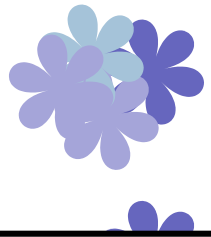


# Activities Related to Earthquake-proofing of Drinking-Water Infrastructure in the Japan Water Research Center (JWRC)

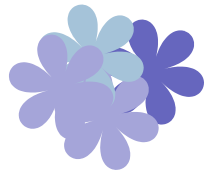
Mikita Amano Japan Water Research Center






# Earthquakes in recent years

| <i>Name of Earthquake</i>   | <i>Date</i>             | <i>Magnitude</i> | <i>Interruption (Households)</i> |
|-----------------------------|-------------------------|------------------|----------------------------------|
| <i>Hyogoken-Nanbu</i>       | <i>17 January, 1995</i> | <i>7.2</i>       | <i>1,270,000</i>                 |
| <i>Niigata Chuetsu</i>      | <i>23 October, 2004</i> | <i>6.8</i>       | <i>130,000</i>                   |
| <i>Noto Peninsula</i>       | <i>25 March, 2007</i>   | <i>6.9</i>       | <i>13,000</i>                    |
| <i>Niigata Chuetsu-oki</i>  | <i>16 July, 2007</i>    | <i>6.8</i>       | <i>59,000</i>                    |
| <i>Iwate-Miyagi Nairiku</i> | <i>14 June, 2008</i>    | <i>7.2</i>       | <i>6,000</i>                     |

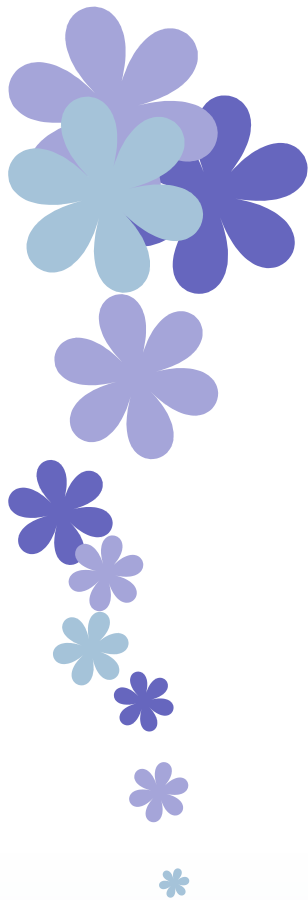




## *Today's topics*

-  ● ***Current situation of earthquake-resistance of drinking water facilities***
-  ● ***Plans to upgrade the earthquake-resistance of facilities***
-  ● ***Simplified method of evaluating earthquake-resistance of water facilities***

# Current situation of earthquake-resistance of drinking water facilities using "Performance Indicator (PIs)"



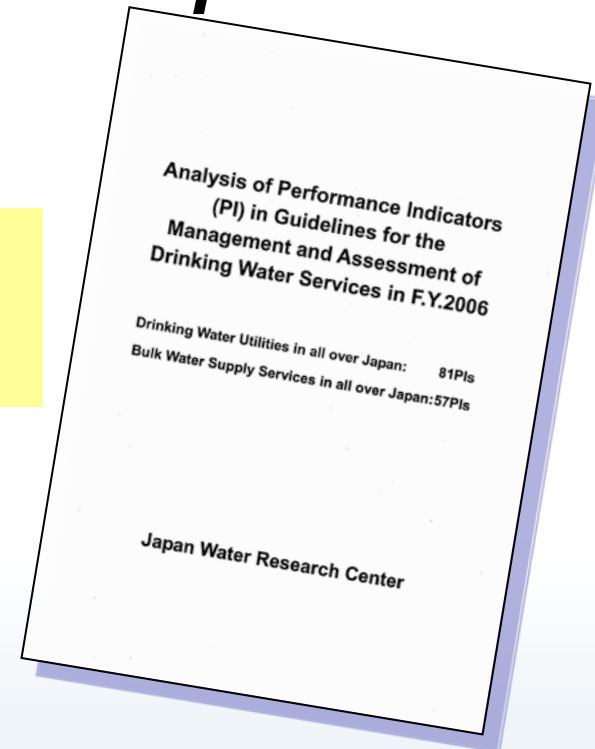
# What are "PIs" ?



