Emergency Water Supply from Fire Hydrants and others, Residents and Municipalities as New Provides

1. Background

Japan is a land of frequent earthquakes, and waterworks facilities throughout Japan have been subject to earthquake damages repeatedly.

According to the data from the Japan Meteorological Agency, the number of earthquakes that caused damages in Japan from 2006 to 2015 is 67. As we put high priority on earthquake resistance in terms of waterworks facilities in Japan, even if an earthquake occurs, the waterworks facilities will not necessarily be damaged. However, even limited to major earthquakes that caused damages of water suspension for more than 10,000 households, there were 7 earthquakes occurred in this quarter century (Table 1).

Table 1: Recent Earthquakes that Caused Damages to Waterworks Facilities
(Source: Created from the Document of the Ministry of Health, Labor and Welfare)

Earthquake	Date of Occurrence	Magnitude	No. of Households Suffered from Water Suspension	Max Period of Water Suspension
Great Hanshin-Awaji Earthquake	1995.1.17	7.3	Approx. 1.300,000	30 days
Niigata Prefecture Chuetsu Earthquake	2004.10.23	6.8	Approx. 130,000	Approx. 1 month
Noto Peninsula Earthquake	2007.3.25	6.9	Approx. 130,000	13 days
Chuetsu Offshore Earthquake	2007.7.16	6.8	Approx. 59,000	20 days
Great East Japan Earthquake	2011.3.11	9.0	Approx. 2,567,000	Approx. 5 months
Kumamoto Earthquake	2016.4.14	7.3	Approx. 446,000	Approx. 5.3 months
Central Tottori Earthquake	2016.10.21	6.6	Approx. 16,000	4 days

In Tokyo Metropolis, it is predicted that an earthquake will occur just under the capital city in the future. When the magnitude 7.3 earthquake occurs at the northern part of Tokyo Bay, near the urban area on the east side of Tokyo, it is assumed that the water suspension rate exceeds 30% (Figure 1).

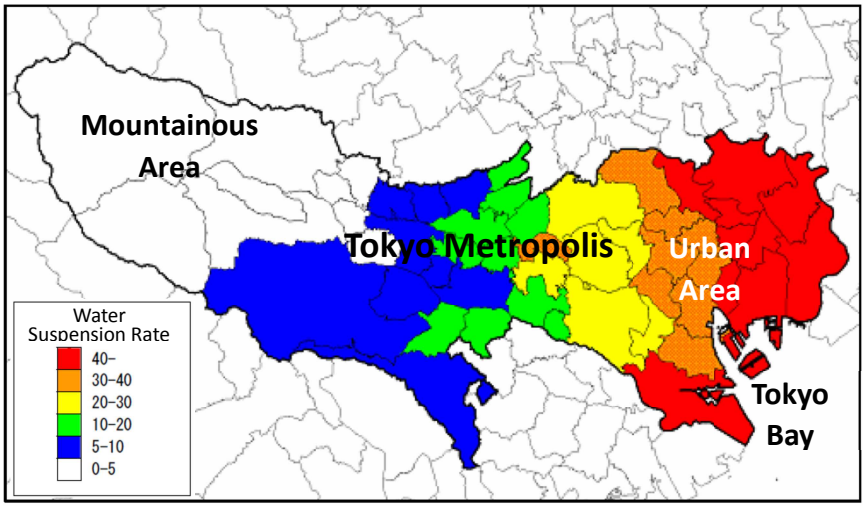

Figure 1: Estimation of Damages in Case of Epicentral Earthquake in the Capital
(Epicenter: Northern Tokyo Bay, Magnitude: 7.3)

Securing water at the time of earthquake is the most critical issue in keeping the sanitary condition of disaster affected area good and protecting life and health of the citizens. Clean water is also indispensable for medical activities. In addition, in the questionnaire on the past earthquakes, "water suspension" always ranks high among things that the victims felt inconvenience in the evacuation life. For this reason, the

Tokyo Metropolitan Waterworks Bureau (TMWB) is reinforcing the earthquake-resistance of its waterworks facilities and introduction of earthquake-resistant joint pipes in the pipelines in order to mitigate damages by earthquakes (Photos 1 & 2).

Photo 1: Damage of Water Leakage due to Earthquake (From the Website of the Ministry of Health, Labor and Welfare)

Photo 2: Demonstration of Earthquake-resistant Joint Pipes

However, as indicated in the damage estimation, there still remains the possibility of water suspension caused by an earthquake. Therefore, TMWB has established multiple emergency water supply methods.

