Preparing for Various Threats in Tama Waterworks: Development of Facilities to Prepare for Disasters in Tama Waterworks

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Abstract: Tokyo Waterworks must respond to new crisis risk factors that threaten stable water supplies, such as volcanic eruptions and acts of terrorism, and implement more effective measures of earthquake-resistance for pipelines and otherwise improve our crisis management in preparation for a hypothetical earthquake located directly under Tokyo. Due to these requirements, Tokyo Waterworks promotes the "Tama Waterworks Management Plan 2017," a plan focused on the Tama area that includes measures such as improved earthquake resistance at waterworks facilities, the installation and increase of in-house power generation equipment, and the covering of water facilities with lids. For waterworks in Tama, Tokyo Waterworks is operating many small-scale facilities while seeking to expand operations over a wider area. These efforts of ours to prepare for various threats will serve to contribute to the promotion of efforts at other small- to medium-sized waterworks utilities.

Keywords: Tama Waterworks Management Plan 2017; earthquake-resistant at the facilities; in-house power generation equipment; covering facilities with lids; countermeasures against terrorism

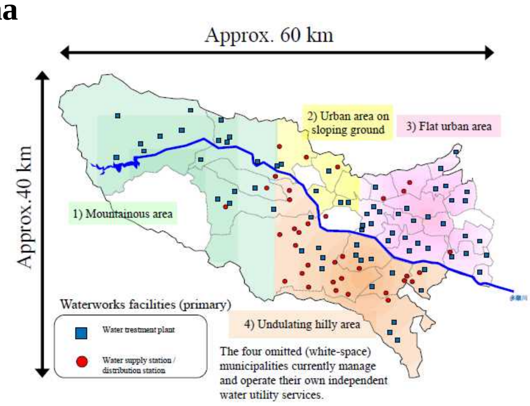
1. Introduction

1-1. Overview of water utilities

In the Tama area of the western part of Tokyo (hereinafter referred to as the "Tama area"), each municipality once independently managed its own water utility. However, these municipalities faced problems such as a severe lack of water sources and disparities in price levels with wards and municipalities in the eastern part of Tokyo (hereinafter referred to as "downtown Tokyo"), which was managed by the Tokyo Metropolitan Government. In response to requests from these municipalities, since the 1970s Tokyo Waterworks has been one of the first water utilities in Japan to promote centralization by integration of municipality-operated waterworks into the Tokyo Metropolitan waterworks system. As of March 2017, the Tokyo-operated waterworks system in the Tama area covers 26 municipalities with a total population of around 3.9 million people served, approximately 2.0 million service connections, and a total distribution pipe network length of approximately 10,000 km, rivalling the scale of Japan's second-largest waterworks utility, Yokohama Waterworks.

1-2. Issues facing waterworks in Tama

In order for waterworks in Tama as described above to further evolve into a strong and reliable wide-ranging waterworks system, it is essential that adequate risk-management measures be taken for Japan as a country of frequent disasters. In Japan, the importance of guaranteeing water supplies during disasters was further highlighted after the M9.0 massive earthquake that occurred in 2011 (hereinafter referred to as the Great East Japan Earthquake).



	Number of water service connections	Characteristics
1	Few (sparsely distributed over a wide area)	Intermittent small-scale facilities
2	Moderate	Intermittent pressure booster / reducer areas
3	Numerous	Possible to establish wide-ranging water distribution zones
4	Moderate	Intermittent pressure booster / reducer areas

[Figure 1] Locations of major waterworks facilities in the Tama area

Another further pressing issue is the taking of countermeasures against the flooding of waterworks facilities, caused by large typhoons and frequent local heavy rains, that forces long water outages and similar problems. Also needed are drastic preventive measures to prepare for the increasing risk of volcanic eruptions and acts of terrorism.

The Tama area extends around 40 km in the north-south direction and 60 km in the east-west direction. The section near downtown Tokyo is flat and level, rising in elevation to the west. The western half of the Tama area is entirely mountainous (Figure 1). Although there is a large river running from the area’s northwest to its southeast, the municipalities own a large number of water wells (primarily deep wells) that they once used as water sources, in addition to small-scale water treatment, drainage, and other facilities that they have inherited and continue to operate to this day. There are 591 of these facilities in total, a small number staffed but most unmanned and remotely managed from a central location. However, all of these facilities, including the pipelines, cannot be described as being sufficiently prepared for natural disasters or other hazards.

