Crisis Management by Waterworks Emergency Service Unit ; Quick Response and Prompt Securement of Water Supply in the Event of Disasters

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ABSTRACT

Bureau of Waterworks, Tokyo Metropolitan Government (BWTMG) is responsible for the mission of stably supplying safe, clean and high-quality water 24 hours a day as a core lifeline supporting the civic life and the urban activities in Tokyo Metropolitan. Especially water supply to the administrative organizations of the country that are the key to restoration in emergency situations and disaster base hospitals that protect the lives of citizens is indispensable. As a facility to support this function, Waterworks Emergency Service Unit was built. The main task of the unit is to secure water supply routes to the central agencies of the capital such as government agencies and disaster base hospitals, and others, within three days from the occurrence of a disaster such as a large-scale earthquake. Even in Tokyo during the Great East Japan Earthquake, main roads became heavy traffic congestion due to the difficulties of returning home, and others, resulting in a long and considerable time to check and confirm the water supply route. Based on this lesson learned, we constructed a system that can monitor water supply pressure so that the unit's headquarters can grasp the situation intensively. This system will be introduced for the first time in Japan as a water supply utility.

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1. Installation of Waterworks Emergency Service Unit

In case of sudden accident such as water leakage, it is necessary to respond promptly such as information communication with the accidental area, public relations activity, valve operation, security measures, and more in order to prevent the spread of damage and to restore the site.

In addition, in preparation for the occurrence of earthquake that directly hits Tokyo area the authorities have steadily promoted measures to mitigate the damage caused by the earthquake, such as strengthening the backup function of pipeline and aseismic construction method. On the other hand, it is important to further enhance the systems such as information communication, emergency water supply and emergency restoration in order to secure as much drinking water as possible and restore normal water supply as soon as possible.

Furthermore, in September 2005, the National Disaster Prevention Council of Japan established the "Outline of Disaster Countermeasures Basic Act", and as a countermeasure against Tokyo Inland Earthquakes, in order to ensure business continuity of the central capitals and other organizations, the Council set functional targets and countermeasures to be fulfilled by the waterworks facilities three days after the disaster in the lifeline infrastructure. In response to this, the authorities revised the "Earthquake Disaster Emergency Action Plan" in June 2006. Regarding the damages on pipeline related to water supply to the capital's central agencies at the time of the earthquake occurrence, we decided to restore the equipment with the highest priority aiming at water supply within 3 days after the disaster. Based on this background, from the viewpoint of strengthening the crisis management function, as a flexible organization capable of dealing with 24 hours at 365 days, which has both quick response and flexibility, and also the technology necessary for early recovery, we decided to establish Waterworks Emergency Service Unit in April 2008 that reorganized special water work team and strengthened crisis management function.

2. Work contents of Waterworks Emergency Service Unit

At the time of the earthquake, Waterworks Emergency Service Unit is mainly responsible for securing the water supply route to the central government institutions, and others, and at the time of the accident, assisting the restoration work concerned (Table 1). In ordinary times, conducting various training to prepare for earthquake etc., and when an accident happens unexpectedly, we are engaged in assisting in restoration work using our mobility and prompt information communication, emergency publicity, emergency water supply and more.

Also, in the Great East Japan Earthquake of March 2011, we dispatched a large number of personnel and vehicles to the affected areas immediately, and are engaged in support activities such as emergency water supply. For this reason, in addition to special emergency vehicles equipped with portable personal computers capable of viewing information communications and pipeline diagrams, generators, valve operating tools, security equipment, and others, as well as information emergency vehicles on the spot, public relations vehicles, water supply cars, water control valve opening and closing cars. Waterworks Emergency Service Unit constantly maintains a dispatch state. Furthermore, among the road congestion assumed at the time of the earthquake disaster, a motorcycle (displacement of 50 CC) is deployed to expeditiously investigate the water flow situation of the central capital and other institutions, and we also developed the valve operating tools (Photo. 1).

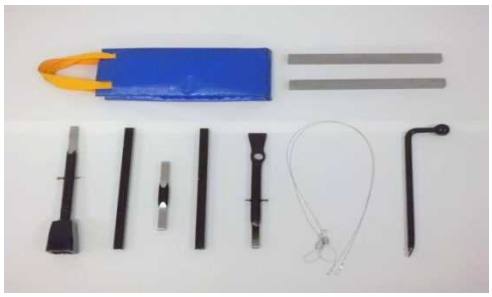

Photo 1 Examples of Tool Development

The unit is the only specialized organization to deal with crisis management as a water supply utilities in Japan, aiming at strengthening the initial structure at the time of the earthquake disaster and accident, and is striving to improve its response capability through day and night training.

