

Concept of Waterworks in Disaster Relief based on the 2016 Kumamoto Earthquake

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ABSTRACT

In the occurrence of the 2016 Kumamoto Earthquake, Osaka Municipal Waterworks Bureau had sent the cumulative total of 42 staff to the affected area in five cycles for one month in which the 1st batch was sent on 16th April, the day of receiving request from Relief Headquarter, until the final 5th batch returned Osaka on 14th May to implement three supporting activities, emergency water supply, emergency restoration and back up support. We reported our performance of supporting activities during the dispatch period and the background of completion of those activities. Based on the experience of the 2016 Kumamoto Earthquake, Osaka Municipal Waterworks Bureau has drawn up the guideline, serving as a road map of supporting activities in case that a large-scale disaster occurs at other cities. This guideline has intended to implement prompt and effective supporting activities when large-scale disaster occurs somewhere in Japan in the future. At the end of this report, we introduce the construction of accepting support plan from waterworks entities of other cities when disaster hits Osaka along with Business Continuity Plan of Osaka Municipal Waterworks Bureau (BCP) that we're currently revising.

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PREFACE

The 2016 Kumamoto earthquake recorded on the Japanese seven-stage seismic scale, which damaged not only human and property but also the waterworks system enormously. In Kumamoto City, located near the epicenter, all households underwent water suspension temporarily. Since The East Great Japan Earthquake, preparation is being re-assessed all over in Japan for anticipated heavy damage or widespread disaster, such as Nankai Trough earthquake and earthquake centered directly under the capital etc. The 2016 Kumamoto Earthquake reminds us that a large-scale earthquake can possibly occurs anywhere in Japan. In this paper, we report on three points; the concept of supporting activities of Osaka Municipal Waterworks Bureau at the affected area in the 2016 Kumamoto earthquake, construction of support system in preparation for large disaster based on the issues arising from the supporting activities this time and construction of system of accepting support in case that we suffer from a disaster and are in a position of accepting support.

OCCURRENCE OF KUMAMOTO EARTHQUAKE

On 14th and 16th April 2016, the inland earthquake, the epicenter of Kumamoto region with the intensity of 7 struck Kumamoto area. It caused enormous damage extensively in Kumamoto city and to its near areas. In Kumamoto City, out of 96 water sources (wells) in service, 69 was disrupted due to increase of the turbidity by foreshock on 14th April, resulting in water suspension for 85,000 households. Furthermore, all 96 water sources were disrupted, resulting in water suspension for all households, 326,000 approximately due to main shock in 16th April. In responding to the foreshock on 14th April, Relief Headquarter of Japan Waterworks Association (hereafter, referred as the Relief Headquarter) was established under the initiative of JWWA consisting of water suppliers and private companies across the nation. In the morning of main shock occurrence on 16th April, the Relief Headquarter requested Kansai regional chapter of JWWA for the support to Kumamoto city. (Figure 1) The flow of this support request is based on "Guideline for Response to Earthquakes and other Emergencies", revised in March 2013. In responding to the request, Osaka city, the head of Kansai regional chapter of JWWA, and six entities belonging to Kansai regional chapter dispatched support team.

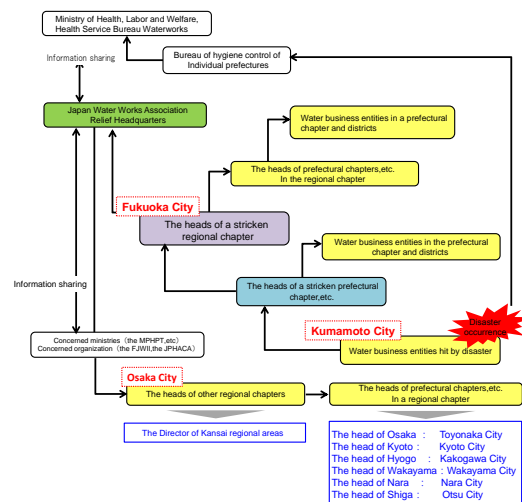


Figure 1. Flow of support request

OUTLINE OF SUPPORTER ACTIVITIES

Emergency Water Supply Team

(1) Role of Emergency Water Supply Team

Emergency water supply point was opened at 33 places maximum in five districts including, Higashi, Nishi, Minami, Kita and Chuo districts. Also the support team, cumulative total of 4,286 personnel from 97 water suppliers implemented supporting activities with the cumulative total of 1,027 water tank trucks. The 1st, 3rd and 4th batches of Osaka City implemented emergency water supporting activities, delivering water to 6 points in Higashi district and each emergency water service point with two water tank trucks (four tons each). Particularly, 4 ton of emergency water tank truck owned by Osaka City was larger than any trucks provided by other cities. It equipped with pressure function and served as supply vehicle, which contributing smooth emergency water supply implementation.

