Sixth Taiwan-US-Japan Workshop
on Water System Seismic Practices

From Chi-Chi Earthquake to Study about Aseismatic Measures and Disaster Crisis Management in Taipei

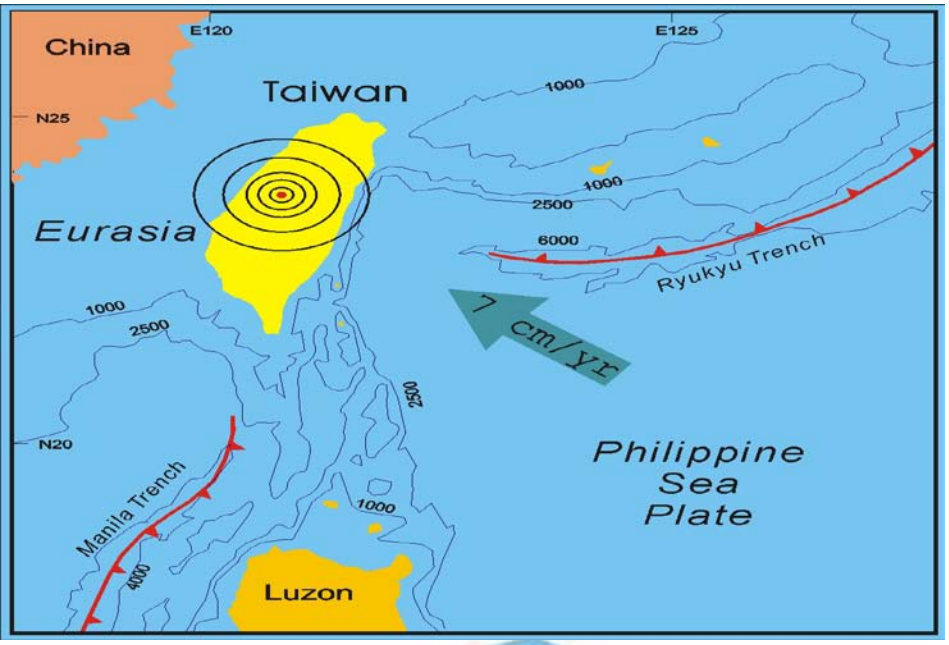
Chin-Tse Cheng and Jiin-Shyang Chen

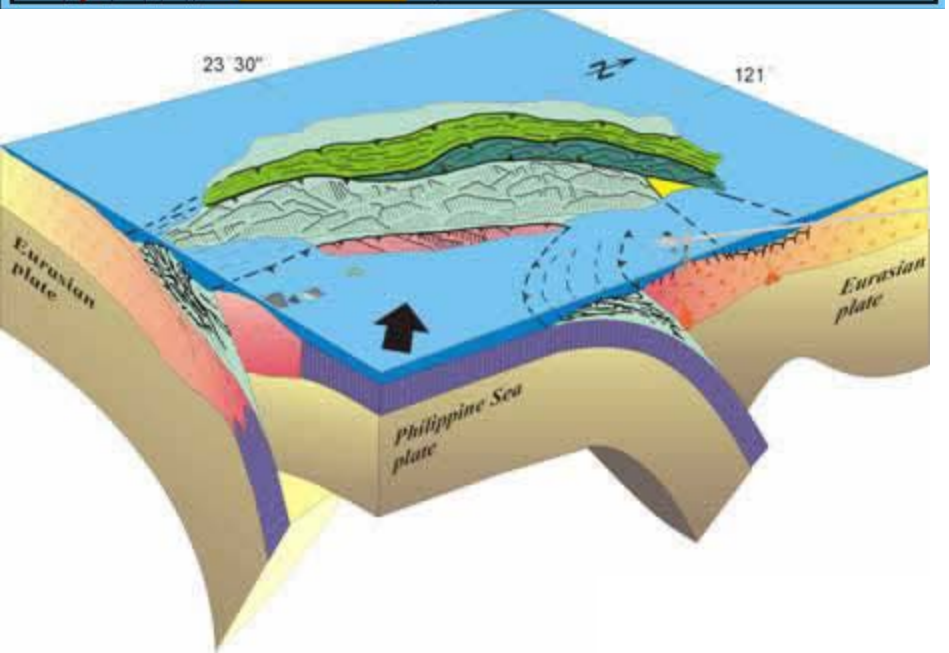
October 14~17, 2009

Outline

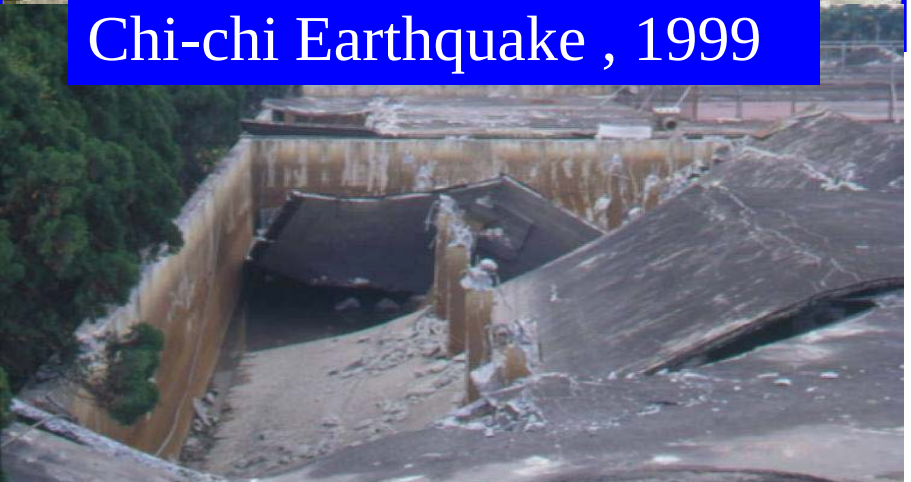
- Introduction
- Aseismatic measures
- Disaster crisis management
- Conclusion

Introduction





- Taiwan is located in a complex, tectonically active region.
- Philippine Sea Plate is subducting northwestward along the Ryukyu Trench in the north.
- Eurasian Plate underthrusts the Philippine Sea Plate along the Manila Trench in the south.
- The Philippine Sea Plate is moving northwestward at the rate of **7 cm/yr** relative to the Eurasian Plate, creating the Taiwan collision zone.
- This reflects have **high tectonic stresses in the Taiwan collision zone** that give rise to the large number of damage earthquakes.



Chi-chi Earthquake , 1999

- In the early morning of September 21, 1999, the **largest earthquake** on land of last century in Taiwan（M_W=7.7,M_L=7.3）, struck central Taiwan. the maximum horizontal displacement of 7 meters and maximum vertical displacement of 4 meters.
- The earthquake resulted in **2,456 deaths**, 10,718 injured, 53,661 houses fully destroyed, and 53,024 houses damaged.
- There were severe **water supply systems destructions** in Taiwan, such as **intake dam**, **steel trunk** and **distribution reservoir**, pipelines, etc.

Problems of Disaster Reduction

- How to effort to mitigate, prevent and response disasters that need to know the problems.
- Most citizens of Taiwan intend to have a **fatalistic attitude** and a **negatives standpoint** to hazards.
- The local governments and communities **disaster management capability is insufficient**.
- Make more efforts at **emergency response** than hazard mitigation.
- Most strategies of **hazard mitigation plans are not specific.**
- Due to need **high budget**, so that do **not take full advantage** of research results.

Effort at Disaster Prevention & Response

- **D**isaster prevention and response is one of the most important government tasks after 921 earthquake.
- **S**ince the 'Disaster Prevention and Response Act' (DPRA) was promulgated in yr.**2000**.
- **D**isaster prevention and rescue has transformed from traditional two-dimensional operations to a **cross-department integrate collaborative task**.

- **Three-level** disaster management system, **Central, County/City, Township**, is established.
- Following DPRA, the following agencies shall be regulating authorities for the Disaster Prevention and Response in charge of **command, supervision and coordination** among administrative agencies and civil utilities to carry out Disaster Prevention and Response operation:
  - **Earthquake**, typhoon, major fire, explosion: **Ministry of the Interior.**
  - Flooding, draught, **civil utilities and life pipeline** disasters: **Ministry of Economic Affairs**.
- **Each level government** needs to develop" **Disaster Prevention and Response Plan(DPRP).**

- **Contact Window** : There shall be a ***National Disaster Prevention and Response Council*** established by Executive Yuan in charge of the following duties:

➢ To **define** the basic Disaster Prevention and Response **guidelines**.

➢ To **authorize** Disaster Prevention and Response **basic plan** and the Disaster Prevention and Response **operation plans** of the central regulating authorities .

➢ To **authorize** important Disaster Prevention and Response **policy and countermeasures**.

➢ To **authorize emergency action** in case of **nationwide disaster**.

➢ To **supervise, evaluate the performance of Disaster Prevention and Response** of the central administration, municipal, and county/city governments.

➢ To carry out any other things and matters as provided by the law or regulations.

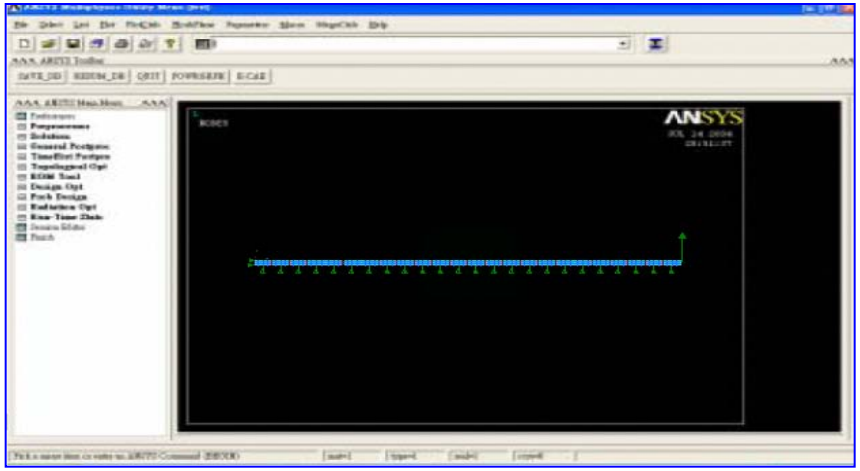
General Introduction of TWD

- Service area
  434 km^2
- Population served
  3.85 million people
- Service pervasion
  99.51%
- Annual water supply volume
  93,330 10^4 m^3

TAIPEI WATER DEPARTMENT

- Purification Plants: 5
- Facility capacity:
  3.74 million m^3/day
- Length of Transmission and Distribution Pipelines:
  3,563 km
- Distribution Reservoirs: 96
  Total Capacity: 400,000 m^3
- Booster Stations: 70

Aseismatic measures(1/4)



Underground pipelines finite-element analysis

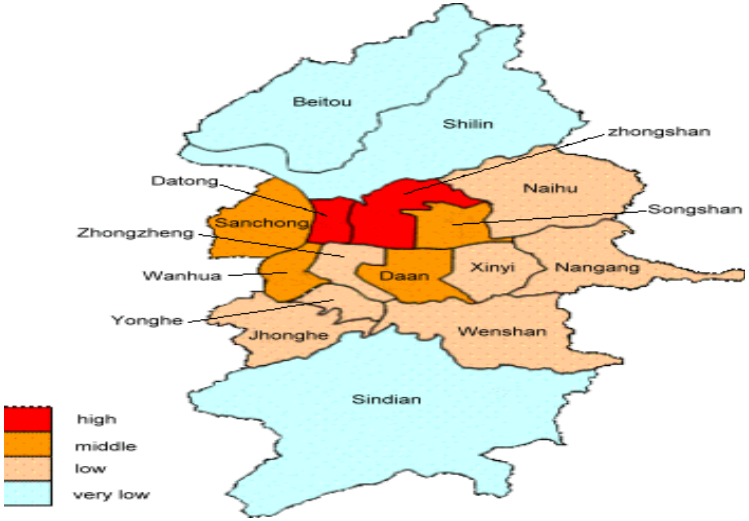
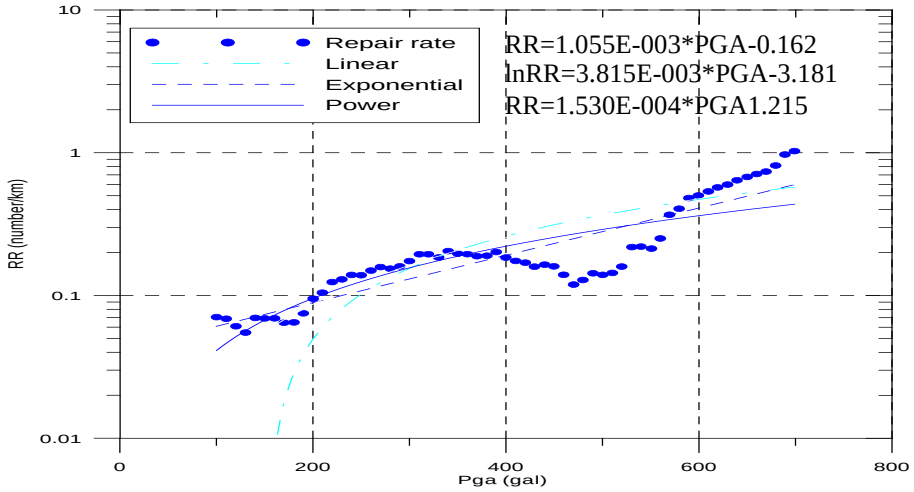


