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TWC's Thoughts on Implementing Seismic Improvement to Large Water Pipelines

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Background (1)

- **Taiwan Water Corporation (TWC)**
  - **Largest water utility in Taiwan**
  - **12 branches all over the island**
  - **144 systems, total capacity 11.42 million CMD**
  - **Serving water to 6.87 million customers (17.98 million people)**
  - **Backbone to the rapid economic development of Taiwan since established in 1974**

Background (2)

- **Problems encountered**
  - **Lots of pipelines and facilities built in early years without any seismic consideration**
  - **Systems vulnerable to earthquake hazards**
  - **Majority of large water pipelines being fragile PCCP** (pre-stressed concrete cylinder pipes) **and PSCP** (pre-stressed concrete pipes)
  - **Seismic enhancement of large water pipes in urgent need**

Target large pipes needing enhancement

- **Suggested by NCREE**
- **Three priorities, 232 pipe evaluation units, based on**
  - **4 importance classes** (very high, high, normal and low)
  - **10 risk groups** (from high to low risk)

Priority	Order	Combination of (Importance, Risk group)	No. of evaluation units
First	1	(Very high, R1)	29
	2	(Very high, R2)	53
Second	3	(High, R1)	51
	4	(Very high, R3)	46
Third	5	(High, R2)	33
	6	(Very high, R4)	20

Key issue for implementing pipeline seismic enhancement

- **How to help all branches and headquarter of TWC to implement in a uniformly manner?**

- **Answer: TWC needs to**
  - **Specify the seismic objective for pipelines of different importance**
  - **Specify the procedure to develop pipeline seismic assessment reports and implement seismic countermeasures**

Seismic objective for pipelines

- **Seismic objective =**
  Performance level to achieve at a specified Seismic demand (hazard level)

- **The more important a pipe is, the higher seismic objective should be satisfied!**

Seismic demand (1)

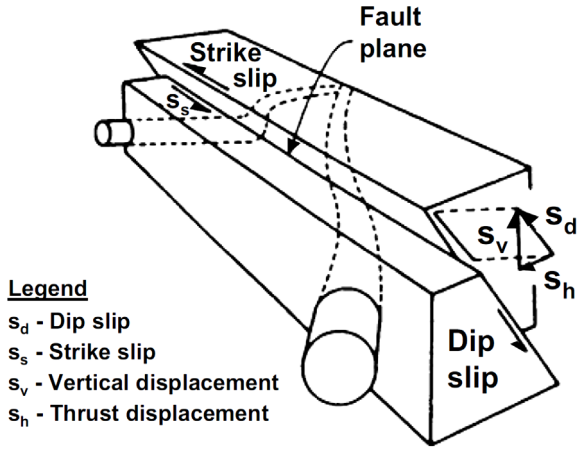
- **Ground shaking**
  - **PGV** at a 10% chance of exceedance in 50 years (design earthquake)
  - Code-specified site amplification and near fault effects considered
- **Soil liquefaction**
  - **PGD** at a 10% chance of exceedance in 50 years (design earthquake)
  - In the pattern of settlement or lateral spreading
  - **Design movement** employed instead to deal with uncertainty (ALA, 2005)

Class of pipeline importance	Design movement
Normal and low	PGD
High	1.35 × PGD
Very high	1.50 × PGD

Seismic demand (2)

- **Fault offset**
  - Mean **offset** by model of Wells and Coppersmith (a function of fault length)
  - **Design offset** employed instead to deal with uncertainty (ALA, 2005)
  - Pattern of fault offset considered

Class of pipeline importance	Design offset
Normal and low	Offset
High	1.5 x Offset
Very high	2.3 x Offset