(2) Constituent of Emergency Water Supply Team

<Dispatch period>

16th April 2016 to 6th May 2016 (21 days)

Active period

17th April 2016 to 2nd May 2016 (16 days)

<Headcount>

1st batch: 7 persons

3rd batch: 6 persons

4th batch: 6 persons

Total 19 persons

(3) Performance of Emergency water supply of Osaka City

The performance of supporting activities by Osaka Municipal Waterworks Bureau is as below

	1 st batch	3 rd batch	4 th batch	Total
Cumulative total person	42	48	12	102
Emergency water supply (ton)	95	26	2	123
Cumulative total emergency water supply points	16	8	2	26

Emergency Water Restoration Team

(1) Role of Emergency Water Restoration Team

Emergency restoration activities were conducted from 17th April to 17th May. In Kengun and Akita water distribution areas, the main water distribution area, leak detection activities and leakages that had been found out by leak detection activities were restored.

Leak detection work was conducted by the support team consisting of the cumulative total of 313 staff from 19 waterworks suppliers across the country. In addition, leak restoration work was conducted by 75 construction companies as well as cumulative total of 5,216 personnel from 54 waterworks entities

The 2nd, 4th and 5th batches of Osaka City implemented emergency restoration activities. Kengun and Akita water distribution areas were divided into 17 blocks, Kansai regional branch was assigned for 4 out of 17 blocks. Among those, Osaka city was responsible for 1 block that covers Chuo and Higashi districts, conducting water leak detection, as well as leakage restoration work for distribution pipes and service pipes in collaboration with the construction companies

dispatched from Osaka city.

(2) Constituent of Emergency restoration team

<Dispatch term>

21st April 2016 to 14th May 2016 (24 days)

Action period

22nd April 2016 to 13th May 2016 (22 days)

<Headcount>

2nd batch: 3 persons

4th batch: 3 persons

5th batch: 3 persons

Total 9 or persons

(3) Performance of emergency water supply activity

The performance of supporting activities by Osaka Municipal Waterworks Bureau is as below

TABLE 2. PERFORMANCE OF EMERGENCY RESTORATION ACTIVITIES

Leak detection	Road surface inspection (Visual inspection)	0.78km ²	22 nd to 24 th April
	Door to door inspection	Total number of inspection • 2,231 Leak detected • 34	25 th April to 13 th May
Leak restoration	Direct management or construction company	35	28 th to 13 th May

On-site Headquarter

(1) Role of on-site Headquarter as Logistics Support of Emergency Water Supply

On-site Headquarter of Osaka City was stationed in Kumamoto Water and Sewage Bureau office. The leader attended a meeting held by Kumamoto Water and Sewage Bureau to learn the progress of emergency water supply activities and collect necessary information for implementing activities. In addition, Osaka City was assigned as the leader of Higashi district along with Nagoya City, comprehending the volume of emergency supply water, developing the deployment schedule of emergency water supply trucks and taking initiative for other support team in Higashi district.

(2) Role of the on-site Headquarter as Logistics Supporter of Emergency Water Restoration

Since it was difficult for Kumamoto Water and Sewerage Bureau to set up the system as affected area, they could not be involved in the overall instruction for the emergency restoration activities. Thus, in accordance with the agreement of time of disaster (Memorandum of mutual support for disaster by the waterworks bureaus of 19) signed by 19 government-designated cities in Japan, Emergency restoration headquarter was established by Fukuoka City, the primary city for aid, and JWWA. Beneath that, six sub-teams were established independently (Figure 2).