It is necessary for us to take all possible measures to fulfill our mission, as one of the most important essential utilities, of providing a stable supply of safe, delicious, high-quality water now and in the future, including during the 2020 Tokyo Olympic and Paralympic Games. These measures include the following.

2. Development of facilities to prepare for disasters in the Tama area

As we work in the Tama area to rebuild its facilities so as to achieve the economies of scale created by the expansion of water utility services across a more widespread area, which has been our ongoing policy as per the Tama Waterworks Management Plan 2017, we will steadily promote development of the following facilities to prepare for a variety of potential threats.

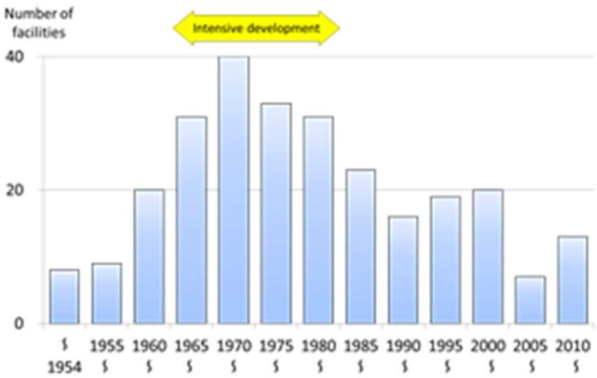
2-1. Earthquake resistance at waterworks facilities

(1) Earthquake damage predictions in Tokyo

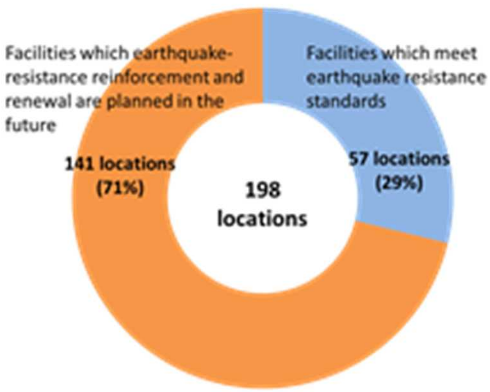
The damage predictions on which earthquake countermeasures are based were revised based on the experience of the Great East Japan Earthquake.[1] Rates of water outages were calculated for four types of earthquakes predicted for the vicinity of Tokyo. Of these, an earthquake caused by the fault zone known to be located in the Tama area (hypothetical magnitude of 7.4) was found to result in rates of water outages exceeding 60% in seven cities. In order to minimize the damage, there is a need to improve the earthquake resistance of pipes, distribution reservoirs, and other civil engineering structures.

(2) Improved earthquake resistance at distribution reservoirs and other civil engineering structures

Many of the water treatment and water distribution facilities (excluding pipelines) in the Tama area were built around the period of 1965 to 1985 in particular (Figure 2). The proportion of facilities complying with Japan's earthquake resistance standards remains at approximately 30% of all facilities (Figure 3). This 30% includes facilities that were reinforced after being found to be lacking in earthquake resistance via seismic diagnosis, as well as those that were originally constructed with earthquake-resistant designs.



[Figure 2] The time when purification and distribution facilities in Tama area were developed



[Figure 3] Status of earthquake-resistance of purification and distribution facilities in Tama area (as of March 2016)

Reinforcement work against earthquakes includes work such as, for example, thickening existing walls and installing new earthquake-resistant walls to fill in the space between pillars in the interior of distribution reservoirs (see Figure 4 for an example of such work). Because this construction will render the target waterworks facilities unusable for long periods (for months to years, depending on the scale of construction), planning is done to avoid water outages by changing usage of the network of water conduits, water pipes, and distributing pipes.