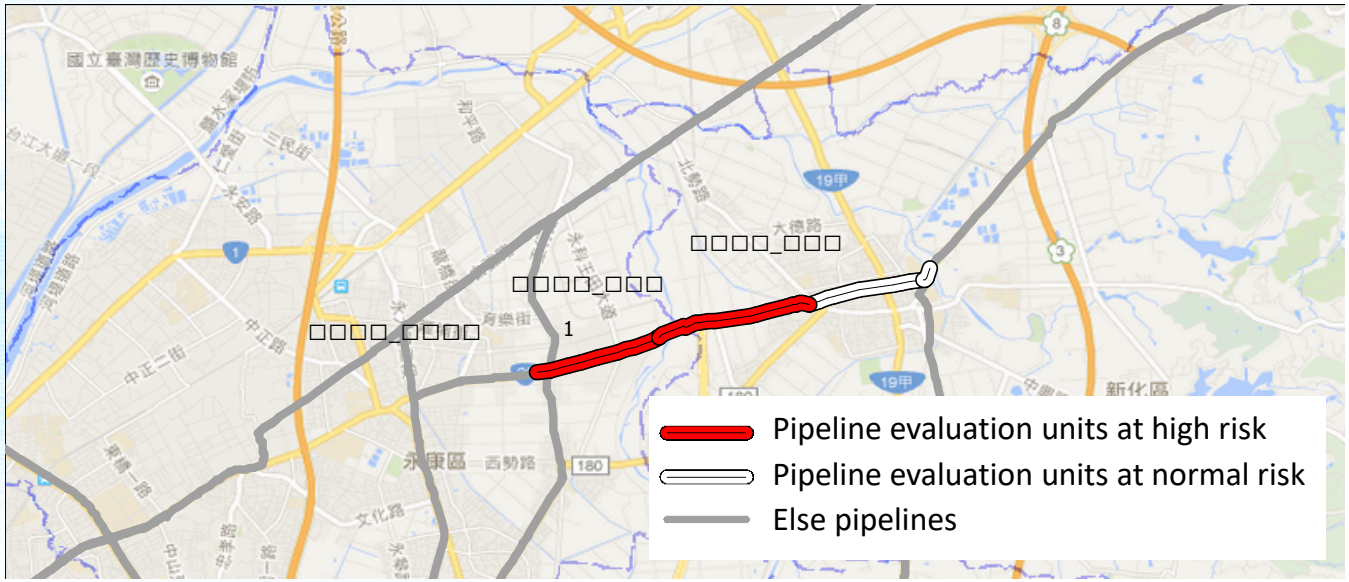
- **Landslide**
  - Not considered

Performance level

- **For pipes of very high importance:**
  - Being functional under specified seismic demand, or
  - If not functional, redundant and supporting pipes (for other systems) are able to provide 50% routine water need or more, or
  - If not functional, redundant and supporting pipes (for other systems) are able to provide 25% routine water need or more, and temporary pipes could be installed within 24 hours and able to provide additional 25%, or
  - Able to be repaired and functional again within 3 days, while there exists sufficient water storage for the first 3 days' urgent need.

Pipeline conveyance units

- **Pipeline conveyance units: the node-to-node links in a pipeline network**
- **In a TWC branch, all units should be identified and treated as the basic units for seismic assessment**