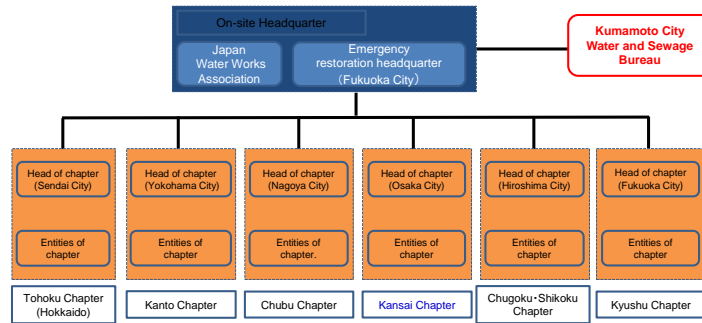


Figure 2 .On-site organization chart of emergency restoration

As the director of Kansai regional branch, on-site headquarter team of the Osaka City attended meeting every morning to comprehend the progress of emergency restoration activities and collect information and share the information within the branch. Also, in order to proceed with water leak detection and leak restoration activities in the assigned areas, we managed the leakage locations and restored areas by describing in a report and took initiative for other entities within the branch.

(3) Role of on-site Headquarter within the Support Team of Osaka City

On-site headquarter reported the activities performed by Osaka Municipal Waterworks Bureau and requested the commodities for implementing activities to Osaka Municipal Waterworks Bureau by 8 O'clock every morning. Also, payment control for procurement of requisite items, accommodation fee, petrol fee, etc., attendance management of staff were conducted by the headquarter.

Completion of Supporter Activities

(1) Withdrawal of Emergency Water Support Team

Since the occurrence of earthquake, the leak detection and leakage restoration effort was given by Kumamoto City and the support teams including Osaka City. As a result, leakage volume was decreased in two weeks and distribution amount was reduced. On the other hand, water pressure started increasing at the furthestmost area from the water source, indicating improvement of water supply condition. (Figure 3)

In line with the trend, Kumamoto City had suggested reduction of support in the afternoon of 28th April, and then stated that water supply system had been restored in the entire of the city on 30th April.

In responding to the statement, Osaka City released emergency water supply team on 2nd May. After 2nd May, the work had been handled by Kumamoto Waterworks and Sewerage Bureau and Kyushu Branch of Japan Waterworks Association, and emergency water supply activities were finally completed on 6th May.

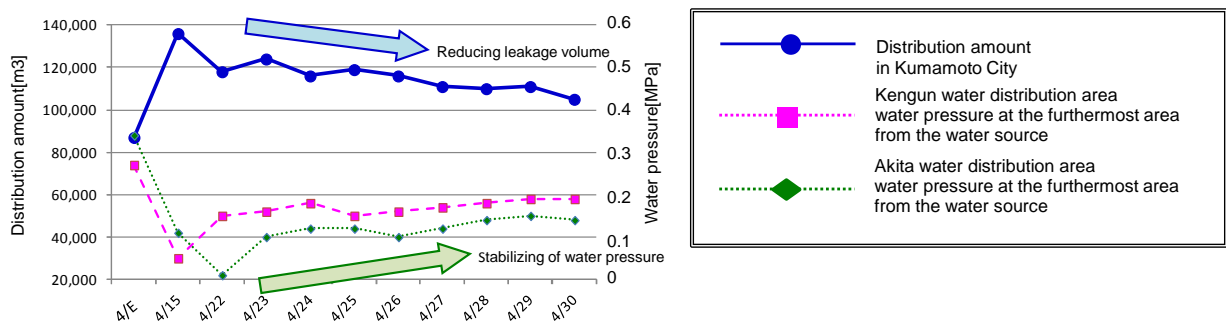


Figure 3. Distribution amount and water pressure at the furthestmost area from the water source (Early April to 30th April)

(2) Withdrawal of Emergency Restoration Team and on-site Headquarter

After that, water supply volume has been decreased due to the effort of leak detection and leak restoration by Kumamoto City and support teams. The water pressure of the furthest area from the water source indicated 0.20MPa. Kumamoto City suggested reduction of emergency restoration system because water supply condition had restored to the same level as before the disaster. Next day 6th May, Relief Headquarter officially announced reduction of support system. Each support team shifted to withdrawal. Then, the emergency restoration activities by support team were finally completed as of 17th May. For withdrawal, Osaka City was committed for completing the restoration service on the leakages detected at the area in charge as the director of Kansai regional branch and handing it over to Kumamoto City. On 13th May, we completed all restoration works and withdrew the support team next day, 14th May.