The remaining approximately 70% of facilities are those without proven earthquake resistance, including those that have been found through seismic diagnosis to lack earthquake resistance, and those that have not had their earthquake resistance studied due to future plans for facility renovations or closure. Thus there are many facilities for which such measures must be taken, and there is a need to steadily proceed with work with due consideration paid to the priority on investment return and ensuring earthquake resistance in light of the number of years that each facility has been in use and its forecasted remaining years of future use.

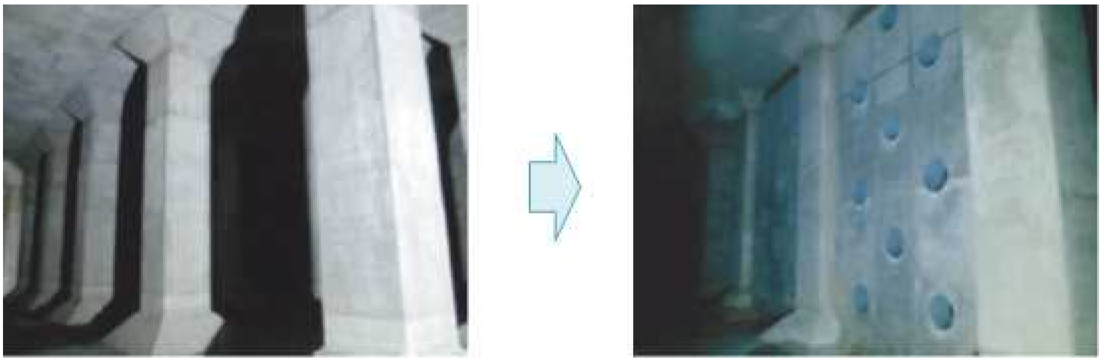
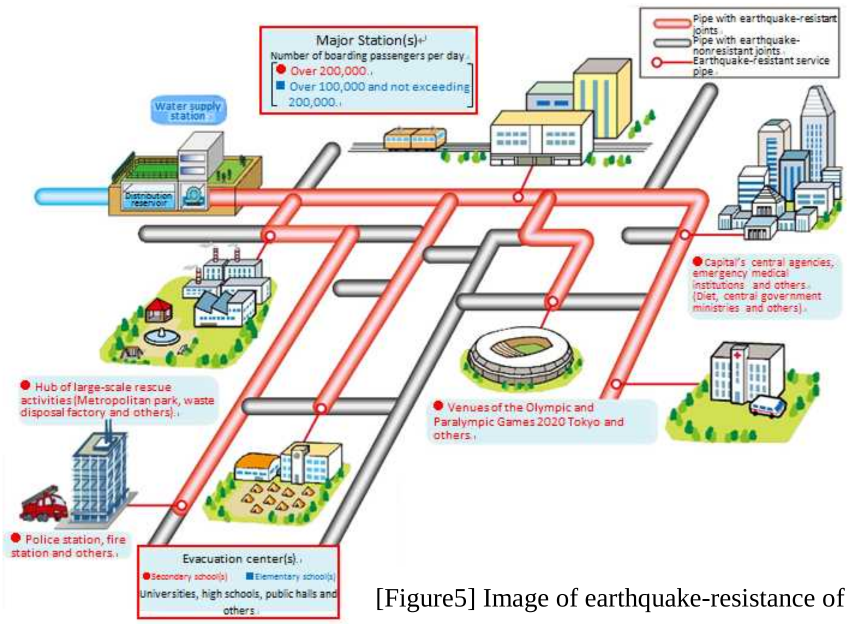


Figure 4: Earthquake resistance reinforcement work on the interior of a distribution reservoir

(3) Earthquake resistance for pipelines

The work of replacing pipelines with highly earthquake-resistant ductile iron pipes has nearly been completed (99.8% of pipelines were ductile iron pipes as of March 2017), but there are worries that joint pipes may become detached during earthquakes. Thus, we are working to install earthquake-resistant joint pipes for pipelines in order to maintain water outages at a minimum and water supplies at their maximum, while also minimizing the number of days required to restore service and rapidly return to everyday life in the event of a disaster. As of March 2017, 42% of all of the distribution pipes in the Tama area had earthquake-resistant joint pipes. The replacement of remaining pipes is performed with an emphasis on installing earthquake-resistant joint pipes on backbone pipelines important to water supply control and management, on pipelines laid in highly corrosive soil, and on supply routes to important facilities such as emergency medical facilities. In addition to medical facilities, priority targets for reinforcement work also include core essential national administrative and economic facilities, evacuation shelters for local residents (primary / junior high schools, etc.), and venues for the 2020 Tokyo Olympic and Paralympic Games (Figure 5).