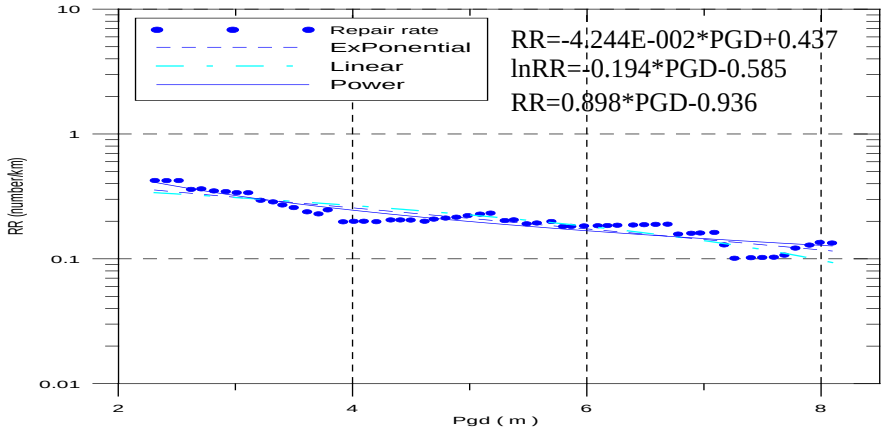
Diagram of seismatic soil liquefaction potentiality in Taipei water supply area

- National Center for Research on Earthquake Engineering had assisted TWD **evaluating and strengthening of the aseismic capacity** in existing water supply system will contribute to **improving daily safety**.
- It conducts the **numerical simulation** by adopting **Taiwan Earthquakes Loss Estimation System (TELES)** and **finite-element software**, ANSYS and SAP2000 to identify the seismic insufficiency .
- The **main analysis parameters** include **pipe diameters, section length, connector types and pipe materials**, which will be applied to evaluate the location and severity in the **most risk potential areas**.

Aseismatic measures(2/4)



Larger pipeline PGA disastrous regression

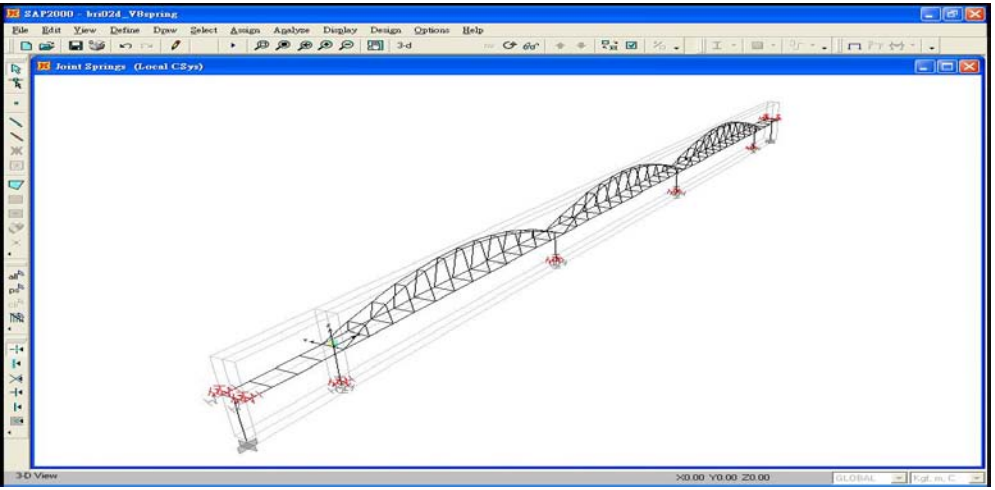


Larger pipeline PGD disastrous regression

- The seismic evaluation of pipelines **according to PGA, PGD and repair rate** will provide the basic estimation of **manpower and time** for post-disaster restoration.
- The disastrous areas in **central Taiwan** are selected as the regression datasets to formulate the **regression equations** for damage estimation.
- With the further consideration of **probabilistic models to include risk analysis and scenario simulation**.

Aseismatic measures(3/4)

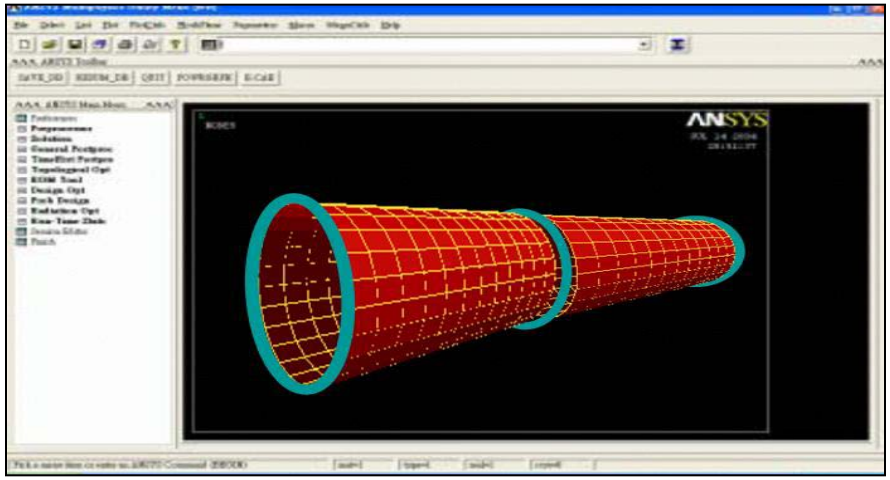
The figure of second main pipeline bridge



The second main pipelines finite-element analysis

- The **countermeasures and strategies of emergency response** will be designed to make **fundamental suggestions** toward pipeline system under major earthquake attack.
- The **pipeline bridge** has enough aseismic capacity to **resist the earthquake**(**PGA is 0.23g**) and **provide the main pipeline**.
- According to the underground embedment ductility iron pipeline analysis result, discovered its main destruction form is by attaches the bend distortion destruction primarily, **destruction scope in 2 sections of tubes lengths**.

Aseismatic measures(4/4)



The model of PCCP mechanics analysis

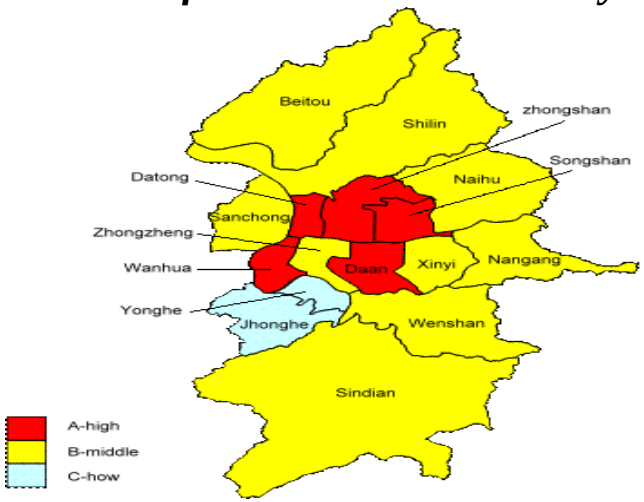
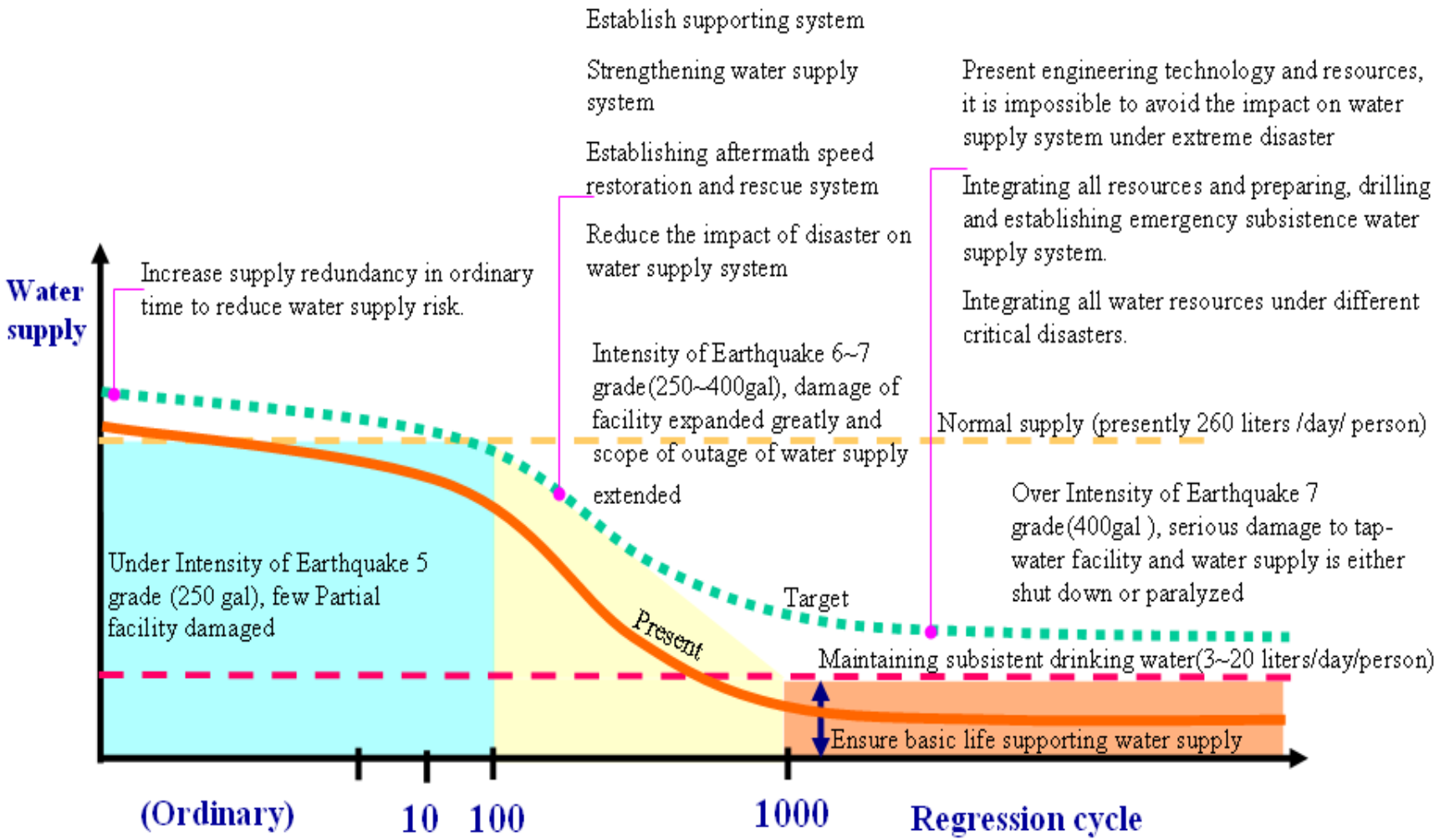
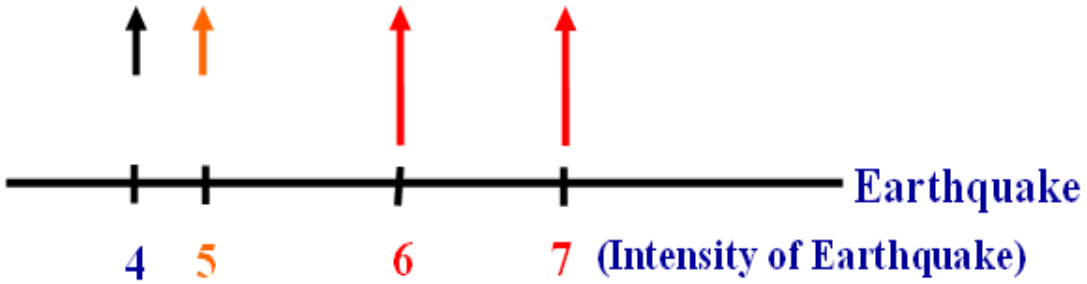


