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# Incorporating Additional Resilience Measures through Operational and System Control Strategies now that the Design is Complete for the Willamette Water Supply System

May 4, 2023

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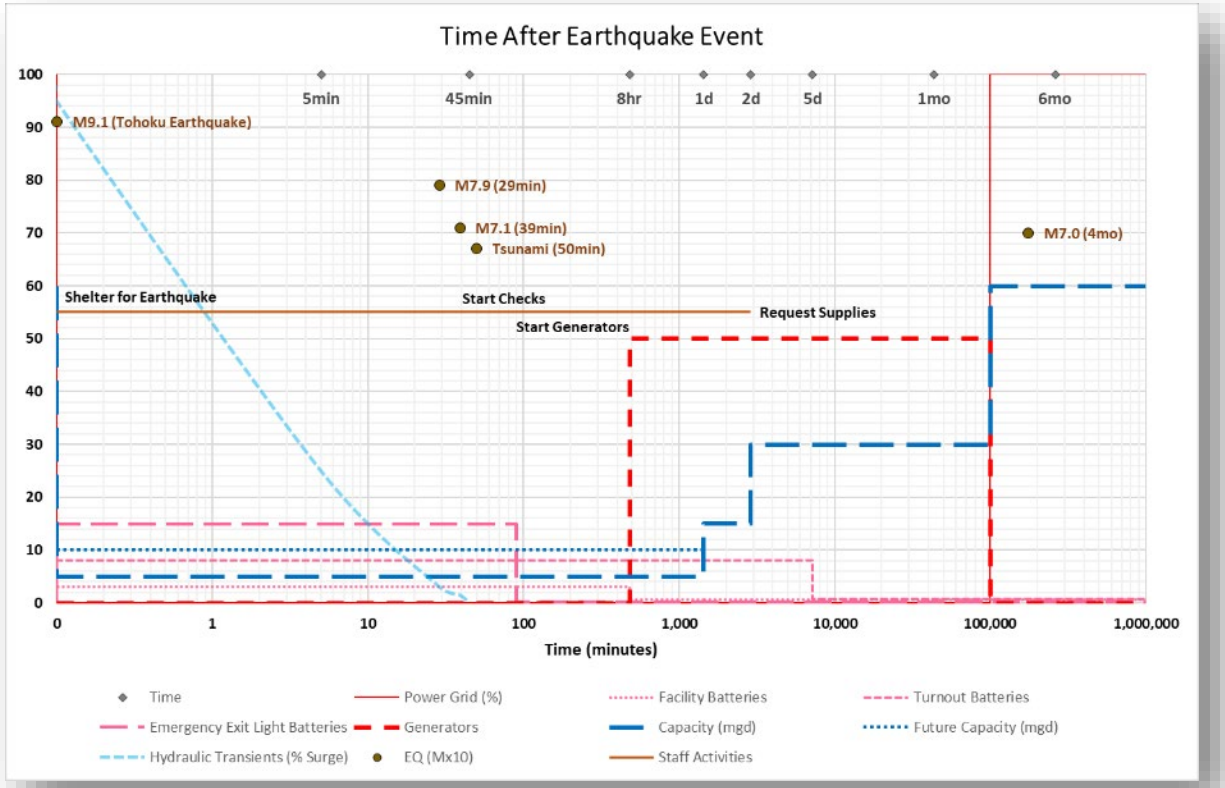
Willamette Water Supply Program

PNWS-AWWA
Water 2023
Kennewick, WA • May 3-5

# Outline

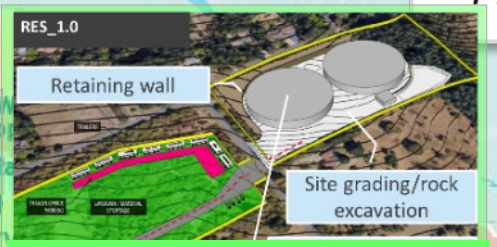
- WWSS Overview
- Level of Service and Time After Earthquake Event
- Timelines after Event
  - Earthquake
  - System Control
  - Power Supply
  - Capacity, Storage, and Hydraulics
  - People/Staff
  - Supplies and Infrastructure Interdependencies



# Willamette Water Supply Program

***Mission Statement: Provide a cost-effective, reliable and resilient water supply system** by July 2026, that benefits current and future generations of the communities we serve and supports a vibrant local economy.*

