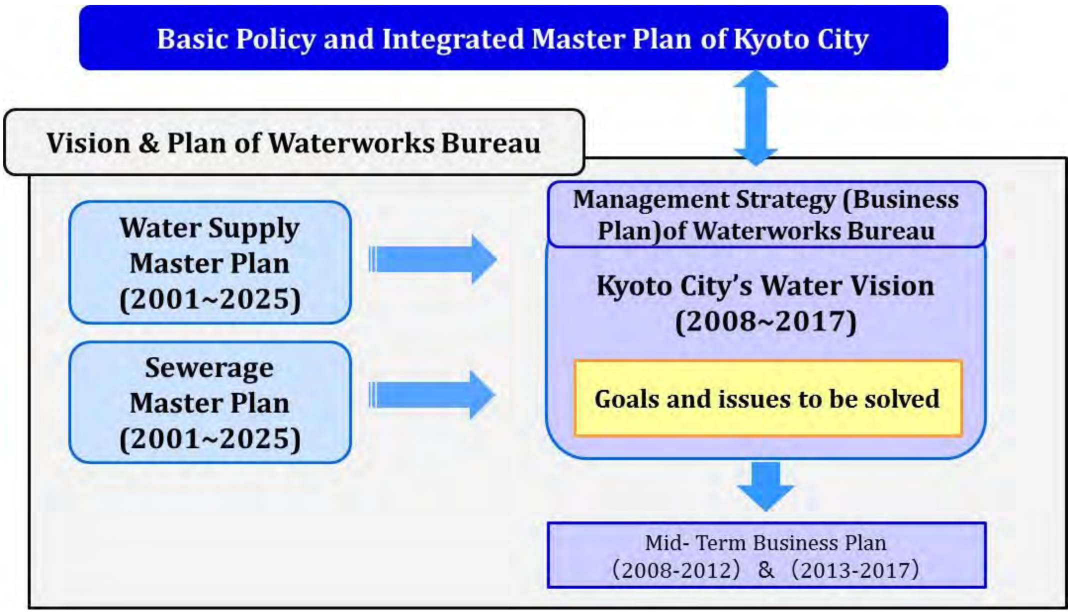
During the peak of water supply development in Japan, every water utility carried out construction of facilities according to its master plan. After the period of expansion, operation and maintenance became the main concern. Some utilities formulated medium and long term plans, analyzed and evaluated the present status and future projections; and presented a future vision and the road map to achieve the targeted outcomes. However, not all utilities have done so.

The Ministry of Health, Labour and Welfare (MHLW) stated the important issues and policies for future water supply in the "*Water Supply Vision*" in 2004. The *2005 Manual for the Development of Local Water Supply Vision* was prepared to systematically implement the Water Supply Vision. The Manual calls for the development of future plans by every utility. Utilities have to analyze their business environments and formulate their management strategies. The exercise can be summarized into the following steps: (1) analyze and evaluate the present business status; (2) set a future vision; (3) set medium and long term goals; (4) develop strategies to realize the future vision; and (5) set a review process to evaluate strategies, based on local conditions. Performance indicators (PIs) are recommended for the analysis and evaluation of present status. Asset management and the formulation of “water safety plans” and “earthquake-response plans” are mandatory in considering implementation strategies. Water utilities must establish a system to continually evaluate their progress and improve their performance. Plans should be revised based on the progress and feedback from concerned parties.

Example: Kyoto City Waterworks Bureau

Kyoto City prepared a Water Supply Master Plan (2001 - 2025) based on its Basic Policy for the period. In 2004, the water bureau and the sewerage bureau were consolidated into the Kyoto City Waterworks Bureau. In 2008 the "Kyoto City Water Vision (2008-2017)" was prepared to integrate water supply and sewerage plans and to describe the challenges and operational goals. 5-year management plans (2008 - 2012, 2013 - 2017) were subsequently prepared to explain the management strategy and targets for every year for achieving the vision.

The Bureau releases information on its annual operation policy, implementation plan and target levels. The Bureau promotes the public's understanding of its business and incorporates citizens' opinions in formulating its business plans. The status of various initiatives is available to the public on its website. Formulation of business plans can help clarify the goals of the organization and reaffirms these among managers and staff. The Bureau promotes the PDCA approach for analyzing, evaluating and improving performance and reflecting the results in the policy for next year. The PDCA cycle is very effective for this process.



Source: created from Kyoto City Waterworks Bureau, "*Kyoto City Water Vision*"

Figure 6. Kyoto City Water Vision and Related Plans

4. Human Resources Development

(1) National Initiative on Human Resources Development

The national government utilized higher education institutions concerning public health to develop the human resources required to develop water supply system in Japan.

The National Institute of Public Health under the Ministry of Health, Labour and Welfare trained the engineers required at the early stages of the national water supply development. These engineers worked in prefectural offices, provided technical advices to municipal governments and led the development of water supply facilities. Later, public health engineering departments were established in national universities and supplied the required expertise. The development of human resources in higher education institutions as a national initiative contributed to the successful nationwide water supply coverage in Japan. Subsequently, public and private universities began to offer courses on public health engineering to develop the capability in the water supply business.

Column: Department of Public Health Engineering, the National Institute of Public Health

The National Institute of Public Health was established under the Ministry of Health, Labor and Welfare in 1938 with financial assistance from the US Rockefeller Foundation for the research & development and training of public health engineers in Japan. Its Public Health Engineering Department became the first research body of public health engineering in the country. Until then, very few people acquired this expertise through formal training. In 1948, the first short-term training course (a 3-month course) on public health engineering was provided for engineers working in municipal water and sewerage or sanitation facilities. By 1970, 662 engineers completed the curriculum. They played substantial roles in the development of water and sanitation facilities.

(2) Human Resources Development in Water Utilities

Employees are trained mainly on the job (OJT; On-the-Job Training) and occasionally sent on courses offered by Japan Water Works Association (JWWA) and other organizations. Some utilities have in-house training centers and develop in-house instructors for knowledge transfer.

Utilities develop their staff capabilities on the job, supplementing this with training programs offered by JWWA and other related institutions. Only some large utilities have their own training centers and their programs are open to other utilities. Training in these various forms is continuous and systematic.

Example: Training at Nagoya City Waterworks and Sewerage Bureau

After World War II, staff working on restoration projects in Nagoya did not have the required training or skills. Nagoya City Waterworks and Sewerage Bureau faced an urgent need to secure labor force and improve their skills for the rapid expansion of water supply facilities. From the late 1950s to early 1960s the Bureau hired junior high school graduates and gave them one year training to develop the workforce. Later the training system was abolished and new employees were trained on the job by more experienced staff. The training became inconsistent and practical skills were taught without basic knowledge. The necessity for standardized training was recognized and the Technical Training Center was established in 1984.

The Technical Training Center identifies the knowledge and skill requirements within the Bureau, delivers standardized programs to constructors, and provides training for credentials as public officers.

Water leakage repair is conducted by private sector based on the qualification program in Nagoya City. Private company workers can be trained and certified through the Technical Training Center programs. The Center also provides training courses for staff from other utilities through JWWA programs and overseas participants of JICA training programs.

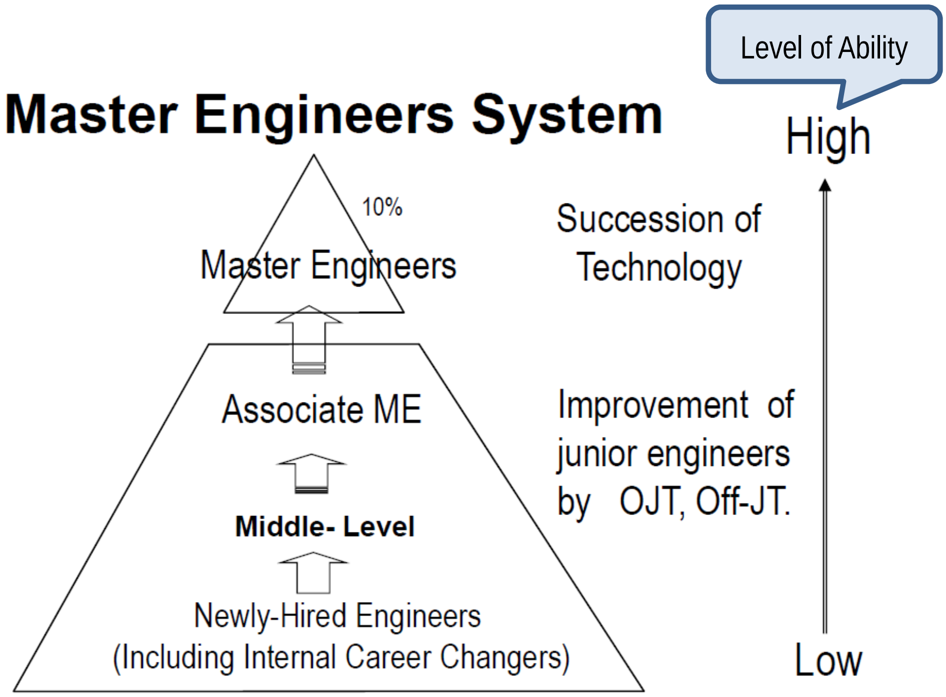
Senior engineers are assigned as full time trainers of the Center. As trainers are assigned in the Center, training courses are planned in cooperation with the job sites taking care not to lose touch with the current needs of the sites.

Source: Presentation materials by the Nagoya City Waterworks and Sewerage Bureau for "*The Third Executive Forum for Enhancing Sustainability on Urban Water Service in Asian Region, 2014*"

Photo 1. Training Program at the Technical Training Center of the Nagoya City Waterworks and Sewerage Bureau

Example: Human resources development at Yokohama Waterworks Bureau

Yokohama Waterworks Bureau develops its human resources along two converging tracks to achieve the knowledge and skill by setting clear goals for its employees. One track develops individual capability through OJT and other trainings. The other uses performance review for career development. Yokohama Waterworks Bureau has a Master Engineers System to mentor junior engineers as a part of succession planning.



Source: Presentation materials by the Yokohama Waterworks Bureau for "*The Third Executive Forum for Enhancing Sustainability on Urban Water Service in Asian Region, 2014*"

Figure 7. Master Engineers System

Column: Training Courses of JWWA and the Japan Small Scale Water Works Association

JWWA is a public interest corporation mainly for the members of Japan's water utilities and engages in research and standardization of water equipment, training programs and publications related to waterworks. The training offered by JWWA includes basic courses on water supply, workshops on water supply business administration, treatment plant equipment, leakage prevention, managing unpaid charges, earthquake response and technical administrator and executive managing director training.

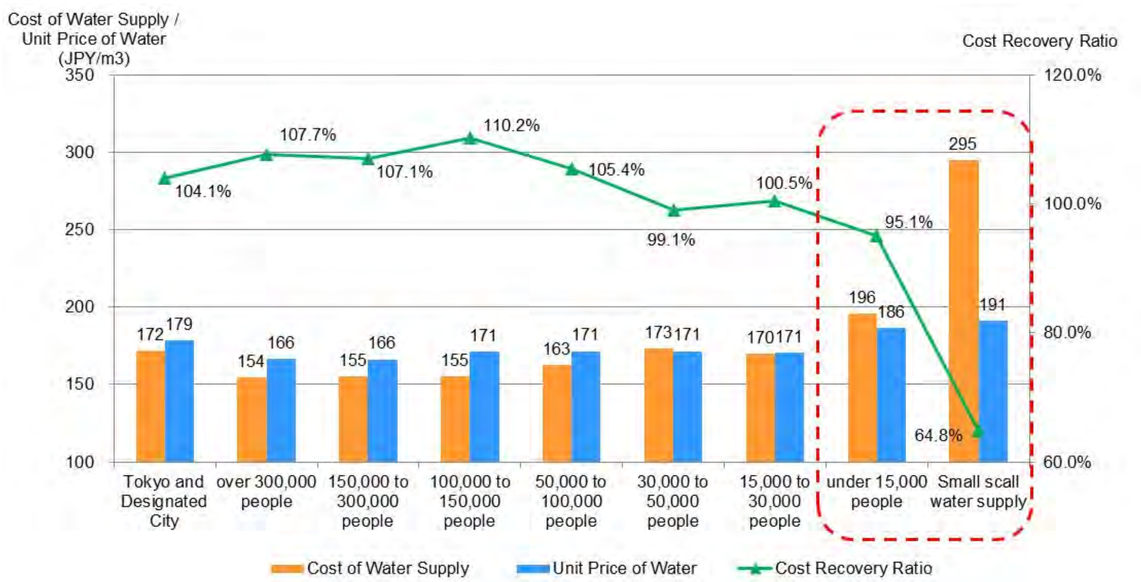
The Japan Small Scale Water Works Association, established to promote Small Scale Public Water Supply in 1955, provides annual training programs for staff of small-scale utilities and Public Health Centers.

5. Consolidation of Small- and Medium-scale Utilities and Regional Collaboration

(1) Challenges of Small- and medium-scale Water Supply Management

Small utilities usually do not collect enough tariff revenue to cover expenses. They also have staff shortages. Consolidation of these utilities can gain economies of scale. Merging of management and administrative functions or plant operations and outsourcing to private sector are also alternatives that can achieve improved efficiency.

It is important to achieve cost recovery based on tariff income. However, Figure 8 shows that the smaller the service population, the larger the relative service cost, making it impossible for small-scale utilities to achieve cost recovery by tariffs alone.



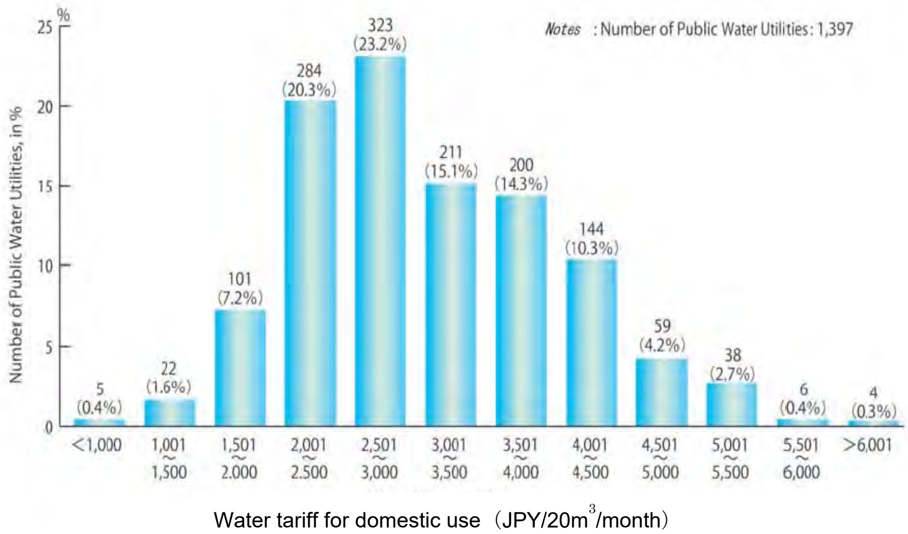
Source: Created from the data of Ministry of Internal Affairs and Communications, "*Survey of Financial Status of Local Public Enterprises, FY 2014*," http://www.soumu.go.jp/main_sosiki/c-zaisei/kouei26/html/mokuji.html

Figure 8. Cost Recovery in Water Supply Business by Size of Operation (2014)

Therefore, there is a problem of water tariff difference between water utilities. The national government has to address this by providing subsidy to Small Scale Public Water Supply. Small utilities also have the issue of lack of human resources. They have to consolidate their operations to gain economies of scale and/or outsource their tasks to a private company.

Column: Differences in Water Tariffs

The location, type of water source (groundwater, dam and Bulk Water Supply), degree of urbanization, category of customers, influence the water tariffs charged by the utility. The monthly average water tariffs vary among utilities, and the difference is more pronounced for the smaller utilities.