2. Methods of Emergency Water Supply

Methods of emergency water supply at TMWB are (1) water supply points, (2) vehicle transportation and (3) fire hydrants and others.

① Water Supply Points

Firstly, emergency water supply at water supply points is a method to supply water stored in emergency water tanks or waterworks facilities such as water purification plants and water supply stations (Photo 3).

Photo 3: Water Supply Point in Water Purification Plant

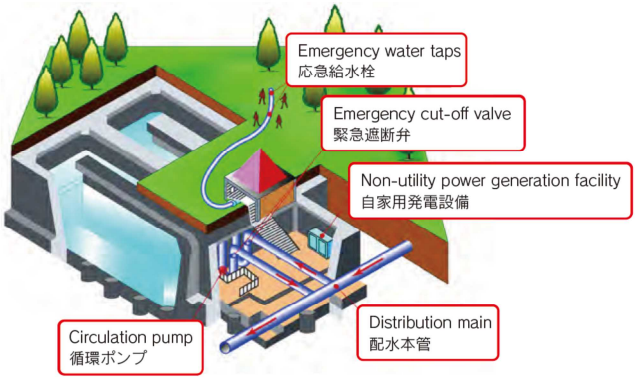

Figure 2: Emergency Water Tank

Among water supply points, some points are emergency water tanks installed at such places as parks, while other points are waterworks facilities such as water purification plants installed with emergency water taps that can provide emergency water supply at the time of earthquakes.

An emergency water tank is a tank that can store 1,500 cubic meters of tap water if it is large-scale, or 100 cubic meters of tap water if small scale. A circulation pump is attached with the tank in order to store fresh tap water all the time. In the event of an earthquake disaster, water circulation is stopped with an emergency cut-off valve so that it can store tap water and provide emergency water supply (Figure 2).

On the other hand, many waterworks facilities such as water supply stations are unattended facilities and only authorized persons can enter in normal times to ensure security. Therefore, in order to enable local residents to quickly provide emergency water supply without waiting for arrival of the Bureau staff members in the event of an emergency, the emergency water supply area is partitioned and maintained within the premises of the waterworks facility (Figure 3).

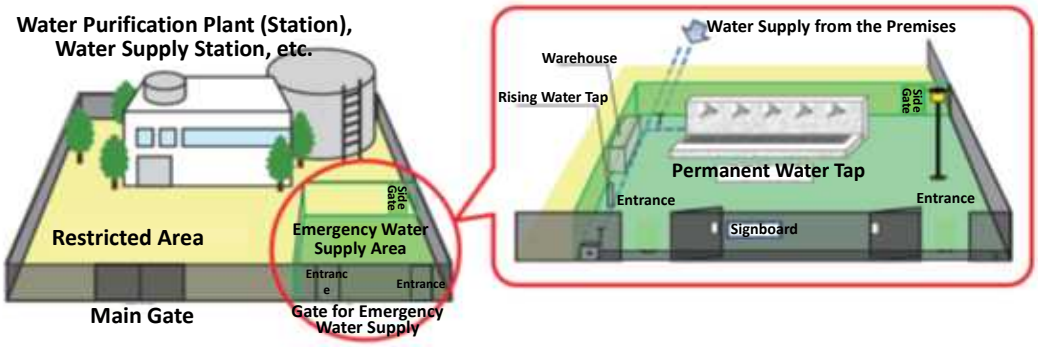

Figure 3: Preparation of Emergency Water Supply Area in Waterworks Facility

② Vehicle Transportation

Vehicle transportation is a method to transport water by using vehicles to places such as medical institutions and evacuation centers upon their request (Photos 4 & 5). In addition to the 14 water trucks owned by TMWB, water trucks dispatched from water business entities in Japan and water trucks of the Self Defense Force are also used. At the time of the Great East Japan Earthquake occurred in 2011, 327 water trucks dispatched from water business entities were used on one day at the peak time.

Furthermore, it is planned to provide emergency water supply by installing an assembling-type tank on a vehicle of carriers that entered into agreements with TMWB.

