Mutual water accommodation with neighboring water suppliers

Bureau of Waterworks, Tokyo Metropolitan Government

1. New concept of widening water-supply areas

Widening water-supply areas has been a repeatedly discussed issue because of stringent state of water supply/demand, increase in waterworks construction cost and rise in water rates, and their regional disparities. The Bureau of Waterworks has so far taken positive steps for unified operation of water supply in Tama district, and has become the largest water supplier with a wide supply area in Japan. We are making efforts to improve stability of water supply by making effective use of the benefit of a large-scale corporation. To put it precisely, we are making effective use of the raw-water connecting function between the different water systems of the Tone River and the Tama River, consolidating the mutual water accommodation function through establishment of a water transmission network, etc.

We are implementing wide-area water-supply services even in the neighboring prefectures Saitama and Kanagawa, covering a certain area in these prefectures for water supply.

However, since water supply services are basically managed by local governments, the cooperation among water suppliers beyond prefectural regions is confined mainly to the software level, such as the mutual support among the bureaus of waterworks of 13 major metropolitan areas at the time of disaster, etc., with the cooperation in the field of facilities still lacking.

Taking measures against diversified risks such as the likely imminent epicentral earthquake in Tokyo, the NBC disaster, etc. has become a problem common to all water suppliers. In order to cope with such problems, measures taken only by individual suppliers don’t go a long way, and a new concept of widening water-supply areas without resorting to the conventional ideas is necessary.

The mutual water accommodation promotes risk sharing by connecting the network of waterworks facilities of each water supplier using connection pipes and through planar expansion of these facilities. Such large-scale mutual water accommodation beyond prefectural regions has taken place for the first time in Japan.

This paper describes the measures so far taken for mutual water accommodation and its future prospects.
2. Measures for realization of mutual water accommodation

With the ultimate goal of realization of mutual water accommodation, we started with the study on the installation of connection pipes for emergency use at the time of disaster in order to promote smooth consensus building among the neighboring water suppliers.

(1) Effect of mutual water accommodation at disaster

In case the infrastructure gets damaged due to disaster, the connection pipes ensure alternative routes, diminishing the risk of water outage or low water. Further, in the case of transmission pipe connection, the networks of water facilities of each water supplier get connected by the connection pipes and improve the backup function in a wider range. Compared with the transmission pipe connection, the distribution pipe connection lacks in wide-area coverage, but it is effective for districts with inadequate backup function.

The example of the Hanshin-Awaji Earthquake shows that one of the key factors for early restoration is the availability of water for restoration. In order to identify the spot of leakage, a large volume of water is required, in addition to the water needed for pipe cleaning and water filling. In the case of Kobe City, water leakage showed a temporary increase as the water supply area expanded, indicating that the water supply area cannot be expanded unless the water supply volume is increased.

The improvement of the wide-range backup function promotes sharing of reserve water owned by each water supplier and ensures the availability of required water volume, thus leading to early restoration of water supply service. Besides, this also prevents the redundant investments on reserve power.

Further, the linkage among the water suppliers having different water systems as the
water resource can contribute to reducing the effect of a large-scale accident involving water quality.

The “Major Measures and Policies” drafted by the Tokyo Metropolitan Government in 2002 includes the item of mutual water accommodation from the viewpoint of wide-range water supply.

(2) Study on the installation of connection pipes

In order to select the candidate sites for the installation of connection pipes, Tokyo Government carried out the basic survey on commission.

a) Basic concepts

In selection of candidate sites priority was given to the conditions given below from the viewpoint of cost. Effectiveness.

- The sites with neighborhood pipelines
- The sites with considerable water volume available for accommodation

b) Sites surveyed

The 6 water suppliers of neighboring 5 prefectures and cities (Kanagawa Prefecture Corporate Agency, Saitama Prefecture Enterprise Bureau, Chiba Prefecture Waterworks Bureau, Wide-area Water Suppliers Group in Kanagawa Prefecture, Yokohama City Waterworks Bureau, and Kawasaki City Waterworks Bureau) and other water suppliers neighboring the Metropolis of Tokyo.

c) Contents of survey

Water supply volume, water supply scope, diameter and extension of connection pipe, rough construction cost, etc.

d) Object of survey

Since the connection pipe is for emergency use, supply water was basically the treated water, with the level of connection pipe being the same as that of transmission or distribution pipe.