- **JWWA published “Guidelines for the Management and Assessment of Drinking Water Supply Service” in January 2005.**
- **The Guideline defines 137 PIs (Performance Indicators), including indicators for earthquakes.**



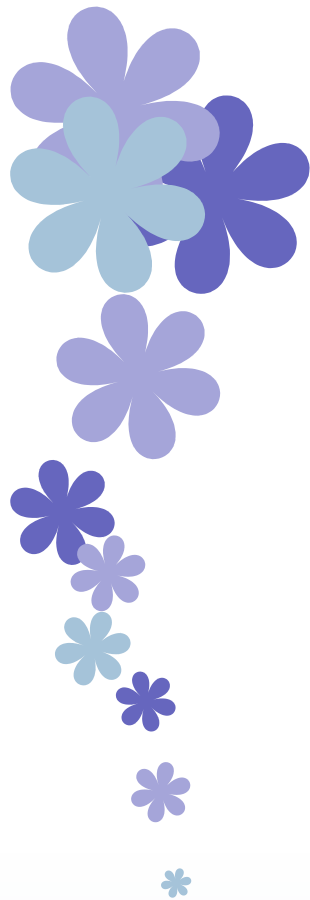
**JWRC has analyzed PIs of utilities in Japan.**



# Current situation of earthquake-resistance using PIs

| PIs related to earthquake-resistance                                  | Average FY2005 | Average FY2006 |
|---|----------------|----------------|
| <i>PI-2207 : Ratio of earthquake-resistant treatment facility (%)</i> | 12.4           | 13.0           |
| <i>PI-2209 : Ratio of</i>   | 20.1           | 23.0           |

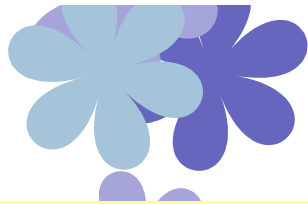
**The Ministry of Health, Labour and Welfare (MHLW) has set a target that these ratio for main facilities and water pipes of **100% by 2025.****



Plans to upgrade the  
earthquake-resistance of  
drinking water facilities

# Development of JWRC's manual

— MHLW published “**Guidelines for Planning to Upgrade the Earthquake Resistance of Drinking-Water Facilities**” in April 2008



JWRC published “**Explanatory Manual of the Guidelines for Planning to Upgrade the Earthquake Resistance of Drinking-Water Facilities**” in October 2008, which includes explanations and reference materials for the guidelines.





# *Planning procedures to upgrade Earthquake Resistance*



***Predicting seismic damage to drinking-water facilities***



***Setting objectives for earthquake-proofing***



***Selecting techniques of earthquake-proofing***



***Determining the methods to formulate plans for  
earthquake-proofing***

# Estimating the rate of broken pipes and joints (eq-1)

$$R_m(\alpha) = C_p \times C_d \times C_g \times C_l \times R(\alpha)$$

$R_m(\alpha)$  : Breakage rate against maximum acceleration [spot/km]

$C_p$  : Correction factor for type of pipe

$C_d$  : Correction factor for pipe diameter

$C_g$  : Correction factor for terrain and soil

$C_l$  : Correction factor for liquefaction

$R(\alpha)$  : Standard break rate [spot/km] ( $= 2.88 \times 10^{-6} \times (\alpha - 100)^{1.97}$ )

