Case	Turbid Water Prevention Efforts and Measures
Water utility	(This is an example practiced by common water utilities in Japan)

General information of the utility (2019) *N/A = Not applicable

Operation type	N/A	Service area (km^2)	N/A
Population served	N/A	Distribution (m^3/d)	N/A
Service coverage (%)	N/A	Pipe length (km)	N/A
NRW (%)	N/A	Number of staff	N/A
Number of water sources	N/A		
Water rates (JPY)	N/A	(in case of 10m^3 of water use per month for residential customers)	

Summary

In Japan, water supply service is available 24/7 to almost 100%[1)] of the population. The number of pipeline incidents has been decreasing year by year[2)] due to systematic mains renewal and regular leakage investigations. In addition, customers are experiencing fewer large-scale service disruptions[3)] or turbidity issues in drinking water owning to the development of dams.

Under these circumstances, there is a growing demand for even safer, higher-quality tap water, and many water utilities are conducting thorough water quality management at every stage from the source to tap.

This paper discusses how common water utilities in Japan prevent the generation of turbid water in the water distribution network.

Current Status & Challenges

In Japan, water mains installed during the rapid economic growth period after the Second World War are facing the time for renewal, and water utilities are implementing capital programs to renew their aged mains systematically. After a new main is installed, its inside is cleaned to ensure the safety of water quality. In addition to the planned construction work, system switch and pipe cleaning are also carried out to deal with sudden leakage incidents.

When system switch and pipe cleaning are carried out, the direction and velocity of the water flow in the distribution network may change, resulting in turbulent flow. In places where the flow velocity is low, tiny foreign substances contained in the tap water accumulate over a long period of time, and turbid water is generated when these substances and the iron rust on the inner surface of unlined mains get rolled up by the turbulent flow created by system switch and pipe cleaning.

To minimize the generation of turbid water by system switch and pipe

	cleaning due to pipe renewal and unexpected leakage incidents, it is important to formulate their work plans appropriately.
Measures & Solutions	**Efforts to deal with turbid water** 1. Consideration of the range for turbid water As mentioned earlier, turbid water may be generated when the flow velocity and direction in the distribution network change. Therefore, when planning valve operations for system switch and pipe cleaning, a pipe network calculation is normally performed to simulate potential changes in the flow direction and velocity. The calculation result shows you the degree of change before and after the valve operations to help you determine the range where turbid water may be generated. Table 1 shows the characteristics of the pipelines in which turbid water may be generated. Table 1 | Pipelines susceptible to turbid water • Pipelines containing aged pipes (unlined cast iron pipes) • Pipelines whose flow velocity largely changes before and after the system switch • Pipelines whose flow direction is reversed before and after the system switch • Pipelines in which water is stagnated • Pipelines located adjacent to the operated valves, etc. 2. Consideration of work hours As shown in Figure 1, the flow rate in the distribution network varies depending on the time. More specifically, the flow rate peaks in the morning and evening, while it becomes low at night (meaning low flow velocity). Therefore, if the work hours can be selected, you can avoid generating turbid water or to reduce its generation range by switching the system at night when the flow velocity is low. As a result of the pipe network calculation, if there is a concern that a daytime work could generate turbid water, utilities make a comparison to see when is the best time to conduct the work on that day to minimize the range of turbid water being generated.

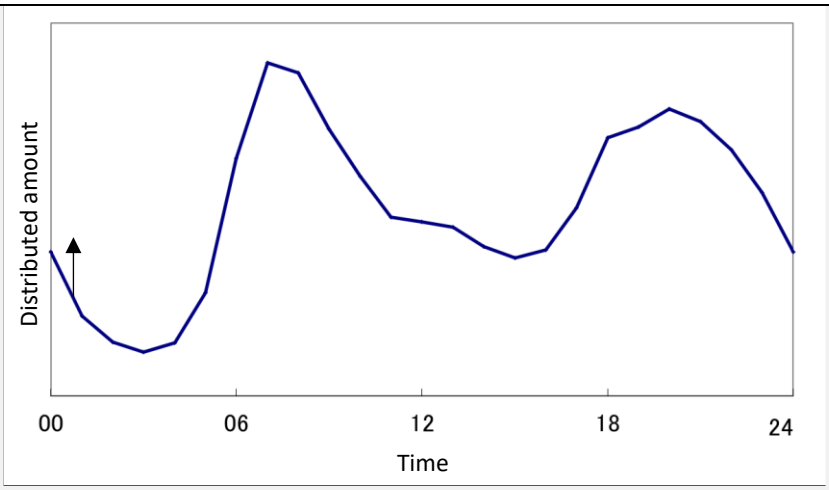

Figure 1 | Fluctuation of distributed amount of water by time (example)

3. Consideration of pre-cleaning

Once turbidity substances get rolled up, they will move with the water flow and affect a wide range of the distribution network. Therefore, when turbid water is expected to be generated even if the work is done at night, utilities limit the scope of turbid water to the mains to be cleaned by cleaning them in advance.

When utilities conduct the pre-cleaning, first, based on the result of the pipe network calculation, they identify the mains where turbid water is expected to be generated, such as those whose flow velocity is expected to increase largely, and get rid of the foreign substances out of those pipes using the drainage facilities and fire hydrants on those mains. To obtain a sufficient cleaning effect, the flow velocity in the main must be 1.0 m/s or higher, or higher than the maximum flow velocity that is normally attained.