GUIDELINE OF SUPPORTER DISPATCH OF OSAKA MUNICIPAL WATERWORKS BUREAU

Background of Developing of Supporter Dispatch Guideline

At the time of large scale disaster, it is important to construct the system to confront danger under the coordination with relevant institutions. Although Osaka Municipal Waterworks Bureau had given support for the 2016 Kumamoto Earthquake and the Great East Japan Earthquake in 2011, the detailed support system for the city outside Osaka was not decided. For this, some confusion occurred to initial response from receiving support request directly after the outbreak of earthquake to dispatching support, which became the issue we had to improve. Based on the lesson and knowledge acquired through the experience of support implementation, we have drawn up "Guideline for dispatching supporter of Osaka Municipal Waterworks Bureau" (hereafter referred as the Guideline) that designates the standard behavior about supporter dispatch system and assignation of administration work for implementing supporter dispatch to the areas outside Osaka City.

Outline and Structure of the Supporter Dispatch Guideline

To develop the Guideline, we heard the opinion of our staff who had implemented on-site supporting activities. We considered that the opinion and knowledge based on on-site experience is the key for creating practical guideline. As a result of hearing, we found the points to be improved as below;

- Support system
Clarify a flow from the occurrence of disaster to deciding support within in-house organization
- Document (Report formant for sharing information within the site)
- Preparation including equipment (Itemizing the equipments to be brought with supporter dispatch and staff in-charge of procurement for those items)

Based on those opinions, we summarized the details of support system, documents and list of equipment etc. in the guideline.

Collecting Disaster Information, Emergency Assembly, Contact and Coordination

As for disaster occurrence information, each action, from information gathering by each staff for the intensity, epicenter and initial damage status through radio or television, etc., to implementing supporter dispatch is extracted (Figure 4).

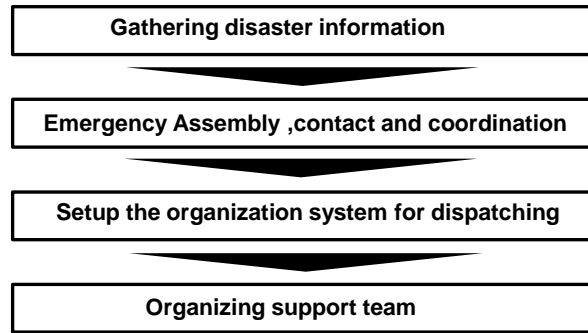


Figure 4.Flow of dispatch support of Osaka Municipal Waterworks Bureau

As a step for developing organization of dispatching support, it is necessary to collect information of damage of water systems at the affected entities, the condition of emergency assembly was added in case of the occurrence of disaster on holiday or off-duty time. (Table 3)

TABLE 3. NECESSARY CONDITIONS FOR ASSEMBLING (HOLIDAY AND OFF-DUTY)

Place of occurrence	The necessary conditions for assembling
○Kansai region 6 prefectures (Osaka, Kyoto, Hyogo, Nara, Shiga, Wakayama) ※In case of Osaka City being affected, Kobe City is included as the primary support city.	Intensity lower 5 or more
○Fukuoka City (Secondary support city in case of Osaka being affected)	
○ Other prefectures	Intensity upper 6 or more

Based on this condition, emergency assembly members (TABLE 4) gather in Osaka Municipal Waterworks Bureau office, they coordinate with the affected waterworks entity or other cities that back up the affected waterworks entity for confirming the damage status and support request as appropriate.

TABLE 4.ASSEMBLING MEMBERS IN EMERGENCY (HOLIDAY AND OFF-DUTY)

assembling members in emergency
Manager for General Affairs Department Manager for Emergency Management Assistant manager for Emergency Management Administrative Staff for General Affairs Department Staff for Emergency Management

Developing Systems for Dispatching Support

In case of being requested for dispatching support, we set up the Aid Headquarter and decide

operation method. Aid Headquarter is positioned as an in-house organization so as to determine the system of dispatching support. We have sorted out the constituent members including the director of Waterworks Bureau, as chief of Aid headquarter, and secretary office. Along with this, the work description of coordinator and logistics support is summarized and the responsibility of each related section is clarified, making it possible for smooth action when dispatching support. (TABLE 5, 6)

<Contact and coordination>

Coordination is implemented by General affairs Department, mainly collecting disaster information of affected waterworks entity and serving as a contact with the related institutions.