Photo 4: Vehicle Transportation (At the Time of the Great East Japan Earthquake)

Photo 5: A Water Truck of Tokyo Waterworks

③ Emergency Water Supply from Fire Hydrants and others

Emergency water supply from fire hydrants and others is a method to supply water in emergency from fire hydrants and drain plugs by using emergency water supply materials and equipment. Emergency water supply materials and equipment include a stand pipe which takes water from a fire hydrant, a temporary water tap, a hose, a plug opener and others (Photos 6 & 7).

Emergency Water Supply Materials and Equipment can be assembled easily without any specialized knowledge. However, since fire hydrants in Tokyo Metropolis are placed under the road and normally covered with solid lids made of iron, opening and closing of the fire hydrant's lid needs attention. In

addition, since high pressure is applied to the water distribution pipe, it is necessary to take care not to let the appliances disengaged due to hasty handling of the fire hydrant valve or not to cause injury due to moves of the hose in an unexpected direction.

Photo 6: Emergency Water Supply Materials and Equipment (Before Being Assembled)

Photo 7: Emergency Water Supply Materials and Equipment (After Being Assembled)

3. New Providers of Emergency Water Supply

① Local Residents Became Providers of Emergency Water Supply

Although emergency water supply from fire hydrants and others had been conventionally arranged as one of the methods of emergency water supply, since the Bureau staff members were supposed to assemble the materials and equipment to install temporary water taps, there was a concern that there might not be enough personnel to implement the supply at the time of disaster. Therefore, TMWB concluded the Memoranda of Understandings with municipalities and lent them approximately 2,600 sets of emergency water supply equipment and initial fire extinction equipment (a nozzle, a hose, etc.), corresponding the number of evacuation centers, from 2013 to 2015 at their request. Therefore, TMWB concluded the Memoranda of Understandings with municipalities, lent them approximately 2,600 sets of emergency water supply equipment and initial fire extinction equipment (a nozzle, a hose, etc.), corresponding the number of evacuation centers, from 2013 to 2015, and made it possible to set up emergency water supply points by initiatives of municipalities and local residents at the time of an earthquake. Therefore, TMWB concluded the Memoranda of Understandings with municipalities, lent approximately 2,600 sets of emergency water supply equipment and initial fire extinction equipment (a nozzle, a hose, etc.), corresponding the number of evacuation centers, from 2013 to 2015, and made it possible to set up emergency water supply points under the initiatives of municipalities and local residents at the time of an earthquake.

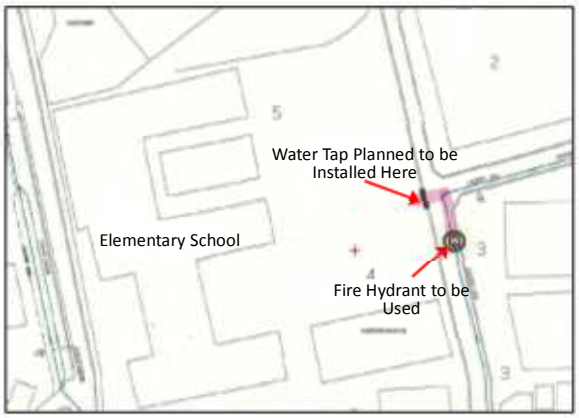

Figure 4: An Example of Designated Place for Installment of Emergency Water Supply Materials and Equipment

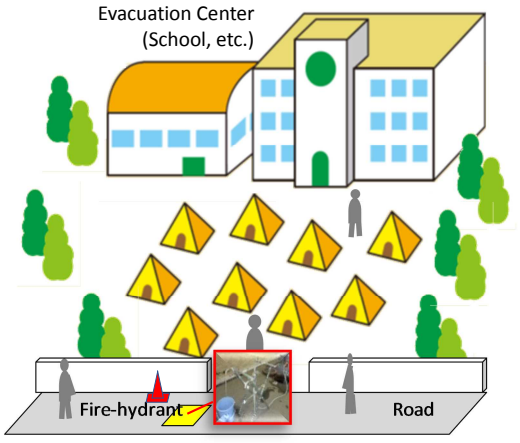

Figure 5: Image of Emergency Water Supply from Fire Hydrant around Evacuation Center

With this mechanism, we were able to drastically increase the number of people to provide emergency water supply. In addition, TMWB has investigated the intention of municipalities and designated a fire hydrant to be used at the time of emergency in advance for each set of the emergency water supply materials and equipment lent to each municipality (Figure 4).