Source: JWWA, *Comfortable Life with Water Supply and Transition of Water Supply Volume*, http://www.jwwa.or.jp/shiryou/water/water.html

Figure 9. Number of Water Utilities by Water Tariff (2013)
(JPY/20 m^3/month, including Consumption Tax)

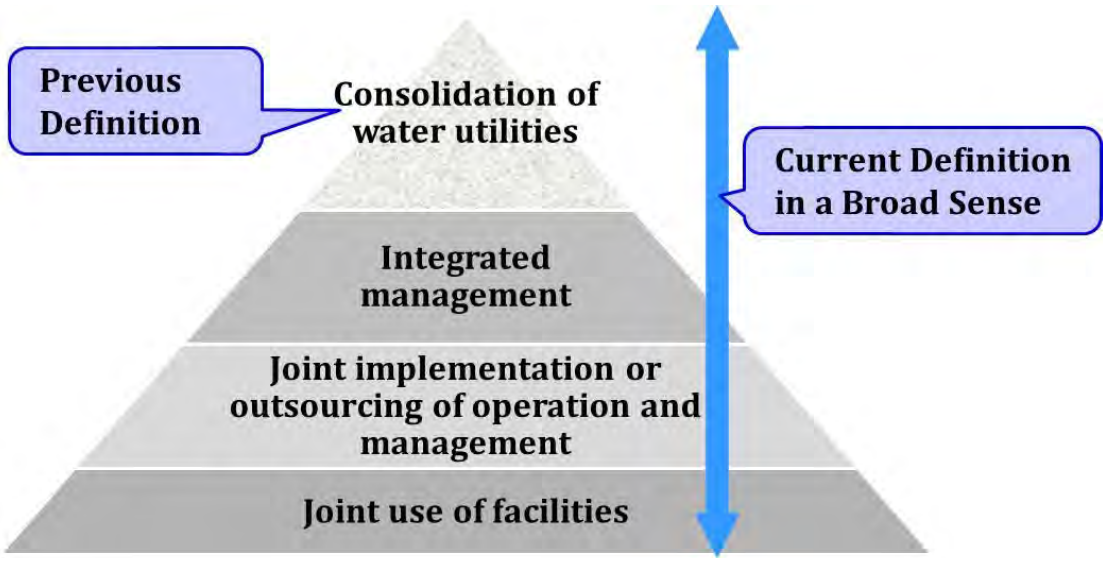
Utilities, with high capital expenses for new construction and upgrade under difficult conditions, need to generate substantial revenue. They can obtain financial resources from the general account of the local governments and allocate from local taxes to avoid higher tariffs.

(2) Towards Regional Collaboration

Bulk water supply system was established in the reorganization of water supply in Japan. Subsidies for the consolidation of water utilities were also provided. The concept of regional collaboration explores various means of integrated management and administration of water utilities.

In the mid-1960s, water supply services in Japan was facing issues such as rising demand, higher construction costs, pollution of water sources, inadequate operation and maintenance of small utilities. Initiatives at the local and national government levels were undertaken to resolve these issues. In 1966, part of the Local Public Enterprise Act was revised and the Water Supply Authority System was established (Paragraph 1, Article 39-2 of the Local Public Enterprise Act), and water supply authorities began to provide bulk water supply to some water utilities. The national government granted subsidies to promote restructuring and consolidation of utilities. However, more needed to be done.

In 1977, the Water Supply Act was revised to incorporate a plan to consolidate water utilities. Consolidation through Bulk Water Supply System was only implemented for a small part of the country. By the early 2000s, the policy was expanded from consolidation to integrated management and sharing of facilities. The Water Supply Act was revised again in 2001 and introduced the system for delegation to a third party. This opened the way for securing services from large utilities and the private sector. (See Figure 10)



Source: JWWA "*Guidelines for the Consideration of Broadening of Water Supply: For the Promotion of Water Supply Vision*"

Figure 10. Previous and New Definition of Regional Collaboration

(3) Constraints on Consolidation

Consolidation of water utilities has many challenges: disparities of facilities development, water tariffs and other administrative aspects, differences in operational issues, local politics, legal systems and procedures.

Consolidation would secure stable water sources, improve management efficiency and gain savings in sharing operations. However, there are many challenges. There are big differences between water utilities in terms of facilities, operational procedures, water tariff structure, priority issues, local government control and legal provisions. Utilities had to work out these differences with the help of national subsidies, before integration can take place successfully. "Program for Promotion of Consolidation of Water Utilities" started in 2010 provides subsidies for small utilities (population served is less than 100,000) to rehabilitate aging facilities when they are consolidated. Large utilities or bulk water supply authorities, which consolidate small utilities, are also provided subsidies to construct and/or rehabilitate their facilities under the Program.

There is much to be gained by merging smaller utilities with a large one to raise the level of service in the region. Okinawa is making a moderate shift from coordination to consolidation with the Okinawa Prefectural Enterprise Bureau providing technical support to small utilities including those on surrounding islands.

However, the process requires time and efforts for difficult adjustments, compromises and building of consensus among stakeholders including customers of water supply. At the initial planning stage for water supply developments, especially for small utilities, consideration should be given to serve a wider area, to gain the economies of scale in terms of operation and maintenance and performance.

6. Private-Public Partnership

(1) Public Ownership Principle of Water Supply

> Water supply facilities have been owned and developed by waterworks bureau or waterworks department of municipalities in Japan.

During the early stages of water supply development, public funds were not enough to cover the construction costs of facilities. Private investments were used when the recovery of investment and satisfactory returns could be expected. However, the private companies had only distributed water and public health concerns such as water quality, were not inherent responsibilities for private companies. The Waterworks Ordinance proclaimed in 1890, gave the ownership and public health responsibility to the municipalities. Water utilities developed facilities by securing public funds with favorable conditions depending on their creditworthiness as public enterprises.

(2) Increasing Roles of Private Sector

> Utilities in Japan used to rely on their own staff and expertise to carry out all their tasks such as design and construction. Over time more and more operations are entrusted to private enterprises to gain efficiency.

The involvement of the private sector in the water supply business started with construction of facilities. Before the World War II, most constructions were implemented directly by water utilities. These were gradually commissioned to private companies.

The Federation of Water Authorities (the predecessor of JWWA), formulated the first standards for cast iron pipes in 1914. Since 1928 JWWA has conducted inspections of materials on behalf of water utilities. In 1962, MHLW issued the notice on “the Use of Materials for Waterworks” requiring the use of standardized products that passed inspections. Private companies often work with utilities to develop better materials and equipment through joint research and experiments. These developments contribute to more efficient operation and maintenance and the improvement of services.

The first consulting firm for planning and design of water supply facilities was established in 1951 and many more were established thereafter. Utilities with no in-house expertise could contract out the planning and design. This has helped to expand the coverage of water supply, especially for utilities in small- and medium sized cities. A qualification system for consulting engineers engaged in planning and design was introduced in 1957, with the passage of the Professional Engineer Act.

The legislated standards and regulations and certification systems, combined to guarantee the high quality of the private sector contributions to the development and operation of the water supply systems.

The Bureau of Waterworks, Tokyo Metropolitan Government (BWTMG), the Yokohama Waterworks Bureau (YWB) and other utilities brought the involvement of the private sector to another level by investing in companies or establishing joint ventures for some of their operations. TSS Tokyo Water Co., Ltd., established in 1987, with 51% BWTMG ownership managed the distribution networks, water purification facilities, technical development, and procurement of equipment and materials as well as related consulting and investigative tasks. Yokohama Water Co., Ltd. 100% owned by YWB was established in 2010 and is responsible for the utility's management, operation, design, construction, investigation, testing and training.

Column: History of Domestic Products for Water Supply

During the early stages of waterworks in Japan, western technologies and products were widely used. The use of domestic technologies and products began to take off after 1912. Good quality cast iron pipes were manufactured in six companies, including Kubota Iron Works Co., Ltd. After the Federation of Water Authorities set the standards for cast iron pipes in 1914, production started in Kurimoto Ltd. Soon after almost all products were supplied domestically. In 1913 water meters were manufactured for the first time domestically. Since then Osaka Machinery Works (present OKK Corporation) and Kimmon Shokai (present Azbil Kimmon Co., Ltd.) have been manufacturing water meters. The manufacturing of water spiral pumps began in 1915. Ebara Corporation, Hitachi, Ltd. and Mitsubishi Zosen (present Mitsubishi Heavy Industries, Ltd.) are producing pumps as good as any foreign products.

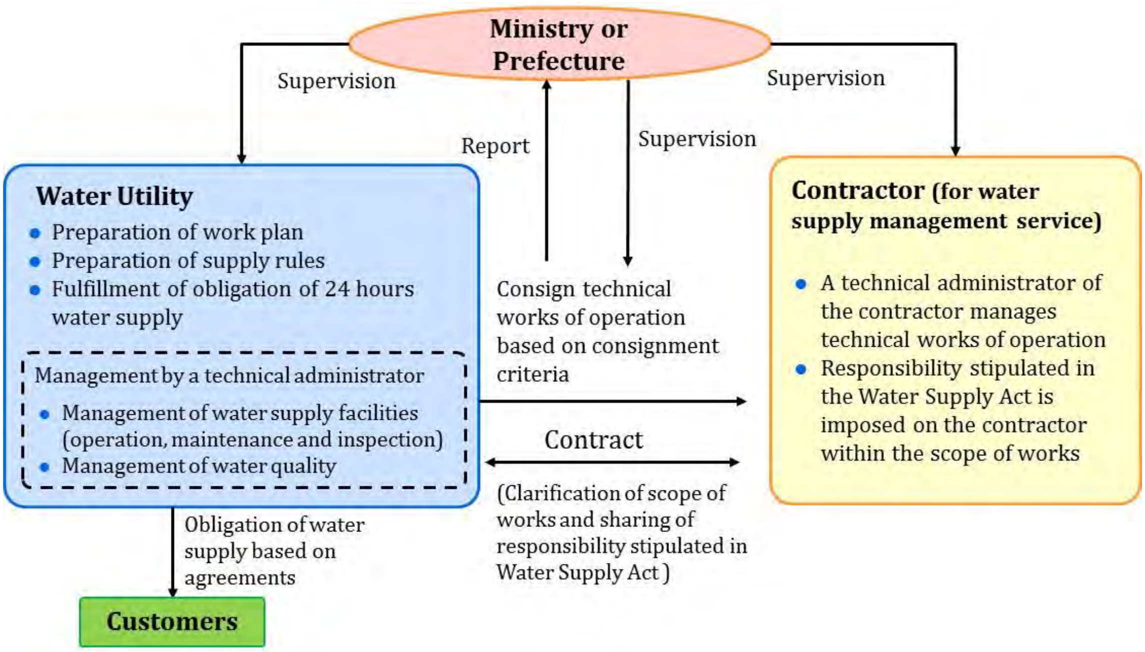
Private companies worked closely with utilities in the rapid expansion of water supply systems to meet the rising demand. In 1966, the Federation of Japan Water Industries, Inc. was formed to foster the development of the water industry including industrial water and sewage management.

(3) Third-Party Consignment

The third-party consignment system was established in 2001 to allow a third party other than the water utility and users to implement technical operations related to the management of water supply.

Since the 1960s, many water utilities have been outsourcing meter reading, tariff collection, counter services, water quality testing, maintenance of measuring devices, computers, electric and machinery equipment. These operations are entrusted under the discretion and responsibility of each utility.

The Water Supply Act revision in 2001 sets the legal framework for the commissioning of technical operations with the liability to a third party (Figure 11). In third-party consignment, regulations of the Water Supply Act are applied to the contractor within the scope of the commissioned work under the direct supervision of the national or prefectural government, which can impose penalties to the contractor.



Source: Ministry of Health, Labour and Welfare "*Third-Party Consignment for Water Supply*"
http://www.mhlw.go.jp/topics/bukyoku/kenkou/suido/kaisei/gaiyo/2-2.html

Figure 11. Framework for Third Party Consignment

(4) Designated Administrator System

The Designated Administrator System allows the comprehensive management of the administrative, financial and technical operations of public sector utilities by private companies, incorporated foundations, or NPOs.

The Designated Administrator System was introduced in 2003. Local governments can commission the operation and management of public facilities to private enterprises, foundations, or NPOs in a comprehensive manner with approval by the local assembly. Until then, only the corporation receiving capital contribution from a local public body was allowed to undertake the operation and management of public facilities.

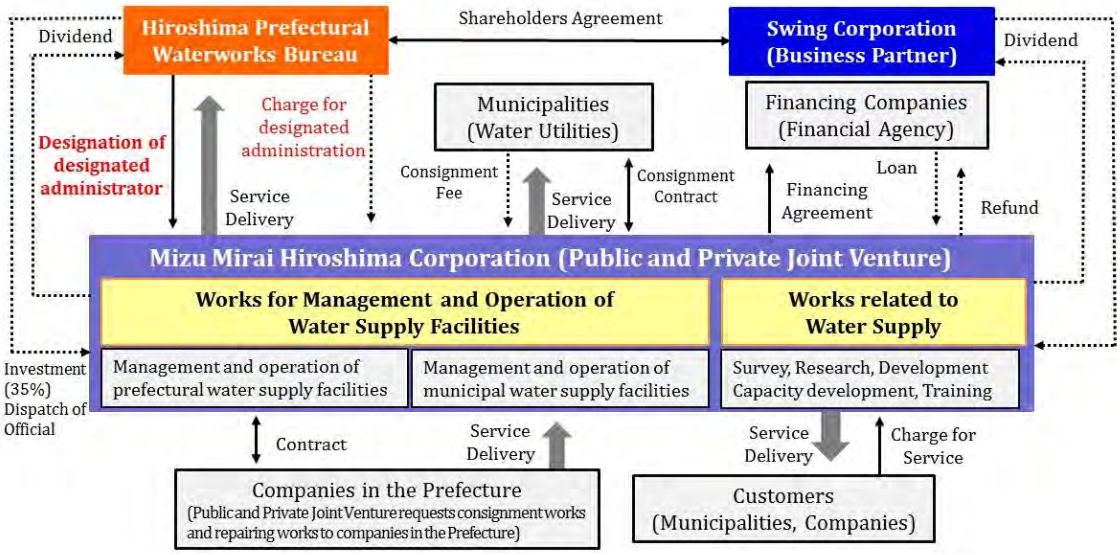
The system has two contract types: tariffs based on usage (independent accounting system) that is received directly by facilities operated and maintained by the designated administrator; and commission-based tariff in which facility management fees are paid by the local government to the designated administrator.

The procedures are more complicated than third-party consignment as the system requires amendment of ordinances and approval by the assembly of local government. Therefore it is less often used in the water supply sector. However, while the scope of third-party consignment is limited to technical operations, all operations of a utility can be commissioned under the Designated Administrator System. Hiroshima Prefectural Public Enterprise Bureau took advantage of both systems in the management of its operations.

Example: Mizu Mirai Hiroshima

Hiroshima Prefectural Government had issues such as declining water demand, rising costs for replacement of aging facilities and attrition of skilled workers. The Prefectural Government contracted operation and maintenance of the water treatment plants of its bulk water supply and industrial water supply to a private company. The scope of work was determined in detail at the bidding process. The tasks of the private company were limited under this arrangement and it was difficult for the company to propose and promote innovative ideas. Furthermore, the consolidation of water utilities to which the Prefectural Government supplies bulk water was not fully implemented due to the difference in water tariffs and slow progress of the initiative.

Therefore, to establish integrated management for regional collaboration of water utilities the public-private consortium (Mizu Mirai Hiroshima Corporation) was established between the Prefectural Government and the private company, using the third-party consignment system and the designated administrator system.



Source: Mizu Mirai Hiroshima Corporation "*Joint efforts of citizens in Mizu Mirai Hiroshima*",

Water Technology Journal, October 2014.

Figure 12. Functional scheme of Mizu Mirai Hiroshima Corporation

Mizu Mirai Hiroshima became the designated administrator of the Prefectural Government's waterworks, and makes use of the know-how and technical skills of the public and private entities. The Prefectural Government retains the authority for water tariff design, facility ownership and licenses for water use (the water rights). Mizu Mirai Hiroshima is in charge of the operation and maintenance of water supply facilities and water quality management. The Prefectural Government is responsible for the company's compliance with the operation and business standards and has developed a monitoring system with which it can provide guidance as needed.

(5) Private Finance Initiative (PFI)

PFI is a way of establishing public-private partnerships for construction, operation & maintenance and management of public facilities by funding public infrastructure projects with private capital and by utilizing technical and management capabilities of the private sector in Japan.

The Act on Promotion of Private Finance Initiative (the PFI Act) came into effect in 1999. Construction, operation & maintenance and management of public facilities can be conducted using funds, management and technical capabilities of the private sector. Unlike the third-party consignment and the designated administrator system, funds are procured by private entities, not the utilities. Utilities can limit their fiscal expenditures for the development of facilities. It is not necessary for a utility to pay construction costs during construction periods (a short-term), but the utility pays fixed contract prices on a regular basis during the PFI contract period (a long-term). BWTMG developed power-generating facilities (cogeneration system) in their water treatment plants in Asaka and Kanamachi using the PFI scheme. Many facilities have been developed by PFI.

PFI projects from design and construction to operation and maintenance have long term contracts that involve many diverse and complex elements with respect to the technical, legal and financial aspects of the business. The MHLW *"Guideline for introduction of PFI projects in waterworks*" and local government guidelines are available to assist with the smooth implementation of PFIs.