Table 1 Main duties in the event of disaster such as earthquake and accident occurrence

Category	Work contents	Details
When an earthquake or other disaster occurs	Initial operations	In the event of an earthquake with a seismic intensity of a lower 5 or greater at night or on a holiday, some of the unit members gather as first responders at the Metropolitan Government Building and carry out information room setup during the initial disaster period, etc.
	Emergency water supply	Conduct emergency water supply requested from the Disaster Response Headquarters especially to medical institutions etc.
	Securing the supply route to the central capital area	When conducting a hydraulic investigation on the water supply pipeline to central agencies of the capital and if a decrease in water pressure is discovered, valves are operated to secure the water supply pipeline
	Support for Emergency Recovery of Distribution Pipes, etc.	Under the instruction of the Water Distribution Recovery Team (head office) and branch offices, the Unit conducts water leakage investigations and water passing works (including pipeline severance works) for other routes.
When an unexpected accident occurs	Accident site safety measures	On-site security measures using safety equipment and soil etc.
	Initial Publication	Emergency publicity at the time of a sudden accident
	Emergency water supply	Using water trucks, distribute drinking water to those residents who cannot use water due to the emergency water stoppage
	Support for suspended service	Under the direction of the branch office at the time of the accident, in cooperation with the branch office, conduct the water suspended service work, system change work and drainage work etc.

	Information communication support	Information collection and dissemination of information using special emergency vehicles and on-board PCs. Emergency team creates accident report under direction of branch office and supports branch office Main pipe cutting work and under-road cavity due to water leak · radar exploration, equipment production etc.
	Tube cutting operation · Cavity inspection etc.	Main pipe cutting work and under-road cavity due to water leak · radar exploration, equipment production etc.

3. Main Deployment Vehicles

Table 2 List of vehicles of Waterworks Emergency Service Unit

Vehicle type		Main task	No.
Emergency vehicles	Special Emergency Vehicle	Information Contact · Equipment Material Transport	2
	Loudspeaker vehicle	Public information on sudden accident	2
	Emergency transporter	Emergency security measures such as secondary disaster prevention	2
	Gate valve open/ close vehicle	A vehicle equipped with a power-driven device to turn the gate valve of water pipes.	2
General vehicle	Water truck	Emergency water supply (2t, 3t, 4t)	10
	Transport Truck	Transport of work equipment	2
	Public information and research guidance vehicles	Public information · various investigations etc.	6
		Total	26

4. Activities in the event of the disasters

The first mission of Waterworks Emergency Service Unit at the event of earthquake, in order to maintain the central agencies of the capital, disaster base hospitals, tertiary emergency medical institutions, financial institutions and embassies, secure the water supply route to these 118 facilities (as of July 2017), and secure water supply route within 3 days after the disaster.

When a disaster happens, the unit goes into action immediately, and investigate the hydraulic pressure with a hydrant, and others on the pipeline along the water supply route to the capital area while exploring the road on the pipeline. Therefore, when a decrease in water pressure is confirmed, the unit shut down the water control valve of the branch destination pipe and keeps the pressure, thereby securing the water supply to the designated facility.

Also, after securing the water supply route to the central agencies of the capital, we also conduct water leakage investigation and water supply work as support for emergency restoration of the pipeline for concerned agencies.

5. Secure water supply routes

5.1 Background and purpose

Extension of water pipes is about 27,000 km (which is equivalent to approximately about two thirds of the equator), in particular Tokyo central area, where the water pipes are networked like a finely-meshed pattern, alternative lines may be secured as a “back-up route” even if water leakage occurs in some parts of the area. In order to maintain the capabilities of the function of Tokyo metropolitan area in the event of the earthquake disaster, it is necessary to promptly secure water supply, especially for the capital’s central agencies. For this reason, after the earthquake, regarding these facilities, promptly confirm water pressure at the site, secure water supply within 3 days for facilities that suffered damage such as water pressure drop by valve operation.