② Prerequisite for Emergency Water Supply from Fire Hydrants and others

For emergency water supply from a fire hydrant, it is a prerequisite that the water supply service is not suspended. Some suspect whether emergency water supply can be provided from fire hydrants at the time of disaster under the situation where the estimated water suspension rate in Tokyo at the time of epicentral earthquake directly under the capital exceeds 30%. However, TMWB has been promoting earthquake resistance of supply routes to important facilities such as medical institutions and evacuation centers, and it is planned to complete earthquake resistance by 2025 at schools and other places that are to become evacuation centers (Figure 6).

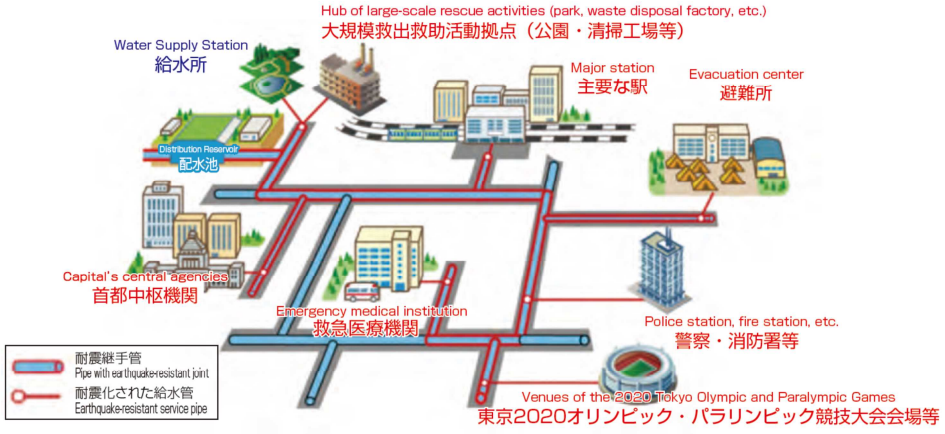

Figure 6: Pipe Jointing by Earthquake-resistant Joints in Water Supply Pipes Connected to Important Facilities

With this measure, the possibility of water supply from fire hydrants around evacuation centers will become higher than in other areas. Even if the water distribution is not suspended, there would be a case that the water service is not available due to the damage of the service pipe inside the building, and thus, emergency water supply from fire hydrants can be found effective.

③ Arrangement of Emergency Water Taps

In addition, as a new initiative from 2017, we decided to install emergency water taps when replacing service pipes of evacuation centers with earthquake-resistant joint pipes or the like as a part of ensuring earthquake resistance of the pipeline (Figure 7). As a result, even if the faucet (water tap) at an evacuation center cannot be used, water can be supplied from this emergency water tap, and thus, that the stability of emergency water supply is further enhanced.

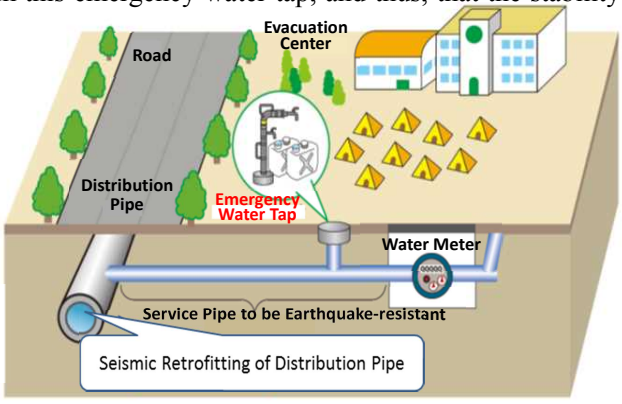

Figure 7: Arrangement of Emergency Water Tap at Evacuation Center

4. Evaluation of Each Emergency Water Supply Method

① Water Supply Points

Water supply points are installed at 212 locations to cover the entire water supply area (Figure 8). Since it supplies water stored in earthquake-resistant waterworks facilities such as water purification plants and water supply stations or quake-proof emergency water tanks, there is high possibility that they can start providing emergency water supply immediately after the disaster. In addition, at the waterworks facilities designated as water supply points, the staff members of TMWB designated in advance are to come to provide emergency water supply even on holidays or at night, while officials of municipalities are supposed to come to the emergency water tanks to start providing emergency water supply. Therefore, the stability and certainty of supply are the highest among the three emergency water supply methods.

However, the number of the points installed is small compared to the area of the water supply area, and users need to walk up to maximum 2 km in a disaster affected area to their respective nearest water supply points (Figure 9).