In PPP projects private sector contributions include supply of qualified engineers and management capability, and improved efficiency. It is necessary to give serious consideration to the necessity and rationale (such as proactive use of new technologies, procurement of materials at lower costs, streamlining of personnel) before commissioning to a private company. A clear plan on how to achieve the organizational objectives must be developed. The public health concern and the monopolistic nature of the water supply business also require a robust legislative framework to ensure the delivery of safe, reliable and affordable services. Identification of risks and their allocations with the private partners are also required for PPP projects.

7. Lessons Learned

The following Japanese experience could be useful for other countries.

- **(Governance of Water Utilities)** In Japan, water utilities are managed as independent public enterprises, under the supervision of the local governments. They are responsible for their own human resources management, having the ability to improve staff competence. They could provide incentives to achieve more efficient management when they promoted expansion of water supply facilities. The job and qualification of the technical administrator is clearly defined and the utilities take the responsibility for all technical matters and for managing the operations effectively. It is important to give water utilities the authority for management including technical matters.

- **(Supervision by the Local Government)** While a utility is independent in its operations, the local assembly maintains the oversight responsibility through the approval of annual budgets and business plans. An advisory committee supports the utility's management by providing opinions and recommendations.

- **(Business Plan and PDCA Cycle)** In the past business plans focused on new construction and facility expansion. Now there is more emphasis on asset management, water safety plans and earthquake-resistance plans in Japan. The business plan guides the utility's staff towards a goal to promote more effective operation. By following the PDCA cycle from a plan to check, the utility also reinforces the operational system.

- **(Training)** In addition to subsidies and the development of technical guidelines/standards, human resources development has been essential to the establishment and operation of water supply systems across the country. Research institutions and universities provide formal training to develop the required expertise. It is necessary for utilities to establish internal training systems and utilize external training programs for sustainable human resources management.

- **(Regional Collaboration)** When constructing water supply systems, sustainability of operation and management after construction needs to be considered. Small-scale utilities built during the implementation of nationwide water supply coverage generally face difficulties with cost recovery and staff shortage. Consolidation and collaboration of operations across a region are the ways to improve the economies of scale and are promoted utilizing the national subsidies.

- **(Private Sector Involvement)** During the early stages of water supply development, private investments were used in Japan. However, the private companies had only distributed water and public health concerns such as water quality, were not inherent responsibilities for those private companies. Then, the ownership and public health responsibility were given to the municipalities. Water utilities of municipalities implemented all works by themselves at first. The private sector began to be involved first in the construction of facilities, then gradually in design, meter reading and operation of water treatment plants. Currently, private consignments on management are promoted.

- **(Regulatory Framework)** As the private sector is getting more involved in the water supply business, qualification system, standards and regulations are established to maintain the quality of products and services without compromising competitiveness, fairness and transparency. A transparent system for supervision is also needed to ensure compliance to regulations on quality of service in the delivery of safe, affordable drinking water. The roles and responsibilities of public and private partners (risk allocation) must be always clearly stated in the contract.

Case Study 1. Collaboration among Water Utilities: Japan Water Works Association

Contents

1. Introduction

Japan Water Works Association (JWWA) plays an important role in the water supply industry in the country. This module explains the history of the organization, its roles, activities and financial structure. Table 1 summarizes the background on the founding of JWWA and its activities.

Table 1. History of Japan Water Works Association

Year	Activities	Social situation	Phase
1904	1st meeting of Federation of Water Authorities held under the theme of "Standardization of water testing methods" (5 attendees from 6 member cities)	Russo-Japanese War started	The early period of modern water supply development
1905	2nd meeting of Federation of Water Authorities (meetings were held annually until the 28th in 1931)	Russo-Japanese War ended	
1914	"*Specifications for Cast Iron Pipe for Water Supply*" (prior to JWWA standards) was established.		
1932	Water Works Association founded, held 1st board meeting and general assembly. The first issue of *Journal of Japan Water Works Association* was published. (132 member utilities)	Shanghai Incident	
1933	Standing committees were formed.		
1934	Inspection service for iron pipes started.		
1941		Japan entered WW II	
1945		Japan surrendered	
1946	"*Water Leakage Prevention Guidelines*" was developed.	The GHQ occupation and chlorination of drinking water started	
1947	(298 member utilities)	Enforcement of the constitution of Japan	Expansion of modern water supply system
1952		Enactment of Local Public Enterprise Act, US-Japan Status Treaty, end of the GHQ occupation	
1953	Printed and distributed "*Water Supply Facilities Maintenance Manual*" developed by the Ministry of Health and Welfare. Published "*Seismic Design and Construction of Water Supply Facilities*"	High Economic Growth	
1955	Joined International Water Supply Association (IWSA, current IWA) as a corporate member.		
1956	Water Works Association changed its name to Japan Water Works Association (605 member utilities)		
1957		Water Supply Act	
1958	Started training programs. Published "*Guidelines for Water Supply Facilities Standards*"		
1973	(1,438 member utilities)	Oil Crisis (called "Oil Shock")	Focus on the Maintenance and Management
1980	Published "*Guidance for Seismic Design and Construction*"		
1988	Cooperative research with American Water Works Association (AWWA)		
1991	Launched Training and International Department (Training Center, International Division)		
1995	Great Hanshin Earthquake emergency headquarters established.	Great Hanshin-Awaji Earthquake	
1996	Published "*Report on Response to Earthquakes and other Emergencies*"		

Year	Activities	Social situation	Phase
1997	Launched Quality Certification Center, started qualification certification service.		↓
2004	(1,902 member utilities)		
2006	Revision of "*Water Supply Facilities Maintenance Manual*" (5th edition)		
2007	Revision of "*Manuals for Earthquakes and other natural Disaster Emergencies*"	Chuetsu Offshore Earthquake	
2009	Revision of "*Seismic Design and Construction Guidelines*" (4th edition)		
2011	Established Emergency Management Headquarters for the Great East Japan Earthquake		
2012	Publication of "*Design Criteria for Water Supply Facilities*" (5th edition)	The Great East Japan Earthquake	
2013	Revision of "*Manuals of Emergency in Earthquake and Disasters*"		

* The items in red character are written in main text. The items in other colors are manuals and guidelines which are published and revised by JWWA.

2. Establishment of Japan Water Works Association

The Federation of Water Authorities, predecessor of Japan Water Works Association was established in 1904, as utilities struggled with efficient management during the early period of modern water supply development. Utilities came together for the first time to discuss water quality testing methodologies.

In Japan, the first modern water supply system was built in Yokohama in 1887, followed by ones at the Sasebo Naval Station and Hakodate City in 1889 and at the Kure Naval Station in 1890. Other developments followed in Nagasaki City (1891), Osaka City (1895), Hiroshima City (1898), Tokyo City (1898), Kobe City (1900), Okayama City (1905), and Shimonoseki City (1906).

At this very early stage, engineering expertise came from abroad. Japanese engineers with no knowledge of advanced water supply technologies learned from translated textbooks and by attending workshops organized among utilities.

Despite the challenges, a modern water supply system was established across the country. Outbreaks of cholera decreased but waterborne diseases were still prevalent, as slow sand filtration and pressurized distribution was used without chlorination at the time.

Each utility worked on its own to develop water quality standards and testing methods. There was a need to share the information among the utilities. The Federation of Water Authorities was established in 1904 as an initiative of utilities such as Tokyo City and Yokohama City, with no prompting by the national government. Its voluntary membership was open to cities with modern water supply systems. It evolved to become Japan Water Works Association that exists today.

At the first meeting of the Federation in 1904, five member cities attended and agreed on a set of water quality testing methods. At the next meeting in the following year, they discussed treatment and distribution technologies and administrative procedures. This voluntary formed federation became the foundation of JWWA, and its members were water utilities, which developed modern water supply system at the time.

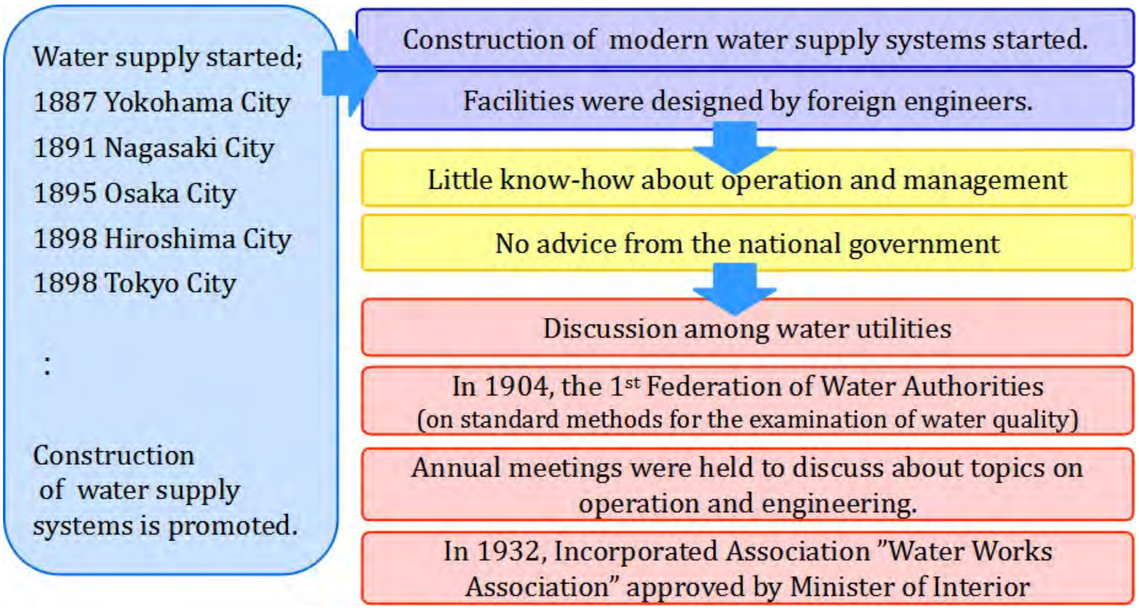


Figure 1. History of JWWA's Establishment

Source: JWWA, *One Hundred Years' History of the Federation of Water Authorities and Japan Water Works Association* (2004).

Photo 1. Attendees of the 11th Meeting of the Federation of Water Authorities (1913)

When the Waterworks Ordinance was issued in 1890, the national government was preoccupied with other regulations and not able to provide guidance on water quality testing and other water supply management technologies to the utilities. Utilities had to solve their own water treatment, distribution, operational and management issues. They set up the platform for information exchange.

At early meetings, members discussed common issues concerning water supply management. The host city covered the cost of the annual meeting. After ten years, as the number of member cities increased to 48, the cost of meeting became too high to be covered by the host city alone. The Federation started to collect membership fees and hired full-time staff (full-time directors, retired utility staff) to organize the regular meetings.

The Federation obtained the Home Minister's[1] approval in 1932 to became a public interest incorporated association, and was renamed Japan Water Works Association.

[1] The Home Ministry was changed to the Ministry of Home Affairs in 1947.

3. Activities of Japan Water Works Association

(1) History of JWWA Activities

Japan Water Works Association engages in a wide range of activities, such as developing standards for materials and equipment, water quality testing, training, and quality certification. The activities are carried out according to requests from water utilities and the government.

The Federation of Water Authorities worked on matters regarding water supply management as the needs arose and based on requests from the utilities. In 1914, it designed the *Specifications for Cast Iron Pipe for Water Supply*, which later became JWWA standards. The standardization of the specifications of water pipes was very much needed by the utilities at the time.

JWWA published the first issue of the *Journal of Japan Water Works Association* in December 1932, the year it was granted the status as a public interest incorporated association. It contained research articles, reports on experiences of different water supply systems, and abridged translations of overseas materials. While the main focus is academic research, members also use it to exchange information on problems and solutions they encounter in their operations and management activities.

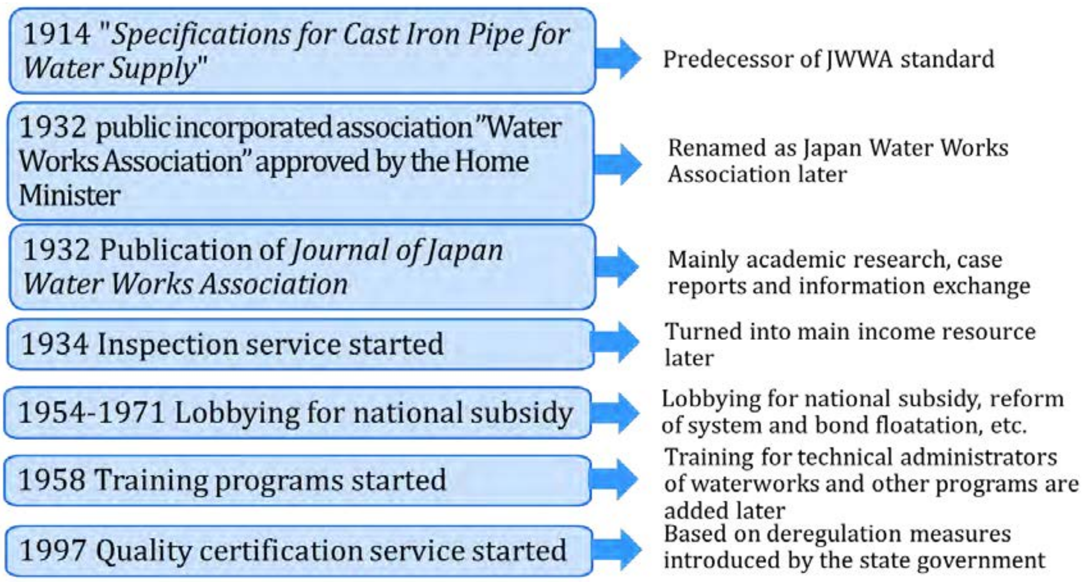


Figure 2. History of JWWA's Activities

Every utility on its own used to inspect manufacturing facilities across the country from which it sourced its products. In 1934 JWWA started to conduct product inspection on behalf of the utilities. This service represents a standardized approach to determining product quality and saves the utilities a lot of money and time. JWWA had to increase its staff dramatically to carry out this service.

After World War II, JWWA devoted substantial efforts in lobbying the government on behalf of the utilities. One such effort helped to reinstate subsidies in 1967 for development of water resources and construction of facilities, which were abolished since 1954. JWWA works with lawmakers and government agencies to support the utilities in implementing activities to meet policy objectives set out by the government.

JWWA made efforts to reinforce government administrative systems relevant to its members as well as successfully established water supply courses at universities in the countryside.

JWWA lobbied the Ministry of Home Affairs[2] to ease utilities' access to bond financing for capital requirements. They argued for extending the bond maturity period to match the useful life of water supply pipes. In 2001, a part of the Local Public Enterprise Act was revised, to declare a 40-year lifespan for domestic and industrial water service pipes of any material. Today, the bond maturity period for financing of water supply pipes is up to 40 years. JWWA submits requests from utilities to the government on matters such as interest rates and budget allocation.

The Water Supply Act (1957) requires every utility to have a qualified technical administrator. JWWA started to conduct seminars for the training of technical administrators at the request of the Ministry of Health and Welfare[3] in 1958. Since then, JWWA has been organizing a wide variety of seminars and workshops.

JWWA increased its staff for product inspections as the economy entered into the period of high growth. The Water Works Engineering General Institute was established in 1994 for research and development of technical issues on water supply. The head of the institute was from one of water utilities, and the secretariat consisted of personnel on secondment or hired directly from the utilities. In 1970, JWWA had approximately 300 personnel, and material inspectors were located all over the country.

The regulations on service connections were revised as a part of the deregulation measures introduced by the government in 1996. In response, JWWA opened the Quality Certification

[2] The Ministry of Home Affairs was merged into the Ministry of Internal Affairs and Communications with other ministries in 2001.
[3] The Ministry of Health and Welfare was merged with the Ministry of Labour to form the Ministry of Health, Labour and Welfare in 2001.

Center and started quality certification of service connection facilities in 1997.

(2) Committees

JWWA has committees and task forces dedicated to specific fields to keep abreast of global trends on technological and administrative issues.

Among the committees, the most notable ones are the Management Standing Committee, the Engineering Standing Committee, and the Water Quality Standing Committee. They conduct research on water utilities management, water supply technologies, and water quality management. Sometimes specific committees and task forces are established under this framework to coordinate research and development.

Other committees include the Publications Committee, the Inspection Committee, the International Committee, IWA (International Water Association) Japan committee, and the ISO/TC224 Japan National Committee. In addition, special task forces are formed on an ad-hoc basis.