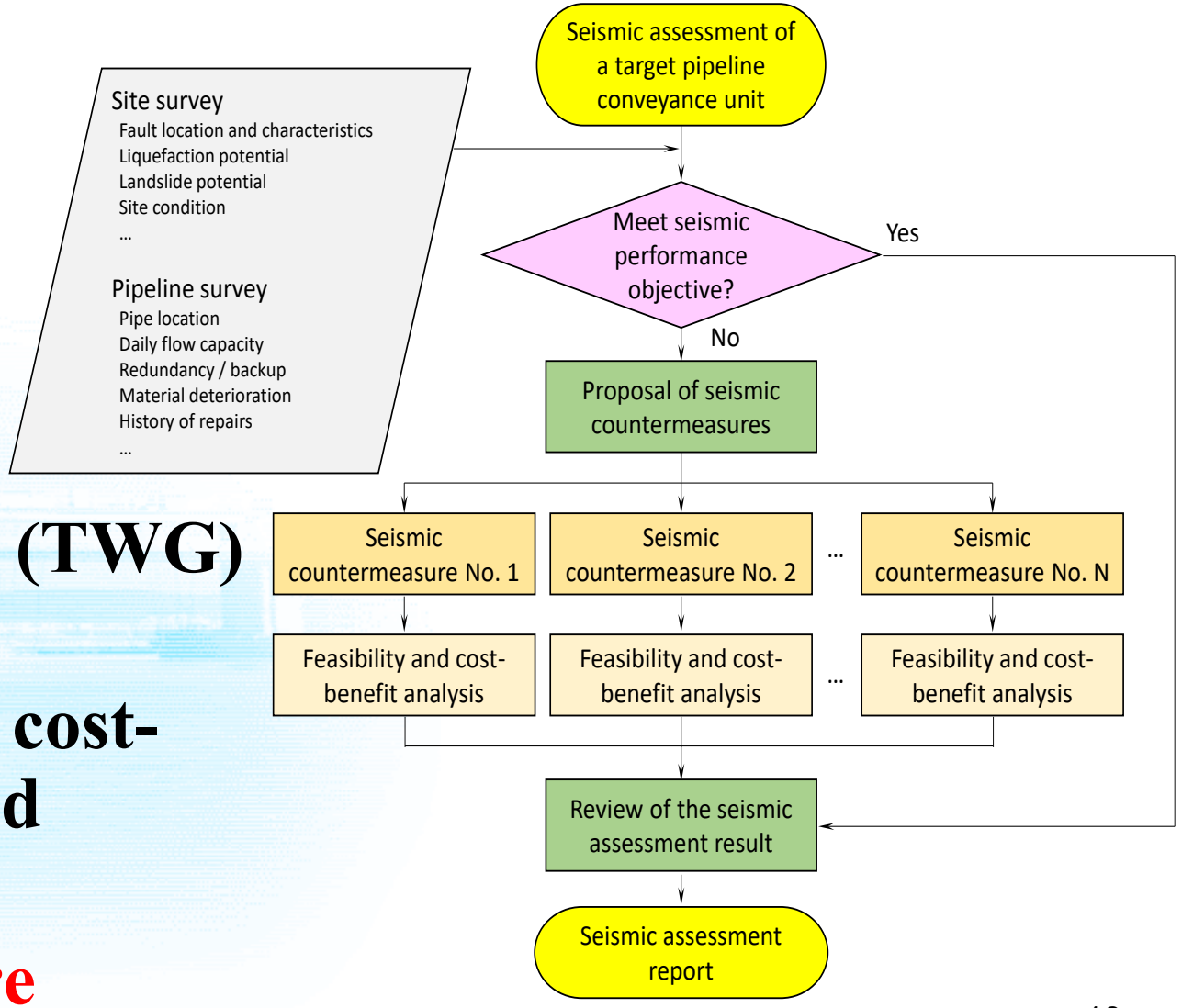
Example of a pipeline conveyance unit

Seismic assessment of a target pipeline conveyance unit

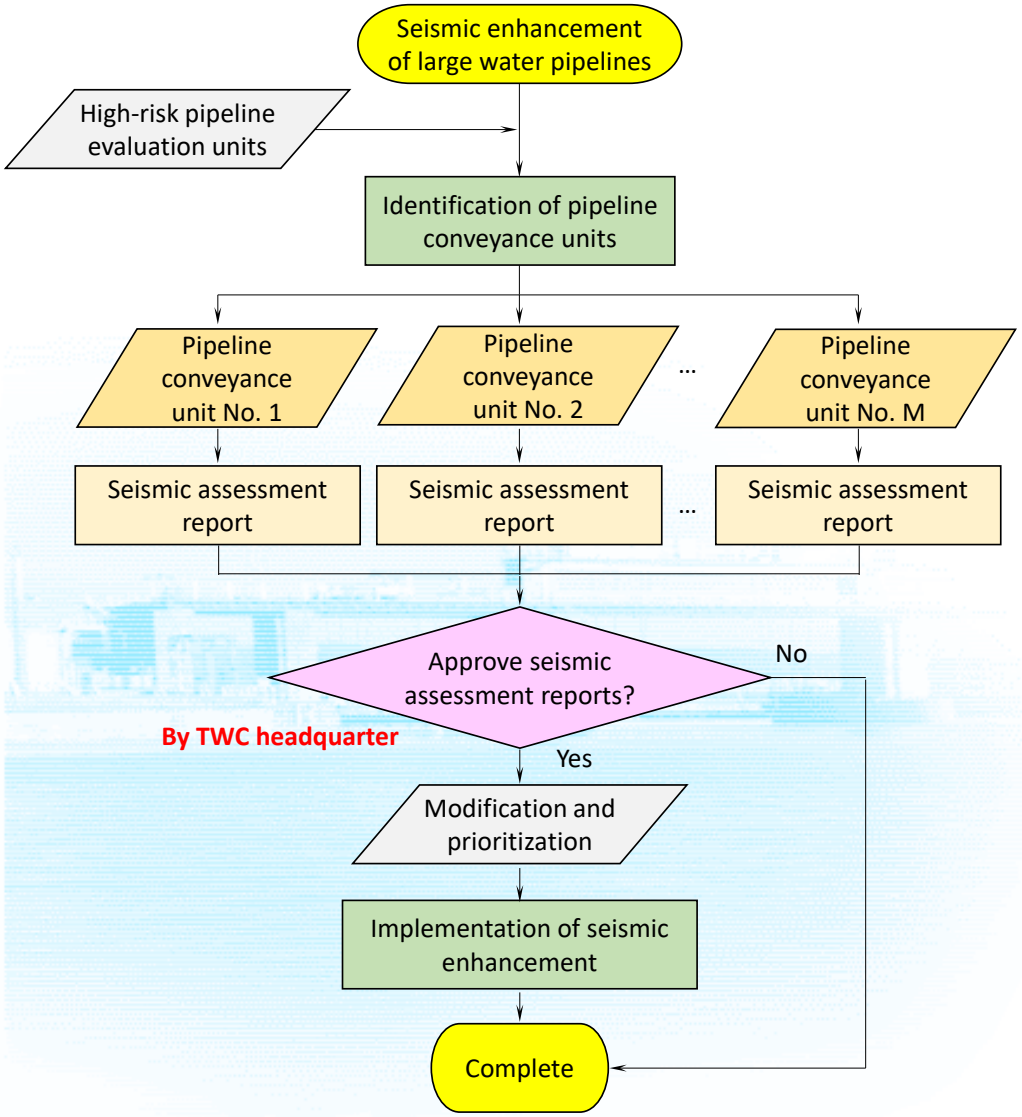
Members of TWG:

system operator
pipeline engineer
geotechnical scientist and engineer
pipe flow analyzer
third-party consultant

- **By technical working group (TWG) at branch level**
- **Feasibility and cost-benefit analyzed**
- **Best seismic countermeasure**



Development and implementation of large pipeline seismic enhancement



- **Based on pipeline conveyance units**
- **To be reviewed and approved by HQ according to**
  - optimal system improvement
  - capital and resources available
  - outside expectation and supports
  - else managerial and financial concerns

Concluding remarks

- Urgent need for TWC to enhance pipelines of (very) high importance and at high seismic risk has been clarified
- Seismic demand and performance level for pipelines of various importance have been proposed
- A procedure for developing pipeline seismic assessment reports and implementing countermeasures has been proposed

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Thanks for your Attention!

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