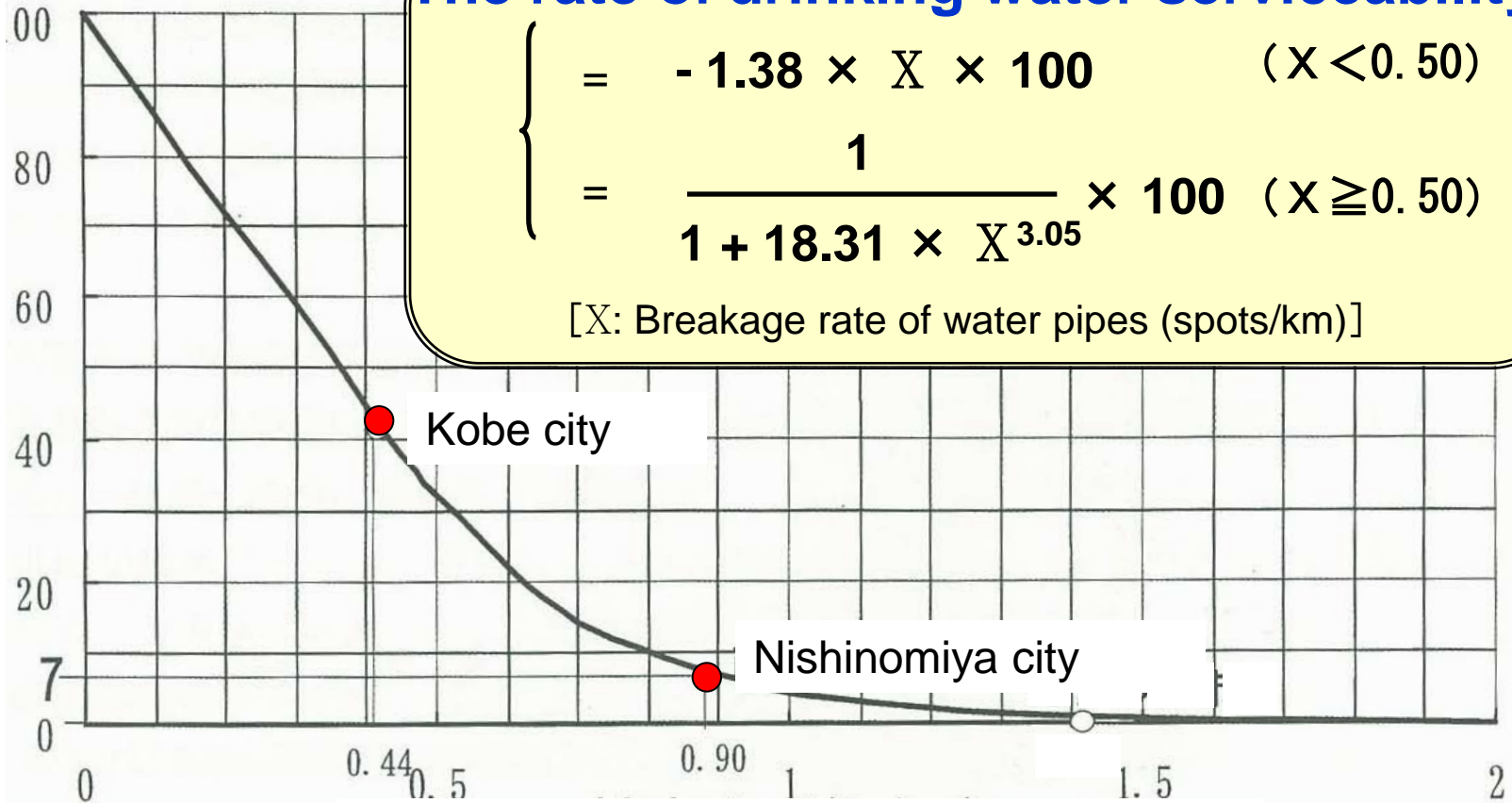
$\alpha$  : Maximum acceleration of earthquake motion [gal]

| Pipe type $C_p$  |     | Pipe diameter $C_d$    |     | Terrain and soil $C_g$    |     | Liquefaction $C_l$ |     |
|------------------|-----|------------------------|-----|---------------------------|-----|--------------------|-----|
| DIP              | 0.3 | – $\phi$ 75            | 1.6 | Modified mountainous area | 1.1 | None               | 1.0 |
| DIP(S, NS, etc.) | 0   | $\phi$ 100– $\phi$ 150 | 1.0 | Modified hilly area       | 1.5 | Medium             | 2.0 |
| CIP              | 1.0 | $\phi$ 200– $\phi$ 450 | 0.8 | Valley, former water area | 3.2 | High               | 2.4 |
| SP               | 0.3 | $\phi$ 500–            | 0.5 | Alluvial flat             | 1.0 |                    |     |
| VP               | 1.0 |                        |     | High-quality ground       | 0.4 |                    |     |
| ACP              | 1.2 |                        |     |                           |     |                    |     |
| Other            | 1.2 |                        |     |                           |     |                    |     |