The members of these committees are experts from water utilities of large cities. Their travel expenses for attending committee meetings are paid by their employers. Their participation is voluntary based on their interest in improving the water supply systems in Japan.

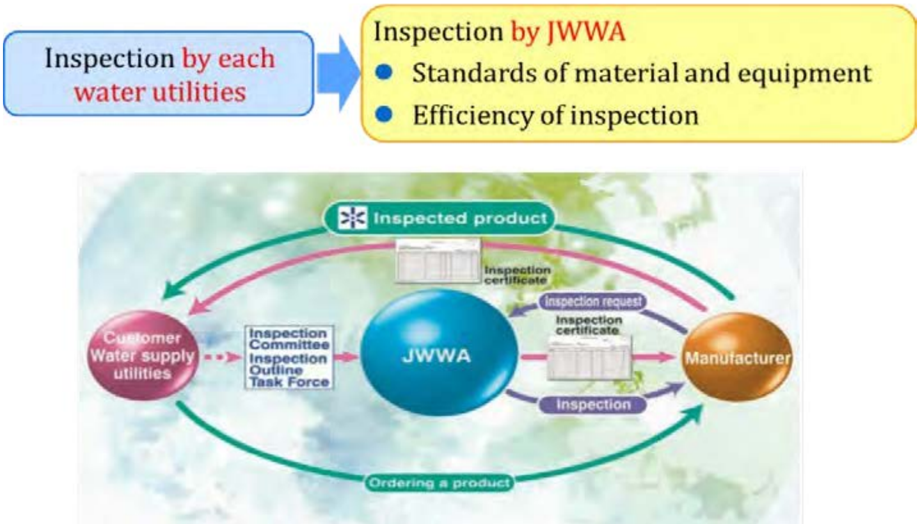
Figure 3. Activities of Committees

(3) Product Inspection Service

JWWA conducts factory inspections to confirm that products meet JIS (Japanese International Standards) and JWWA standards and order specifications. This service improves the business efficiency of member utilities and generates revenue for JWWA to support other activities.

In spite of the specifications (mostly for iron pipes) set by the Federation of Water Authorities in 1914, the quality of materials and equipment was still not always uniform. Each water utility conducted its own factory inspections of the products they ordered. Independent inspections were felt necessary also because city logos and control numbers were specific to orders from each utility. These inspections were eventually brought under one operation managed by JWWA. This resulted in huge cost savings for the utilities, and at the same time, standardized and improved the efficiency of the inspection process.

The JWWA inspection service became even more practical when the industry started to adopt a wide range of new materials. JWWA organized the standards for the new materials and set the required inspection process as the technology advances. JWWA has been conducting strict and fair inspections, to ensure that the supply of quality materials and equipment meets the requirements specified in the Water Supply Act.



Source: JWWA, *Profile Public Interest Incorporated Association Japan Water Works Association*, http://www.jwwa.or.jp/jigyou/kaigai_file/JwwaProfile2015.pdf

Figure 4. Inspection System for Water Supply Materials and Equipment

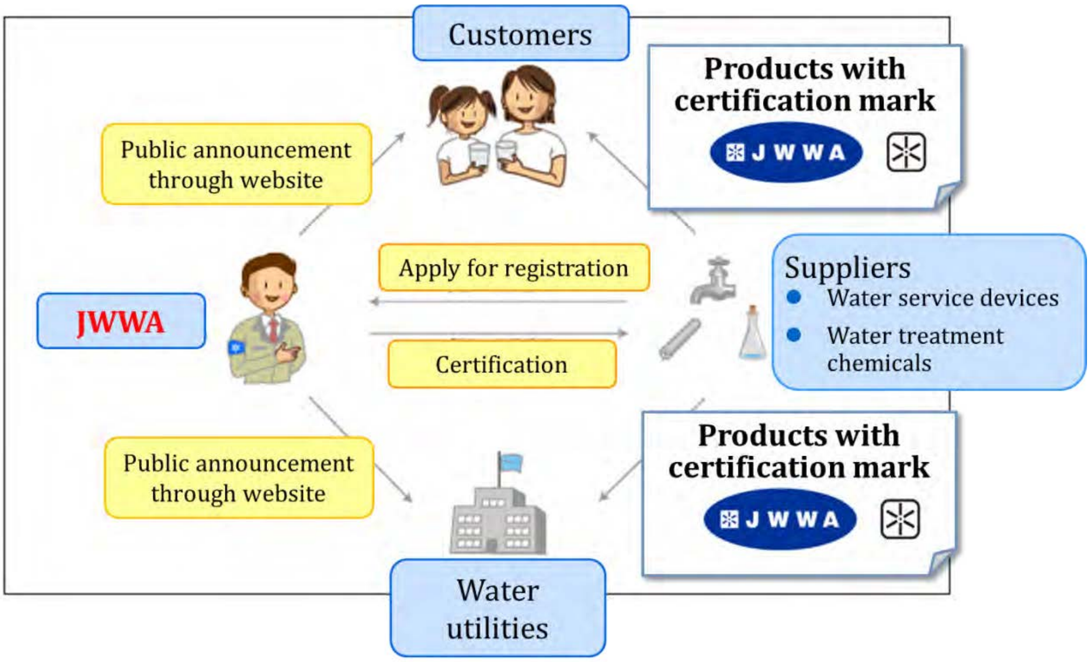
JWWA is a registered certification body recognized by the Japan Industrial Standards (JIS), based on the “Conformity assessment - Requirements for bodies certifying products, processes and services” (ISO/IEC 17065/JIS Q 17065). The inspection fee paid by the manufacturer is a source of revenue for JWWA.

(4) Quality Certification Service

JWWA conducts quality certification of water supply equipment and chemicals. JWWA evaluates the products’ compliance to standards specified in the Ordinance of Ministry of Health, Labour and Welfare. Products that meet the standards are registered before they come on the market.

The Ministry of Health, Labour and Welfare sets the standards for water supply devices and materials used in water supply operations. These standards include device/equipment structure, types of material, performance (e.g. proof pressure, elution rates), and quality (e.g. amount of impurities in chemicals such as chlorine). All materials must comply with the standards.

The JWWA Quality Certification Center was established in 1997 to check whether water supply related products meet the standards specified by the Ordinance of the Ministry of Health, Labour and Welfare. It evaluates the products based on requests from manufacturers and registers the products that meet the standards. The registered products are then checked for their quality. Approximately 2000 products per year pass the check and receive the certification stamp.



Source: JWWA, *Business outline*, http://www.jwwa.or.jp/Center/02gyom/main02_1.html

Figure 5. Quality Certification Process

(5) Training Programs

JWWA provides training programs to develop human resources in the industry.

The training programs started in 1958, and since then have expanded to cover subjects in the operational and the technological aspects of the water supply industry. Today, there are 14 programs and 48 sessions, attended by more than 3,000 fee-paying participants every year. These programs are not limited to JWWA members and are open to workers from small-scale water utilities and administrative personnel from local governments. They contribute to improved administrative and engineering capabilities of water supply businesses across the country.

Table 2 shows the training programs provided annually by JWWA. Other programs are added when there are changes in the Water Supply Act or the Drinking Water Quality Standards.

Since 1968 JWWA started to provide training programs for developing countries as requested by JICA. As of 2011, the total number of participants from 92 countries reached 548.

Table 2. Training Programs Conducted by JWWA (in 2016)

	Title	Target Participants
Administrative	Workshop for appointed waterworks managers	Waterworks managers of regular members and supporting members
	Workshop for newly appointed waterworks managers	Newly appointed waterworks managers of regular members
	Workshop for administrative tasks of waterworks managers	Administrative managers and assistant managers (or equivalent) of regular members and supporting members
	Workshop on administrative tasks in waterworks	
	1) Management section	
	Course A	Administrative personnel of regular members (under 3 years of experience) and supporting members
	Course B	Administrative personnel of regular members (over 3 years of experience) and supporting members
	2) Labor section	Mid-level administrative personnel of regular members and supporting members
	Workshop for late payment management	Personnel engaged in tasks related to bill collection, of regular and supporting members
	Seminar on consumption tax practice	Administrative personnel of regular members and supporting members
Administrative and technological	Seminar on the basics of waterworks	Newly appointed administrative and technological personnel of regular and supporting members
Technological	Workshop for water technology manager	Technical Administrator for Waterworks of regular members and supporting members
	Workshop on water leakage prevention	Technological personnel of regular members and supporting members
	Workshop for technological practice for water treatment plants and other facilities	Technological personnel of regular members
	Workshop for water engineers	
	Course A	Technological personnel of regular members (under 3 years of experience) and supporting members
	Course B	Technological personnel of regular members (over 3 years of experience) and supporting members
	Specialized workshop for water engineers	Mid-level technological personnel of regular members
	1) Design, construction, maintenance and management of water transmission and distribution facilities	
	2) Advanced water treatment	
	3) Water service devices	
	4) Water quality management	
	5) Water purification facilities	
	6) Machinery, electricity, and instrumentation facilities	
	Workshop for water engineers, by regional block	Water engineers in cities/towns/villages nationwide and supporting members
	Workshop for the qualification of Technical Administrator for Waterworks	Personnel recommended by her/his immediate manager
	Workshop of water plumbing techniques	Personnel engaged in plumbing or supervising work at water pipes laying
	Workshop for piping design	Personnel in charge of designing the layout of water pipes
	Certification and registration of Water Facilities Managing Engineer	

Source: JWWA, *Training Programs*, http://www.jwwa.or.jp/kensa_index.html

(6) International Activities

JWWA represents Japan in the International Water Association (IWA) and contributes to international cooperation by providing training, dispatching senior technical experts and supporting the establishment of waterworks association in developing countries.

JWWA joined the International Water Supply Association (IWSA) as a corporate member in 1955. JWWA's international activities became well-established when it opened its headquarter office to coincide with the 12th IWSA World Congress held in Japan in 1978. JWWA joined IWSA's Asia-Pacific Group (ASPAC) and conducted cooperative research with the American Water Works Association (AWWA). It established its International Committee in 1987 and an International Department that engages in activities of International Exchange Fund and training programs.

After the International Association on Water Quality (IAWQ) merged to form International Water Association (IWA) in 1999, JWWA participated at IWA board meetings as the Japanese representative in coordination with the Japan Society on Water Environment.

JWWA provides overseas training and sends senior technical experts to developing countries under its own projects and JICA initiatives. It also works with developing countries to establish waterworks associations.

(7) *Design Criteria for Water Supply Facilities*

JWWA developed the *Design Criteria for Water Supply Facilities*. The document is revised every 10 years and contributes to the standardization of water supply facility design.

Although water supply is indispensable for healthy living, there were no criteria for the design and construction of facilities to ensure reliable supply of safe water until 1955. National standards with a universal set of criteria and minimum requirements were thought to be useful for designing of water supply systems.

JWWA published the *Water Supply Facilities Standards* in October 1955. Adding detailed instructions and illustrations, the *Guidelines for Water Supply Facilities Standards* was published in the first edition of *Design Criteria for Water Supply Facilities* in November 1958. An expert working group revises the document every 10 years. The *Design Criteria* is an important reference and guide for small- and medium-sized cities where there are few specialized engineers. It contributes to the standardization of water supply facilities nationwide.

In revising the *Design Criteria*, JWWA not only accommodates the requirements of the Ordinance of the Ministry of Health, Labour and Welfare, but also takes into account latest developments including changes in the social environment, water quality issues, and technical needs such as the seismic retrofitting or rebuilding of facilities. JWWA emphasizes flexible requirements to accommodate characteristics in terrain and population density, needs of residents, or capacity for incorporating new technologies in the future. These principles are reflected in the 2012 version that contains the latest technical information.

The *Design Criteria* are based on the know-how of experienced utilities, and have contributed considerably to the development of small facilities in rural areas that do not have adequate knowledge in water supply management. The Design Criteria represent the cumulative knowledge and experience in constructing high standard facilities relevant to utilities of any size.

Column: Revisions of the *Design Criteria for Water Supply Facilities*

Design Criteria for Water Supply Facilities has been revised five times since 1958:

Guidelines for Water Supply Facilities Standards 1958
Guidelines for Water Supply Facilities Standards 1966
Design Criteria and Guidelines for Water Supply Facilities 1977
Design Criteria and Guidelines for Water Supply Facilities 1990
Design Criteria for Water Supply Facilities 2000
Design Criteria for Water Supply Facilities 2012

The Ministry of Health, Labour and Welfare Ordinance issued (in April 2000) for the law on Preparations of Related Laws for Promoting Decentralization, specifies performance based technological requirements for water supply facilities. The year 2000 version of the *Design Criteria* was prepared to give utilities more concrete criteria for water supply facilities design.

(8) *Water Supply Facilities Maintenance Manual*

The *Water Supply Facilities Maintenance Manual* published by JWWA provides updated information on maintenance and management to its members.

The Water Supply Act specifies that the water utilities should continuously and reliably supply clean, safe, abundant and affordable water to consumers. The water supply facilities must be kept in the best condition through appropriate daily maintenance to fulfil this mandate. JWWA publishes the *Water Supply Facilities Maintenance Manual* to provide the basic standard requirements on maintenance and management.

In the 1950s there were several outbreaks of waterborne infectious diseases of the digestive system due to inadequate maintenance and management of the water supply system. The Ministry of Health and Welfare prepared the *Water Supply Facilities Maintenance Manual*, as a measure to prevent future accidents. JWWA printed and distributed the first edition in 1953 and was put in charge of subsequent revisions and publications. The manual was first revised in 1959 and the 5th edition was published in 2006. The latest issue covers topics on third-party commission system allowed under the amendment of the Water Supply Act, revision of Water Quality Standards, enhancement of water quality control, and advanced water treatment technologies such as membrane filtration. The 6th edition is under preparation as of 2016.

(9) *Seismic Design and Construction Guidelines*

JWWA developed the *Seismic Design and Construction Guidelines for Water Supply Facilities* and contributed to the improvement in earthquake-resistant of water supply facilities. The contents are revised regularly to reflect lessons learned after major earthquake occurrences.

Japan is one of the most earthquake-prone countries in the world. Before 1953, no information was available in Japan on earthquake-resistant construction for water supply facilities. On the request from water utilities, JWWA published the *Seismic Design and Construction of Water Supply Facilities* in 1953, and contributed to improving the seismic capacity of these facilities. The guidelines have been revised four times, incorporating the experiences from each earthquake incident. Notably, the *Seismic Design and Construction Guidelines for Water Supply Facilities 1997*, included the analysis of the observations of the 1995 Great Hanshin-Awaji Earthquake, and greatly contributed to the country-wide development of earthquake-resistant water supply systems.

Its latest edition was published in 2009, and the next revision is under preparation which would incorporate the knowledge obtained from the 2011 Great East Japan Earthquake and the 2016 Kumamoto Earthquake.

(10) Disaster Response

When a catastrophic disaster occurs, JWWA liaises with affected utilities to assist with their recovery through systematic coordination of its members.

Since the Great Hanshin-Awaji Earthquake, JWWA has been enhancing its disaster response coordination. In 1996, it published the *Report on Response to Earthquakes and Other Emergencies* based on the experience of emergency support activities. The report sets the rules for support activities among water utilities across the country.

These rules were developed into the *Manual for Earthquakes and Disasters Emergencies 2008*. The manual drew on experiences from the Chuetsu, Noto and Chuetsu offshore earthquakes and called for the establishment of a system in which the Ministry of Health, Labour and Welfare, prefectural and municipal governments, and JWWA would coordinate activities for swift, effective and well-organized response. JWWA uses the knowledge obtained from the Great East Japan Earthquake of March 2011, for the revision of the manual and training programs on responses to natural disasters affecting a wide region.