TABLE 5. IN CHARGE OF CONTACT AND COORDINATION

Work description (According to the timeline after the occurrence)
<input type="checkbox"/> Collecting and integrating basic information about affected entity (Receiving support request from the affected entity)
<input type="checkbox"/> Setting up and running Aid Headquarter
<input type="checkbox"/> Providing information to General manager of Head Office, staff of Head Office
<input type="checkbox"/> Providing information to the media
<input type="checkbox"/> Reservation of accommodation and transportation for dispatching support
<input type="checkbox"/> Itemizing the commodities and goods to be brought with support dispatch
<input type="checkbox"/> Information sharing with support team members
<input type="checkbox"/> Arrange the expense claim for dispatching support

<Back up support>

Each procurement team arranges the personnel and materials required for emergency water supply, emergency restoration activities and on-site headquarter activities.

TABLE 6. IN CHARGE OF BACK UP SUPPORT

In charge of procurement	Work description
Related Department	<input type="checkbox"/> Arrangement of the personnel of support team
Water Distribution/ Water Service Installation department	<input type="checkbox"/> Arrangement of the vendors for emergency restoration
Emergency management Section, General Affairs Department	<input type="checkbox"/> Arrangement of uniform (disaster prevention cloth) <input type="checkbox"/> Arrangement of emblem for dispatch support vehicle (stickers, banners) <input type="checkbox"/> Arrangement of stationaries for on-site activities <input type="checkbox"/> Arrangement of requisite supplies for life and hygiene
ICT Promotion Department	<input type="checkbox"/> Setting of information sharing tools (Google account) <input type="checkbox"/> Arrangement Personal Digital Assistance (Portable PC, Smart phone)
General Affairs/ Accounting Department	<input type="checkbox"/> Arrangement of funds required for support activities
Personnel Department (Training/Welfare)	<input type="checkbox"/> Arrangement of spare uniforms and rain gears for support team members <input type="checkbox"/> Arrangement of foods, etc. <input type="checkbox"/> Arrangement of medical supplies, first aid kit, etc.
Waterworks Maintenance Center	<input type="checkbox"/> Arrangement of vehicles to dispatch (Chief car, Emergency water supply truck) <input type="checkbox"/> Arrangement of emergency water supply material (Emergency water supply bag, temporary water tap) <input type="checkbox"/> Arrangement of emergency restoration materials (leak detector, leak sound detection bar)

Organizing the support system

Next, we developed a basic framework of support team to be dispatched.

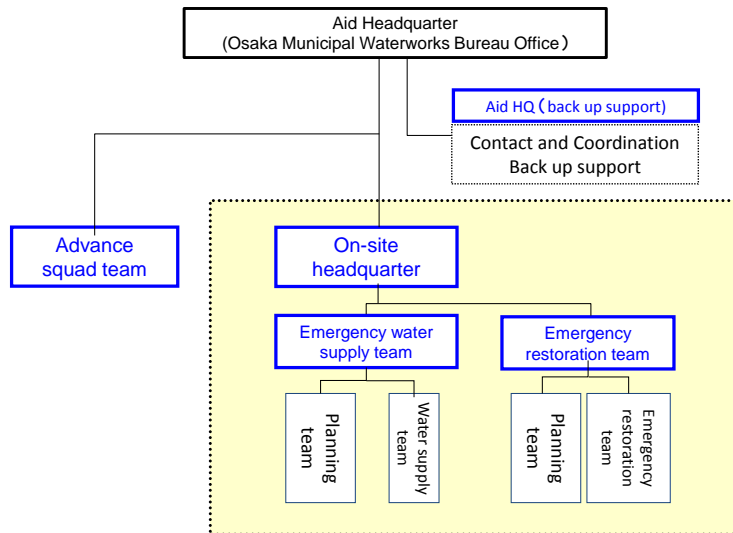


Figure 5. Standard organization of support team

Although Aid Headquarter will decide the scale of each team and its constituent members considering the detail of support request and damage status, etc., the guideline for each team is standardized based on the dispatch activities in the past. (TABLE 7)