However, the Great East Japan Earthquake that occurred in March 2011, although Tokyo Metropolis is more than 300 km away from the epicenter, main roads encountered heavy traffic jams due to the suspension of operations of public transportation and it took considerable time to check the water supply to important facilities by vehicles. Meanwhile, in the Kumamoto earthquake last April, there was also a report that some medical institutions hindered medical activities because of suspension of water supply.

Based on these lessons learned, from this fiscal year 2017, the unit decided to install hydraulic pressure monitoring devices which use PHS lines (*1) at water meters of important facilities so that the situation can be intensively grasped at the headquarters of the unit. The reason for adopting the PHS line is that while another mobile phone line implemented the call restriction at the time of the Great East Japan Earthquake, the PHS line was regulated.

With this system, it is possible to pinpoint the damaged water supply route and quickly secure water supply to important facilities in a short time.

As for the water supply route to important facilities such as the central agencies of the capital, we work diligently to complete the seismic coupling by the end of FY2019.

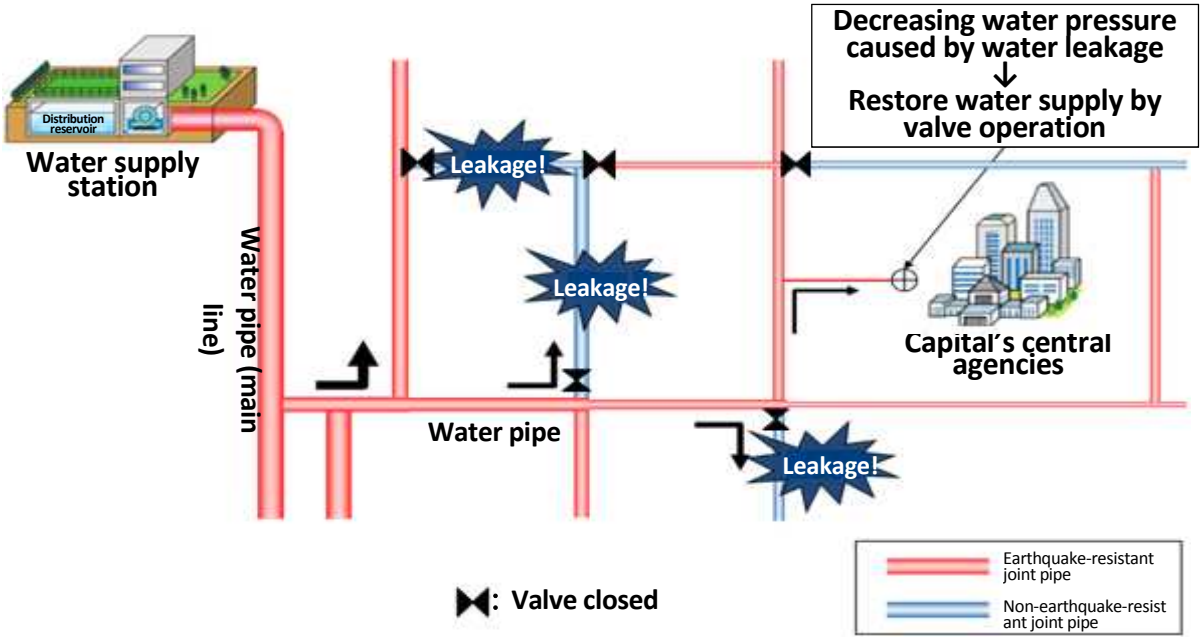

Figure 1 Image of water supply provided at the time of disaster

5.2 System Configuration

The system formulated in this project is constituted of "communication lines" which sends and receives the water supply pressure data, a "terminal unit" which measures water supply pressure on site, and the "data collection center" in the office which monitors the water supply pressure. Thus, this system allows the monitoring of the water supply pressure on site from the data collection center via communication lines.