30+ Miles of 66” & 48” Welded Steel Pipelines




15 MG Storage Tanks

New Water Treatment Plant

Modified River Intake

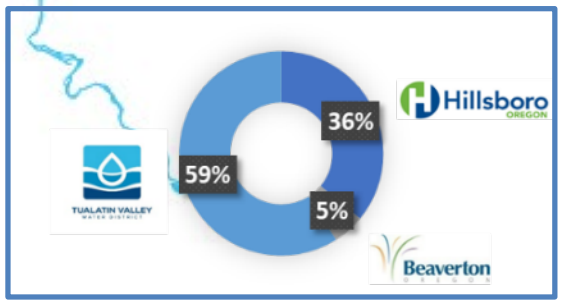



Image from the Regional Water Providers Consortium

***It’s important to think about this as a “system” when considering seismic resilience***

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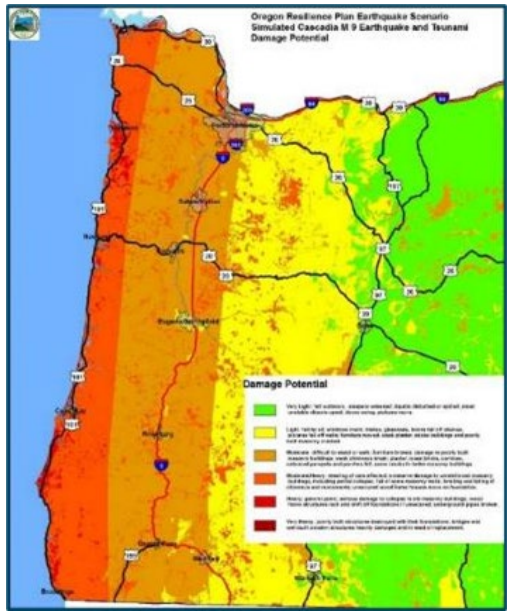
# Level of Service and Time After Earthquake Event[1]

Level of Service Goals followed ***Oregon Resilience Plan*** Guidance (for Backbone Systems)




| System Component | Capacity | Timing |
|---|---|---|
| Pipeline | 80 – 90% | 0 – 24 hours |
| Reservoirs | 80 – 90% | 0 – 24 hours |
| Turnouts | 80 – 90% | 0 – 24 hours |
| Raw Water Facilities | 25%<br>50% | 24 hours<br>48 hours |
| Treatment Plant | 25%<br>50% | 24 hours<br>48 hours |