TABLE 7. RESPONSIBILITY OF EACH TEAM AND CONSTITUENT MEMBERS

Formation of support team	Responsibilities	Head counts
<div style="border: 1px solid black; padding: 2px; width: fit-content;">Advance squad team</div>	<ul style="list-style-type: none"> • Secure (select) the transportation route to the affected area • Gather information of affected area (Disaster status, water suspension and restoration progress and prospect) • Set up on-site operation headquarter • Secure the operation site (including accommodation) • Contact and coordination with affected area and comprehend the requisite support 	Per team 2 or more members
<div style="border: 1px solid black; padding: 2px; width: fit-content;">On-site headquarter</div>	<ul style="list-style-type: none"> • Comprehend the disaster situation • Contact and coordination with Aid HQ (Osaka) and report the progress • Contact and coordination with related institution on site • Coordination with authoritative support team and integration of information • Develop the emergency supply water plan and restoration plan • Back up support of each team (select and procure the requisite goods) • Contact and coordination as Director of Kansai regional area of JWVA 	Per team Leader: 1 Member: 2 or more (including sub-leader)
<div style="display: flex; align-items: center; gap: 5px;"> <div style="border: 1px solid black; padding: 2px; width: fit-content;">Emergency water supply team</div> <div style="display: flex; flex-direction: column; gap: 5px;"> <div style="border: 1px solid black; padding: 2px; width: fit-content;">Planning team</div> <div style="border: 1px solid black; padding: 2px; width: fit-content;">Emergency water supply team</div> </div> </div>	<ul style="list-style-type: none"> • Take command at site, Report the progress of emergency water supply team (early stage of support) • Take command at site, Report the progress of on-site operation status • Develop the emergency water supply plan • Gather necessary information for emergency water supply plan / contact and coordination • Manage and integration of claim and request from the users • Emergency water supply activities and water supply activities at site 	Per team (2 emergency water tank trucks) Member: 4 or more
<div style="display: flex; align-items: center; gap: 5px;"> <div style="border: 1px solid black; padding: 2px; width: fit-content;">Emergency restoration team</div> <div style="display: flex; flex-direction: column; gap: 5px;"> <div style="border: 1px solid black; padding: 2px; width: fit-content;">Planning team</div> <div style="border: 1px solid black; padding: 2px; width: fit-content;">Emergency restoration team</div> </div> </div>	<ul style="list-style-type: none"> • Take command at site, Report the progress emergency restoration team (early stage of support) • Planning of water suspension work • Leak detection • Supervise the contractors (Leak restoration work) 	Per team Leak detection: 3 or more Supervise the contractor : 2 or more

Dispatch term

Furthermore, in case of large scale disaster, dispatch period is assumed to prolong, the idea of the term and rotation is sorted out based on the actual supporter dispatch.

Except the survey team dispatched immediately after the occurrence of disaster, the dispatch period of each team is short term (1 week to 10 days) as a rule, middle term (2 weeks approximately) at a maximum considering the on-site activities, accommodation status, and health condition of members.(TABLE8)

TABLE 8. DISPATCH PERIOD OF SUPPORT TEAM

Support team	Dispatch term
Advance	Several days
On-site headquarter	Short term (1 week to 10days) ~middle term (2 weeks approx.)
Emergency water supply	
Emergency restoration	

(1) The status in Kumamoto Earthquake in 2016

During one month of the support for the 2016 Kumamoto Earthquake, all members of support team were changed each time. In that case, when a handover took place in a day time, the advance team members could stay only for a short time as they had to go back to Osaka. As a result, only a short time could be spent on handover. On the other hand, in case of handover overnight, longer time could be spent, however as the number of people who stayed in accommodation became twice as much, reservation for accommodation was difficult.

(2) Solution

To solve this issue, the half of members are changed as a rule so that the members of newly-arrived batch can work on supporting activities while taking over from the advance team member, making it possible for smooth handover. In addition, sub-leader is assigned in each team so that he or she assists the leader of advance team while taking over from the leader, and in the late half period he or she takes over the position of leader at the timing of rotation, enabling smooth handover of operation of leader. Also, in order to exchange information effectively, it is important to arrange the rotation timing flexibly so as to avoid overlapping the rotation period with other waterworks entities as much as possible.