Moreover, based on the lessons of the major 1995 Kobe area earthquake, major national road networks and roads connecting these to disaster preparedness and protection centers have been designated emergency transportation routes in order to ensure smooth emergency transport (of aid supplies, equipment for restoration work, etc.) in the immediate post-earthquake period and beyond. To ensure that those functions are not hindered, earthquake-resistance work is done on the relatively large-caliber distribution pipes installed under these emergency access roads.



[Figure5] Image of earthquake-resistance of pipeline

2-2. Development and improvement of in-house power generation equipment

Tokyo Waterworks consumes a tremendous amount of energy—approximately 800 million kWh per year—in the process of supplying tap water to customers in both downtown Tokyo and the Tama area. This amounts to around 1% of the electricity consumed in Tokyo as a whole.

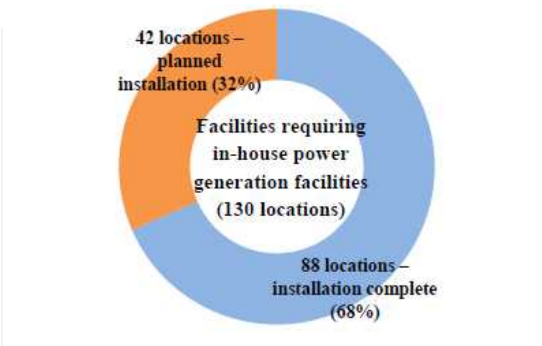
Above all, a great deal of electricity is used to operate water treatment and supply facilities and equipment. To address this, we take advantage of opportunities provided by the new establishment and renovation of water utility facilities to make energy use more efficient, such as by restructuring facilities into those that take proper advantage of water's potential energy and implementing solar or small-scale hydroelectric power generation. However, in the event of a commercial power outage caused by a disaster, water distribution would also stop, leading directly to large-scale water outages.

During the Great East Japan Earthquake, as the electric power supply was placed under strain by demand due to damage to nuclear power plants and other facilities, planned power outages were conducted by area and time period. This resulted in the shutdown of pumps at some water distribution and water treatment facilities in the Tama area. Via press releases and similar, customers were altered of the likely occurrence of water outages, shortages, and dirtiness; educated about the potential for the long-lasting impact of the earthquake; and asked to cooperate with efforts to reserve and conserve drinking water. In the end, there were around 9,000 cases of water outages and around 256,000 cases of water dirtiness (totals during the planned power outage period).

Building on these lessons, we are working to install in-house power generation facilities sufficient to maintain average daily amounts of water distribution and to augment and expand fuel tanks (Figure 6).

[Figure6] In-house power generation equipment and fuel tank

The installation, augmentation, and expansion of these facilities has been completed at around 70% of facilities requiring in-house power generation equipment (Figure 7). Of the remaining 30% at which installation is planned, facilities are prioritized that will cause water outages for all or part of their supplied areas in the event of a power outage.



[Figure 7] Installation status of in-house power facilities (as of March 2016)

Among facilities with in-house power generation facilities that can be operated for a maximum of less than 24 hours, fuel tanks are being augmented and expanded at those facilities with the space for such expansion. This work will equip facilities will the capacity to operate for three days on in-house power, but in cases where restrictions are faced due to the Fire Services Act or overcrowding in the facility, the largest-capacity fuel tanks possible are installed.

2-3. Other multifaceted measures

In addition to the preparations for risks described in sections 2-1 and 2-2 above, there are heightened risks in recent years of terrorist acts contaminating water flowing into treatment facilities and similar dangers, as well as fears of flooding caused by local torrential rainstorms and ash from volcanic eruptions. The following measures are implemented to ensure stable water supplies even in situations such as these.