Diagram of seismatic surface displacement potentiality in Taipei water supply area

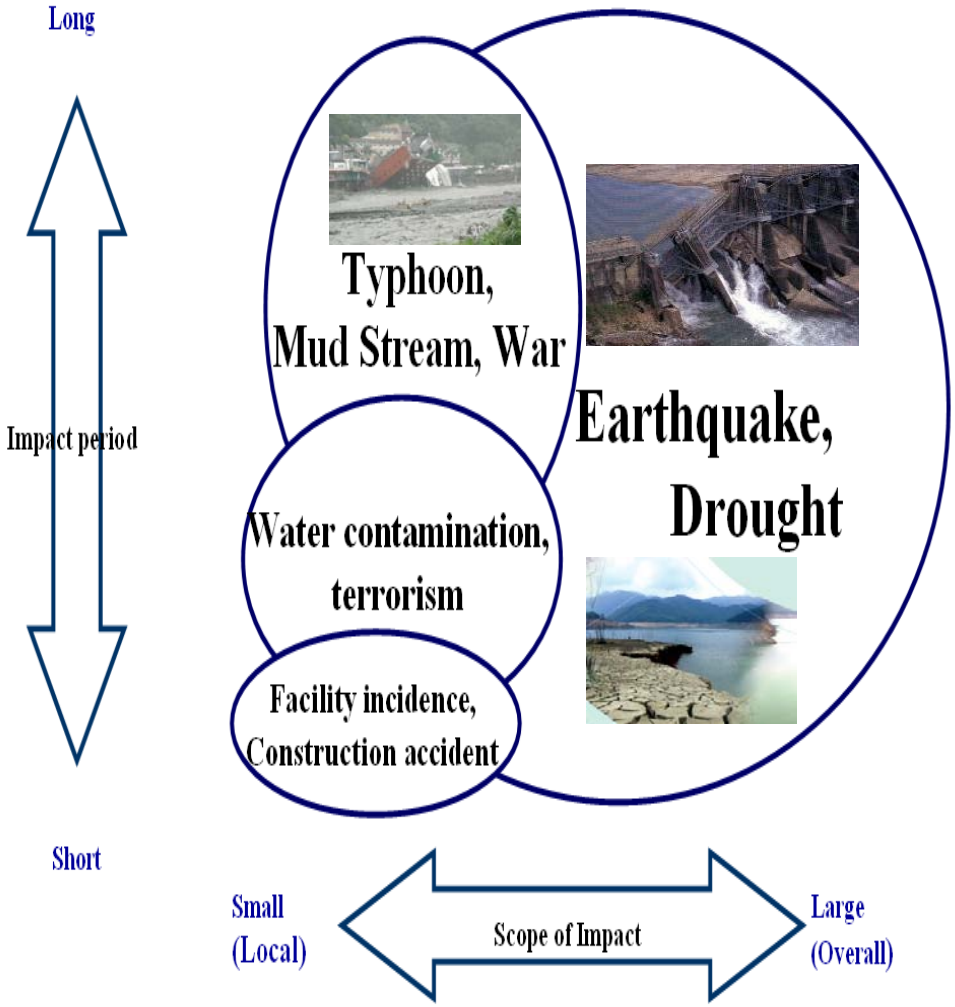
- According to **PCCP mechanics** analysis result, discovered reaches above **75 cm** when the **surface relative displacement**, can have the connector destruction and to create the water distribution function to lose.
- According to potential analysis results, **Shilin** district, **Daan** district, **Sindian** city and **Junghe** city are **potential higher damage regions**.

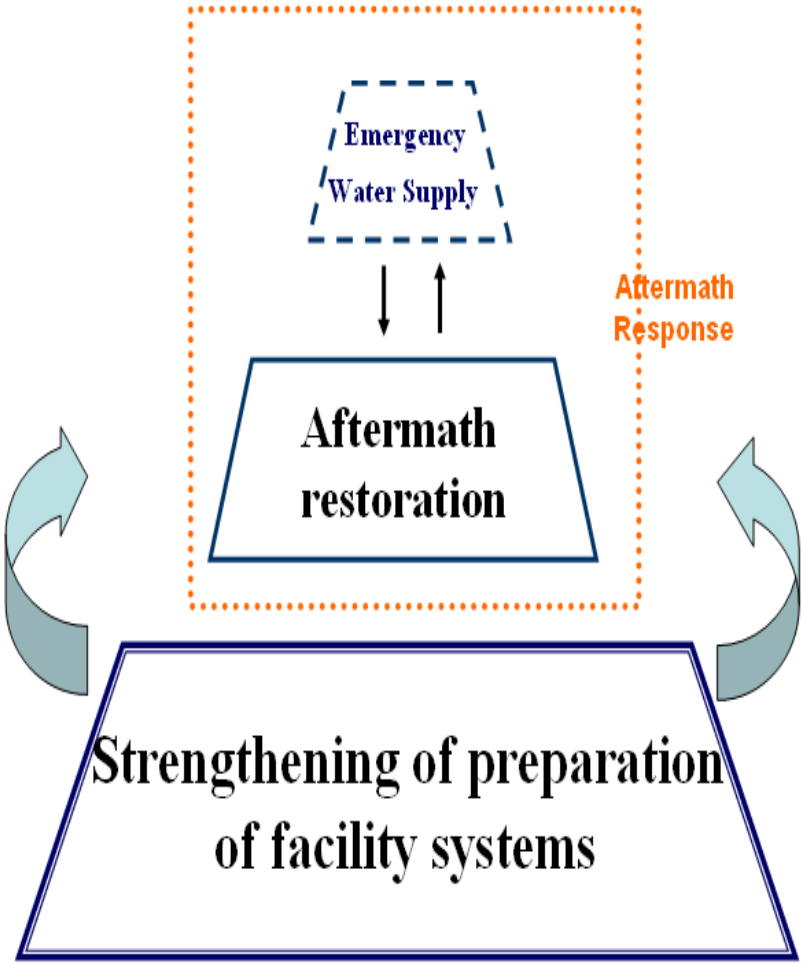


Average Pipe Damage of Taipei Water Supply System Under Earthquake :
In Intensity of Earthquake 0~4 grade, average pipe damage 0.
5 grade, average pipe damage rate is 0.05 event/ km
6 grade, average pipe damage rate is 0.5 event/ km
7 grade, average pipe damage rate is 1.0 event/ km