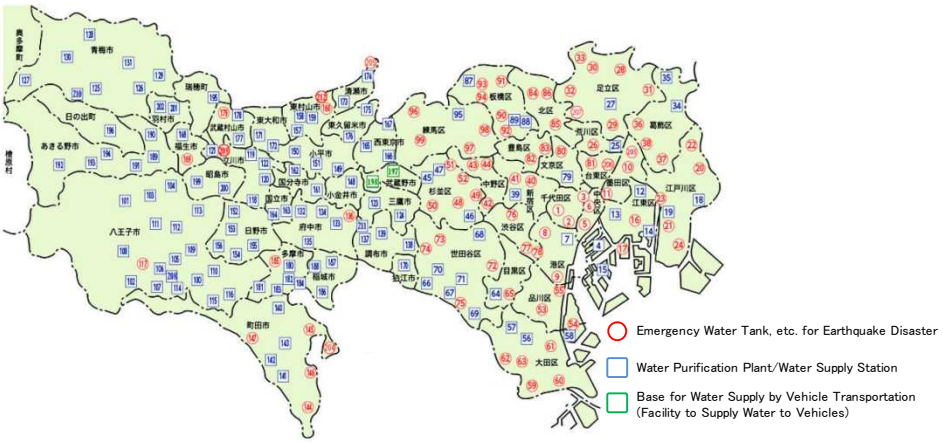

Figure 8: Water Supply Points in Tokyo Metropolis

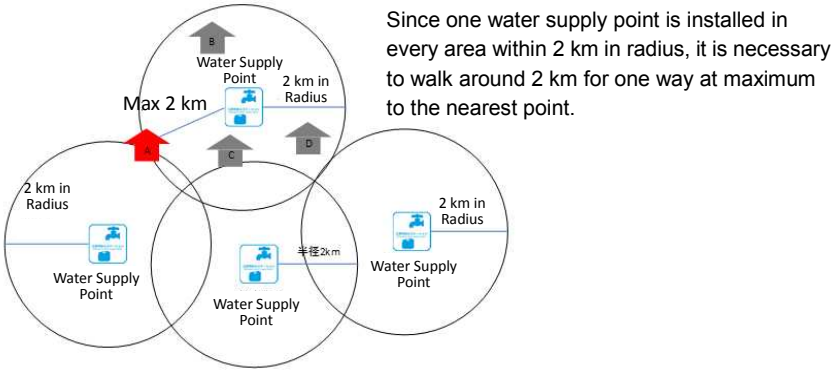

Figure 9: Concept of Designation of Water Supply Points

② Vehicle Transportation

Vehicle transportation is highly convenient for users because it transports water to places near them such as medical institutions and evacuation centers upon request. However, in the event of a large-scale damage, it is obvious that 14 water trucks owned by TMWB cannot meet demand, and it is a prerequisite that water trucks from water business entities nationwide should back up and join in providing emergency water supply.

Besides, immediately after the disaster, the traffic conditions might deteriorate such as wreckage scattering on the road. As a result, the stability in water supply by vehicle transportation is relatively low.

③ Emergency Water Supply from Fire Hydrants and others

Places designated for emergency water supply from fire hydrants and others greatly increased more than water supply points by lending emergency water supply materials and equipment from TMWB to municipalities. Since the emergency water supply materials and equipment were placed at schools and other facilities where evacuation centers are planned to be opened, it became unnecessary for users to go to remote water supply points, and the convenience of evacuees in evacuation centers and residents in the vicinity of evacuation centers has been increased. Furthermore, since there is no need to transport water to the sites, it is superior to other emergency water supply methods in terms of the amount of supply.

On the other hand, hydrants cannot be used in the event water suspension occurs in distribution pipes, and municipalities and local residents have to install them, there is uncertainty in implementation rate whether water supply from fire hydrants and others can actually be supplied when necessary.

④ Evaluation of Each Emergency Water Supply Method

The evaluation of the three emergency water supply methods as explained above is summarized in Table 2.

As emergency water supply immediately after disaster is primarily to ensure drinking water essential to life supporting, it is expected that water is mainly supplied at water supply points which have high stability in supplying even though the amount per capita is small. In addition, if it is necessary to urgently supply a large amount of water at specific places such as medical institutions, vehicle transportation will be utilized from a relatively early stage after the disaster. However, as time passes and the demand for water to support daily life would be increased, water supply from fire hydrants and others, which is convenient and can provide a large amount of water easier, would become more effective. Since each of the three emergency water supply methods has its advantages and disadvantages, having these three water supply methods complement each other according to situations at different times in the process from disaster to recovery would allow us to respond to the changing needs of users at the time of earthquake disaster.