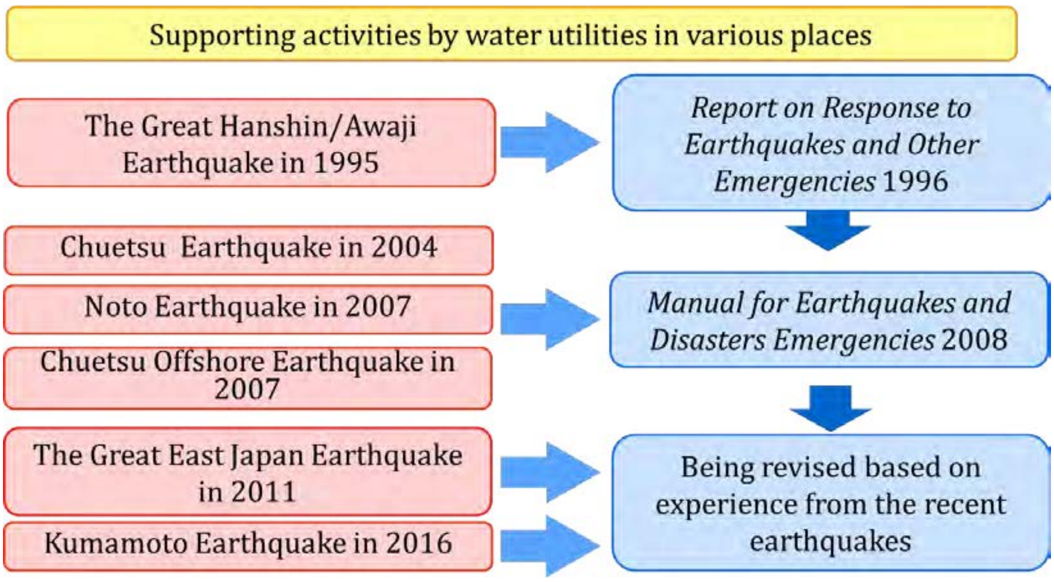


Figure 6. History of JWWA's Disaster Response Effort

"Suido Ikka" (Water Works Family)

The term "Suido Ikka" (Water Works Family) is used when talking about how water utilities nationwide help facilities and regions affected by a natural disaster by dispatching personnel and/or water trucks to provide emergency water supply. In the Nihon Suido Shimbun, the headline of the article on the April 2016 Kumamoto earthquakes, read: "Hurry, 'Suido Ikka,' to the Disaster-Hit Area! – Utilities Nationwide Formed an Aid Team."

This is an affectionate reference to the water supply services, noting the importance of the service to people's everyday lives, the shared goal to provide stable reliable supply of safe water and the extraordinary mutual support among the utilities. This was exemplified during the period of rapid economic growth, when the personnel from different water utilities worked as one team, for one goal. JWWA is the embodiment of the idea of "Suido Ikka."

Member utilities are organized systematically under the JWWA umbrella, with utilities in each prefecture belonging to prefectural branches, which are in turn grouped into 7 regions, except for Hokkaido which operates as a regional branch[4].

When a catastrophic disaster occurs, JWWA headquarters gathers information on the situation and the needs for support through its regional branches, which in turn obtain the information from the prefectural branches. At the prefectural level, major local branches stay in contact using satellite telephones and pass relevant information to the regional level. This efficient flow of information contributes to the ability to carry out broad-based support activities effectively.

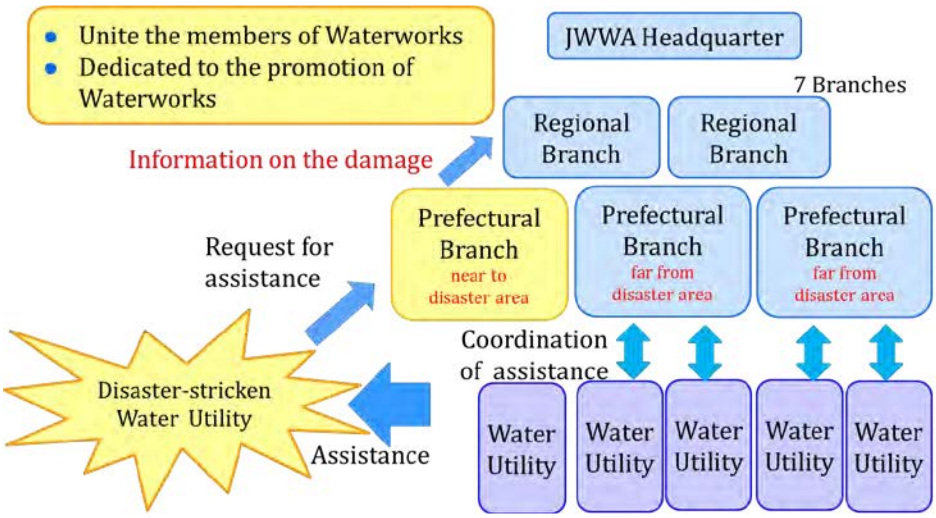


Figure 7. Assistance in the Water Works Family Scheme

4 Prefecture is the first level of administrative division of Japan. There are 47 prefectures in Japan and some prefectures form one region. The largest prefecture, Hokkaido forms Hokkaido region by itself.

Emergency Response for the Great East Japan Earthquake

JWWA set up the "Great East Japan Earthquake Relief Headquarters" immediately after the earthquake hit at 2:46 PM on Friday March 11, 2011. JWWA worked all day and all night, gathering information from the affected utilities, arranging water trucks to be dispatched, and coordinating relief activities with the Ministry of Health, Labour and Welfare and other water-related organizations. As the lead agency of the region, Sendai City Waterworks, was damaged by the disaster, JWWA stepped in as Relief Headquarters.

An extremely wide area was affected, 2.56 million homes had no water supply. A large number of water trucks were needed. 41,000 personnel and 13,500 vehicles from approximately 550 utilities (official members of JWWA) were sent over 5 months (more than 150 days) to provide emergency water supply.

In addition, approximately 3,500 personnel from utilities nationwide were dispatched to provide recovery assistance, such as repairing water leaks, in coordination with other organizations.

After the initial phase, JWWA continued to support the affected area by transitioning its activity from “response” to “reconstruction.”

From September 2011 to February 2012, JWWA technical officers visited and surveyed the needs of the utilities in the 3 most affected prefectures. Officers from other utilities were sent to the affected facilities that requested assistance under the coordination of "The Liaison Council for Supporting the Restoration of Water Supply Affected by the Great East Japan Earthquake” led by the Ministry of Health, Labour and Welfare.

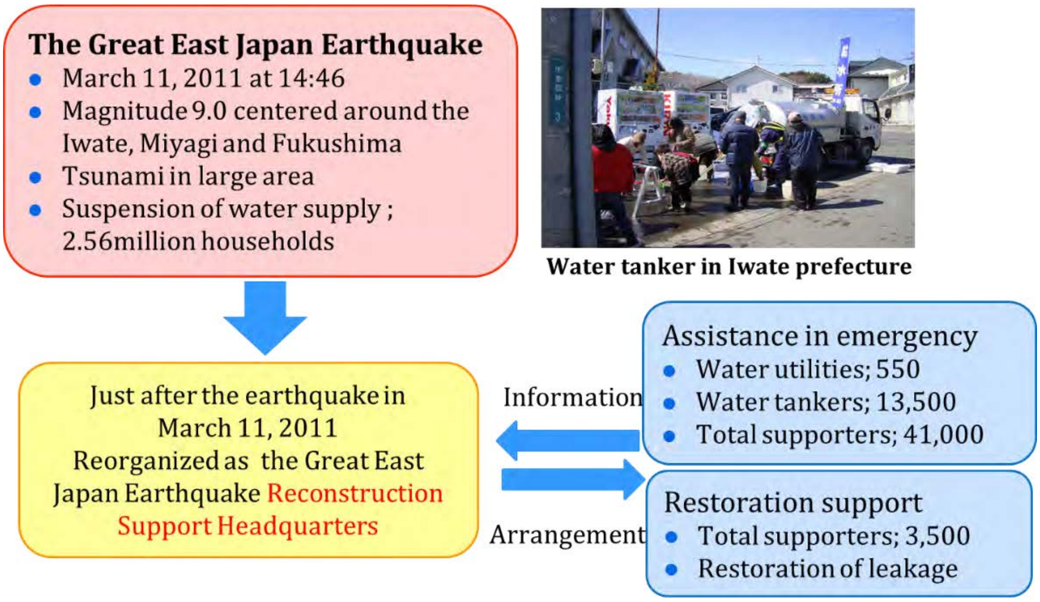


Figure 8. JWWA's Activities after the Great East Japan Earthquake

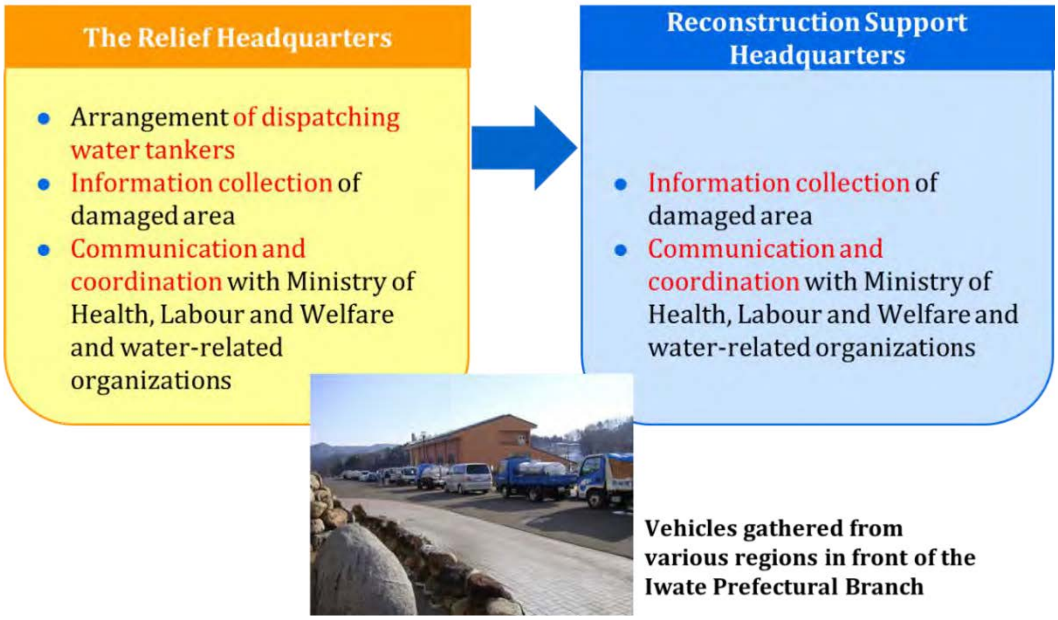


Figure 9. Damage and Recovery Efforts after the Great East Japan Earthquake

4. Financial Structure of Japan Water Works Association

(1) Membership Fees

JWWA membership fees partially finance the organization's activities. Fees vary according to the size of the member utility.

JWWA has honorary, regular (water utilities), special (academics specialized in water supply), and supporting (private companies related to water supply) members.

The annual membership fee for special members is at the fixed rate of 14,000 JPY; supporting members' fee ranges from 200,000 JPY to 1,000,000 JPY. As of FY 2016, there are 407 special and 543 supporting members. Total revenue from membership fees is about 200,000,000 JPY per year.

The annual membership fee for a regular member consists of the base amount of 43,000 JPY and a contribution amount based on the size of the utility. For example, for a utility serving a population of 13,000, with annual revenue water of 1 million m^3, the membership fee would be 73,000 JPY. For another utility serving a population of 300,000 with annual revenue water of 30 million m^3, the membership fee would be 420,000 JPY. The annual fee for the largest utility in Japan, the Bureau of Waterworks, Tokyo Metropolitan Government is approximately 5.5 million JPY. The membership fee reflects the considerable differences in local conditions, population densities and other characteristics, and the size of the operation.

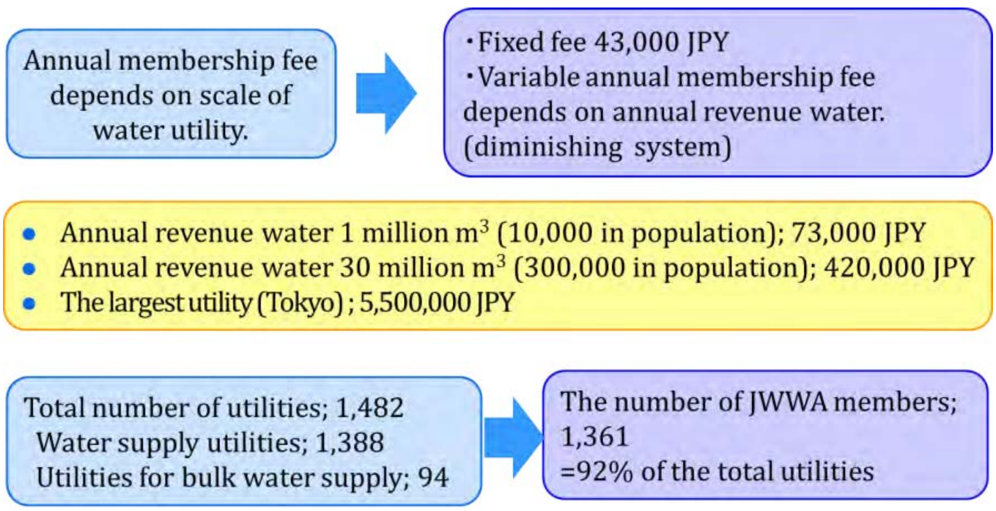


Figure 10. JWWA Membership Fees

As of 2016, there are 1,361 regular members, representing 92% of 1,388 water supply utilities and 94 bulk water supply utilities.

(2) Changes in Revenue Sources

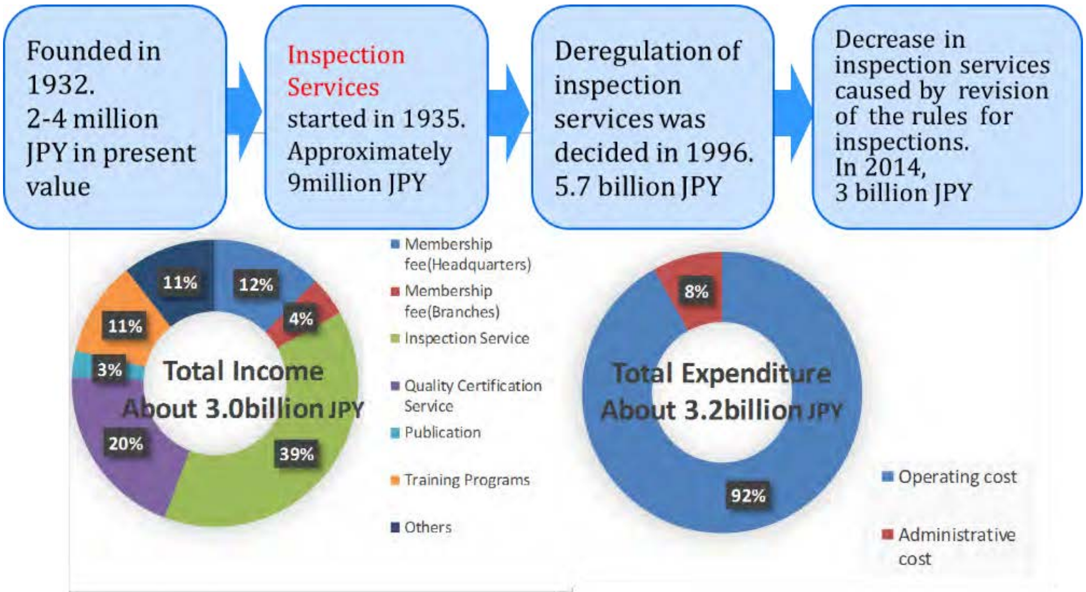
The income of JWWA was approximately three billion JPY in FY 2015. Membership fees made up 16% of the income, while 39% was from inspection services and 20% from certification services.

When JWWA was founded in 1932, the total revenue was approximately 43,488 JPY, equivalent to a present value of 2-4 million JPY. As a private organization, it receives no financial support from the government. The revenue tripled when JWWA started the inspection services in 1935 and increased further during the period of water supply system expansion after WWII. The membership fees and inspection charges were revised several times to keep pace with the rise of labor and material costs.

In 1996, total revenue peaked at approximately 5.7 billion JPY, with 4.2 billion from inspection services, 10 times as much as membership fees. In 1997, the regulations on water supply devices were revised as a part of the deregulation policies of the government. The resulting changes include the following: the existing model-approval and inspection systems for water supply devices were abolished; the standards for structures and materials were clarified; and the standards for performance were established. The Ordinance of the Ministry of Health, Labour and Welfare regarding the standards for structures of water supply devices was issued. At the same time, economic and social stagnation continued and public works spending was drastically reduced. As the income from inspection services dropped significantly, by 2015 JWWA's total revenue declined to approximately 3.0 billion JPY, with 2.35 billion from inspection services, 508 million from membership fees, and other revenues.

Administrative overhead accounted for about 250 million JPY and the total expenditure of 3 billion JPY. The organization runs a deficit despite cost cutting adjustments.

In spite of the overall deficit, revenue generating services such as training programs and inspection services are covering the costs of a variety of public-interest activities.



Source: JWWA, http://www.jwwa.or.jp/about/disclosure_pdf/h27_yosan.pdf

Figure 11. JWWA Breakdown of Revenue and Expenditures (2014 financial statement)

5. Other Organizations in the Water Supply Sector

In Japan, there are other organizations which are engaged in dissemination of technical information, research, and training related to water supply. There are also professional newspapers dedicated to the sector.