***Performance Goals***

Pressure Integrity

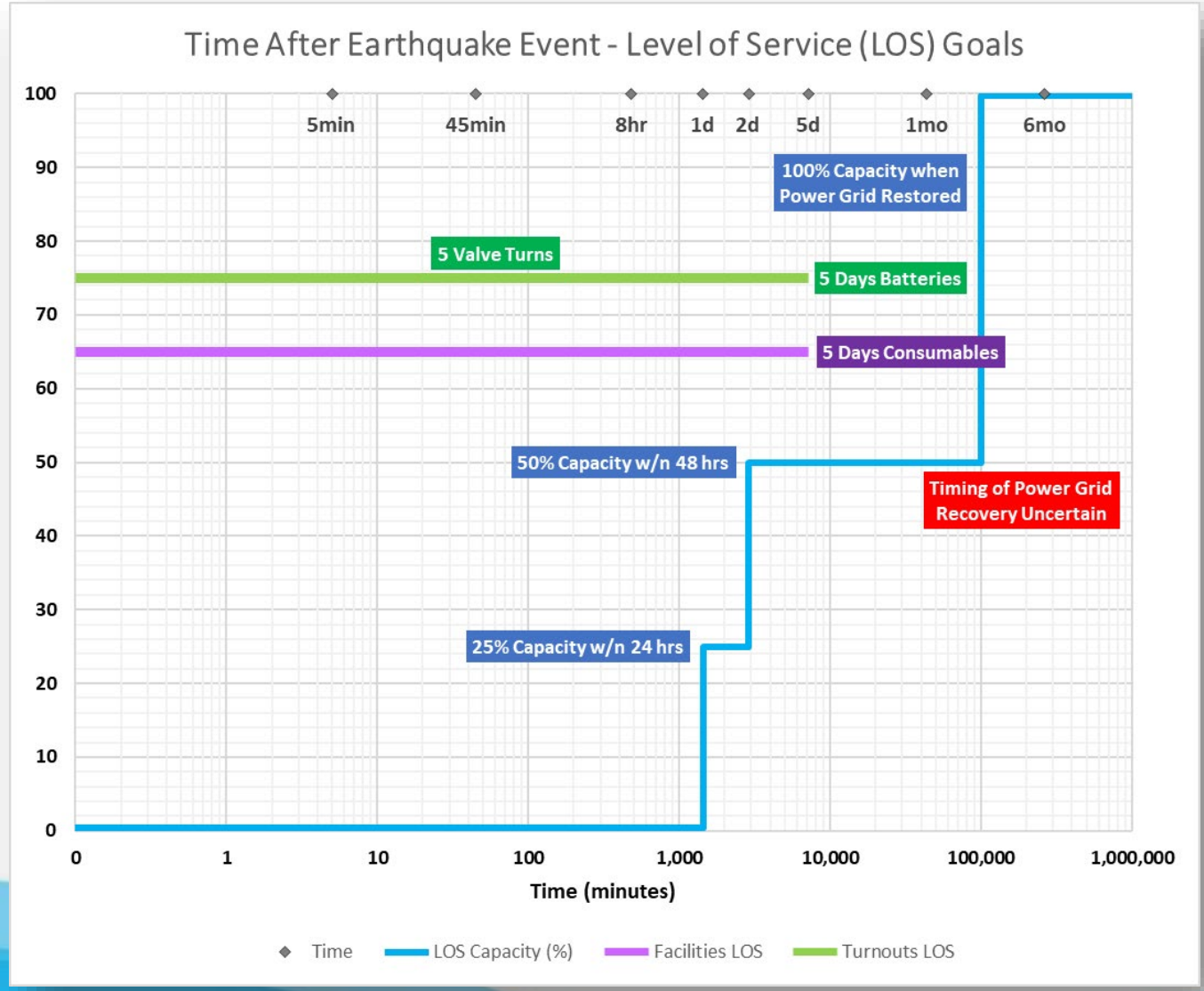
Operational Performance

Focused on controls for Facilities and Turnouts in this presentation

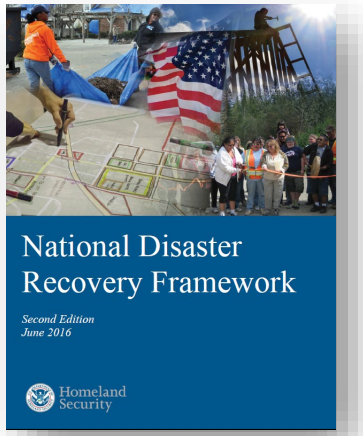
[1] Also considered infrastructure dependencies

# Level of Service and Time After Earthquake Event

LOS Goals and Time After Earthquake Event for Facilities and Turnouts



# Level of Service and Time After Earthquake Event




National Disaster Recovery Framework
(Second Edition June 2016)