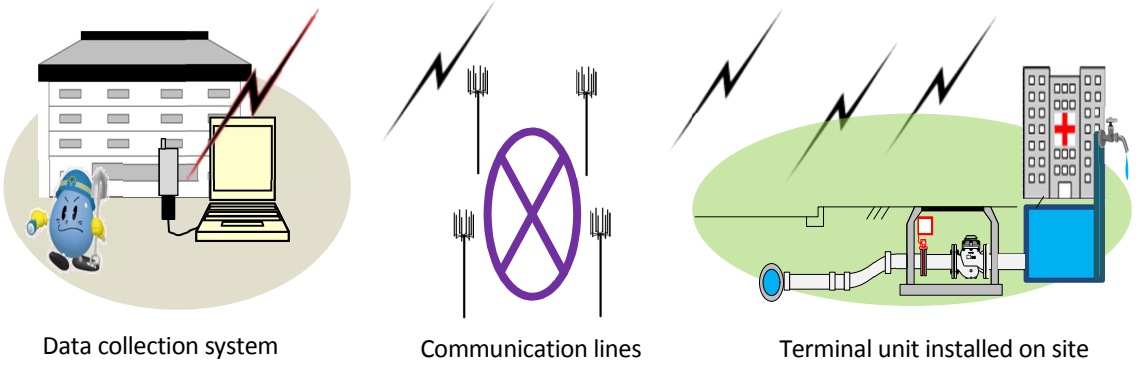

Figure 2 Image of system configuration

5.3 Utilization of PHS Communication Lines

For the communication line, we decided to use the PHS line. The reason for this is that the PHS line is easy to secure a line even in the event of a disaster in urban areas among current communication infrastructure in Japan. As evidence based on the fact, communication was restricted due to the concentration of access to mobile phone lines at the time of the Great East Japan Earthquake, but the PHS line was not subject to communication restrictions. Another reason is that with the PHS lines we can save more energy and call rates compared to using other mobile network systems. Furthermore the PHS lines have low electromagnetic waves which may less affect medical devices at the target hospitals compared to using other mobile network systems.

5.4 Development of a Terminal Unit for Checking Pressure

Bureau of Waterworks, Tokyo Metropolitan Government aims to develop a terminal unit that can be installed at the pipe joint which allows to measure water supply pressure in a distribution pipe at the facility.

(1) Performance requirement of a terminal unit

① Water supply pressure can be measured at a point close to the facility.
② No affection to existing water supply pipes including water meters.
③ Battery-powered, easily replaced.
④ Have a predetermined waterproof function.
⑤ Daily maintenance and inspection are not required.

(2) Configuration and specification of a terminal unit

The terminal device is composed of a pressure sensor and data conversion/transmission apparatus.

[Pressure Sensor]

A protective guard made of resin was attached to the pressure sensor, and a special fitting for measuring water pressure was sandwiched between the flanges in the upstream part of a meter (18 to 24 mm thick).

Also, the special fitting shall satisfy the requirements to be provided as part of the water supply pipe.

[Data conversion/transmission apparatus]

The data conversion/transmission apparatus shall be a box (201 mm wide × 151 mm high × 80 mm thick) with waterproof levels equivalent to IP 67 under the International Electrotechnical Commission (IEC) standard, accommodating the "communication line unit," the "pressure conversion unit" and "replaceable lithium batteries."

As a result of trial calculation of battery life, it was confirmed that continuous operation can be performed without battery replacement for 10 years or more under the following operation conditions.

- The "communication line unit" is always kept on “standby”.
- To confirm water supply pressure, receive data once a day by communication.

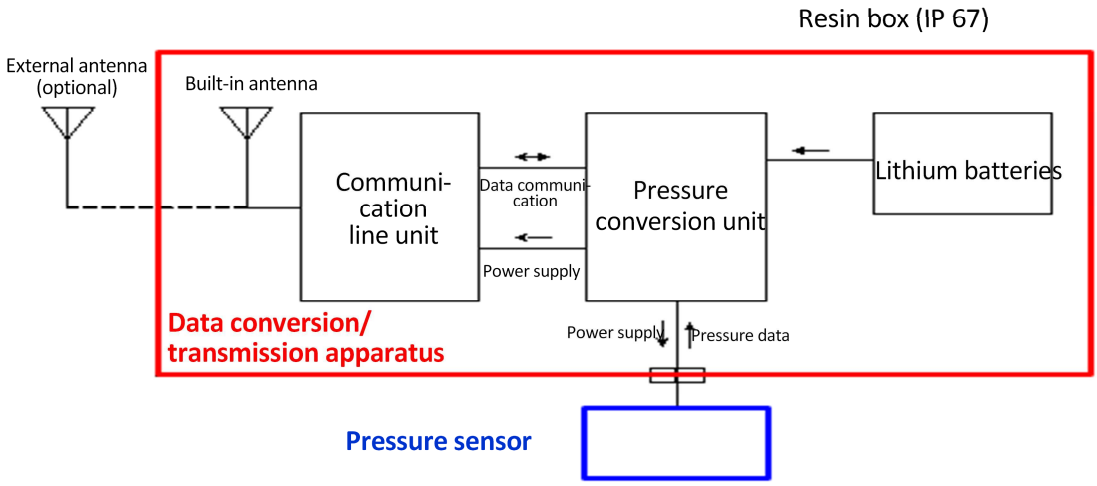

Figure 3 Configuration of terminal device (Data conversion/transmission apparatus and pressure sensor)

5.5 Development of the Data Collection System

A data collection system was developed to collect data from terminal units via communication lines, which enables the main unit to check the water supply pressure of many target facilities.