In Japan, other organizations in the water industry include the Japan Small Scale Water Works Association, the Japan Water Research Center (public interest incorporated foundation), and the Federation of Japan Water Industries, Inc.

The Japan Small Scale Water Works Association is made up of municipal governments with small-scale public water supply systems. Establishing water supply system for small towns and villages can be a challenge for local governments. The Association helps these towns and villages join effort in lobbying for government subsidies. The association prepared the *Practical Handbook for Water Supply*, an annual publication on application for subsidies, and is used by many utilities, not just small-scale ones.

The Japan Water Research Center is an incorporated foundation formed by the merger of the Pipeline Research Center (founded in 1988) and the Water Purification Process Association (founded in 1991). It engages in information gathering, surveys, research and development, and promotional activities. The Center works with water utilities, private corporations, administrative agencies, non-profit organizations, and academic researchers to solve common problems and share information on the issues related to water supply technologies.

The Federation of Japan Water Industries, Inc. consists of major corporations and organizations in the water supply industry in Japan. This organization indirectly supports the activities of corporations that provide technologies, products, and know-how to the drinking water, sewerage and industrial water supply. It promotes technological cooperation among private entities, such as bringing different disciplines together to solve issues in the water industry, coordinating cooperation among organizations; collecting information on technology development and management, and providing information on products and technologies to customers.

Other organizations related to water supply include: the Japan Water Plumbing Engineering Promotion Foundation, which aims to improve the technologies of water plumbing engineering; and the Japan Finance Organization for Municipalities, which is involved in the issue of local bonds for capital financing of water facilities construction.

Apart from professional and special interest organizations, there are two weekly newspapers dedicated to information on water supply. The *Nippon Suido Shimbun* (Japan Water Supply News) and *Suido Sangyo Shinbun* (Water Supply Industry News) report on matters such as latest regulatory changes and introduction of new technologies in the water industry.

6. Lessons Learned

The following Japanese experience could be useful for other countries.

- **(Cooperation among Water Utilities)** JWWA was founded through discussions among water utilities on water quality, and operation and management of water supply. Cooperation among members plays a critical role in sharing knowledge and experience and mutual support in case of disaster response.

- **(Communication between Government and Utilities)** JWWA plays an important role in facilitating communication between the national government and water utilities, e.g. it disseminates and draws its members' attention to national policies and lobbies for government support on behalf of the utilities.

- **(International Activities)** JWWA participates at IWA board meetings in coordination with the Japan Society on Water Environment. JWWA contributes to overseas training, dispatches experts and supports establishment of waterworks associations in developing countries.

- **(Materials and Equipment Quality)** JWWA develops standards for materials and equipment, and guarantees their high quality level with its inspection and quality certification services.

- **(Publication of Guidelines)** JWWA publishes the "*Design Criteria for Water Supply Facilities*," "*Water Supply Facilities Maintenance Manual*," and "*Seismic Design and Construction Guidelines for Water Supply Facilities*" to provide the latest information to water utilities. These publications have contributed to stable operation of water supply nationwide even in rural areas.

- **(Disaster Response)** Natural disasters occur frequently in Japan. JWWA organizes disaster response activities and makes valuable and significant contribution to effective emergency response and restoration of damaged utilities.

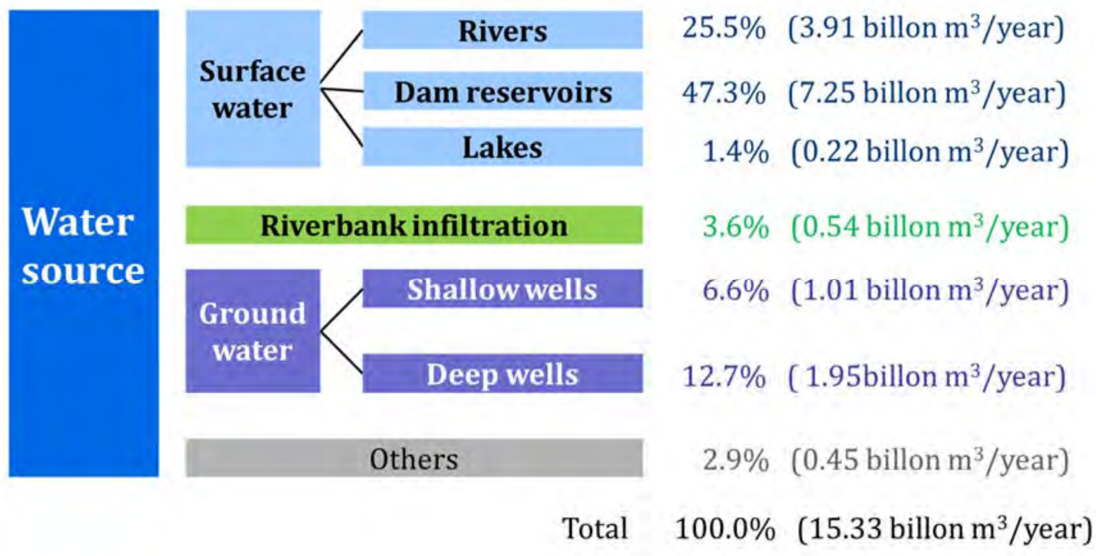
- **(Financial Structure)** JWWA's revenue comes from membership fees and revenue generating services such as inspection and certification, which contribute substantially to its sound financial foundation. The income generating services contribute to the improvement of the water supply industry. However, the income from these services is declining because of recent regulatory changes. The revenue sources of the association need to be diversified in order to mitigate the risk caused by changes of regulations and business environment.

Case Study 2. Water Resources Development:
Yodo River System, Okinawa Prefecture and Fukuoka City

Contents

1. Introduction

Water sources for drinking water supply include rivers, dam reservoirs, lakes and groundwater. In Japan, 70% of the water supply is drawn from surface water (e.g. rivers, reservoirs and lakes) and the rest from riverbank infiltration and groundwater.



Source: Japan Water Works Association, *Statistics on Water Supply in Japan 2014*

Figure 1. Water Sources in Japan

This module summarizes the background of water resources development in Japan and illustrates this with some practical examples. It covers intends to answer the question which is frequently asked by the participants of water supply training courses; how Japan secured water resources in response to rapid increase in demand.

2. Background of Water Resources Development

Surface water is a suitable source for large scale utilities that require a large amount of water. Drinking water supply competes with other uses such as irrigation and hydro-electric power generation. Therefore, surface water withdrawal should be coordinated among various stakeholders.

(1) Water Rights

In Japan, the necessity of fair water resource allocation was recognized a long time ago as it went through historical conflicts concerning irrigation water use. Laws and regulations were developed to ensure fair allocation of water rights.

Growing rice in paddy fields requires significant amounts of water and is a well-known fact for more than 2,000 years in Japan. Even today, after industrialization, agriculture accounts for approximately 70% of water use. Allocation of water has been an important issue since the old times when conflicts concerning water use were not uncommon.

This circular water distribution facility was built in 1938 for dividing water accurately. The water is siphoned into the central cylinder and flows to the outer cylinder. The 180 orifices on the outer cylinder distribute the water correctly. The volume of water that is distributed is decided based on the area served. The service area includes rice paddies (877 ha) in 3 municipalities.

Source: Akita prefectural government, *Nanataki Waterway and Mt. Nanataki*, http://www.pref.akita.jp/fpd/tuchi/nanataki.htm

Photo 1. Circular Water Distribution Facility at Rokugou Town, Akita Prefecture

After the 19th century, settling conflicts concerning water resources became very important, because the policy of national prosperity and the drive for modernization was based on reclaiming farm land and increasing food production. The concept of water rights was included in the promulgation of the River Act in 1896 and the system of water rights was almost fully developed by 1961. The granting of water rights prevents unauthorized use because withdrawal of river water is not allowed without a license from the river administrator. However, water rights granted prior to the establishment of the River Act are exempt and deemed as customary water rights that would not compromise usage of water in a practical way.

(2) Comprehensive River Development

Japan has promoted comprehensive river development to deal with flood control and water utilization since 1930s.

The Comprehensive River Development approach had its origin in the "River Water Control Plan" proposed by the Home Ministry[1] in the 1930s which aimed to integrate the implementation the efforts for flood control, irrigation and power generation. Comprehensive management mitigates the risk caused by rainfall variation, stock and utilize the water effectively by building dams and river facilities.

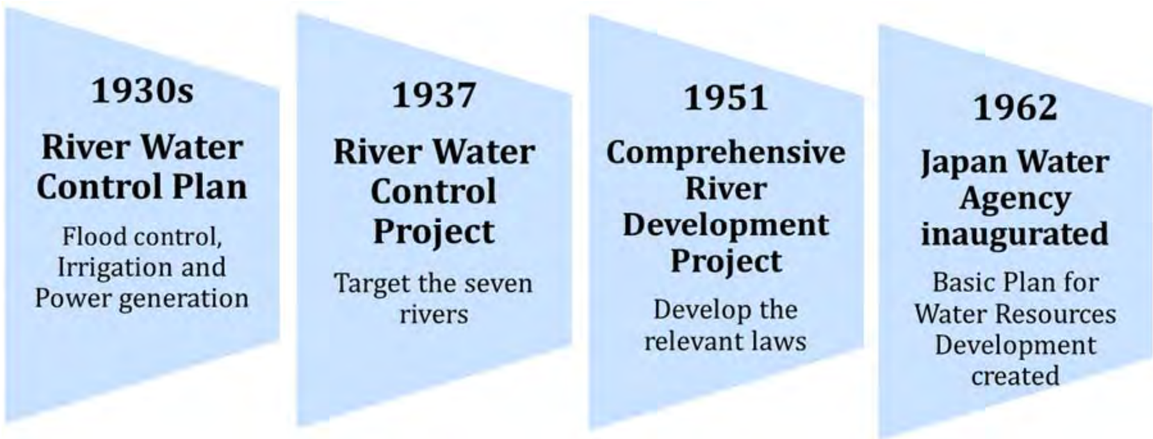


Figure 2. History of Comprehensive River Development

[1] The Home Ministry was changed into the Ministry of Home Affairs in 1947, then it was merged into the Ministry of Internal Affairs and Communications in 2001.

The plan for comprehensive river development targeted 7 rivers of the principal rivers identified in the 1937 survey, following the example of the work of the Tennessee Valley Authority (TVA) in the USA. The Comprehensive River Development Project was implemented in 1951, replacing previous development plans. River development related laws were established soon after.

Under the Act on Advancement of Water Resources Development promulgated in 1961, the Minister of Land, Infrastructure, Transport and Tourism designates water systems where water resources management in a wide area is necessary to meet the needs of industrial development and urban population growth. The Minister determines "the Basic Plan for Water Resources Development" (as known as the "Full Plan") targeting designated water systems.

(3) High Economic Growth and Drought in Urban Areas

During the period of high economic growth between the 1950s and 1970s, Japan experienced frequent droughts in urban areas. The national government adopted several approaches: water resources development by construction of multipurpose dams, promotion of efficient water use, adjusting water rights and coordination among stakeholders from water source areas and downstream to deal with water shortages.

High economic growth in the 1950s to 1970s brought rapid increase in population and water demand in major cities. Drought conditions exacerbated the pressure on water resources.

There is a limit to how much water can be extracted from the rivers. Dam construction can increase the capacity of water resources but is expensive. Therefore, to utilize this high cost investment efficiently the dam must serve multiple purposes, such as flood control, irrigation and hydropower generation and river maintenance.

The government also has to distribute the limited resource effectively. During drought events, irrigation water may have to be shifted to urban use.

In addition to resource distribution issues, there is also the challenge of balancing the burden to be borne by water source areas and the benefits to users. Lengthy negotiations are often necessary to reach agreement among stakeholders. Sometimes development projects are suspended pending the intervention by the Water Resources Development Public Corporation (established in 1962). In some cases, ways have been found for downstream users to contribute to development activities in the water source areas.

(4) Act on Advancement of Water Resources Development and Water Resources Development Public Corporation

In 1961, the Act on Advancement of Water Resources Development was established for comprehensive development of water resources and rationalization of water usage. The Act defines the principle of multipurpose dam development. The Water Resources Development Public Corporation was established as to promote water resources development.

There must be adequate water supply to meet the growing demand of industry and urban population. In 1961, the Act on Advancement of Water Resources Development was established for comprehensive development of water resources and rationalization of water usage. The Act designates water systems for water resources development and specifies the requirement of basic plans. The Water Resources Development Council was established and project leaders were appointed. In 1962, the Water Resources Development Public Corporation (now Japan Water Agency) was established to conduct projects for the development and use of water resources.

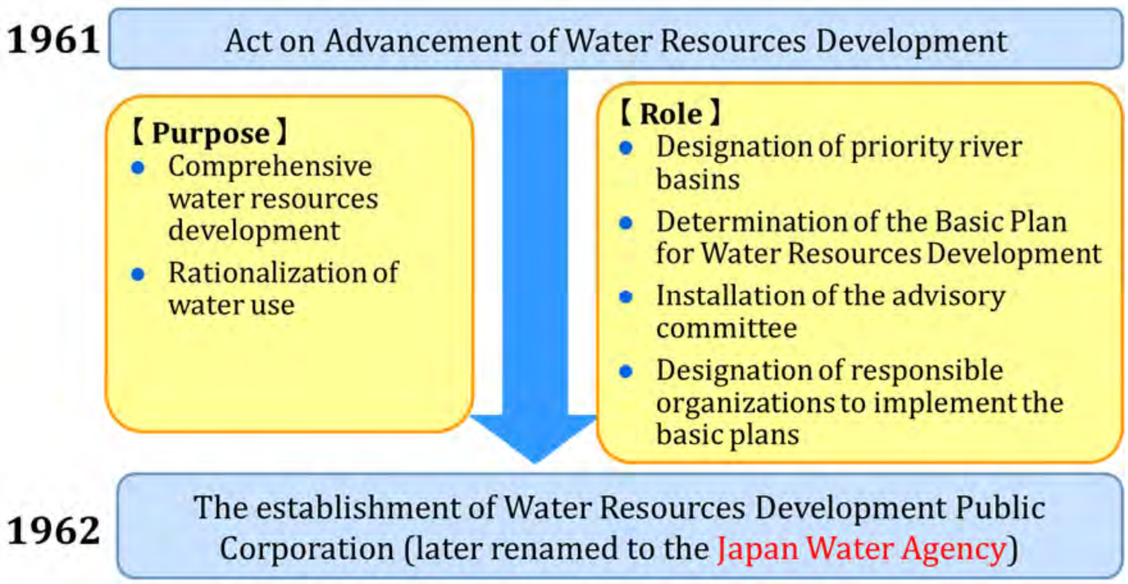


Figure 3. Act on Advancement of Water Resources Development and Water Resources Development Public Corporation

The Water Resources Development Public Corporation constructs and manages dams, barrages and canals. It is also responsible for the development of lakes and ponds as specified under the "Basic Plan for Water Resources Development" for Tone River, Arakawa River, Yodo River, Chikugo River, Kiso River, and Yoshino River water systems.

The basic plans for dam developments must integrate flood control with effective water utilization. One of the important characteristics of Japanese dam development is balancing the capacity required to handle a large 100-year flood event (or in some cases 50 to 200 year flood event depending on the importance of the river) and the capacity required to provide stable water supply during 10-year drought event.

(5) Bulk Water Supply

Utilities are run individually by municipalities, making it challenging to pursue regional collaboration to gain efficiency by broadening the coverage with integrated operations. Bulk Water Supply was developed to solve the problems of water resources development and to provide stable water supply for municipalities.

Bulk Water Supply is more than a means to secure water resources for the utilities. Several utilities, i.e. a broad area, can be served by the bulk supply thus improving the management efficiency and levelling out the capacity of the utilities. Integrating the operations of utilities for better efficiency is not easy because of their many differences in capacity, operation and management under local governments. Bulk Water Supply dealt only with securing water resources, while leaving the time consuming integration process aside.

Bulk Water Supply involves large scale water resources development and thus has the advantage that the huge development cost is shared among a number of users, who can count on a stable water supply. There are also savings in maintenance costs. However, this arrangement leaves the distribution of water to customers as a diminished operation that can run into financial difficulties because of fixed amount of water supply for long term and inefficient use of facilities, reduced operational scale, budget and personnel, while not benefitting from the cost savings from the Bulk Water Supply. Based on the experience, it is encouraged to collaborate water supply and distribution in developing water supply system in pursuing regional integration.