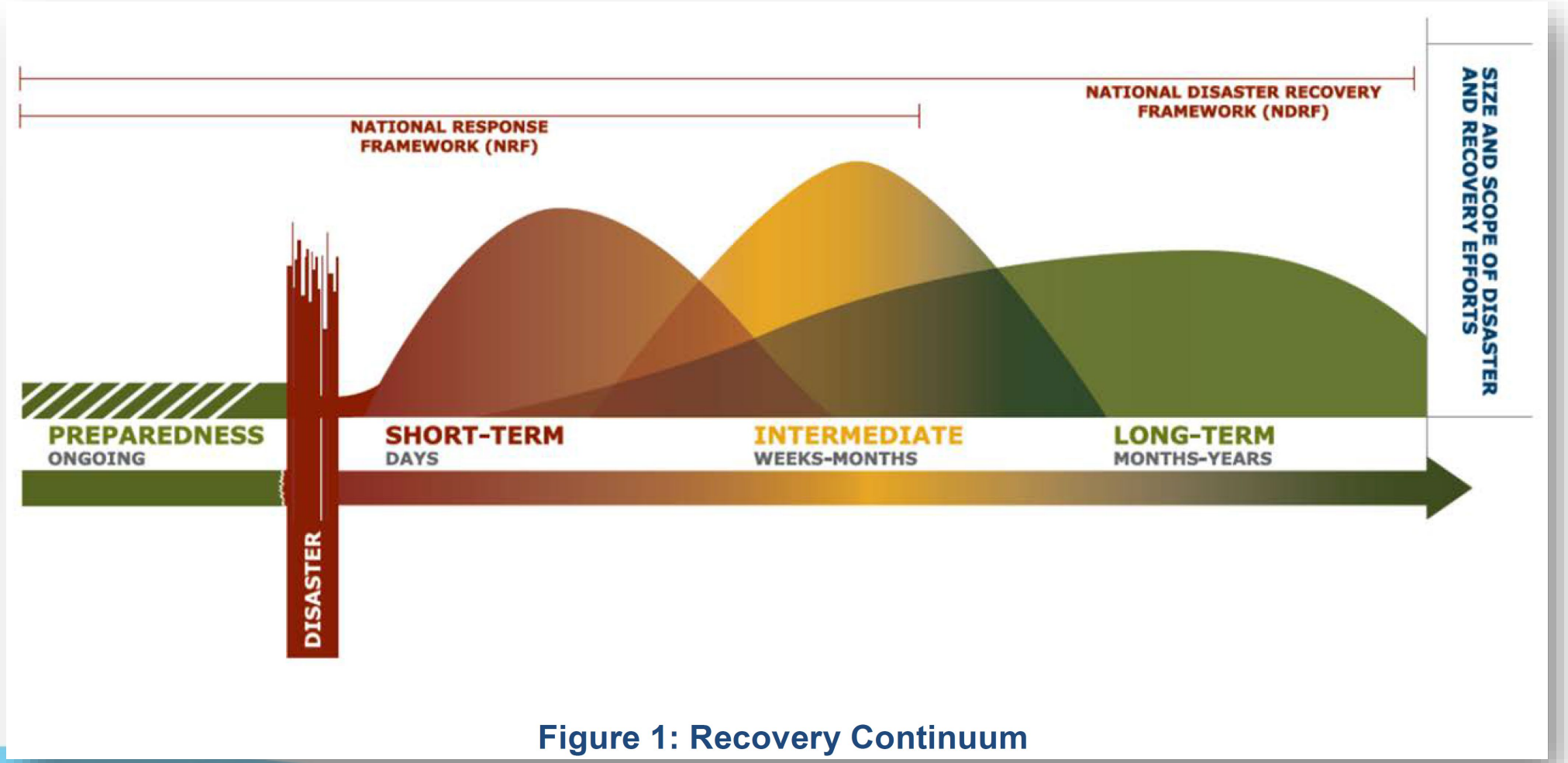
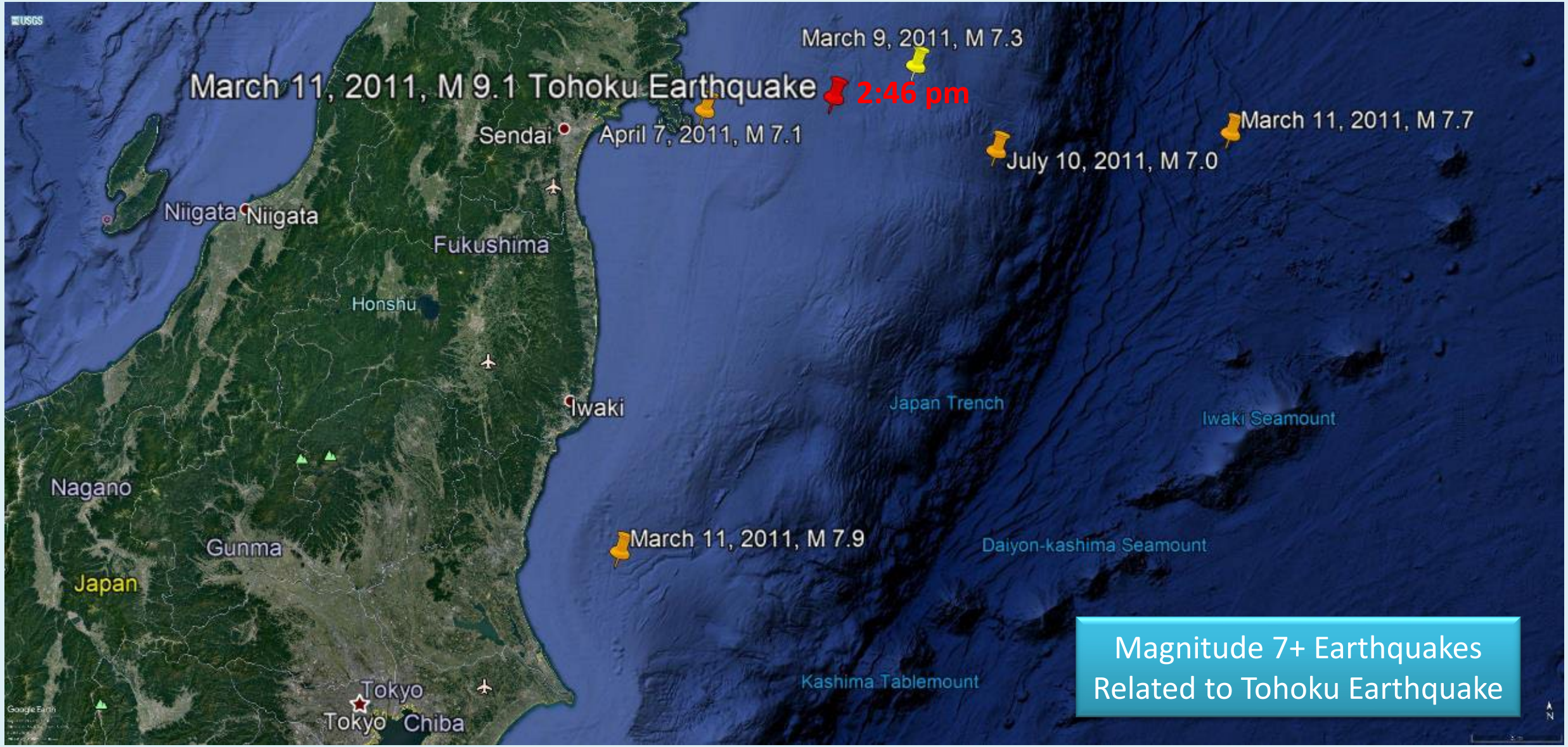