e) Volume of supply water

The supply water volume was set to be within the scope of the reserve capacity of the water supplying facility, and was calculated so as not to give adverse effect to the water distribution in the service area of the supplying side. First of all, the reserve capacity was obtained by the difference between the capacities of the water purification plant or pump station facility at the upstream of the water distribution system where the connecting pipe is located and the average daily water distribution volume. The supply water volume of transmission pipe was calculated on the basis of operating states (at rest, at total head, etc.) of the transmission pipe in both sides. In calculating the supply water volume of distribution pipe, the water head drop of the connected section on the supplying side was set to 5 m or under at the time of water supply. This is because, at the time of supplying accommodation water, the normal volume of distribution water added with the accommodation water is distributed, causing a
frictional loss larger than the normal value to occur between the source and the connected section. The water distribution volume at the receiving end and the upper limit of pipe flow velocity were also taken into account in calculation of accommodation water volume.

f) Study on the serviceable scope
After verifying the water head of the receiving side connecting site and the altitude of the receiving side water system using 250 m-mesh, the site was judged serviceable if the effective water head was found to be 15m or over.

g) Survey result
The relationship between the total accommodation water volume of the 22 candidate connection sites and the rough construction cost is shown in Fig. 3, indicating that the ratio between total accommodation water volume and rough construction cost in Asaka and Noborito is minimum, i.e. the cost vs. effect ratio is maximum. Further, taking into consideration of the geographical conditions, Machida was also found to have a high cost vs. effect ratio next to the above two.

![Fig. 2 Study on the serviceable scope using 250 m-mesh](image1)

![Fig. 3 Relationship between total accommodation water volume and rough construction cost](image2)

(3) Study framework with neighboring water suppliers
A meeting was held in August 2002 to exchange views regarding the joint study attended by the water suppliers of 8 local authorities. Four such meetings have so far been held, with the main items on the agenda being the basic attitude and elaborate study method regarding the mutual water accommodation. We have also positively promoted bilateral discussion for feasible sites with high effect.

As an achievement, the “Asaka Connection Pipe” with Saitama Prefecture, the “Noborito Connection Pipe” and the “Machida Connection Pipe” with Kawasaki City were put to place.
3. Outline of connection pipes

The general items of each connection pipe are given in Table 1.

Table 1: General items of connection pipes

<table>
<thead>
<tr>
<th>Name</th>
<th>Asaka connection pipe (Saitama)</th>
<th>Noborito connection pipe (Kawasaki)</th>
<th>Machida connection pipe (Kawasaki)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conclusion of basic agreement</td>
<td>October 2003</td>
<td>December 2003 (Alteration made in February 2005)</td>
<td>February 2005</td>
</tr>
<tr>
<td>Diameter extension</td>
<td>800Φ × 40 m</td>
<td>800Φ × 25 m</td>
<td>400 Φ × 45 m</td>
</tr>
<tr>
<td>Accommodation water volume</td>
<td>Daily 100,000 m³ (treated water) --- Equivalent to the scale of a city with about 300,000 people</td>
<td>Daily 15,000 m³ (treated water)</td>
<td></td>
</tr>
<tr>
<td>Construction cost</td>
<td>Approximately 170 million yen (on halves)</td>
<td>Approximately 90 million yen (on halves)</td>
<td>Approximately 70 million yen (on halves)</td>
</tr>
<tr>
<td>Completion</td>
<td>September 2005</td>
<td>FY2006 (expected)</td>
<td></td>
</tr>
<tr>
<td>Remarks</td>
<td>Asset classification: Common ownership; Main executing body: Tokyo</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As for the Asaka connection pipe and the Noborito connection pipe, since Asaka Water Purification Plant is located in Saitama Prefecture and Nagasawa Purification Plant in Kawasaki City, their large-diameter pipelines cross outside Tokyo. In the case of the Machida connection pipe, because of the existence of enclave in Kawasaki City, the pipeline of Kawasaki City is laid across Tokyo, causing the pipelines to cross each other. These connection pipes need only short extension for connection and can provide adequate accommodation water, thus making good sites with favorable conditions.

Fig. 5: Connection pipe locations
(2) Outline of facilities
The Asaka connection pipe had the valves installed to both ends of the pipeline, with the flow regulator, flow meter chamber, air valve and drain facility installed in-between. In consideration of the operation at emergency, manual valves were adopted, and portable flow meters easily mountable at the time of operation were used for easy maintenance. The same concept is to be adopted for the facilities currently designed for Noborito and Machida connection pipes.

(3) Operation system
In the case of Asaka connection pipe, the Asaka Treated Water Administrative Office of Tokyo, in charge of maintenance and control, jointly works as the counter (window) with Okubo Water Purification Plant of Saitama Prefecture, and builds up a communication system well coordinated with their respective bureaus. Further, they hold joint drills once every year to allow prompt and safe supply of water to connection pipes during emergency.