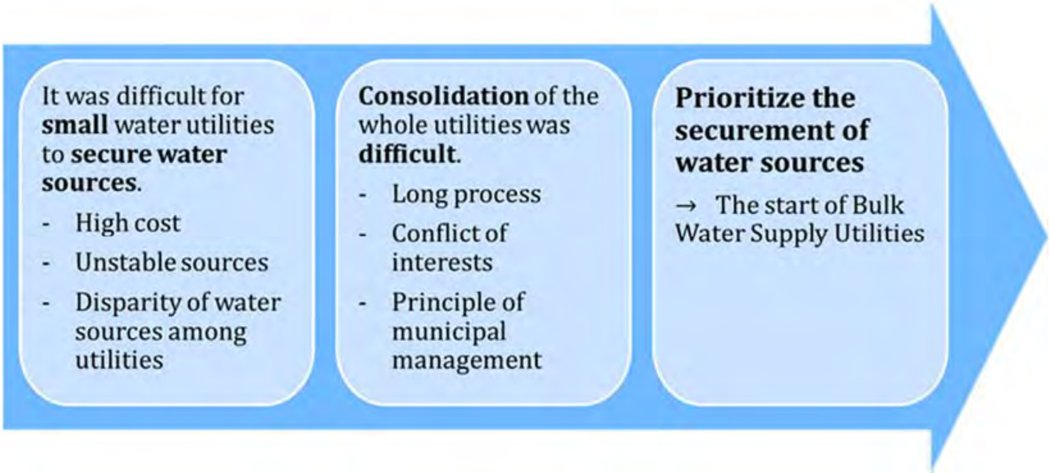


Figure 4. Background of the Bulk Water Supply in Japan

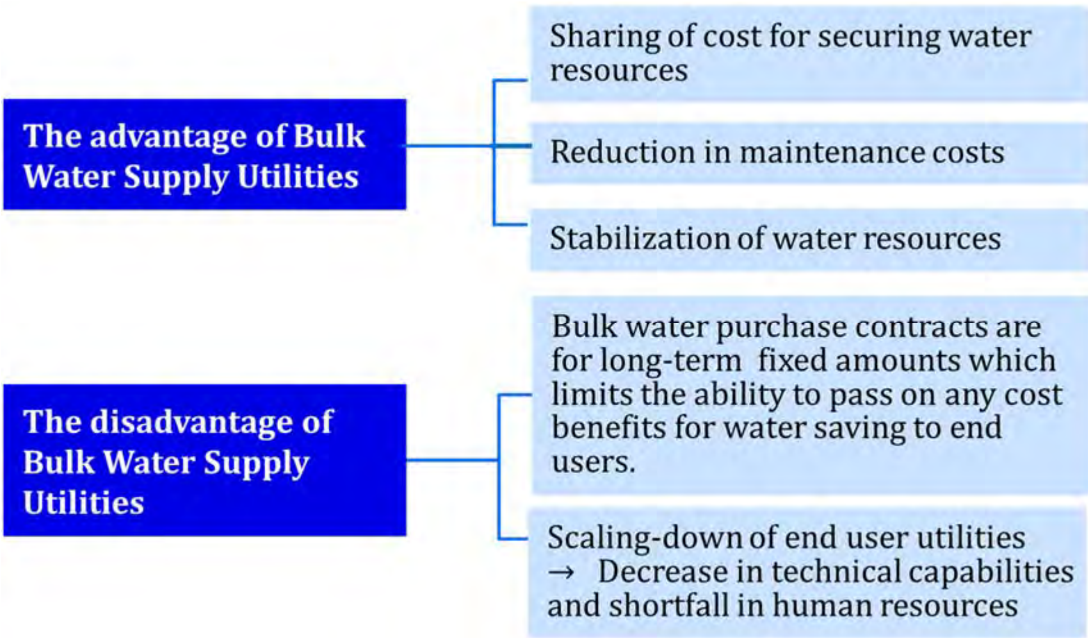


Figure 5. Concepts of Water Source Development

(6) “New” Water Sources

Japan promotes effective water use such as leakage reduction and water conservation. Unconventional water resources such as recycled water and seawater desalination are also introduced in the areas where drought occurs frequently.

In Japan, excessive groundwater withdrawal is restricted. Water resources development has been mainly focused on surface water. Other efforts to secure more water resources are turning to efficient water use, including recycling of industrial water, leakage reduction, and changing water use habits to conserve the resource. In areas where drought occurs frequently, water utilities engage in rainwater utilization, recycling and seawater desalination.

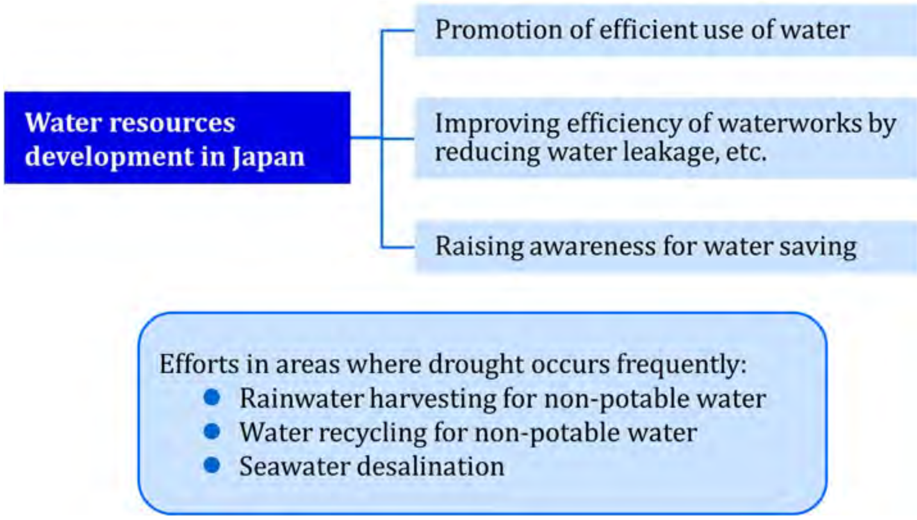


Figure 6. Concepts of "New" Water Sources

Source: Sumida City, *What is rain water use*?
https://www.city.sumida.lg.jp/kurashi/kankyou_hozen/amamizu/whats_amamizu/index.html

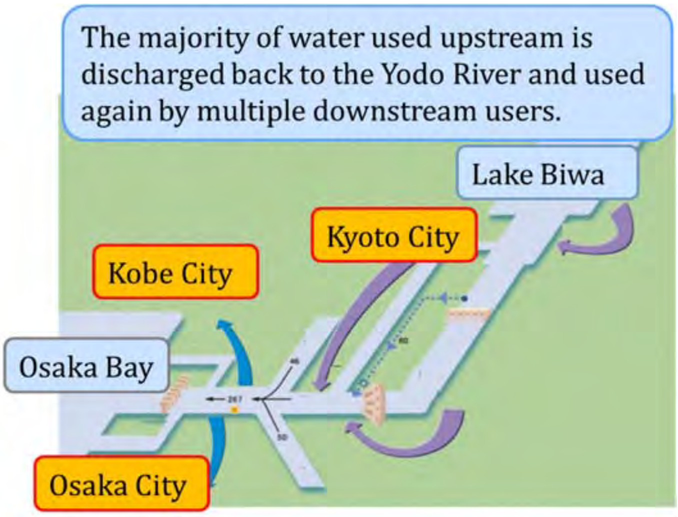
Figure 7. Rainwater Utilization in Sumida City

3. Case 1: Yodo River System Water Resources Development

(1) Background on Development of Yodo River System

Osaka City, Kyoto City and many other cities are located in the Yodo River watershed. The Yodo River water system serves different water usages in highly populated areas. Several pioneering projects for water resources development were conducted in the area because the origin of Yodo River is Lake Biwa, the biggest lake in Japan which has important environmental conservation issues.

Yodo River is the main water source for Osaka Prefecture. The river system starts at Lake Biwa, the largest freshwater lake in Japan, and flows through the valley in Otsu in Shiga Prefecture, continues south through the Kyoto Basin, merges with the Kizu and Katsura Rivers, before flowing south and west through the Osaka Plain. From the three river confluence the river is called Yodo River. It splits into the Kanzaki and Okawa Rivers before reaching Osaka Bay. The flow is stable and the large catchment area of 8,240 km^2 has a population of 12.09 million (Lake Biwa-Yodo River Water Quality Preservation Organization in 2010). There are many cities in the watershed with Osaka City being a major urban center and Kyoto City upstream. The environmental conservation of Lake Biwa has been a big issue. The need to provide water to multiple users and the high population density is making future developments of this river system the focus of special attention. Many pioneering projects have been launched in this system for water control and utilization.



Source: Ministry of Land, Infrastructure and Transport Yodogawa River Office, *Water use along the Yodo River*, http://www.yodogawa.kkr.mlit.go.jp/know/data/use/index.html

Figure 8. Water Use along Yodo River

(2) Securing Water Resources for Downstream Water Utilities

One of the issues for water utilities in the Yodo River basin was how to secure water resources. They succeeded to do this by sharing the cost for the development of Lake Biwa and the Yodo River system. The development considered all aspects of flood control, water utilization and environmental protection. The utilities managed to secure the long-term water rights and a stable water source.

Securing stable water resource had long been a challenge for the Osaka area. Many water utilization and flood control developments along the Yodo River, the only large water system for the region, were implemented and operated independently. They did not achieve the most efficient and effective outcomes. The Yodo River Control Project carried out from 1943 to 1952, was the first time that water utilization and flood control operations were planned and implemented in a comprehensive manner. The weir and facilities on the shores of Lake Biwa were rebuilt for water level control to manage water utilization and electric power generation. When the weir at Lake Biwa was operated for flood control only, approximately 50% of the annual discharge was wasted. The comprehensive development gained 15.157m^3/s of new water for the Yodo River Basin, enough to meet the demand at the time. Utilities shared the development costs, with 3/4 of the costs covered by beneficiaries of the project.

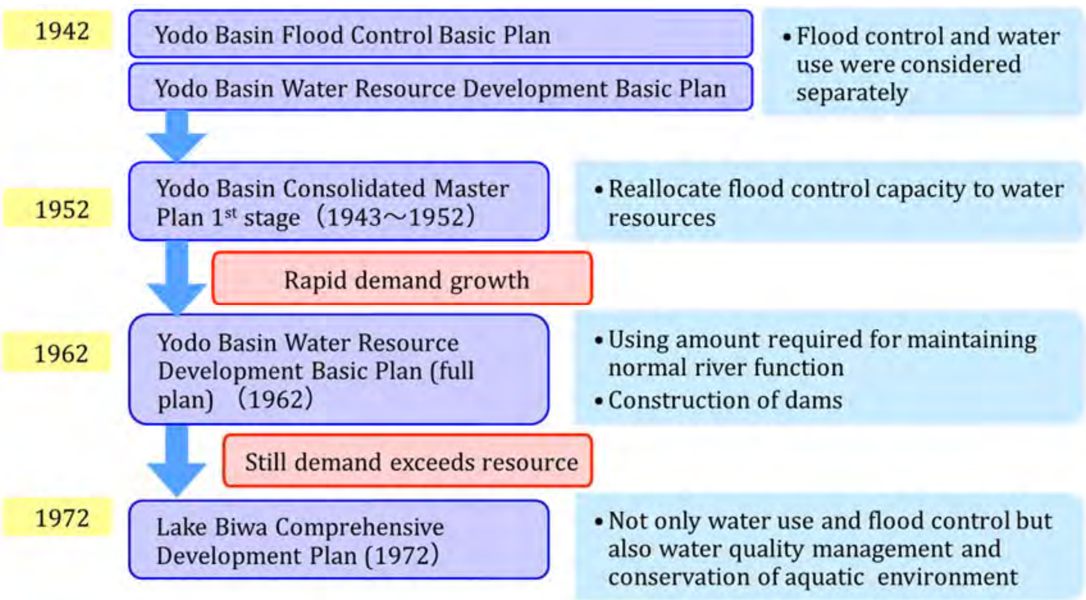


Figure 9. History of Utilization of Yodo River

After the mid 1950's, securing new water resources was urgently required as the population and water demand increased significantly. In 1961, the Act on Advancement of Water Resources Development was promulgated and the Water Resources Development Public Corporation was established. The Basic Plan for Water Resources Development for the Yodo River was determined the year after. The Water Resources Development Public Corporation led the efforts on the construction of dams in the water system and the allocation of water use to minimize any environmental impact.

At that time, although the water supply facilities had enough treatment capacity to meet the demand in the Osaka area, they did not have the water rights. To get around this problem, many projects were launched to use water from Lake Biwa. The Act on Special Measures concerning Development of Lake Biwa was enacted in 1972. Lake Biwa Comprehensive Development Project was launched to allow the withdrawal of water to 2.0 meters below the normal level, for water control and utilization in the Yodo River watershed. Shiga Prefecture, where Lake Biwa is located, insisted that withdrawal should be limited to 1.5 m below the normal level to protect the industries and environment around the lake. The final agreement allowed facilities to be built for water intake below 2 m, but any intake that would bring the water level below 1.5 m would require the approval of the Minister of Construction.

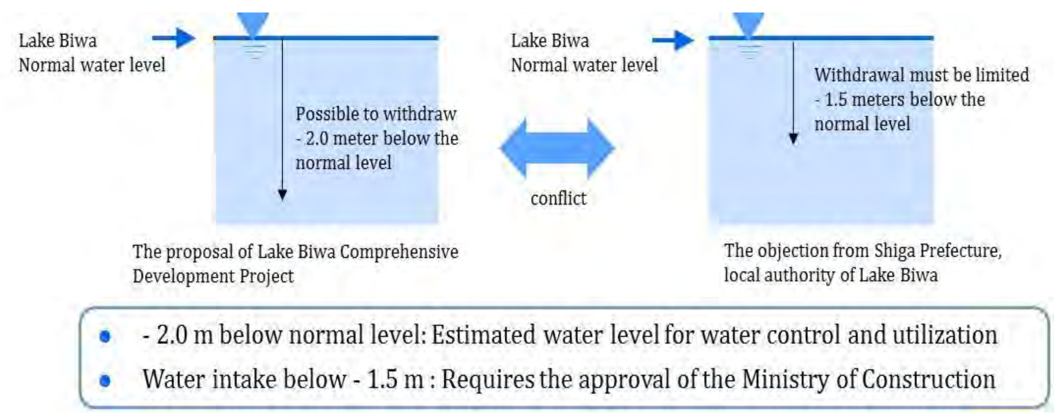


Figure 10. Lake Biwa Comprehensive Development Project

Maintaining water quality and preservation of the environment of Lake Biwa are also important objectives in the Lake Biwa Comprehensive Development Project. Eutrophication had been observed in the lake since 1950s, musty odor for the first time in 1969, and freshwater red tide occurred in 1977. Water quality improvement of the lake became a big issue. Projects such as construction of sewage treatment plants, livestock industry's environmental improvement facilities were promoted. These efforts reduced the pollution load even while the population in catchment areas increased. The water quality of the river flowing into the lake improved and eutrophication was suppressed.

When the River Act was revised in 1997, improvement and conservation of river environment was added to the original objectives of flood control and water utilization. Consequently, the “Basic Policy for River Improvement” and “River Improvement Plan” were developed. The latter was prepared reflecting extensive opinions from local governments, academic experts and residents. The Yodo River Water System Committee was established in 2001, led by the Kinki Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism. They discussed a wide range of issues, including flood prevention, water resources development, adjustment of water utilization, and conservation of the watershed. The committee accommodated the interests of stakeholders in the river basin.

Treated wastewater effluent from upper catchment cities including Kyoto, is discharged into the Yodo River, and is reused by Osaka and other downstream cities. The River Administrator and water utilities are actively engaged in water quality management in the watershed. There are regulations concerning the preservation of water quality of the Seto Inland Sea into which the Yodo River eventually flows.

With these efforts, the Hanshin area including Osaka secured enough water to meet the demand. By the time the water rights were issued, the demand for water supply began to decrease. The allocated volume and the nominal capacity of the treatment plants is enough to provide the daily maximum supply. There has been no need to seek the approval from the Construction Minister to draw water below 1.5 meters.

4. Case 2: Securing Water Resources in Okinawa Prefecture

(1) History of Okinawa Prefecture and its Water Shortage

Okinawa Prefecture consists of several islands and the watersheds are typically small. There are frequent water shortages because fresh water resources are scarce.

Okinawa Prefecture consists of 160 large and small islands that were governed by the USA from 1945 to 1972. Although the annual rainfall in Okinawa's main island exceeds that of the national average, the amount of available water resources per capita (area x [precipitation – evaporation] ÷ population) is about 60% of the national average. Water resources are very difficult to utilize because the rivers in Okinawa are short and steep, the watershed is small, runoff goes immediately into the sea and there is a big difference in the flow between the wet and dry seasons.

