Impacts – Water Systems

- 1994 Earthquake impacted numerous water systems in the San Fernando, Santa Clarita and Simi Valleys
  - Los Angeles Department of Water & Power
  - Metropolitan Water District of Southern California
  - Valencia, Newhall, Castaic Lake Water District
  - San Fernando
  - Calleguas Municipal Water District
  - and more

- Greatest impacts to LA Water System
- Presentation will focus on LADWP water system
LADWP Water System Overview

- Largest Municipal Utility in USA
- Founded 1902
- Serves 4.1-million people (3.8M in 1994)
- 712,000 water service connections
- 1,214-square kilometer service area
- Receives water from:
  - 4 aqueducts
  - Local wells
- LADWP owns and operates the water and power systems
Impacts LADWP Water System

- 14 repairs to raw water pipes
- 60 repairs transmission pipes
- 1013 repairs distribution pipes
- 200 service connection repairs
- 7 damaged reservoirs
- 1/2 treatment plant out of service
- Lost power up to 27 hrs
- Pump and chlorine stations were undamaged
Impacts – LADWP Water System

City Trunk Line

Granada Trunk Line
Balboa Blvd

First Los Angeles Aqueduct

Second Los Angeles Aqueduct
Impacts – LADWP Water System

- High Speed Channel
- LA Reservoir Tower Bridge
- Lower San Fernando Drain Line No. 1
- Tailrace
- Granada High Tank I/O Lines
# Water Services

- Service restoration will be presented in the following categories:

<table>
<thead>
<tr>
<th>Service Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Delivery</td>
<td>Able to distribute water to customers, but the water delivered may not meet water quality standards (requires water purification notice), pre-disaster volumes (requires water rationing), fire flow requirements (impacting fire fighting capabilities), or pre-disaster functionality (inhibiting system operations).</td>
</tr>
<tr>
<td>Quality</td>
<td>Water to customers meets health standards (water purification notices removed). This includes minimum pressure requirements.</td>
</tr>
<tr>
<td>Quantity</td>
<td>Water flow to customers meets pre-disaster volumes (water rationing removed).</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>Able to provide pressure and flow of suitable magnitude and duration to fight fires. In many water distribution systems the minimum pressure required for fire protection is 20 psi (140 kPa), with flow quantities varying by neighborhood.</td>
</tr>
<tr>
<td>Functionality</td>
<td>System restored to meet or exceed pre-disaster functionality and reliability (operational constraints resulting from the disaster have been removed/ resolved) including pressures.</td>
</tr>
</tbody>
</table>
1994 NORTHRIDGE EARTHQUAKE
L.A. WATER RESTORATIONS

Desoto Reservoir
Area shown in Figure 2
(power loss)
(roof collapse)
(damage @ 2 locations)
(damage @ 3 locations)
(power loss, damage to south half)
(damaged influent and effluent lines)

Van Norman Complex
Additional Damage
- High Speed Channel
- Bypass Channel
- Power Plant Tailrace
- LA25 (MWD connection)
- LA35T (MWD connection)
- VNPS I Discharge Line
- VNPS II Discharge Line

GHT

Damaged Tanks
BGT = Beverly Glen Tank
CCT = Coldwater Canyon Tank
GHT = Granada High Tank
TT = Topanga Tank
ZT = Zelzah Tank

Time (days)
Los Angeles Water Service (%)
1994 L.A. Delivery Services

- 159,434 service connection outages
- 22% of all services
- ~670,000 residents
- Deployed water tankers
  - 15 locations

GHT = Granada High Tank
BGT = Beverly Glen Tank
CCT = Coldwater Canyon Tank
TT = Topanga Tank
ZT = Zelzah Tank

Damage (2 locations)
Damage (3 locations)
Damage to south half
Power loss
Roof collapse
Damaged influent and effluent lines

Van Norman Complex
Additional Damage
- High Speed Channel
- Bypass Channel
- Power Plant Tailrace
- LA25 (MWD connection)
- VNPS I Discharge Line
- VNPS II Discharge Line

7 DAYS
1994 L.A. Quantity and Fire Service

- 203,164 service connection outages
- 28% of all services
- ~850,000 residents
- All quantity restore in 8.5 days
- All fire flow restored in 9 days