(4) Investment effect
The construction cost for 1 m³/day accommodation water is approximately 600 yen for Asaka and Noborito connection pipes and 2,400 yen for Machida connection pipe, with almost no maintenance and operation cost needed.

On the other hand, an equivalent level of steady water supply by using connection pipes laid inside Tokyo, the installation of water purification plant for backup purpose
and development of water resource would be needed. The recent records show that the
development of water resource costs 160,000 yen for 1 m$^3$/day, and the construction of
water purification plant costs 140,000 for 1 m$^3$/day, with the initial costs coming to
about 300,000 yen for 1 m$^3$/day in addition to the accrued maintenance and operation
cost. In other words, from the viewpoints of both initial costs and maintenance and
operation cost, the investment effect of connection pipe installation is obviously high.
However, in the future approach to the installation of connection pipes for emergency
use, not only investment effect but also risk management should be taken into account.

4. For Further wide-range (wide-area) cooperation

(1) Problems of connection pipes for emergency use

The 3 connection pipes so far concluded after discussion are excellent in terms of
investment effect, but from the standpoint of the facility characteristics of the
connection pipes for emergency use, they generally have the problems given below.

- Since the volume of accommodation water is fixed within the scope of the reserve
capacity of the existing waterworks facilities, it is subjected to restriction by the
reserve capacity of the pump and the frictional loss of the pipeline between
supplying facility and connection site. This limits the scope of the accommodation
water supply volume, falling short of the wide-area service.

- In case there is pressure difference between the two pipelines, the accommodation
water cannot be supplied to the pipeline with higher pressure, thus limiting the
operation of the connection pipe.

- Longer extension of connection pipe gives rise to a problem demanding measures
against detention water.

For realization of wider-area water accommodation, it is considered necessary to
improve the mutual water accommodation in terms of facilities as well as operation in
addition to the installation of emergency connection pipe for connecting the two
pipelines. It is utterly important to obtain adequate volume of accommodation water
by connecting the major facilities such as water purification plants, supply stations,
etc., and to take measures for utilization of accommodation water even at the time of
drought or at normal time in order to maximize the investment effect.
(2) Utilization at drought
a) Effect
The water outage and low water can be reduced through effective use of the existing water resources by connecting multiple water systems beyond the boundaries of water suppliers.

b) Problems
The River Law stipulates for the procedures regarding mutual accommodation of raw water among the users as an exception to the use of water facility so that there seems no legal problem to arise. However, the environmental conditions surrounding the water resources greatly differ in the Tone River, the Ara River, the Tama River, the Sagami River and the Sakawa River, and with their established interests and historical backgrounds being complicated, it is difficult at present to build consensus among the neighboring water suppliers.

(3) Utilization at normal time
a) Effect
Based on the geographical conditions such as intake point, vertical drop, etc., connection pipes with water conveyance capacity higher than the ones in Tokyo can be installed, leading to energy saving in water operation through the effective use of natural flow-down. Further, various other measures can be taken by making the effective use of the wide-area accommodation, such as utilization of wide-area backup function in the case of a drastic drop in capacity when a facility undergoes large-scale renewal, taking water preferably from the water system with excellent water quality, etc. It is also possible to promote a constant and appropriate water distribution control by reorganizing the water distribution systems in the neighborhood of the administrative district in defiance of the boundaries of Tokyo as in the case of mutual water accommodation.

b) Problems
The Waterworks Law controls the supply of water by a supplier to the area beyond its supply area. Further, since the water is accommodated to the organization other than the one authorized with water right, it may be regarded as the use of water beyond purpose and violate the rule of water utilization. Hence, revision of the authorization of water right becomes necessary. Thus, the mutual water accommodation at normal time is difficult under the current legal systems.
Conclusion
The wider the operation scope and the larger the facility scale, the greater is the effect of water accommodation. On the contrary, it gives rise to complicated and difficult problems such as increase of cost, nonconformity with the current legal system, different situations of the suppliers, etc. In order to overcome such problems it is important to deepen the understanding and cooperation with the neighboring water suppliers.

As an example of the cooperation among the suppliers, together with Saitama Prefecture we have made a joint demand with the national government for upgraded financial measures against the installation of wide-area connection pipe. As a result, the adoption criteria for government subsidy against wide-area connection pipe installation were eased, and Asaka Connection Pipe became the first enterprise to get the subsidy.

Drawing attention of the national government through aforesaid activities and sharing the problems faced by each supplier and bringing profit to all concerned parties; i.e. building up a win-win relationship is on demand.

References
1) Waterworks Vision by Health Bureau, Ministry of Health, Labour and Welfare, June 2004