During the cleaning process, the valves are normally shut off to prevent the turbid water from flowing into other mains than the ones to be cleaned. At this time, it is also important to check the valves' opening/closing status properly so as not to shut off the inlet valve of the customers who have a single point of inflow because its shut-off would cause them disruption of water supply.

4. Public relations

If the occurrence of turbid water is still unavoidable after taking these measures, advance notification to the public is necessary. Ways of notification include a customer notification through the utility website and handout distribution at their premises that gives information on the potential service disruption or turbid water generation. Providing necessary information in advance is helpful to obtain understanding from the customers on the utility's work.

Below is a detailed example of a preventive measure against turbid water generation, in which a water pipe bridge on a primary main (Figure 2) is intentionally disrupted to repair a leakage.

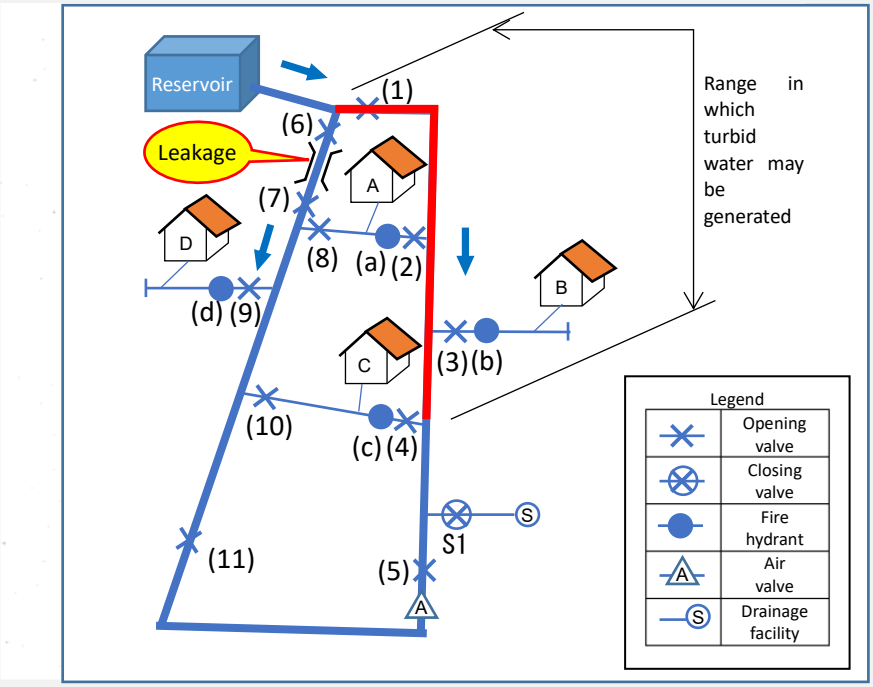

Figure 2 | Image of mains

The primary pipe is looped, and the water pipe bridge has a leak that needs to be repaired.

During the repair, it is necessary to shut off the valves (6) and (7) located at the front and rear of the pipe bridge, but when they are closed, the pipeline will be non-looped.

A pipe network calculation under peak demand condition showed that the flow velocity in a wide range of pipes would be higher than the normal velocity, and that turbid water would occur widely.

On the other hand, a pipe network calculation under night-time condition showed that the flow velocity would be higher than the normal velocity only in the range shown in red. And no turbidity is expected to occur in the pipes whose flow velocity is normal or lower than normal since their water is flowing without getting turbid every day during peak hours.

Fortunately, the amount of leakage was small and therefore the risk of secondary damage was also small, so the utility decided to repair the leakage at night. Before doing that, they planned a pre-cleaning and public notification procedure as shown in Table 2.

	Table 2 | Pre-cleaning procedure 1. Shut off the branch mains to prevent turbidity substances entering from the primary main. Tighten valves (2) and (4) while cleaning them with fire hydrants (a) and (b). (Note: Make sure that valves (8) and (10) are opened in advance) (Note: Valve (3) cannot be tightened, so the customer at B should be notified of turbid water) 2. Tighten off the downstream portion of the primary main. Tighten the valve (5) while flushing it with the air valve. 3. Clean the primary main. Open the drain valve S1 and drain the water to flush the foreign substances out of the main. By taking these measures, it will be possible to address leaks while reducing the range affected by turbid water.
Future plans	There is no end to mains renewal process, and efforts to minimize related impact of turbid water on customers will stay important. In that regard, the advancement of ICT such as mapping systems have a potential to make it possible to take more effective measures to prevent turbidity issues by enabling centralized management of information required for maintenance and management of facilities.
References	Source: 1) Water supply statistics (Ministry of Health, Labour and Welfare). https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/topics/bukyoku/kenkou/suido/database/kihon/index.html 2) The number of incidents in water supply (Water Supply Hot News, Japan Water Research Center). http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjQpa-mtsTrAhUexYsBHah7Bi0QFjADegQIBBAB&url=http://www.jwrc-net.or.jp/hotnews/pdf/HotNews563.pdf&usg=AOvVaw0BvlATxjJURB0No8gvNhoP 3) Effectiveness of dams during droughts (Ministry of Land, Infrastructure, Transport and Tourism). https://www.mlit.go.jp/river/bousai/main/saigai/kassui/dam_effect_index.html References: Guidelines for Management and Maintenance of Water Supply Facilities (Japan Waterways Association).

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