Since the USA relinquished the control of Okinawa in 1972, water supply facilities had been developed without much success in keeping pace with the increased demand until 1990's. From 1981 to 1982, Okinawa's main island experienced 326 days of water restrictions, the longest in Japanese history. There were frequent water supply disruptions until 1994, when the water resources developments described below were initiated.

(2) Dam Development

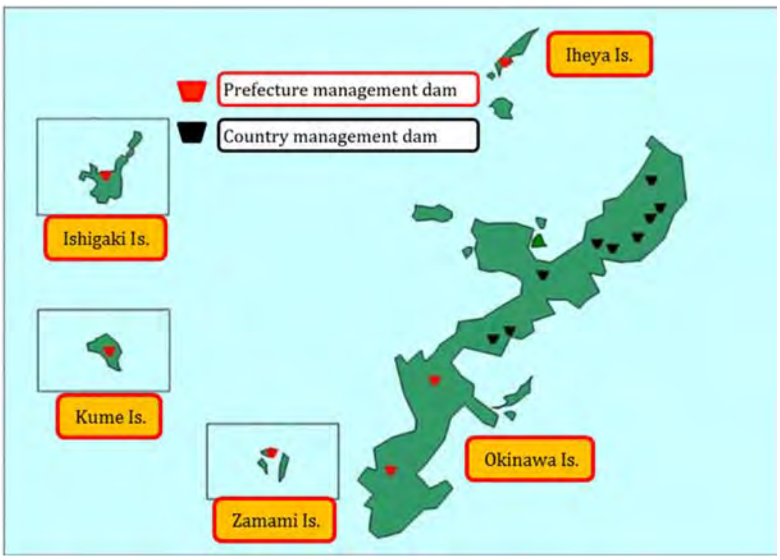
Okinawa Prefecture developed dams to ease water shortage with the national government's active involvement based on the Act on Special Measures concerning the Promotion and Development of Okinawa. Okinawa Prefecture installed transmission pipelines bringing water from the dams to the cities across the main island and manages the Bulk Water Supply for the municipalities.

Fukuchi Dam is the largest dam on Okinawa's main island, with an effective storage capacity of 52 million m^3. When Okinawa was returned to Japan, securing stable water resources was one of the most important issues in promoting regional development. However, under the system at the time, the national government could only construct and manage multipurpose dams on Class A rivers that span several prefectures. Since Okinawa only has Class B rivers which are administered by the prefectural governors, special provisions had to be set under the Act on Special Measures concerning the Promotion and Development of Okinawa, to allow the national government to be actively involved. The national government took over the construction of the Fukuchi Dam, which was half-finished by the US Army Corp of Engineers, and completed the project in 1974.

Later on, the national government constructed ten dams mainly in the northern area of the main island. Nine of them are managed by the national government after their completion. The prominent feature of Okinawa's water resources development is the active involvement of the national government which lessened the burden on local governments and addressed the urgency of water resources development.

The water sources developed in the northern area of Okinawa's main island are located far away from the water-consuming area in the south. About 100 kilometer of water distribution and conveyance pipelines had to be installed. Ryukyu Domestic Water Corporation (established in 1958 and reorganized as Okinawa Prefectural Enterprise Bureau in 1972) draws water from the dam reservoirs, manages the water treatment plant and supplies water to the residents. Ryukyu Domestic Water Corporation provides technical support for the development of the water utilities. The corporation has a strong relationship with the Okinawa Prefectural Enterprise Bureau.

Areas in the northern mountains have their own water source, and are not included in the bulk supply coverage. In these areas, the Foundation for Water Sources supported the development of water source forest. The Foundation (now dissolved) was organized by the national and prefectural governments and the water supply utilities.



Source: Okinawa Prefectural government, http://www.pref.okinawa.jp/site/doboku/damu/kanri/ken-damu.html

Figure 11. Dams in Okinawa Prefecture

(3) Rainwater Utilization

Rooftop tanks were used to store tap water and utilize rainwater to deal with frequent droughts in Okinawa.

Okinawa used to suffer from frequent water shortages because of droughts. Houses were built with roof top tanks to store tap water, collect and utilize rainwater. These are no longer needed after March 1994 when stable water resources were developed but residents still install tanks as an entrenched custom from the early days.

Photo 2. Rooftop Tanks in Okinawa Prefecture (December 28, 2016)

(4) Seawater Desalination

Seawater desalination is pursued as a stable water source when the usual water source is in short supply during frequent droughts.

From the 1980s to 1990s, Okinawa's main island suffered from repeated droughts. While dam development was on-going, construction of a seawater desalination facility was also taking place as an alternative measure to fill the gap between demand and supply capacity. The facility was completed in 1996. As the demand stabilized and dam developments completed, the facility does not need to operate at its full capacity of 40,000m^3/day. The system is fully established to provide a stable supply of water if needed or if an emergency arises.

Photo 3. Seawater Desalination Facility in Chatan Water Treatment Plant (February 25, 2016)

(5) Promoting Water Conservation in Times of Drought

Okinawa, where people suffer from frequent droughts, promotes water conservation in various ways.

Okinawa residents are used to water shortages. Many public outreach activities are carried out to encourage people to save water during droughts. For example, electronic bulletin boards display “Conserve water during drought” at road sides. In 2014, when rainfall was extremely low, newspapers published daily information on falling water level at dams and appeals for water conservation were broadcasted on radio and TV.

5. Case 3: Water Resources Development and Developing Fukuoka into Water Conservation-Conscious City

(1) History of Various Water Resources Development

Fukuoka City does not have abundant water resources. In fact, it is the only city with no Class A river (designation by government ordinance). The city promoted 19 water resources development and water supply expansion projects. Water is brought from the Chikugo River outside of the city. The city also has one of the largest seawater desalination facilities in Japan.

Fukuoka City started operating a water supply system in 1923, with the planned service population of 120,000 and the maximum treatment capacity of 15,000m^3/day. Water demand kept increasing because of the merging of municipalities, economic growth and urbanization. The city has been making efforts to secure water resources since the 1950s, but water restrictions still occurred every two years in the 1960s. The city had to take further measures such as dam construction in rivers near the city, reducing irrigation water losses by replacing open channels with iron pipes and using the recovered losses for potable water supply, and developing the transmission system from Egawa Dam located at the branch of the Chikugo River.

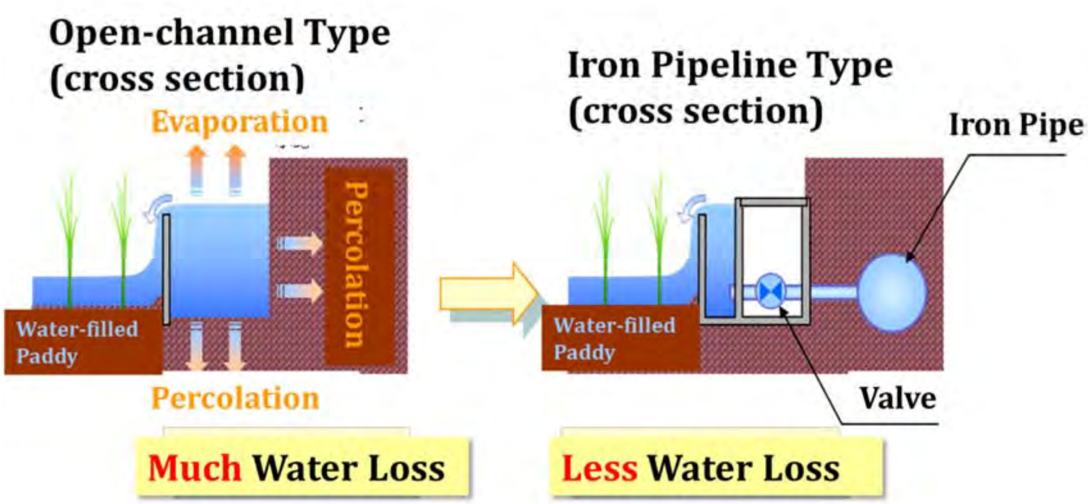


Figure 12. Efficient Use of Agricultural Water

The historic drought of 1978 brought a long period of water restriction that lasted 287 days. This experience convinced citizens that “water is a valuable and limited resource” and the city started to implement various policies based on the concept of “stable water supply” and “Water

Conservation-Conscious City"

In 1983, the city completed the inter-basin water transmission project from the Chikugo River system, which is away from the city and runs not only Fukuoka Prefecture but also different prefectures. This project had been envisioned since the water supply system was first established. Its achievement was the result of the understanding and cooperation of residents and other stakeholders in the watershed. The city also implemented several other projects such as: constructing various types of dams, increasing the capacity of existing dams by dredging, increasing the water abstraction rights for drinking water use by recharging rivers with treated wastewater and reallocating other water rights and river maintenance flows. The city participated in the construction of the Uminonakamichi Nata Sea Water Desalination Center to secure stable water supply even in times of drought. The city has been receiving water from the facility since 2005. (The facility's maximum treatment capacity is 50,000 m^3/day including 16,400 m^3/day allocated to Fukuoka City.)

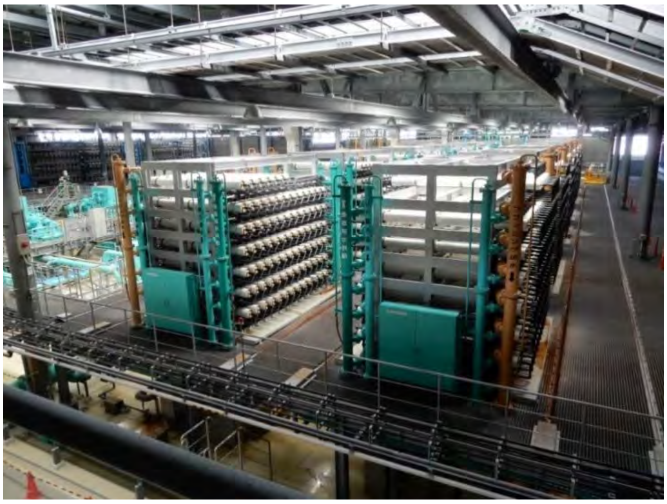


Photo 4. Uminonakamichi Nata Sea Water Desalination Center

The city is constructing the first dam for emergency water supply during extraordinary drought events in Japan. Water will be stored upstream of a river near the city and only distributed during extraordinary drought events which occur less than once in a decade. Ordinary dams for water shortage are normally dedicated to deal with drought once every ten years.

(2) Water Conservation-Conscious City

Fukuoka City not only actively developed water resources, but made extraordinary efforts to promote Water Conservation-Conscious City with the cooperation of its citizens, after experiencing two severe droughts in 1978 and 1994. Thus, water consumption per capita is the lowest among large cities in Japan and its leakage rate is one of the lowest in the world.

The 287-day water restriction in 1978 occurred because of extraordinary low precipitation which persisted since the previous year. Residents and the municipal government recognized the value of water and the difficulty in securing water source in Fukuoka City. In 1979 the city enacted the “Guidelines on Water Use and Conservation” to secure stable water supply. Water conservation efforts to promote Water Conservation-Conscious City were also needed because of the unreliable rainfall and increasing population. In 2003 the city revised the Guidelines and enacted the “Ordinance on the Promotion of Water Conservation,” the first ordinance of this kind in Japan. The city enforces policies on “effective and reasonable use of limited water resources.” Residents understand and support the initiative on “water use with care.”

1) Promotion of Water Reuse

Fukuoka City promotes various water reuse systems to emphasize its goal of becoming a “Water Conservation-Conscious City.” Individual reuse system is installed in a building for treating effluent to be reused for toilet flushing. A wide-range reuse system treats sewage water for watering gardens in parks and roadsides, and toilet flushing around large building complexes and housing developments. Rainwater collection is also practiced. It is obliged to install individual reuse system to flushing toilet for the building with the floor larger than reference area in Fukuoka City.

2) Introduction of Water Distribution Control

During the severe drought in 1978, Fukuoka City was not able to maintain water pressure evenly for different elevations. There was also the problem of uneven water distribution caused by the difference of water sources. In 1981 Fukuoka City established the Water Management Center which controls water pressure and flow from treatment plants to taps, aiming to fill the gap in the quality of water supply service.

3) Promotion of Leakage Reduction

Since 1956, Fukuoka City has actively promoted leakage reduction to save water and avoid accidents such as sinkhole along roads caused by leakage through the following measures:

Basic measures: The investigation plan for leakage reduction is reviewed every four years. The review analyzes the collected data and studies the causes of leakage, as well as evaluates the investigation methods and considers implementation of new technologies.

Corrective measures: Leakage risk in each area is regularly analyzed for early detection and quick repair. Leaks are investigated in an efficient and effective way by using sound listening rod, acoustic leak detector, and leak noise correlator. Repairs are carried out immediately 24 hours a day.

Preventive measures: Old distribution and service pipes which reached or exceeded its lifespan are replaced according to a planned schedule. Adjustment is made to prevent excessive pressure or fluctuations which can cause leakage.

4) Improvement of the Water Distribution System

Fukuoka City modifies its water distribution system systematically to achieve stable water supply based on the following principles:

Improvement of pipelines: to improve water flow by replacing or upgrading old pipes and by rearranging pipes to make loops to decrease stagnation.

Water as a lifeline in emergencies: to reconstruct or reinforce facilities to enhance their earthquake-resistance to ensure that there is a continuous water supply in case of emergencies.

Balanced distribution and efficient operation: to control water distribution from five treatment plants in response to water consumption in each area, to develop distribution reservoirs for provisional storage.

Full coverage by the distribution system: to install distribution pipelines in the areas not covered by the existing network, in order of priority.

In addition to the above measures, Fukuoka City aims to survive droughts with the cooperation of its citizens. If every resident in Fukuoka City saves 10 liters of water a day, it will result in savings of approximately 5.5 million m^3/year, which is an amount larger than the capacity of the Nagatani Dam, the water source of the city. If everyone bears in mind the need to "use water with care" this will be as effective as any effort in water resources development. It will be like having a virtual dam built by the residents and it supports to promote Water Conservation-Conscious City.

5) Public Relation Activities

Fukuoka City carried out many public relation campaigns for water conservation since 1979. The city designated a period for “water saving days” and created the “water saving logo” to commemorate the 1978 drought event as well as recognizing it as an opportunity for appreciating the value of the resource. The “careful water use” campaign is conducted during the “water saving days” from June 1st to August every year, when water demand is high. During the campaign, the Waterworks Bureau distributes “Mizu-dayori (Water News)” to all households and publishes educational material, “Mizu to Watashi tachi (Water and Us),” for 3rd and 4th grade students. Water treatment facilities are open for public tours year-round. The city’s efforts to become Water Conservation-Conscious City are very successful in fostering the notion of water as a limited and valuable resource and the need to use it carefully.

6) Diffusion of Water Saving Devices

Fukuoka City encourages its citizen to install a “water saving tap washer” which is replaced with usual washer in tap and it can reduce water flow compared to the normal one. The city also advocates the usage of water saving toilets (approximately 4 liters/flush) and similar devices.

Fukuoka City has succeeded in reducing its non-revenue water to less than 5.1% during 20 years, and as low as 3.9% in 2015. Residents of Fukuoka City are highly aware of the need for water conservation. The 2015 survey found that approximately 86% of residents are conscientious about water conservation. They use the least water (FY 2015: 194 l/person/day) among large cities in Japan.

6. Lessons Learned

The following Japanese experience could be useful for other countries.

- **(Comprehensive River Development)** While securing water resources is a top priority for utilities, the use of river water must be well planned and controlled in a fair and equitable manner. The Japanese system makes great efforts in this regard, by allocating water rights and implementing comprehensive river development. The Water Resources Development Public Corporation (now Japan Water Agency) balances the needs for flood control and water utilization.

- **(Multipurpose Dams)** Dam construction is expensive but effective for water resources development. Therefore, dams are constructed with a multi-purpose concept to be cost effective. In Japan, reasonable cost sharing among users and coordination among government organizations and dam reservoir users have been emphasized in dam development.

- **(Bulk Water Supply)** Water utilities can cooperate to utilize Bulk Water Supply as their water source. They also benefit from integrated management by joining efforts from resource development to water distribution to end users.

- **(Other Means to Secure Water Resource)** Dam construction takes a long time to complete; therefore, other means to secure water resource must be implemented at the same time. The combined efforts in rainwater utilization, leakage reduction, reuse and water saving campaign have all helped to make lower water consumption in Fukuoka City than the national average. Seawater desalination is much more expensive than the use of surface water, so it is still only a supplemental method to obtain additional water resources.