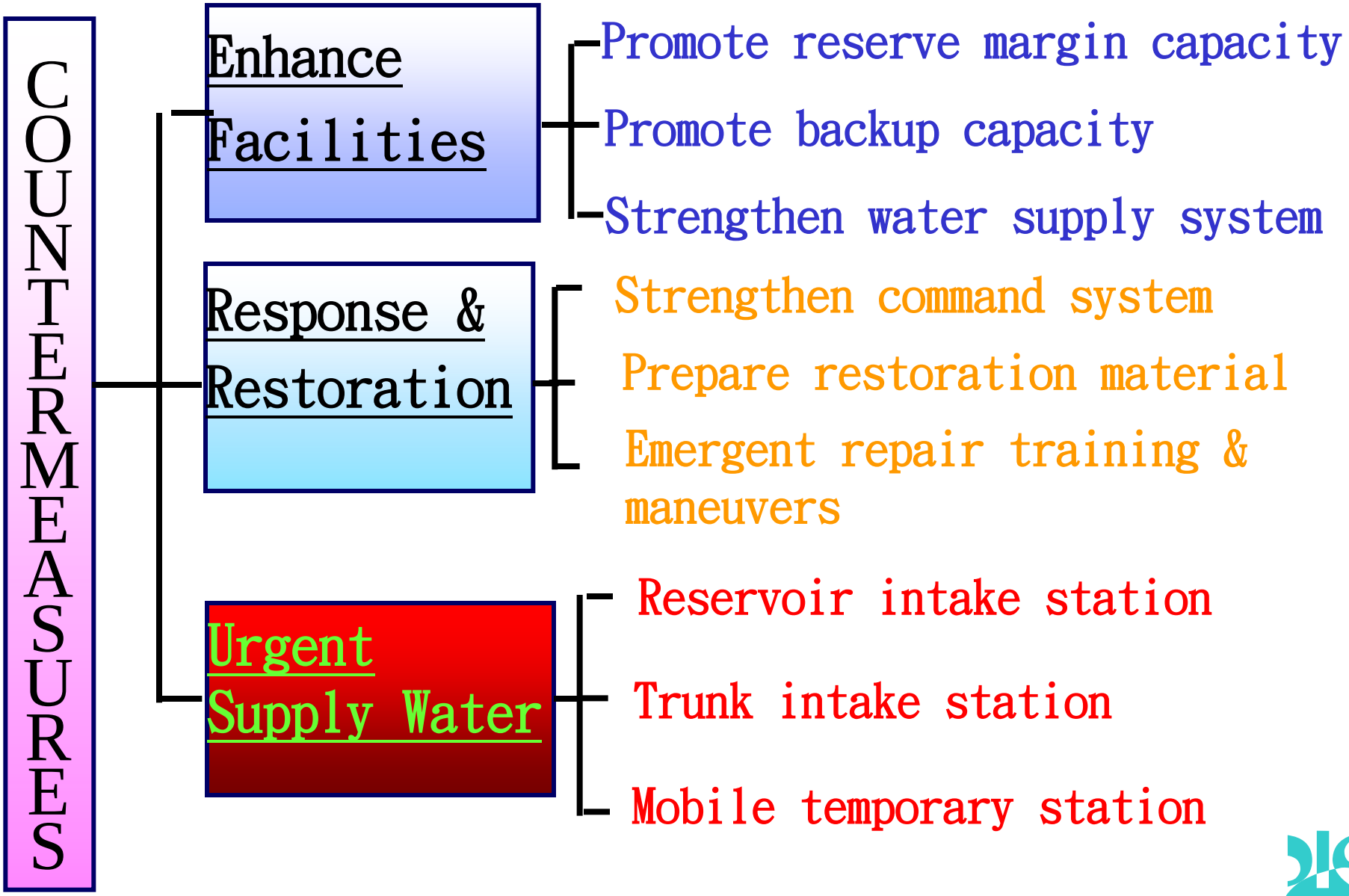


Disaster Crisis Management



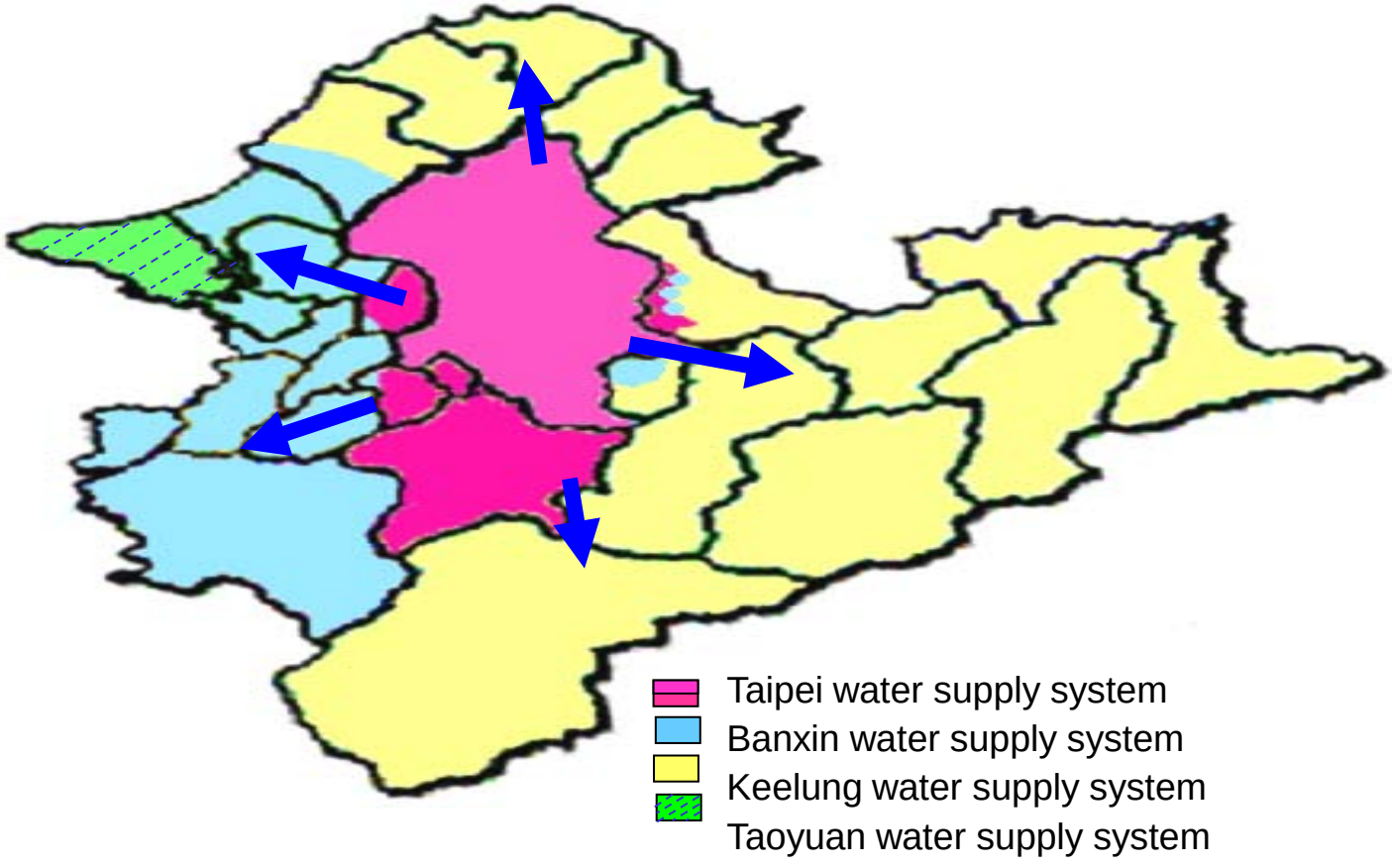


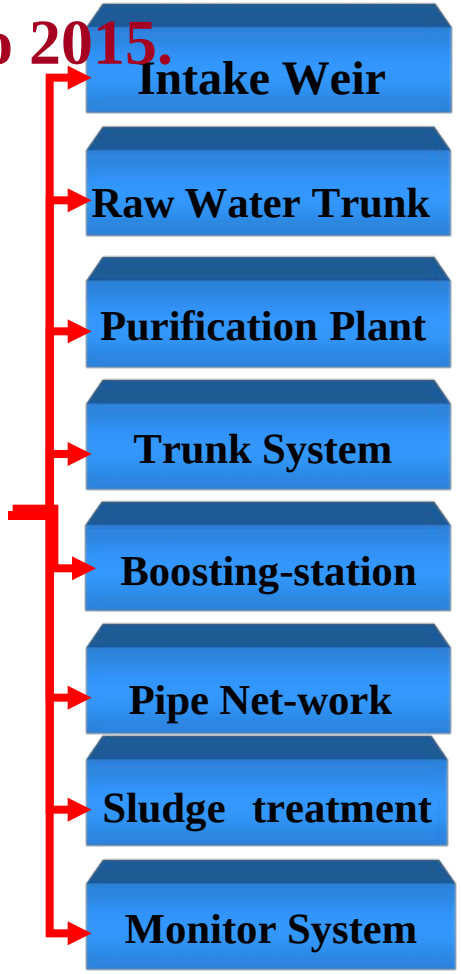
Taipei Water Department Disaster Management



Enhance Facilities - Water Supply Expansion 5th Phase Plan

- **Satisfy 2030 Taipei District Water Demand & Other Districts Supply System Emergent Water.**
- **First stage 21.9 billion NT dollars from 1991 to 2010.**
- **Second stage 15.3 billion NT dollars from 2006 to 2015.**

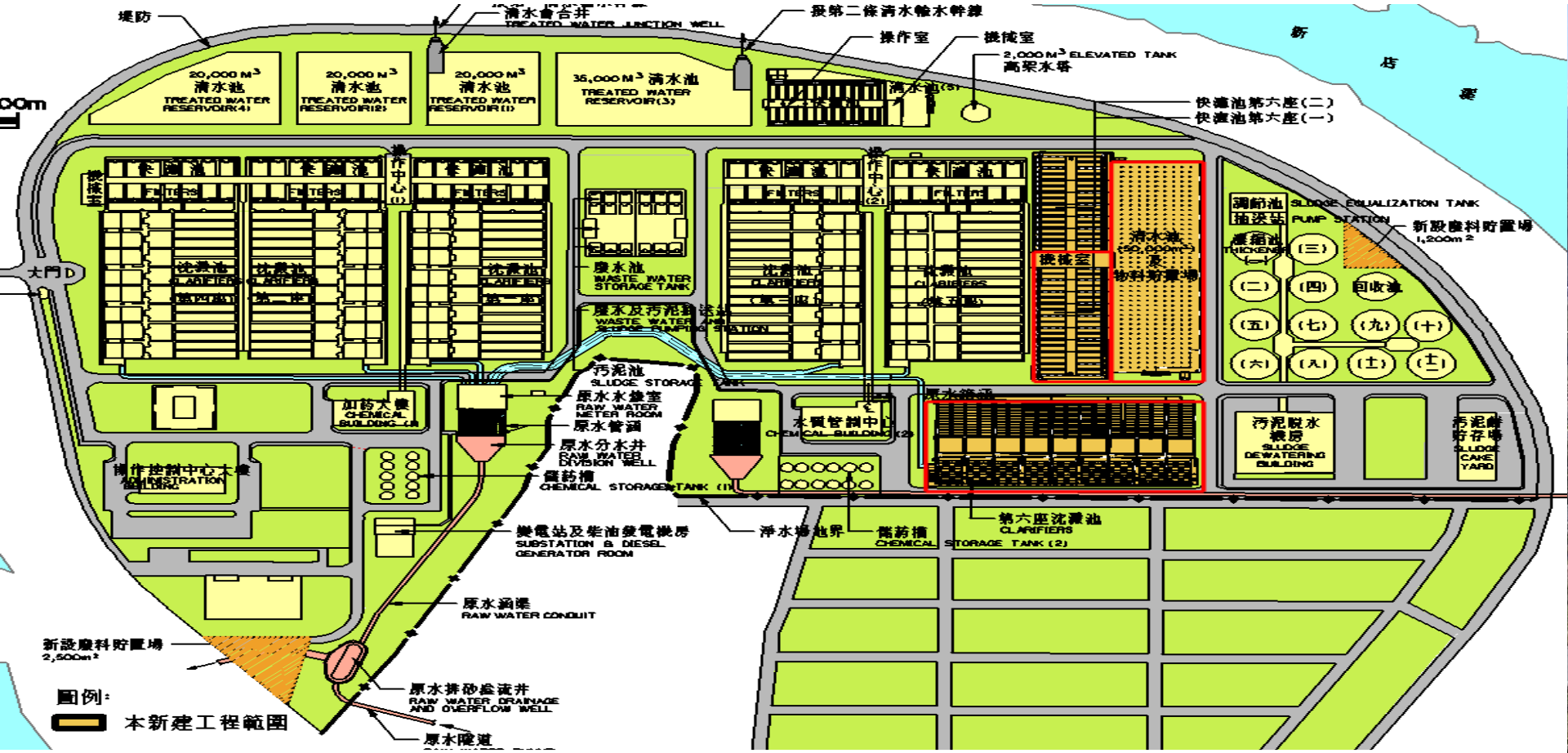




Enhance Facilities - Water Supply Expansion 5th Phase Plan

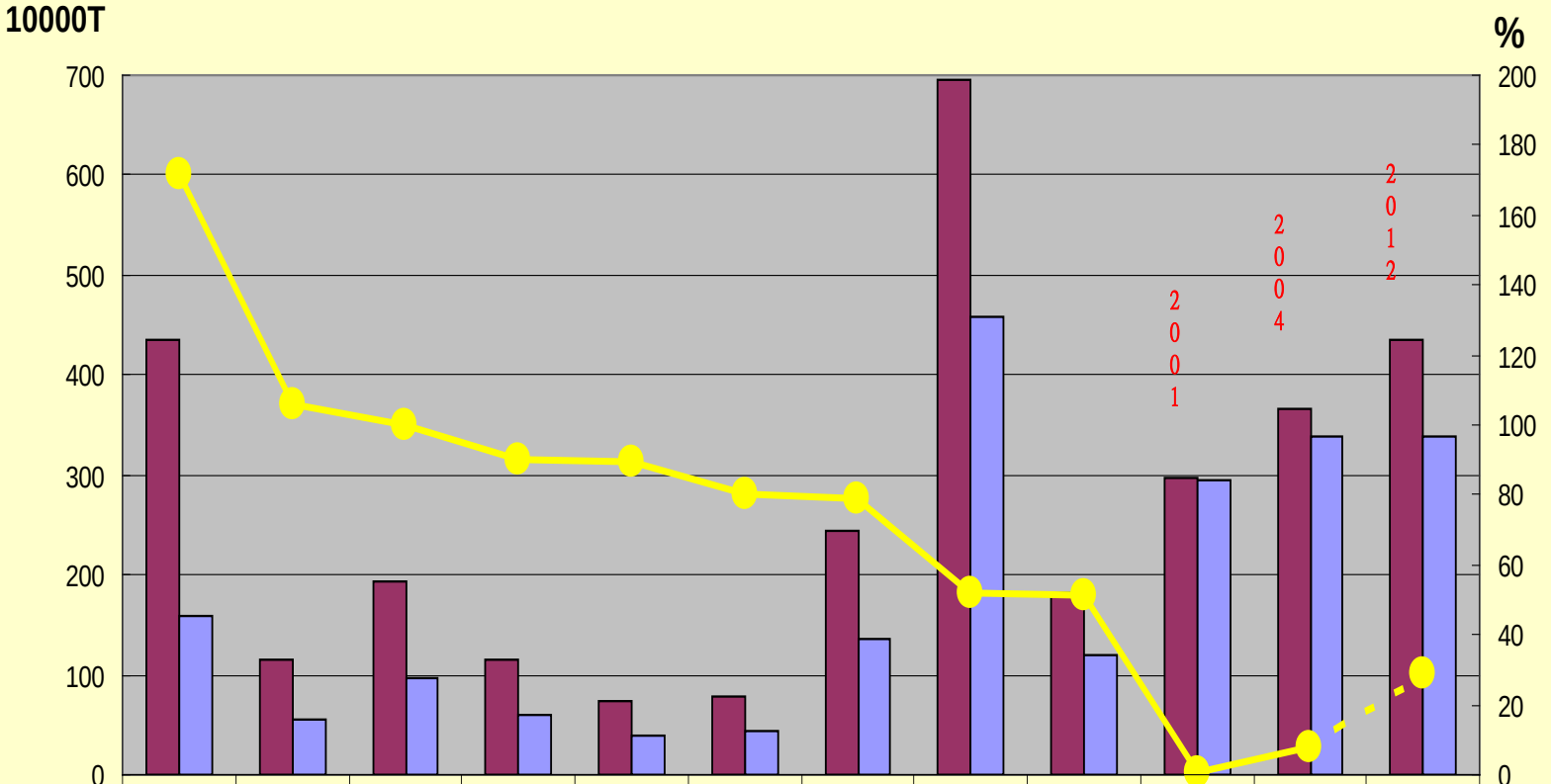
❖Purification Plant Reserve Margin Capacity