**Figure 1: Recovery Continuum**

# Timeline After Event - Earthquake



# Timeline After Event - Earthquake

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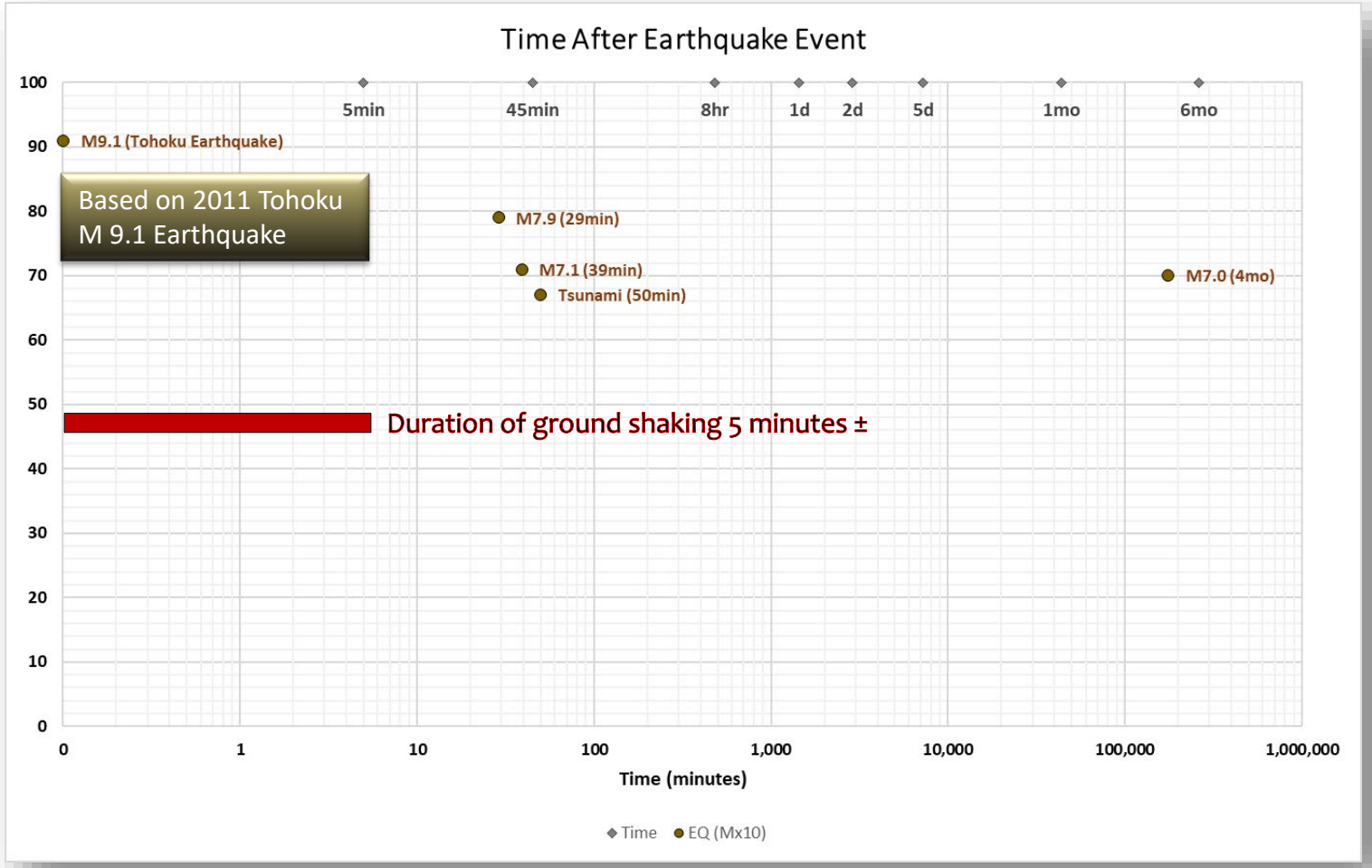
Okawa primary school, where 74 children and 10 staff died in the tsunami in the 2011 Tohoku Earthquake