# Estimating the rate of drinking-water serviceability at the beginning of restoration work (eq-2)

The Rate of drinking water serviceability

at the beginning of restoration work (%)



The rate of drinking water serviceability

$$\begin{cases} = -1.38 \times X \times 100 & (X < 0.50) \\ = \frac{1}{1 + 18.31 \times X^{3.05}} \times 100 & (X \geq 0.50) \end{cases}$$

[X: Breakage rate of water pipes (spots/km)]

Breakage rate of water pipes (spots/km)

# Predicting seismic damage to drinking-water facilities JWRC

**Estimating break rate at pipes and joints**  
<using **eq-1**>

● **number of broken pipes**

● **period of restoration**

**Estimating the rate of drinking-water serviceability**  
<using **eq-2**>

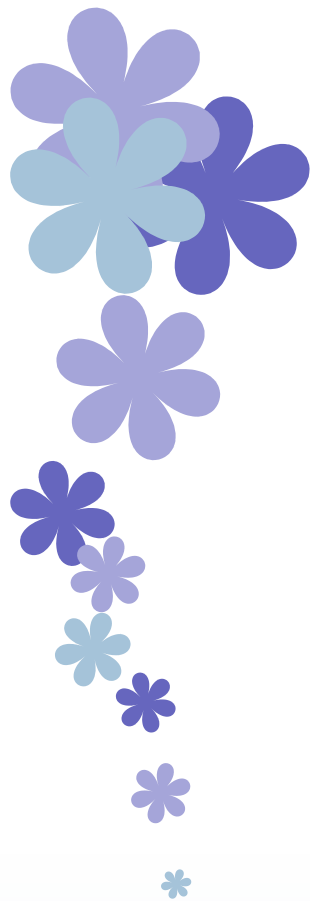
● **Predicting damage**

● **Determining countermeasures**

● **population interrupted**

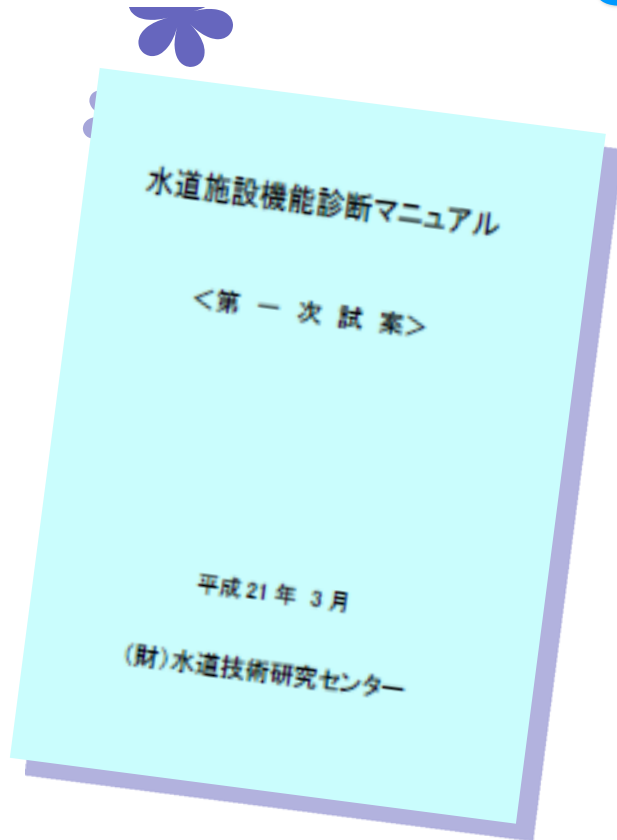
● **amount of water for emergency supply**