- 2004 finished Chihtan Purification Plant
  5th treatment facilities (capacity 700KCMD)
- 2012 will be finished Chihtan Purification Plant
  6th treatment facilities (capacity 700KCMD)



Enhance Facilities - Water Supply Expansion 5th Phase Plan

Reserve Margin Capacity Comparison



	SYDNEY	KOBE	PARIS	BERLIN	FUKUOKA	PRAGUE	OSAKA	TOKYO	YOKOHAMA	TAIPEI	TAIPEI	TAIPEI
facilities capacity(10000T)	434	115	194	114	75	78	243	696	182	296	366	436
supply volume(10000T/d)	160	56	97	60	40	43	136	458	120	294	339	339
reserve margin rate(%)	171.4	105.9	100.0	90.0	89.4	80.0	78.7	52.1	51.4	0.6	8.0	29.0

Enhance Facilities - Water Supply Expansion 5th Phase Plan

❖Promote backup capacity

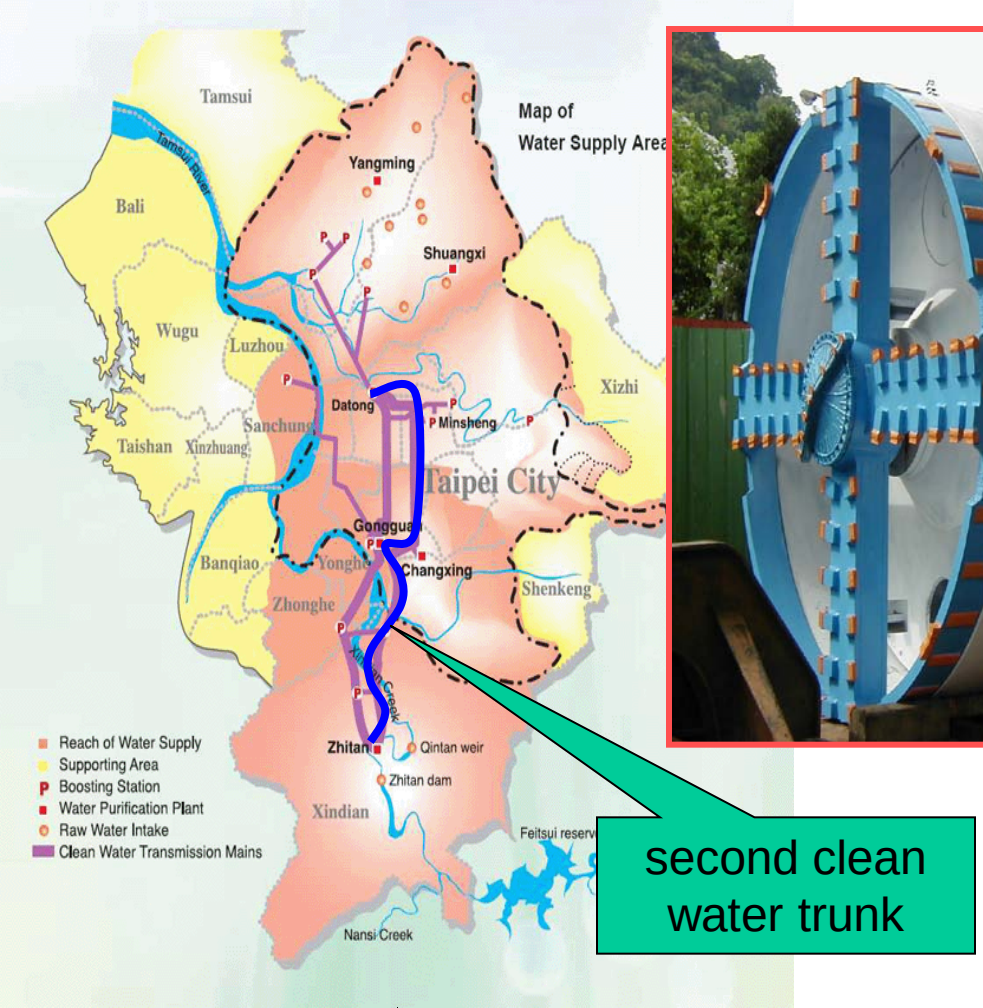
➢Setup second raw water trunk.

• It will be finished in 2009.

second raw water trunk

Enhance Facilities - Water Supply Expansion 5th Phase Plan

- 2002 finished second clean water trunk, 20.8km backup system.
- enhancement safety and emergency management



Enhance Facilities - Water Supply Expansion 5th Phase Plan

❖Strengthen water supply system

2006 had finished Minsheng boosting station

- Promote water supply capacity from 2.4hr to 3.6hr.
- Backup Water districts supply capacity.

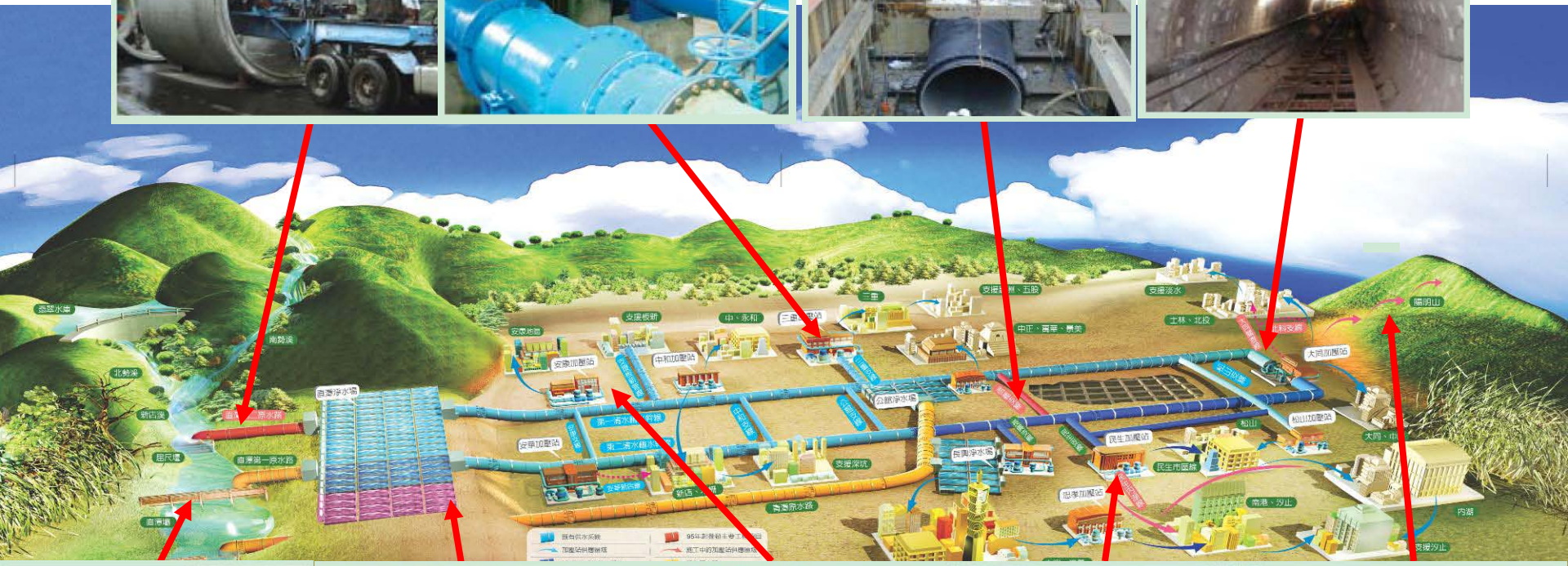
Taipei Water Supply Expansion 5th Phase Plan- backup systems

Second raw water main

San Chung 2 boosting station

Xinyi sub-trunk

Gumdo main



Zhitan dam retrofit

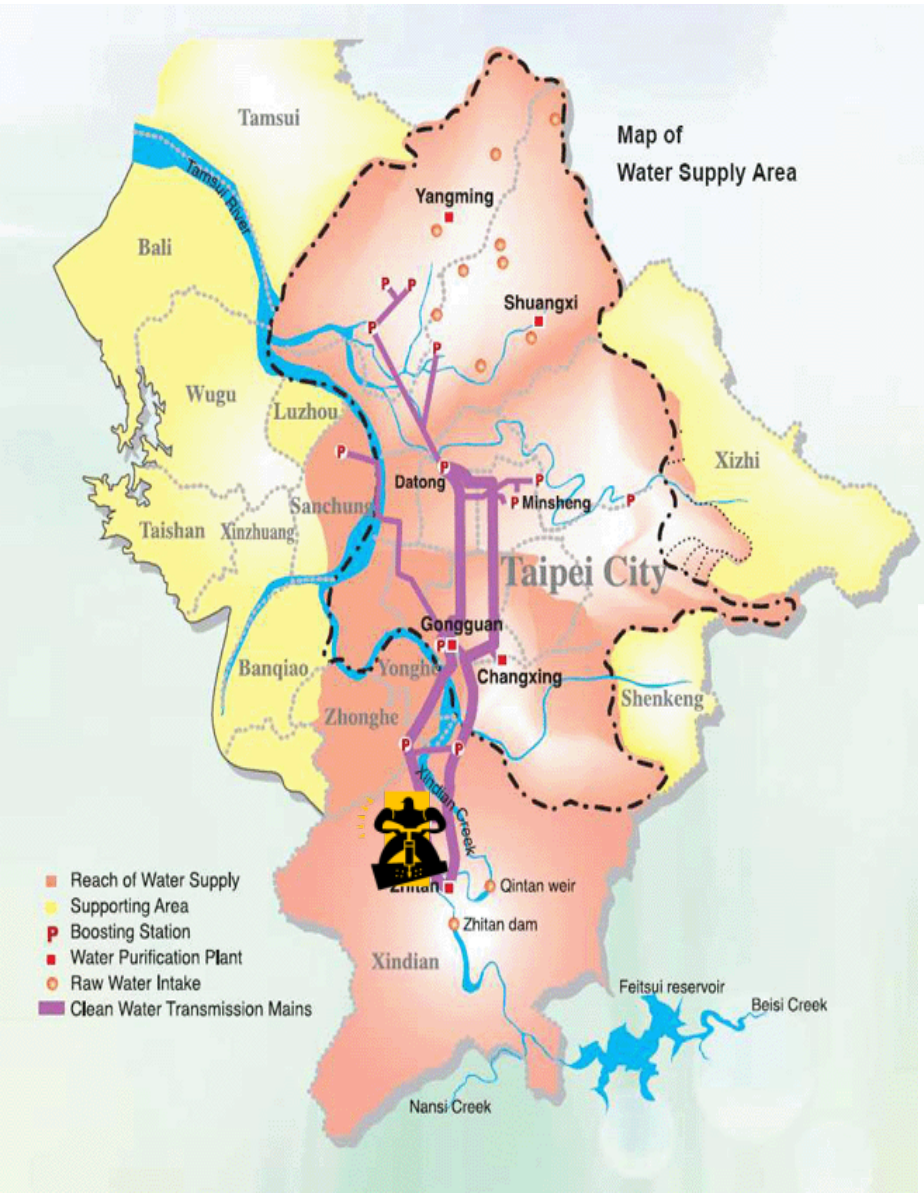
Zhitan 6th purification plants

Enfa boosting station

Minsheng boosting station

Yangming boosting system

Backup systems crisis management



- **Low Pipeline Replacement Rate → Improvement Ineffective**
- **Poor quality of pipeline material → High damaging rate**