# Timeline After Event - Earthquake



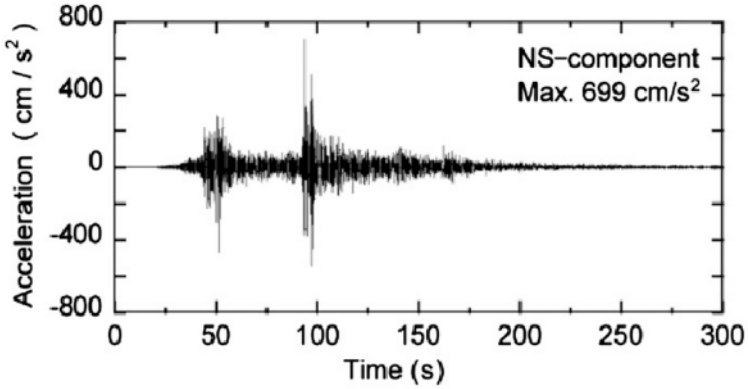

**Historic Earthquakes Durations**

- M 7.9 San Francisco (1906) – 45 sec
- M 6.6 San Fernando (1971) – 12 sec
- M 6.9 Loma Prieta (1989) – 20 sec
- M 6.7 Northridge (1994) – 10 – 20 sec
- M 8.0 Mexico City (1985) – 3 – 4 min
- M 9.1 Tohoku (2011) – 6 min
- M 9.2 Alaska (1964) – 4 ½ min

**Subduction Zone Earthquakes**

# Timeline After Event – System Controls

**Earthquake occurs**



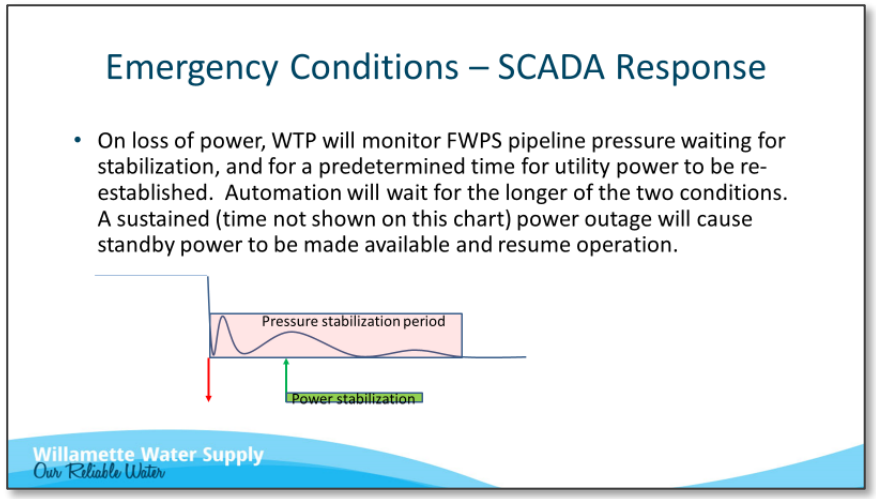

Observed seismic acceleration record in Sendai city (Nankodai Higashi elementary school) during the 2011 earthquake.

Mori, Tomohiro & Tobita, Yoshio & Okimura, Takashi. (2012). The damage to hillside embankments in Sendai city during The 2011 off the Pacific Coast of Tohoku Earthquake. Soils and Foundations. 52. 910–928. 10.1016/j.sandf.2012.11.011.

- Earthquake Response:
  - Local accelerometer or “early warning system” provide signal
    - WWSS System Controls are initiated
      - Goal to get equipment to most stable state:
        - » Stop all mechanical systems
        - » De-energize all equipment
      - When external power supply stops, battery systems provide power to critical systems
      - Remain in stable state until post-earthquake critical activities complete