(1) Performance Requirement of Data Collection System

① Water pressure can be confirmed at an arbitrary timing.
② The acquired water pressure data, electric field intensity, and remaining battery power can be displayed with spreadsheet software.
③ The schedule function which acquires the data at the specified day and time in advance is carried.

(2) Configuration and specification of data collection system

The data collection system is composed of a personal computer and a communication terminal on which dedicated software is installed.

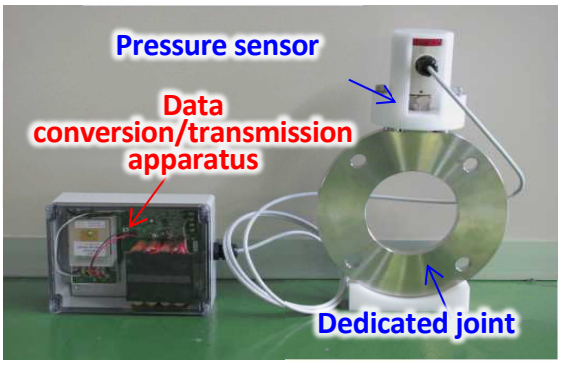

Photo 2 Terminal unit set

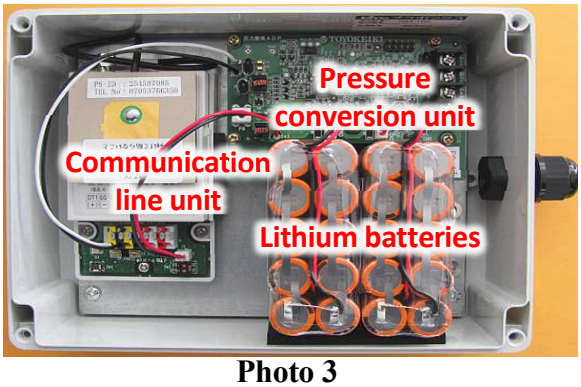

Photo 3
Data conversion/transmission apparatus

【Software functions】

In order to satisfy required performance, software having the following functions was developed.

- Function 1: It is possible to collect water supply pressure values of target facility as a data batch method (available period collection with an interval of 1 min to 60 min)
- Function 2: It is possible to simultaneously measure the remaining battery level and the electric field strength of the transmitter of water supply pressure value and data conversion unit and display it on the screen and automatically save data with the spreadsheet software
- Function 3: Automatic collection schedule setting and normal pressure range can be set for each target facility.

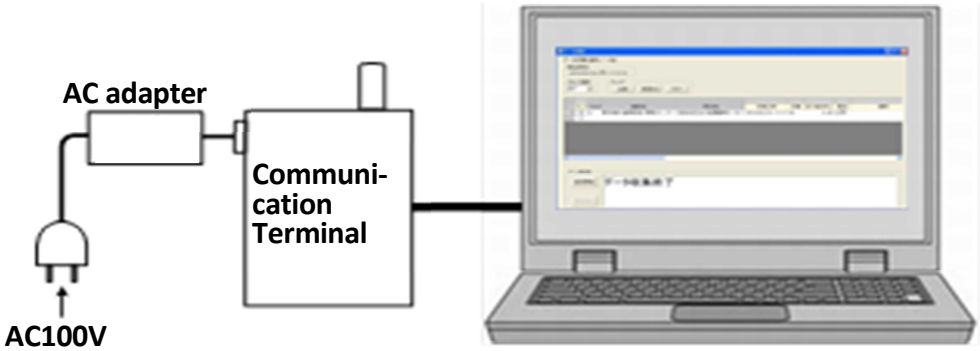

Figure 4 Configuration of Data Collection System

Figure 5 Configuration of Data Collection (sample screen)

5.7 Result of the Network Test

Three disaster base hospitals distant from the unit were chosen and the network proof test was executed in order to validate the developed system.