# Simplified method to evaluate earthquake -resistance of drinking water facilities

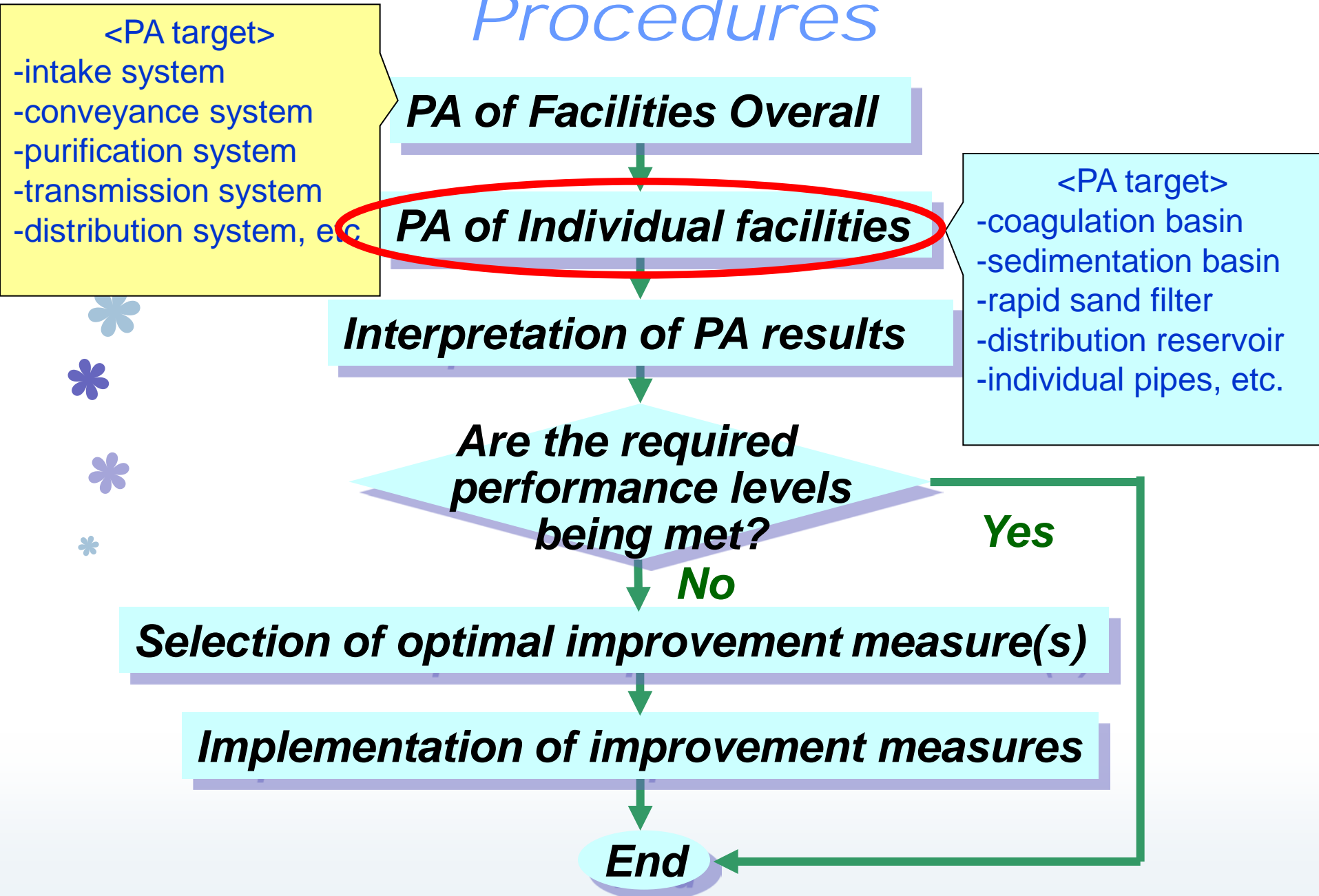
# Technical Performance Assessment Manual for Drinking Water Facilities