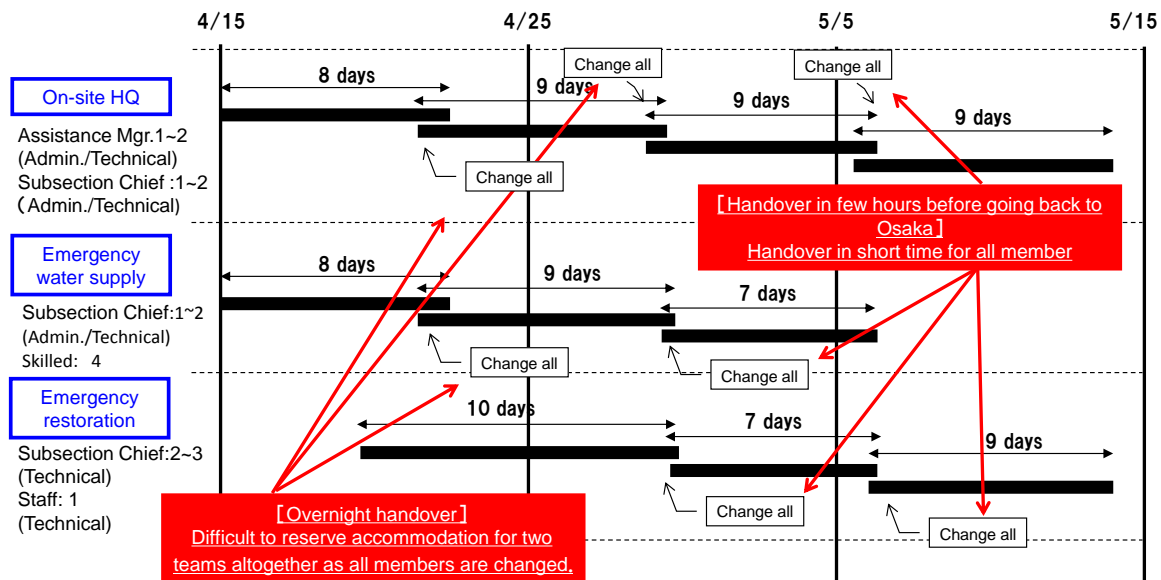


Figure 6. Supporter dispatch system for the 2016 Kumamoto Earthquake (change all members)

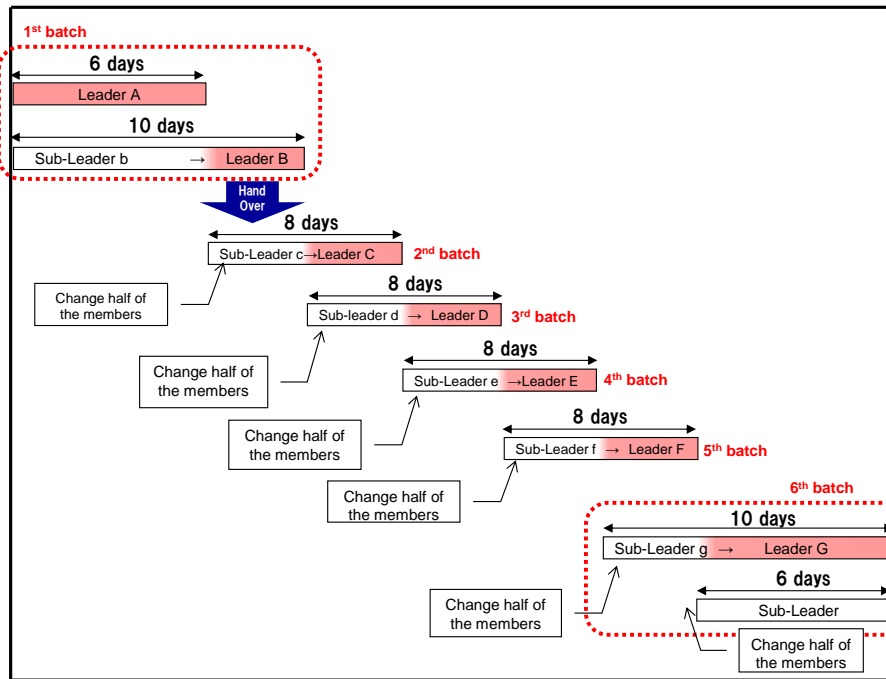


Figure 7. Image of changing half of the team members

CONCEPT OF ACCEPTING SUPPORT

With respect to the supporter dispatch, the guideline has been developed based on the experience in the past. On the other hand, the importance of accepting support is now being recognized in case that Osaka City suffers from disaster. In this chapter, we report on the Osaka Municipal Waterworks Bureau Business Continuity Plan (BCP).