(1) Installation of terminal units

After checking the electric field strength in the water meter BOX in advance in the premises of three sites, we installed the pressure sensor and the data conversion transmitter.

【Installation of pressure sensor】

The pressure sensor was installed, sandwiched by the upstream flange portion of the water meter.

Photo 4 Installation of Pressure Sensor

【Installation of data conversion/transmission apparatus】

As for the data conversion/transmission apparatus, we measured the electric field intensity in a water meter box using the PHS communication unit for about two weeks in advance, and installed it in the water meter box when the communication is stable.

Photo 5 Installed Data Conversion/Transmission Apparatus

(2) Result of the Network Proof Test

As a result of performing the test at three disaster hospitals for three months, we were able to construct what can satisfy the original performance required, with a satisfactory result from both of the terminal units and the data collection center.

【Communication success rate】

We checked communication on the hour (24 times a day) for 3 months after installation (6,549 times in total). Initially there was no retry function, which led to failure sometimes due to the weak electric field and busy base station. However, all communication attempts succeeded after we added one retry function, achieving 100% of the communication success rate.

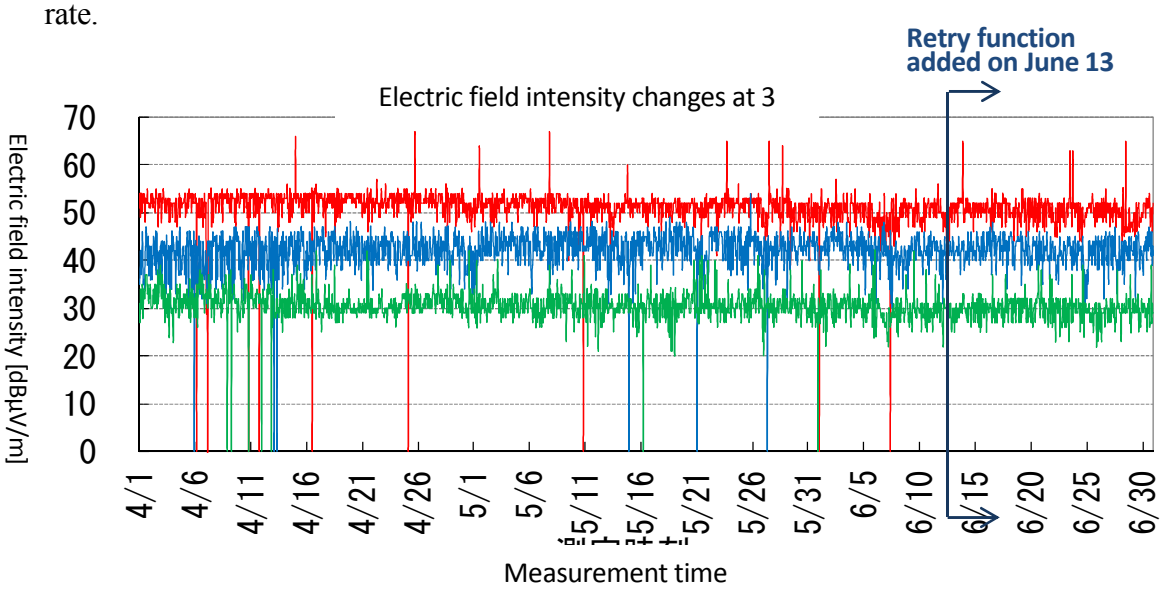

Figure 6 Electric field intensity changes at 3

【Measured values of water supply pressure】

We reviewed whether the water supply pressure value measured on site using the pressure sensor was appropriate. As a result, it was confirmed that the water supply pressure values detected at the target facility were similar to the values measured at the neighboring fire hydrant, and were appropriate.

【Data collection function】

We reviewed whether the water supply pressure data communicated to the data collection system was correctly collected and stored via the terminal units installed. As a result, each communication was saved correctly in an Excel file.