**This manual will:**

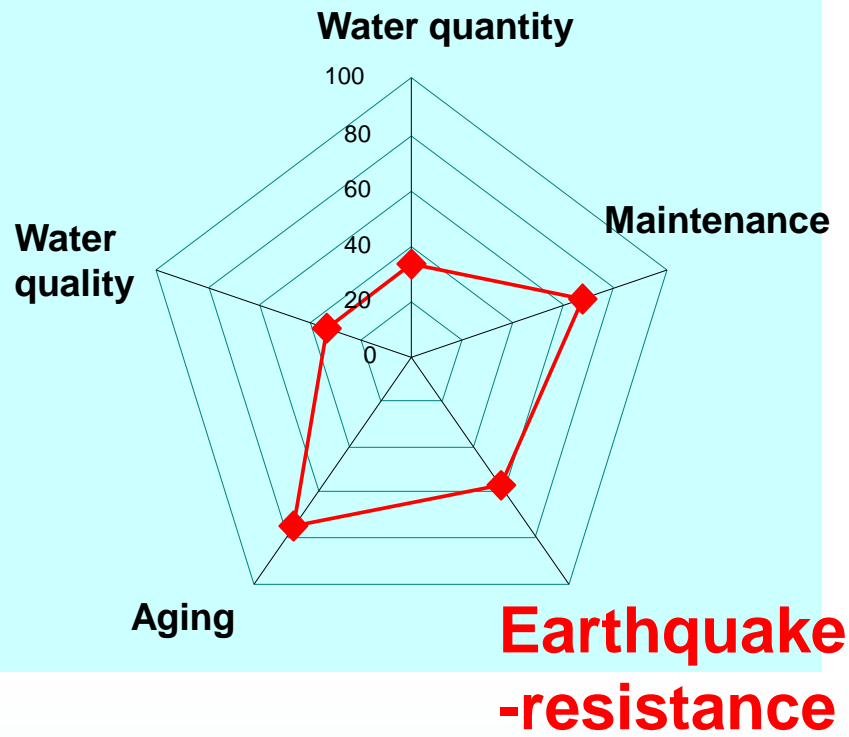
- enables the user to **assess performance of drinking-water facilities**, including earthquake resistance.
- Provide users with simple **“Check-sheet”** to evaluate earthquake-resistance.

# Performance Assessment (PA) Procedures

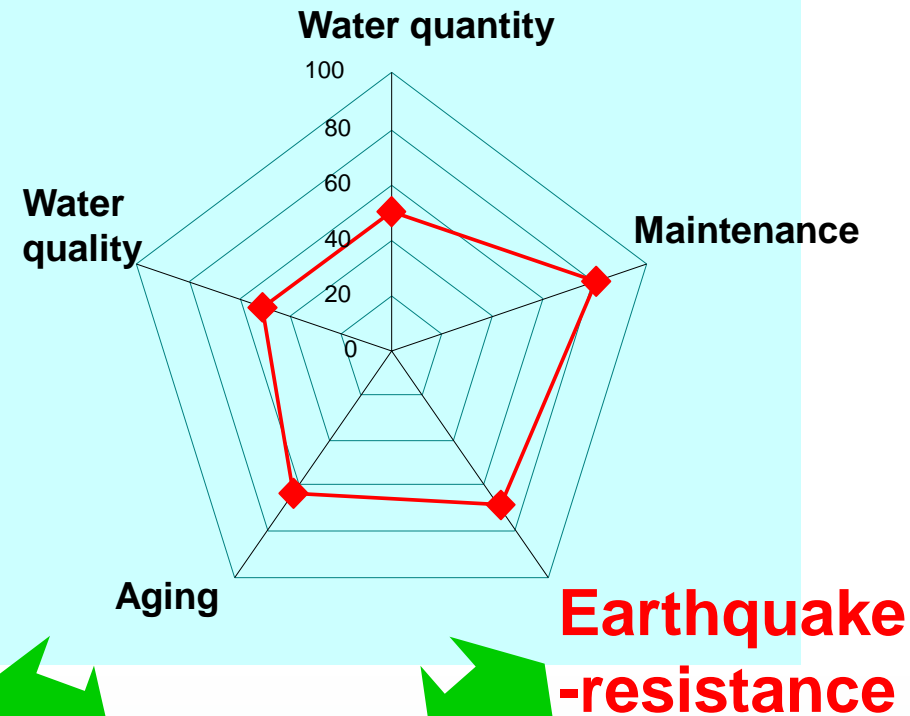


# PA results of Individual facilities

## Disinfection facility



## PAC adsorption facilities



“CHEAK SHEET”