# Timeline After Event – System Controls

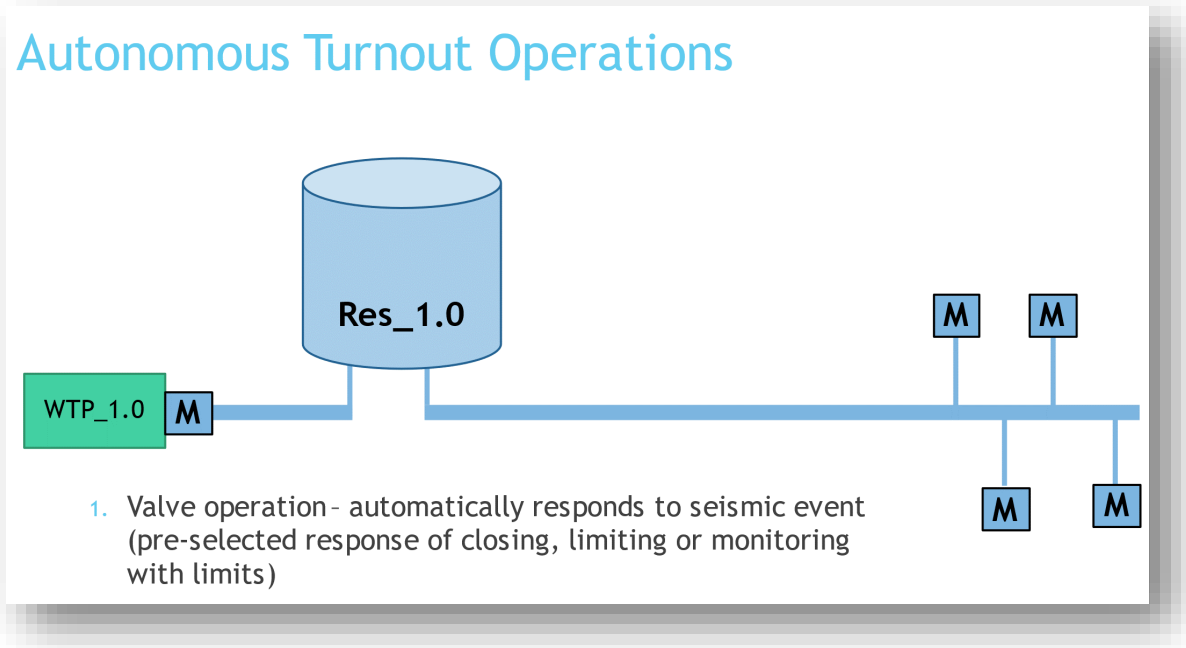
- Post-Earthquake Activities (prior to energizing generators):
  - System hydraulic transients dissipate
  - Life safety/staff activities:
    - Individual safety
    - Staff safety check
    - Off-duty staff report in (as available)
  - Aftershocks
  - System Checks