Review of Business Continuity Plan (BCP) of Osaka Municipal Waterworks Bureau

(1) Circumstances of Osaka Municipal Waterworks Bureau Business Continuity Plan

Osaka Municipal Waterworks Bureau has determined the policy, system and procedure in Business Continuity Plan issued in 2010 in order to continue the key business or recover the business as quickly as possible even under the occurrence of large scale disaster such as earthquake. It has been developed based on the damage prediction for city-wide pipeline in 2005 to 2006 and the evaluation on influence of reducing water and water suspension in the city based on the prediction. However, it has been almost ten years since the prediction of city-wide pipeline damage and the survey on influence of reducing water or water suspension. Considering the fact that disaster beyond the prediction and complex disaster occurs in recent year, it is obvious that the data of 10 years behind does not keep up with the current situation.

The government has reviewed predicted immersion caused by river flood or tide in accordance with partial revision of Flood Control Act. In Osaka City, Nankai Trough earthquake was added for new anticipated earthquake, and possible disaster and damage is now being reviewed.

On the other hand, Osaka Municipal Waterworks Bureau has proceeding with enhancing the facilities such as earthquake resistance of water purification plants and pipelines, or expansion of main line network, development of service reservoir, etc. For constructing the system of accepting support of Osaka Municipal Waterworks Bureau in time of large-scale disaster, it is necessary to comprehend the possible damage upon re-evaluating the existing assumption of damage considering the change and progress of internal and external environments.

Estimation of Damage and Accepting Support System

(1) Estimation of the Volume of City-wide Pipelines Damage

First of all, it is planned to estimate the volume of damage of city-wide pipeline by predicting the ground motion and possibility of liquefaction considering the latest enhancement status such as earthquake resistance of pipelines and water purification plants. The number of damage of city-wide pipelines is estimated using a formula developed uniquely by Osaka Municipal Waterworks Bureau that can incorporate damage characteristics of both liquefied and non-liquefied grounds through the combined data of Great Hanshin and Awaji earthquake and the Great East Japan earthquake.

(2) Estimation of required team and instruments

Next, the number of team required for emergency restoration activities is estimated based on the assumed restoration progress considering the volume of damaged city-wide pipeline. To minimize the water suspension area, water supply plan is developed by calculating the number of team necessary for emergency water supply activities and the quantity of required instruments.

In times of great disaster, much manpower is required. Osaka Municipal Waterworks Bureau has signed the agreement of mutual assistance with the waterworks entities of other cities, preparing for the shortage of human and material resources. For this, we have determined the number of teams and equipment which we can acquire by ourselves. Then, as for the shortage, we determine the number of team required for restoring normal water service within the restoration period defined for each predicted earthquake, provided that we accept the assistance such as personnel and instruments etc., under the agreement of mutual assistance with waterworks entities of other cities.

(3) Construction of Accepting Support System

As a preparation of accepting support team, we set up a single contact for accepting support, preparing message for support request (the scale of support, assembly place, etc.), facility for accepting support (hub for supporting activities after assembly, capacity of people as water facility, car parking, etc.), also for preparation of smooth emergency work activities after accepting, support accepting system (activities of support team, information providing for activities), record of support progress (develop a format for comprehending the restoration status), etc., which will be clarified as accepting support plan and reflected onto Business Continuity Plan.

CONCLUSION

The 2016 Kumamoto Earthquake was the large-scale disaster that directly hits Kumamoto City, which is one of the government-designated cities in Japan.

After main shock, all households underwent water suspension and the city-wide pipelines were damaged. However, prompt restoration was conducted thanks to the numerous supports given from all over Japan, which showed the strong bond of waterworks industry. On the other hand, the supporting dispatch made us recognize the importance of setup of support system for the affected waterworks entity after the earthquake, in addition the importance of preparation for accepting support in case that we are in a position of being supported from waterworks entity of other cities. We consider it as our mission to make use of lesson and knowledge we learn from the dispatch supporting activities and construct the support and accepting support system.