(1) Security measures against acts of terrorism and similar

In 1995, a ghastly act of indiscriminate terrorism was committed on trains in the Tokyo subway crowded with morning commuters as the nerve agent sarin was released on three train lines in the same period of time. After this major event, initiatives were put in place to strengthen security at waterworks facilities. In the Tama area, waterworks services operated by individual municipalities have been gradually integrated together, and yet it cannot necessarily be said that services are provided in a unified way. Therefore, last year, after reconfirmation of the status of security at individual facilities, measures in need of implementation were organized in terms of the type of facility in question, such as for intake facilities or water conveyance facilities. Moving ahead into the future, facility management and monitoring will be improved based on this.

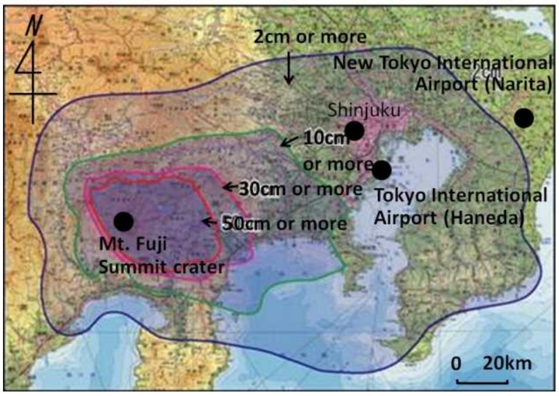
For example, outer fences for facilities will be replaced with fences conforming to pre-determined specifications, more facilities will be equipped with monitoring equipment using fish to quickly detect contamination of raw water, and more facilities will utilize card-key systems with tension-type sensors or infrared sensors.

(2) Preparations for natural disasters

Recent years have repeatedly seen damage caused by volcanic eruption, local severe rainfall, and other natural phenomena. Depending on the scale of these phenomena, there can be a tremendous impact on property, urban functionality, or human lives. The impact on the Tama area is of particular concern, due to the presence of a large river and several mid- to small-sized tributaries flowing through it, and the area's location just 50 to 100 km away in a straight line from the summit crater of Mt. Fuji, an active volcano.

[Figure8] Construction example of flood

Torrential rains may cause the inundation of rivers, thereby resulting in flooding of waterworks facilities in some areas and breakdowns in electrical equipment. This in turn may result in an interruption in water supplies. Some facilities have already installed cut-off walls and taken similar measures (Figure 8). However, each municipality publishes maps of predicted inundation depths under conditions such as record maximum precipitation levels in the



[Figure9] Prediction of ash fall at the time of eruption of Mt. Fuji (produced by processing the map in the Report of Mt. Fuji Volcanic Hazard Map Examination Committee (2004), Cabinet Office)countermeasures area, and there is a need to consider the necessity of facility development based on this data.

In the event that Mt. Fuji experiences an eruption on par with its most recent major eruption (1707), damage is predicted across a wide-ranging area due to the resulting volcanic ash.[2] Ash is predicted to fall at a volume of 2 to 10 cm (Figure 9). This will cause an increase in sedimented sludge and filter blockage in particular at open-air bodies of water, and it is predicted that this may be impossible for water treatment processes to handle. For this reason, lids are being added to water treatment facilities during facility renovations (Figure 10). (These new lids will also contribute to the aforementioned security measures aiming to stop water contamination.)

[Figure10] Water purification facility covered by lids

3. Summary

It is said that "the Japanese think water and safety are free." From a global point of view, Japan is one of the few countries where each person can receive safe drinking water.[3] The culmination of past wisdom and technology have resulted in a water supply coverage of 100.0% for the service area of Tokyo Waterworks, and the people take it for granted that they can get safe and delicious water from the faucet during normal times. In order that safety- and security-supporting water supply services can serve to calm any panic that may spread in a disaster, it is important for the water utility to keep those things that are "usual" at normal times "usual" at times of disaster as well. We reconfirm that this is a mission of utmost importance to us as a waterworks utility for the capital city of Tokyo, and we are committed to steadily advancing the state of our facilities.

We are convinced that these initiatives of Tokyo Waterworks can serve as useful case studies for other water utilities in Japan and around in the world.

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