Table 2: Evaluation of Emergency Water Supply Methods

	Emergency Water Supply Stations in Disasters		
	(1) Water supply points	(2) Vehicle transportation	(3) Fire hydrants,and others
Number of locations (in Tokyo)	212	Medical institutions,evacuation centers,and others which have made a request	2,531 (Emergency water supply materials/equipment)
Responsible organizations	TMWB,Municipalities	TMWB	Municipalities,Residents
Stability (stability of supply)	Exellent	Average (Dependent on the transportation system)	Average (Not usable in case of water failure)
Convenience (accessibility)	Average	Exellent	Excellent
Amount supplied	Good	Average	Excellent

5. Improvement of Residents' Disaster Response Capacity

① Training of Municipalities and Residents

To enhance the effectiveness of emergency water supply from fire hydrants, it is necessary for relevant municipality's officials and residents to learn the operation procedure by training. For that purpose, Tokyo Waterworks and each municipality made an agreement under which TMWB shall lend the municipality emergency water supply materials and equipment, while the municipality shall conduct regular training for emergency water supply with the residents in return (Photo 8).

Photo 8: Training of Emergency Water Supply from Fire Hydrant

② New Initiative for Improvement of Disaster Response Capacity

Moreover, TMWB, in cooperation with Tokyo Fire Department, started the project to support municipalities training of emergency water supply materials and equipment in 2016 in order to further enhance the disaster response capacity of the municipalities and residents (Figure 10).

In this project, in order to allow residents themselves to experience the training for initial fire extinguishment and emergency water supply, staff members of Tokyo Fire Department and TMWB perform initial fire extinguishing demonstration and support training for emergency water supply and operation in training courses conducted for local residents by municipalities.

In the event of a large-scale earthquake, roads are blocked by multiple disasters occurring simultaneously or by collapsed buildings, and staff members of administrative organizations such as a fire department and a waterworks bureau cannot always arrive at the disaster site immediately. At such time, local residents need to cooperate and respond to the disaster. TMWB is determined to improve the disaster response capacity of local residents, such as initial fire extinguishing and emergency water supply, so that the residents themselves can protect themselves at the time of disaster through training supported by us and Tokyo Fire Department.

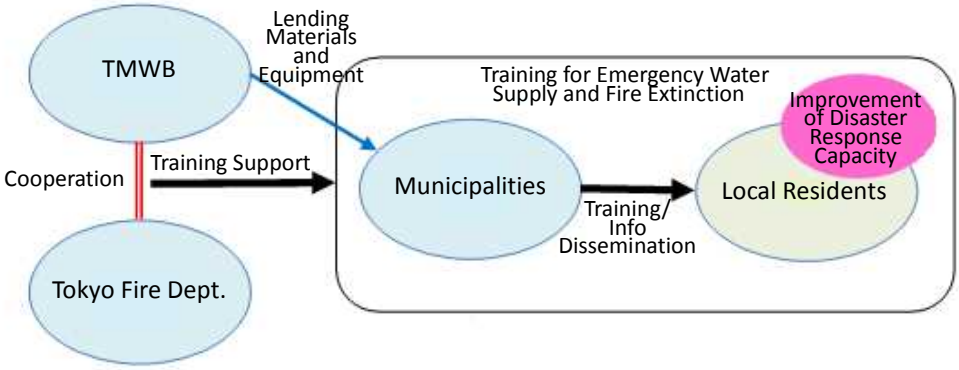

Figure 10: Training Support in Cooperation with Tokyo Fire Department

6. Towards a Disaster Resistant City

Under circumstances where a large-scale disaster such as an earthquake immediately under the capital occurs, there are limitations to the capacities of the administration. In order to protect lives and properties of residents, it is necessary not only for the administration to make efforts of the administration but also for the residents to have awareness of self-help and mutual assistance and to improve their disaster response capacity by themselves. TMWB has adopted the idea of self-help and mutual assistance also for emergency water supply, and has prepared a system of emergency water supply from fire hydrants and others. We are aiming to realize a disaster-resistant city through further collaboration between the administration and residents.