- Damaged Tanks:
  - BGT = Beverly Glen Tank
  - CCT = Coldwater Canyon Tank
  - GHT = Granada High Tank
  - TT = Topanga Tank
  - ZT = Zelzah Tank

- Additional Damage:
  - High Speed Channel
  - Bypass Channel
  - Power Plant Tailrace
  - LA25 (MWD connection)
  - VNPS I Discharge Line
  - VNPS II Discharge Line

- Days to Restoration:
  - 8.5-9 days

- Map of Damage Locations:
  - (power loss)
  - (roof collapse)
  - (damage at 2 locations)
  - (damage at 3 locations)
  - (damage to south half)
1994 L.A. QUALITY RESTORATION

January 17
8 PM

January 18
10 PM

January 21
10 AM

January 22
2:46 PM

January 23
10 PM

January 23
3 PM

12 DAYS
Improvements

- Pipe relocations (out of hazard zones)
  - Granada Trunk Line
  - SLAA at Terminal Hill

- Pipe Design Improvements
  - Fiber wrap
  - Base Isolation systems protecting against ground movement

- Tank Flexible connections
Improvements

- Dam Stability Re-Evaluations
  - Use improved geo- and seismo-technology
- System evaluation and Restoration Modeling
  - Worked closely with Researchers
  - GIRAFFE (Cornell Univ. – LADWP collaboration)
- Increased Seismic Instrumentation
- ShakeCast, CISN Display
Pilot Project - Main Replacement
Earthquake Resistant Ductile Iron Pipe

- Contour Drive
- LADWP replaced 1750’ of 6” line
- Installation completed April 2013
- 4 more pilot project sites
- Positive results so far
ShakeOut Scenario

Regional M7.8 Earthquake Scenario on San Andreas Fault

Water Supply Results

- Aqueduct flow restoration > 18 mo.
- Insufficient supply
- Severe rationing
- Firefighting impacts
- Some w/o water for 6 months or more
- Greatest economic impact of all
  - >50% total BI
  - >25% total losses
  - >2/3 fire + water

Davis & O’Rourke, 2011, “ShakeOut Scenario: Water System Impacts from a Mw7.8 San Andreas Earthquake,” EQS, 27:2, pp 459-476
Next Steps

- Systems Evaluations
  - Supply, transmission, distribution systems
  - Identify & improve vulnerabilities

- Develop resilient distribution network
  - Use earthquake resistant pipes and designs
  - Allow for acceptable losses

- Incorporate lessons learned from recent disasters
  - Great East Japan
  - Christchurch New Zealand
Next Steps – Water Supply

- Improve local water supplies
  - Ground water (clean up contaminations)
  - Storm water capture
  - Reclamation
- Work with LAFD to improve post-earthquake fire water supply
- Work with LA EOC to improve post-earthquake water accessibility
- HDPE Elizabeth tunnel
Next Steps – Water Supply

- Elizabeth tunnel Seismic Enhancement

HDPE Pipe

Elizabeth Tunnel

San Andreas Fault

Instruments
Next Steps and Recommendations for Water Supply Systems

- Southern California Water Supply is too critical to fail, aqueduct water losses for minimum 12 to 18 months is too long!
  - A Water Supply Task Committee (WSTC) needs to be formed by the supply agencies (LADWP, MWD, DWR)
  - The WSTC should coordinate their efforts for
    - identifying water supply vulnerabilities,
    - how to mitigate, and
    - planning for emergency response and recovery
Recommendations

- Improve assessment of regional economic impacts from water system disruption
- Improve post-earthquake water system restoration modeling
- Develop water system restoration goals
- Maps identifying potential ground displacements need to be prepared and available for all to use
  - Ground Failure causes the greatest lifeline disruption – to all lifeline pipes and cables
- Develop uses for Earthquake Early Warning
Recommendations

- California Department of Public Health change “Boil Water Notice”
  - We should not be encouraging the community to light fires in a disaster situation
  - The “Boil Water Notice” actually makes many recommendations for purification than boiling water
  - The LADWP has initiated this process by implementing a “Tap Water Purification Notice”