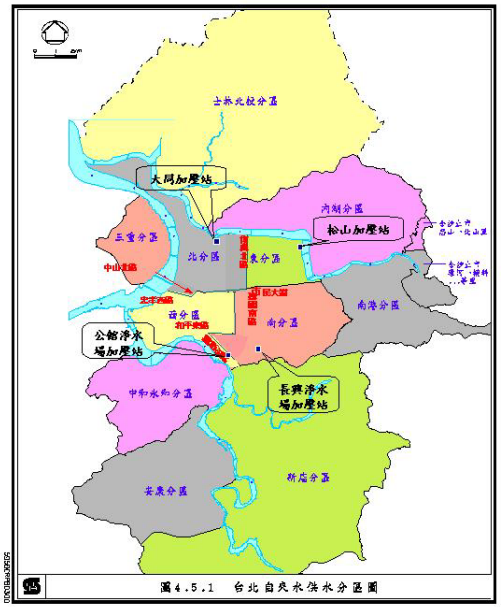
PB pipe crack

MJP corrosion

GIP corrosion

Enhance Facilities - Pipe Net-work Improvement Plan

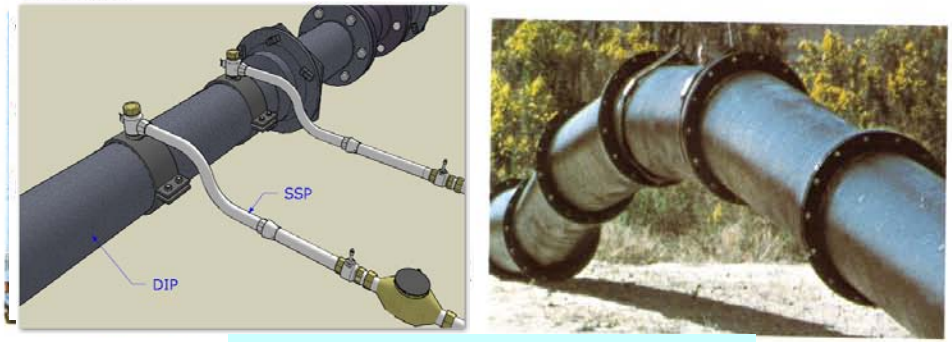
- 2003-2006 medium range plan
  2.52 billion NT dollars



Water District Management

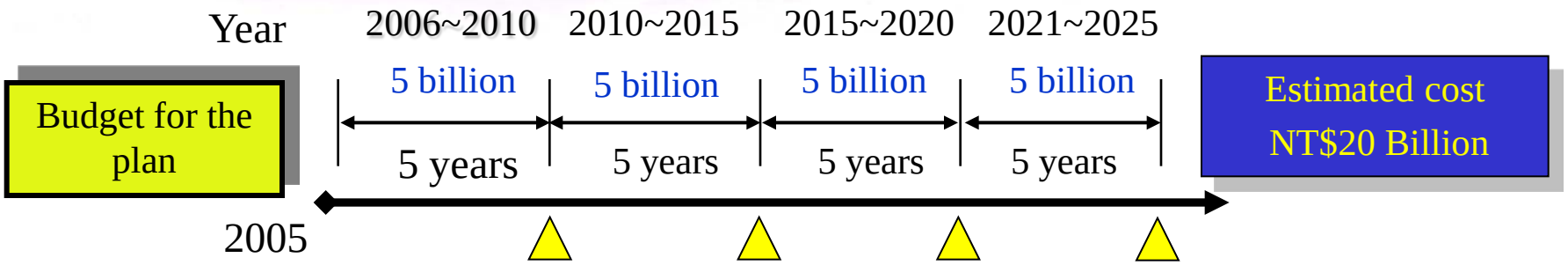
Monitor-control facilities improvement

Pumping facilities improvement

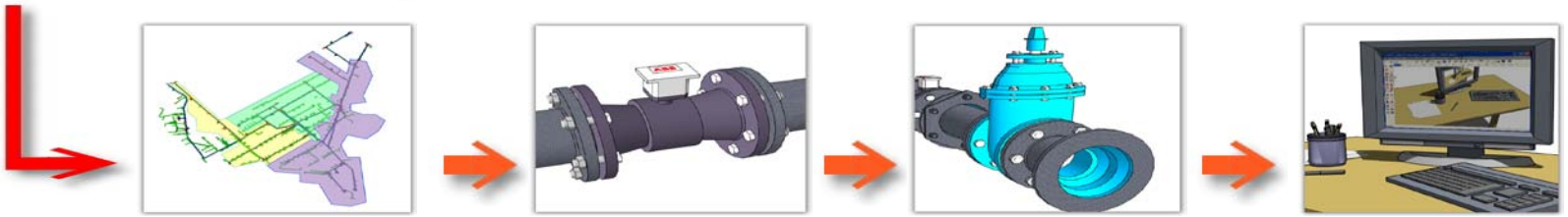


Pipe joint improvement

Water Supply Network Improvement and Management Plan – Long term strategic guideline



District Metered Area (DMA)



Block Planning

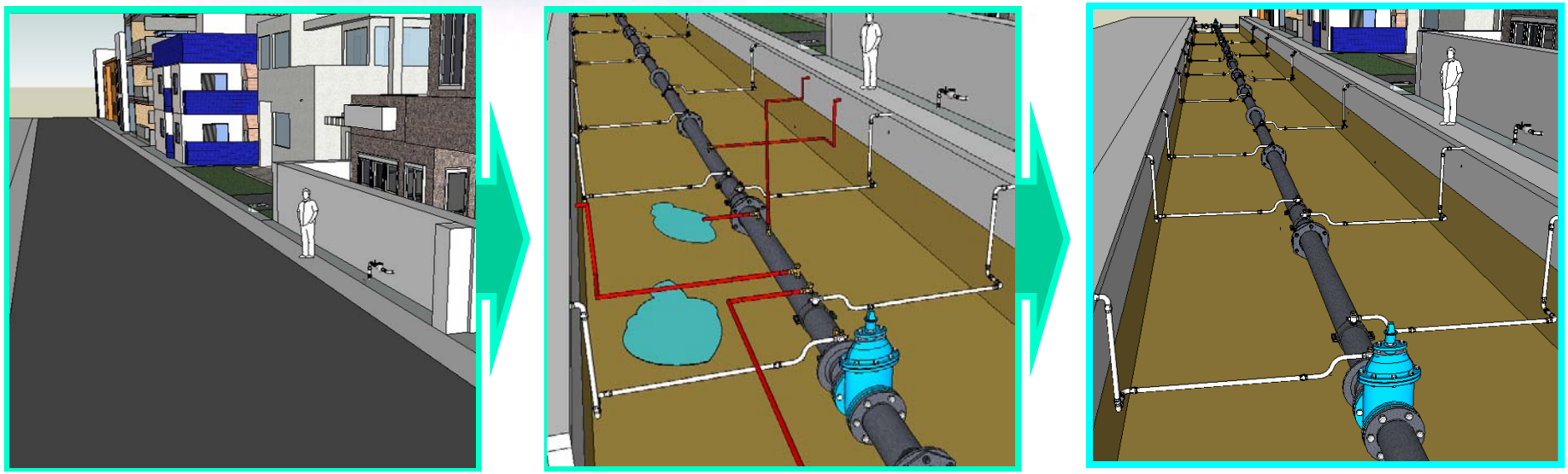
Install meters and measure

Pipeline Network improvement

Long term management

Methodology of Implementation

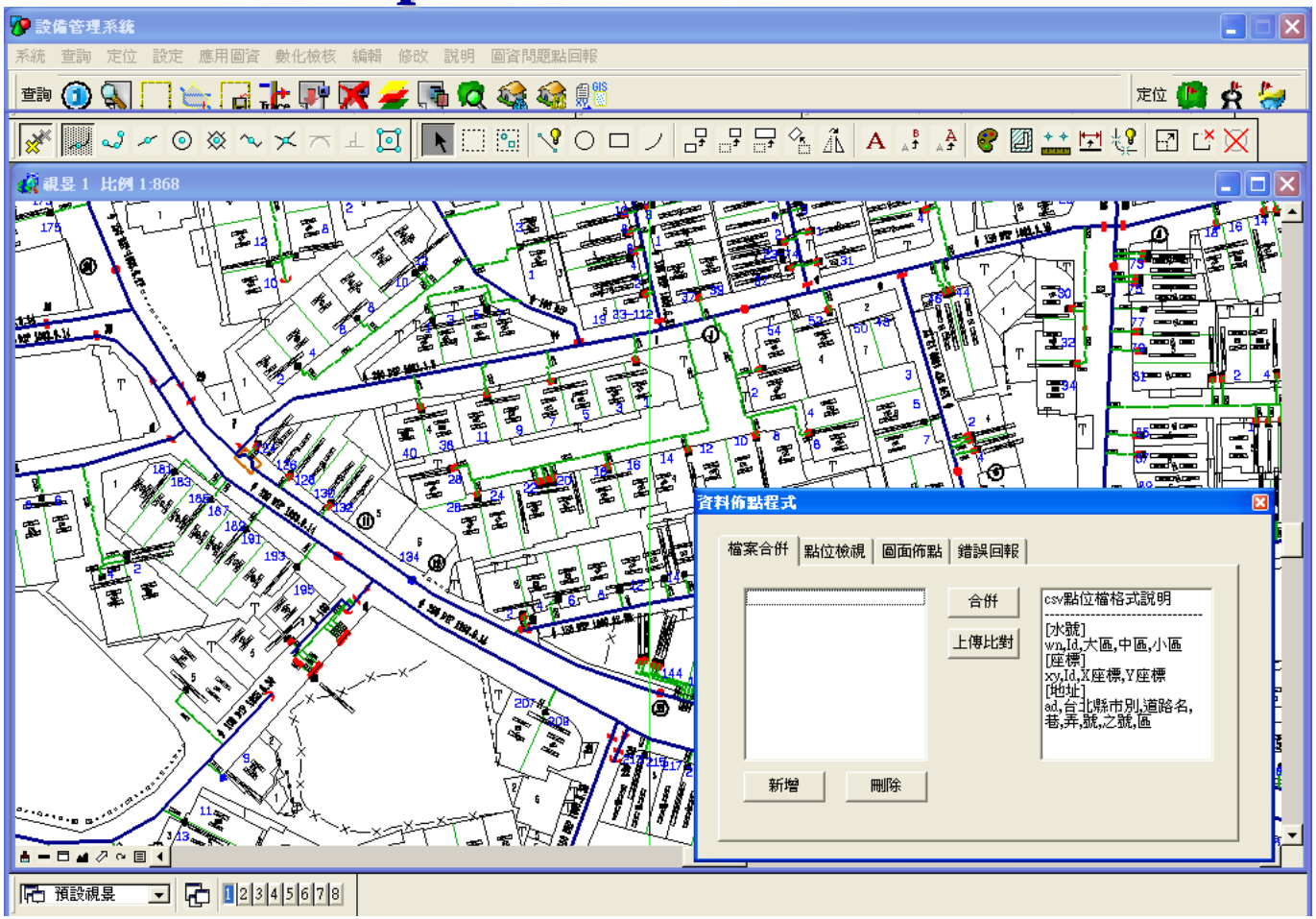
- **Full-line excavating to clean residual pipe completely.**



- In 2007, TWD excavated about 14,000 m and uncovered near 240 disconnect joints.
- In average, there is one unidentified residual pipe every 60 m.