	ﾌﾞﾛｯｸ	施設名	所在地	収集日時	収集	圧力値(MPa)	電池	備考
83	ﾃｽﾄ	B病院	江戸川区臨海町1-4-2	2014/02/04 00:00	OK	0.29	正常	
84	ﾃｽﾄ		江戸川区臨海町1-4-2	2014/02/04 01:00	OK	0.31	正常	
85	ﾃｽﾄ		江戸川区臨海町1-4-2	2014/02/04 02:00	OK	0.31	正常	
86	ﾃｽﾄ		江戸川区臨海町1-4-2	2014/02/04 03:00	OK	0.32	正常	PHS電波微弱/
87	ﾃｽﾄ		江戸川区臨海町1-4-2	2014/02/04 04:00	OK	0.32	正常	
88	ﾃｽﾄ		江戸川区臨海町1-4-2	2014/02/04 05:00	OK	0.31	正常	

Figure 7　Storage status of collected data

6. Conclusion

By adopting this system, water supply pressure in capital's central agencies can be monitored from the office. This will make it possible for us to identify facilities with decreasing water supply pressure early on and to quickly narrow down facilities to be investigated and recovered on a priority basis.

As a result of the measures, time needed to recover the damaged facilities will be shortened. For example, if 58 facilities (about half of the existing 115 facilities) are damaged, they will be recovered in 40 hours in the new system. It is shorter by 40 % than the estimated 63 hours under the conventional system, and water supply will be restored much quicker.

BWTMG plans to implement this system to all of the 137 central capital institutions by the end of FY2017.

BWTMG will further enhance emergency measures by introducing the system to more than 800 key facilities, including refugee centers and medical institutions, which give aid to and accommodate disaster victims.

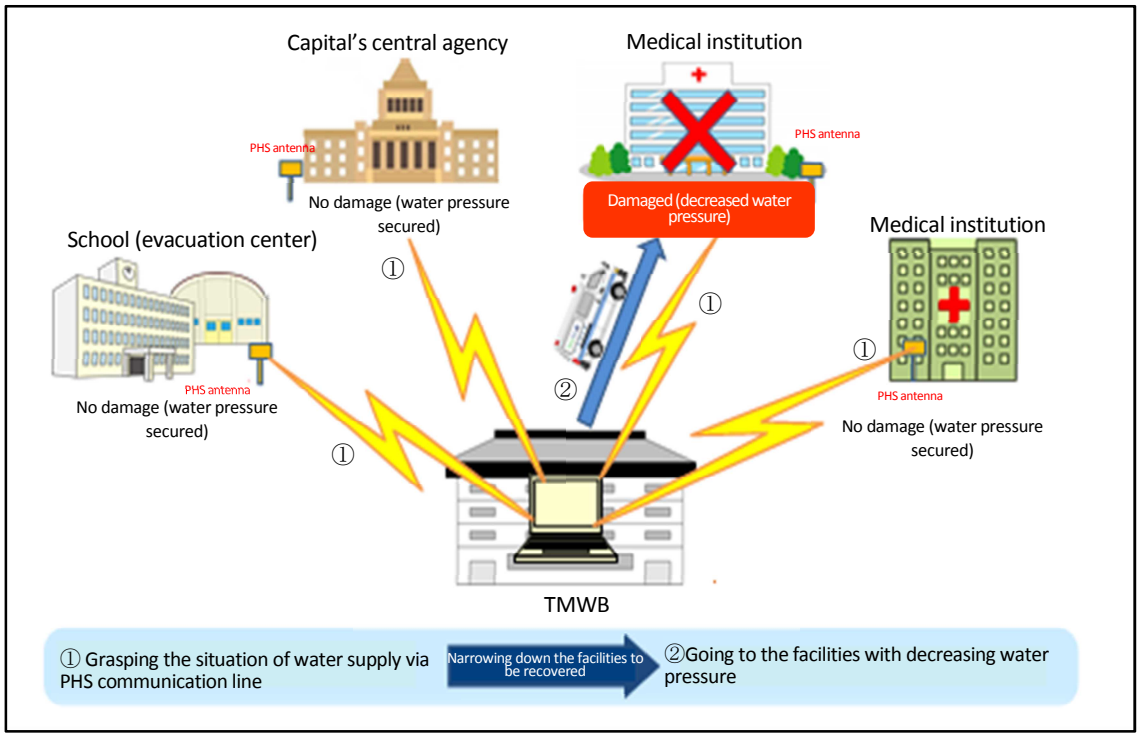

Figure 8　Image of Facilities targeted for Accommodation

(※1) Abbreviation for Personal Handy-phone System
Wireless communication lines using the frequency of the 1.9 GHz band in Japan