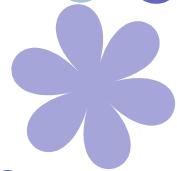
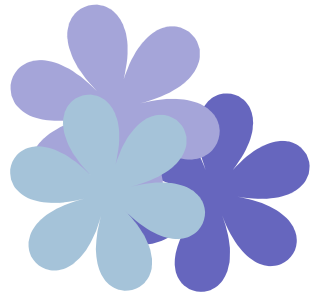


# "CHECK-SHEET" for Earthquake-Resistance (For Water pipe bridges)

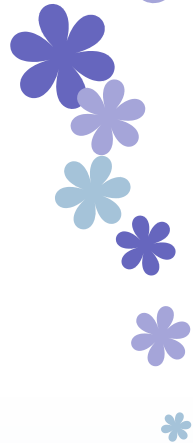
| Category                              | For water pipe bridge                   |               |          |   |
|---------------------------------------|---|---------------|----------|---|
| Items                                 | Category                                | Weight Factor | Point    | Remarks   |
| Ground                                | Type I                                  | 1.0           | 1.4<br>✗ |   |
|                                       | Type II                                 | 1.4 →         |          |   |
| Pipe Type                             | Ductile cast iron                       | 1.0 →         | 1.0<br>✗ |   |
|                                       | Cast iron                               | 2.4           |          |   |
| Joints                                | Expansion, anti-slip-out mechanism type | 0.5 →         | 0.5<br>✗ |   |
|                                       | Other joints                            | 1.0           |          |   |
| Seismic Intensity<br>(Japanese scale) | 5                                       | 1.0           | 2.2<br>↓ | Levels according to the Japan Meteorological Agency |
|                                       | 6                                       | 2.2 →         |          |   |
|                                       | 7                                       | 3.6           |          |   |
| Earthquake Resistance                 | High                                    | 14 >          | 9.7      |   |
|                                       | Medium                                  | 14~28         |          |   |
|                                       | Low                                     | 28 <          |          |   |

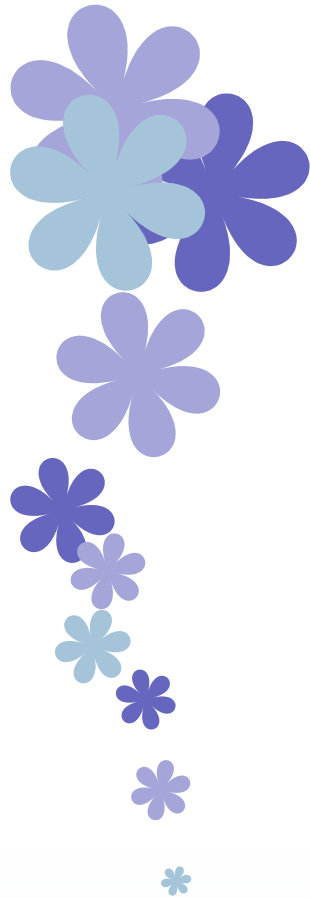
# Conclusions

- MHLW has set the earthquake-proof ratio for main drinking water facilities and pipes at 100% by 2025.
- Pls indicate earthquake-resistance ratio of drinking water facilities, and they show that currently Japan's facilities have unsatisfactory earthquake-resistance. This situation is slowly improving.
- Implementing an appropriate earthquake-proofing plan is essential.
- MHLW's published "Guideline for Planning to Upgrade the Earthquake-resistance of Drinking Water Facilities" to help utilities improve earthquake-resistance.
- "Technical Performance Assessment Manual for Drinking Water Facilities" will enable users to easily evaluate earthquake-resistance through simple "CHECKSHEET".
- Through these efforts, this situation will be great improved.



Thank you for your attention.





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