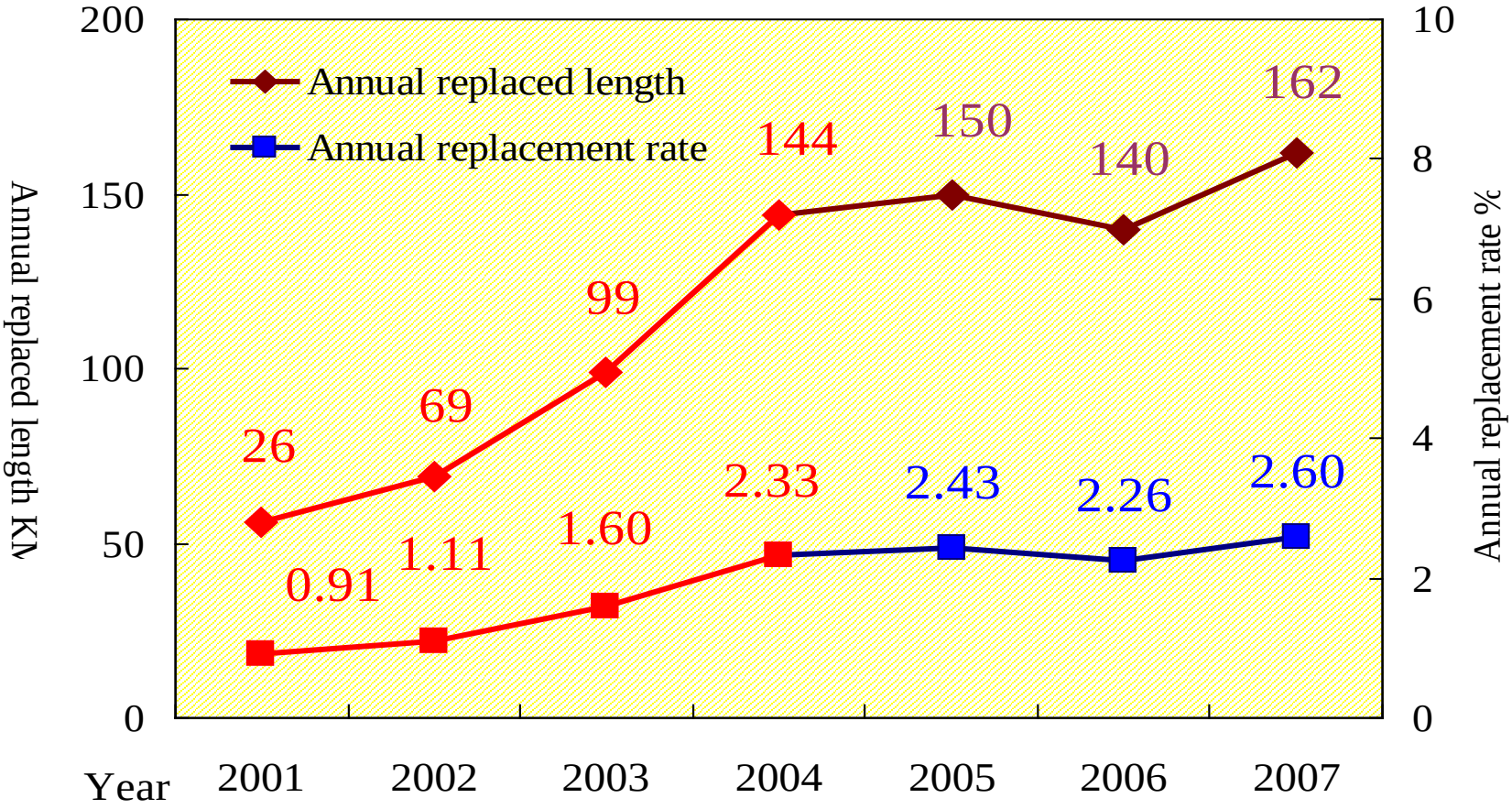
Methodology of Implementation

- **Establishing GIS Pipeline Equipment System to Monitor the Pipelines Information**



Results of Execution

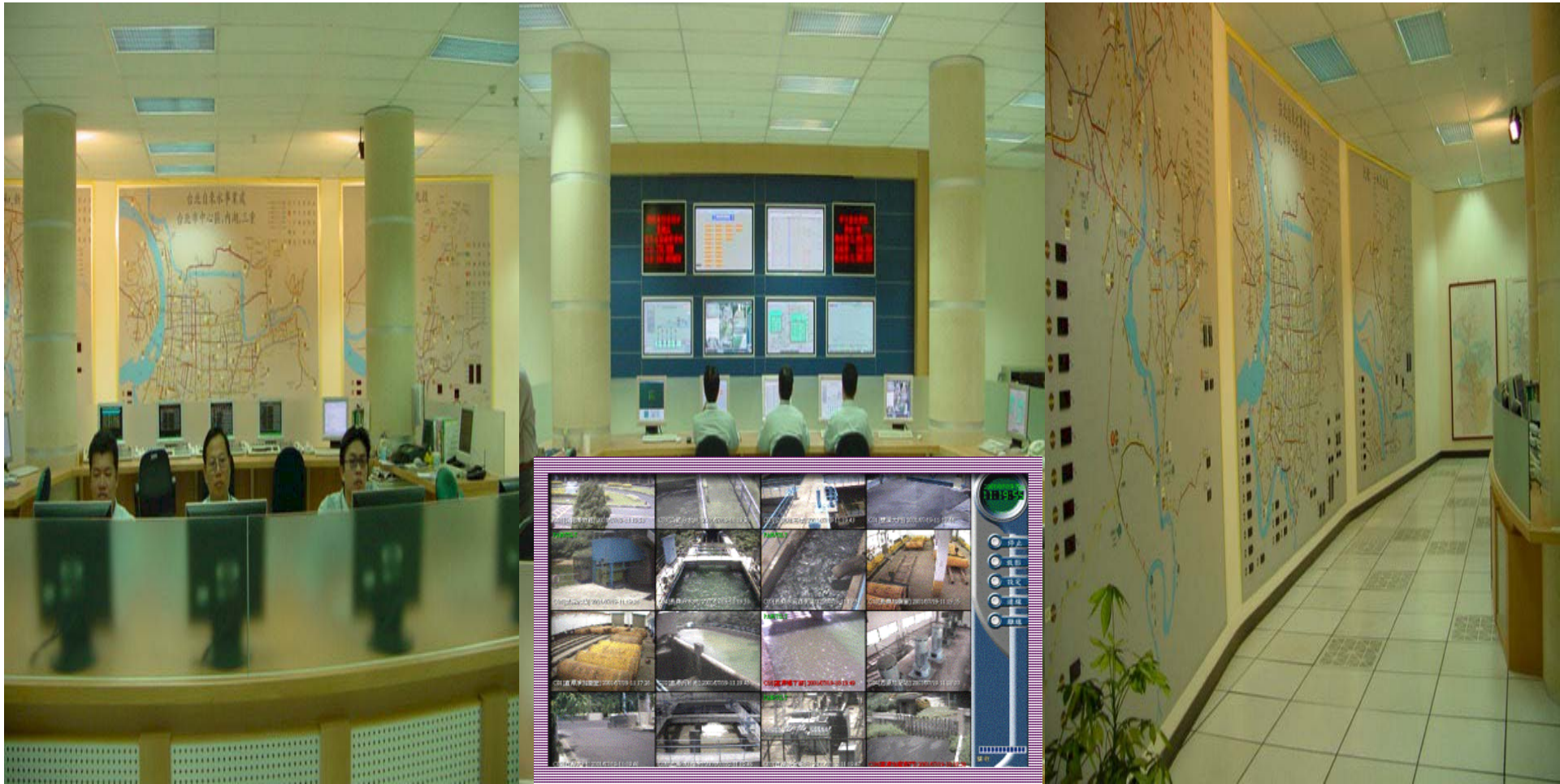
- **Length and Percent of Replacement of TWD Pipelines → Growing annually**



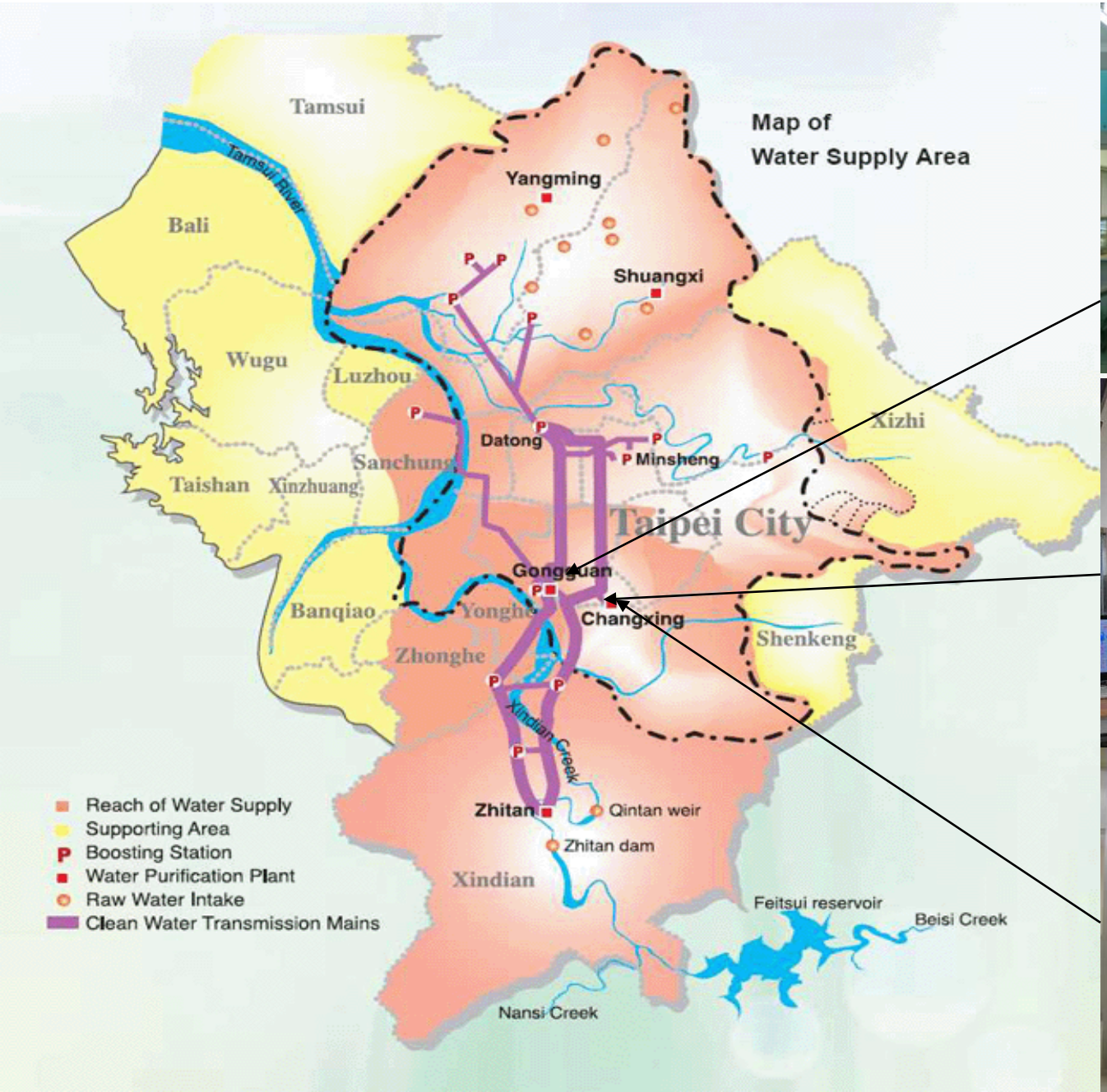
Strengthen Water Supply Control & Command System

❖24hr on-line control & command system

- 70 pump-stations monitor & control system
- 127 monitor points including pressure, water level, electrically operated valve, flow capacity。



Strengthen Plant Prevent- Response Command System



Prepare Restoration Materials

Prepare restoration materials for works, response and prevent disasters.

Repair Training to promote techniques

From training to promote techniques for works, response and prevent disasters.

TWD engineer 338 man-time

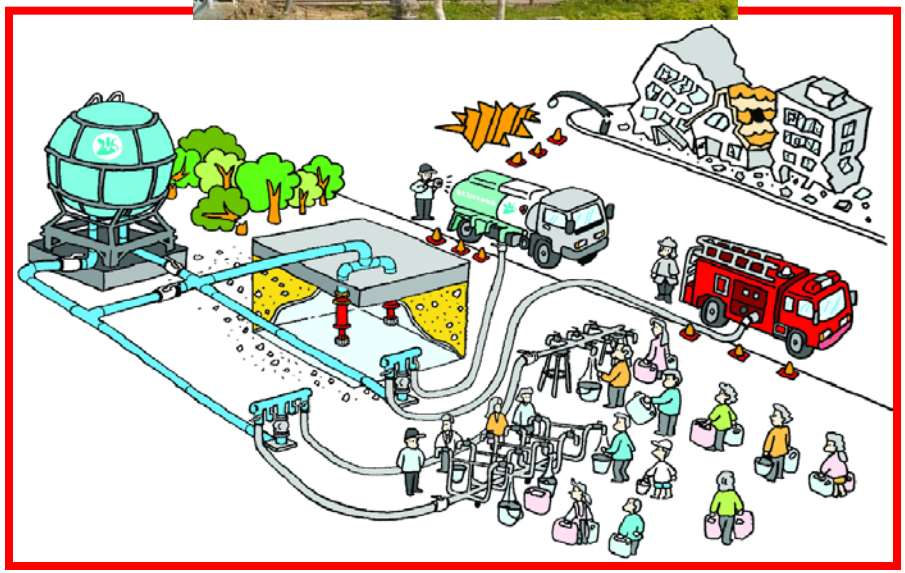
Consulters, TWC 964 man-time

Total 1302 man-time

Maneuver to Promote Emergent Response Techniques

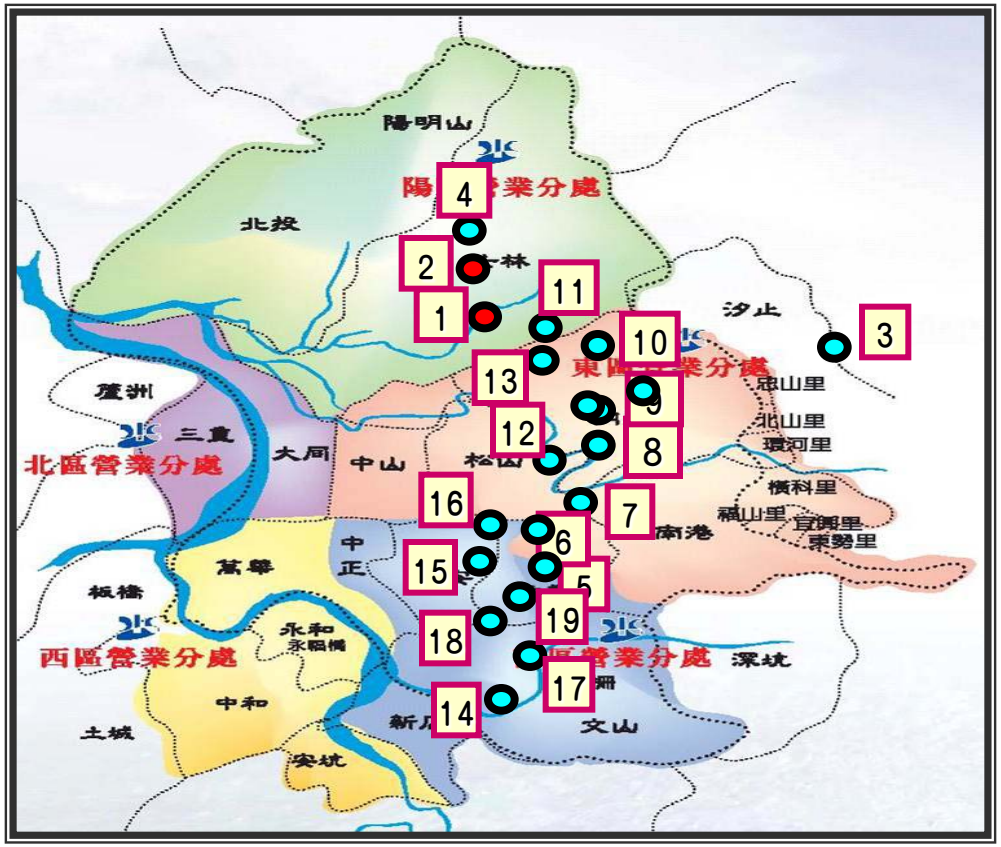
Urgent Supply Water-Reservoir Intake Station

- 2008 had finished 11 emergent life-water reservoir Intake stations.



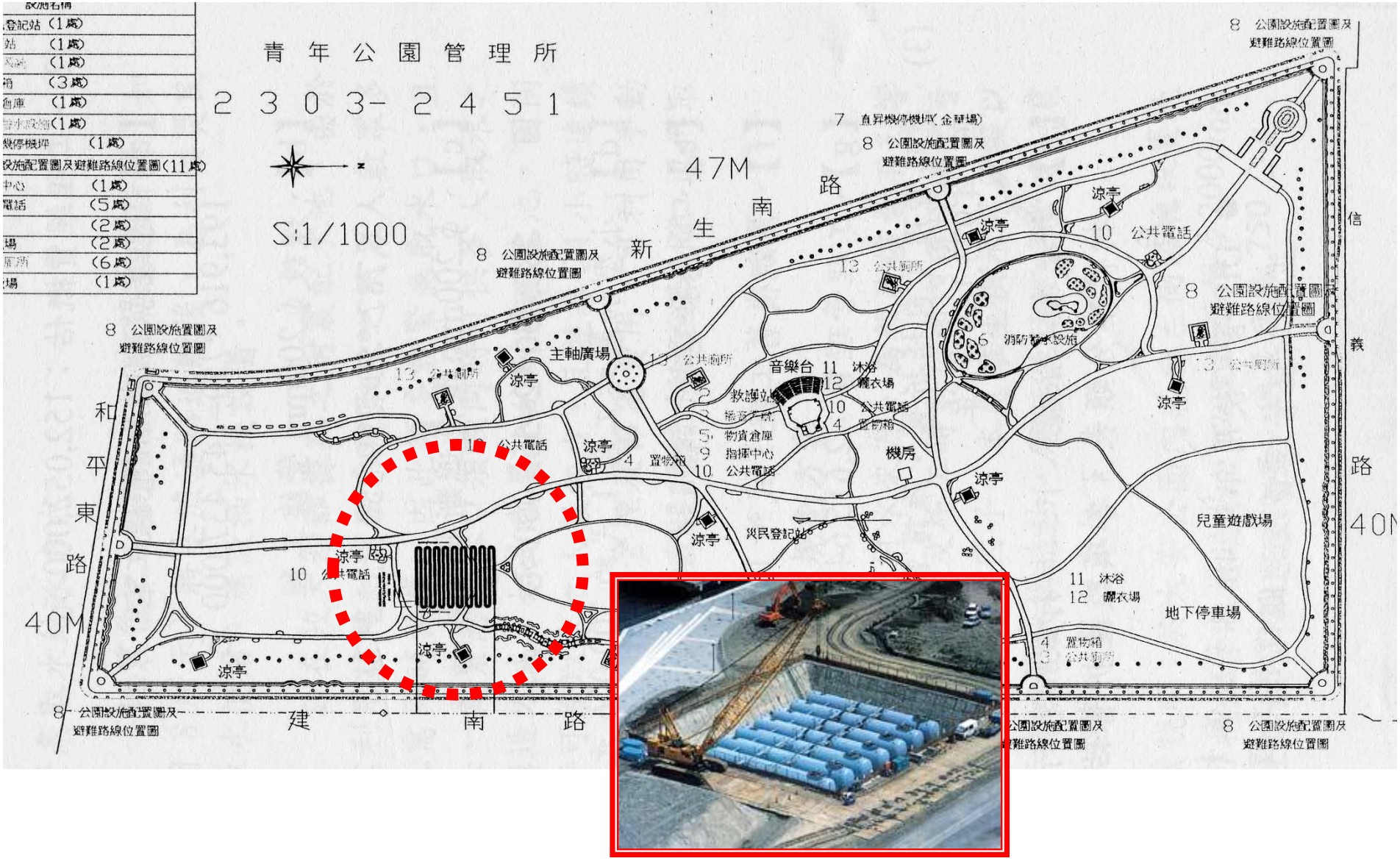
Urgent Supply Water - Trunk Intake Station

- 2008 had finished 19 life-water Trunk intake stations.
  →Benefit：could be supplied district consumers
  300 kilotons life water 25 days
  to fight time for restoration. **(3 Liter/day/person)**

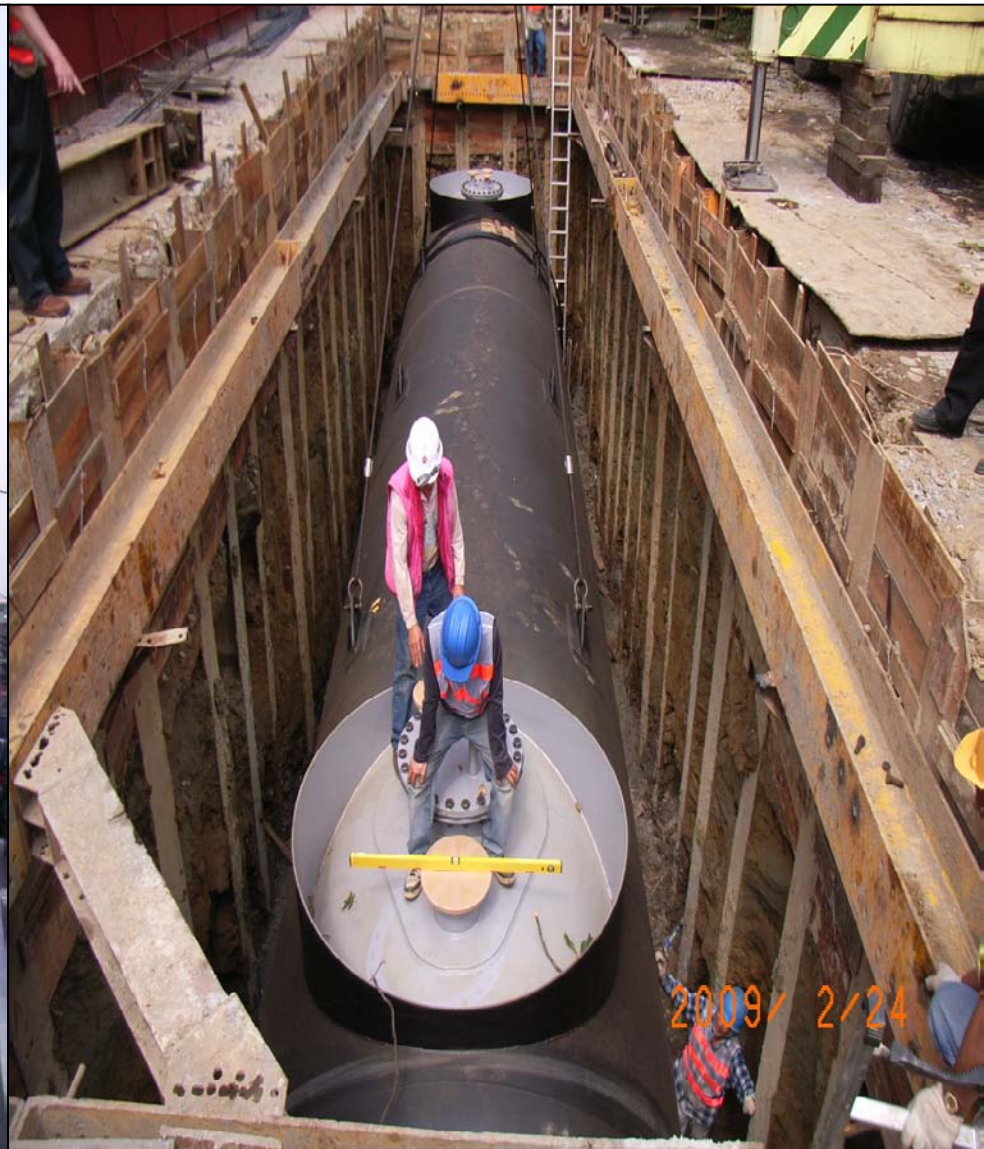


Urgent Supply Water - Aseismatic Garden

Taipei City government is planning 12 aseismatic gardens



Urgent Supply Water Site Construction



Urgent Supply Water - Mobile Temporary Station

Conclusion

- In order to strengthen response capacity of water supply system toward earthquake, in addition to establish complete hazard protection and minimization system in conjunction with hazard prevention and rescue units, **water utilities shall build complete and proper water supply system, promote the adjustment and response ability in water supply** , so as to control the scope of damage to keep it from expanding and / or deepening after occurrence of earthquake, or secondary hazard.
- The emergency water supply intake stations are located based on distribution ponds and available trunk line or in aseismatic parks, they could not be located evenly and the density will not be sufficient. **In future, finding other feasible places for establishing emergency water supply stations, so that the system may be as perfect as possible.**
- Finally, we will still facing natural disaster, **avoid weakness of water supply, TWD needs continuous to check for counter-measures from technical, institutional and decision aspects, and shall raise funds to improve aged and poor pipelines and equipment for stabilizing water supply & promote crisis management**.

2010臺北國際花博
TAIPEI INT'L EXPO

Thank you for your attention

臺北自來水事業處

Welcome to Taipei