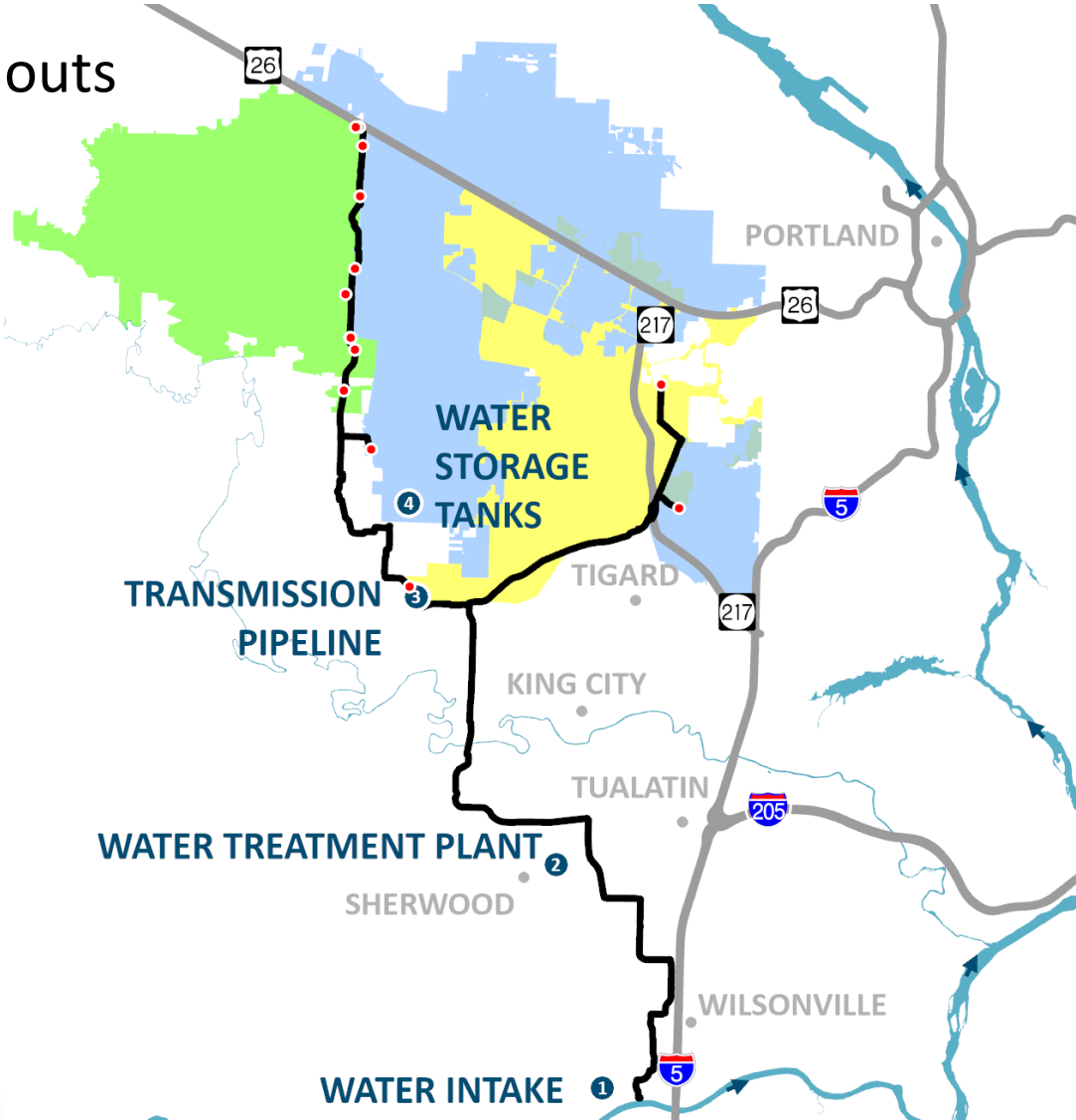


# Timeline After Event – System Controls

## Automated Control Actions – Seismic Valves at Turnouts

- Turnouts supply water to Partner Agencies' systems

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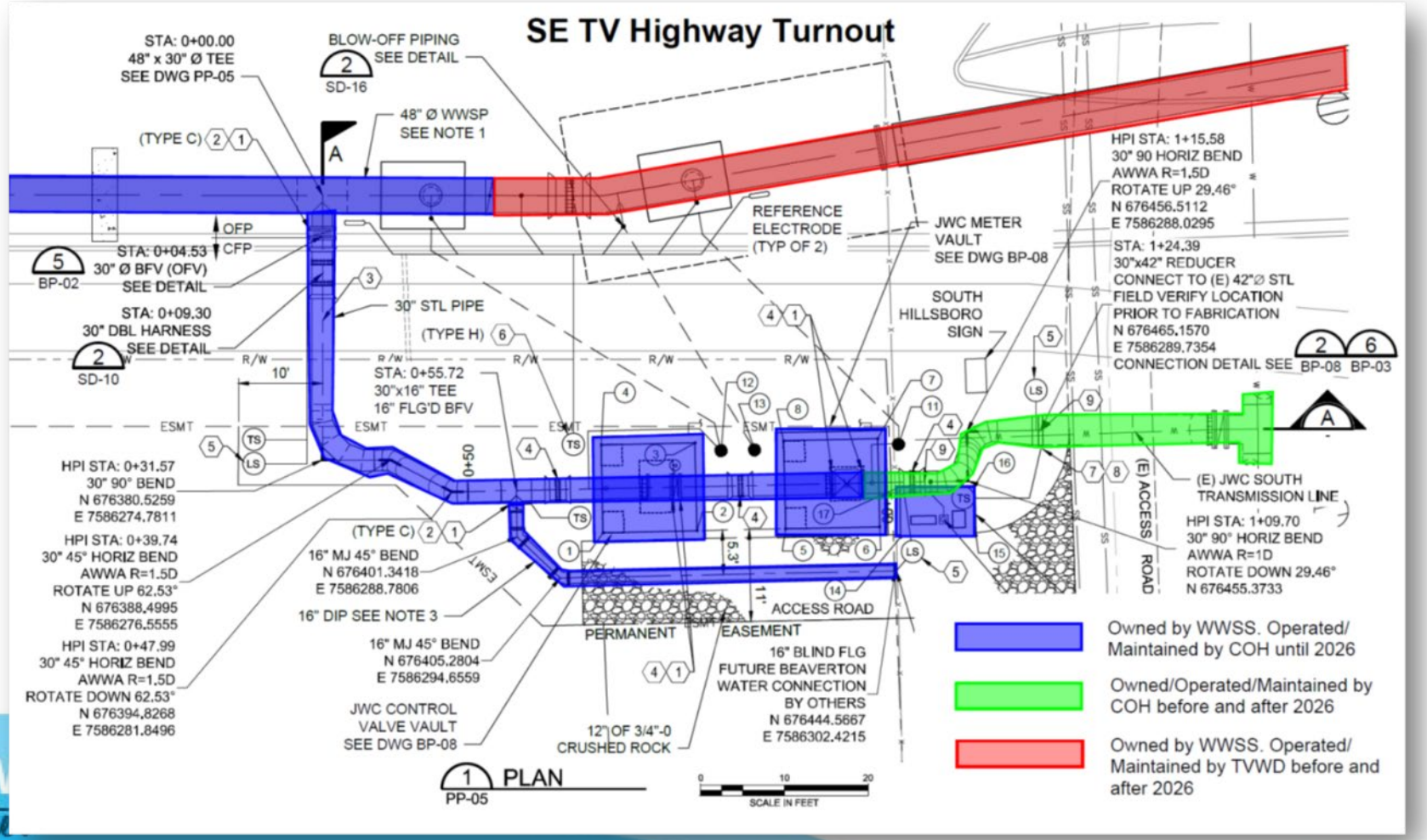
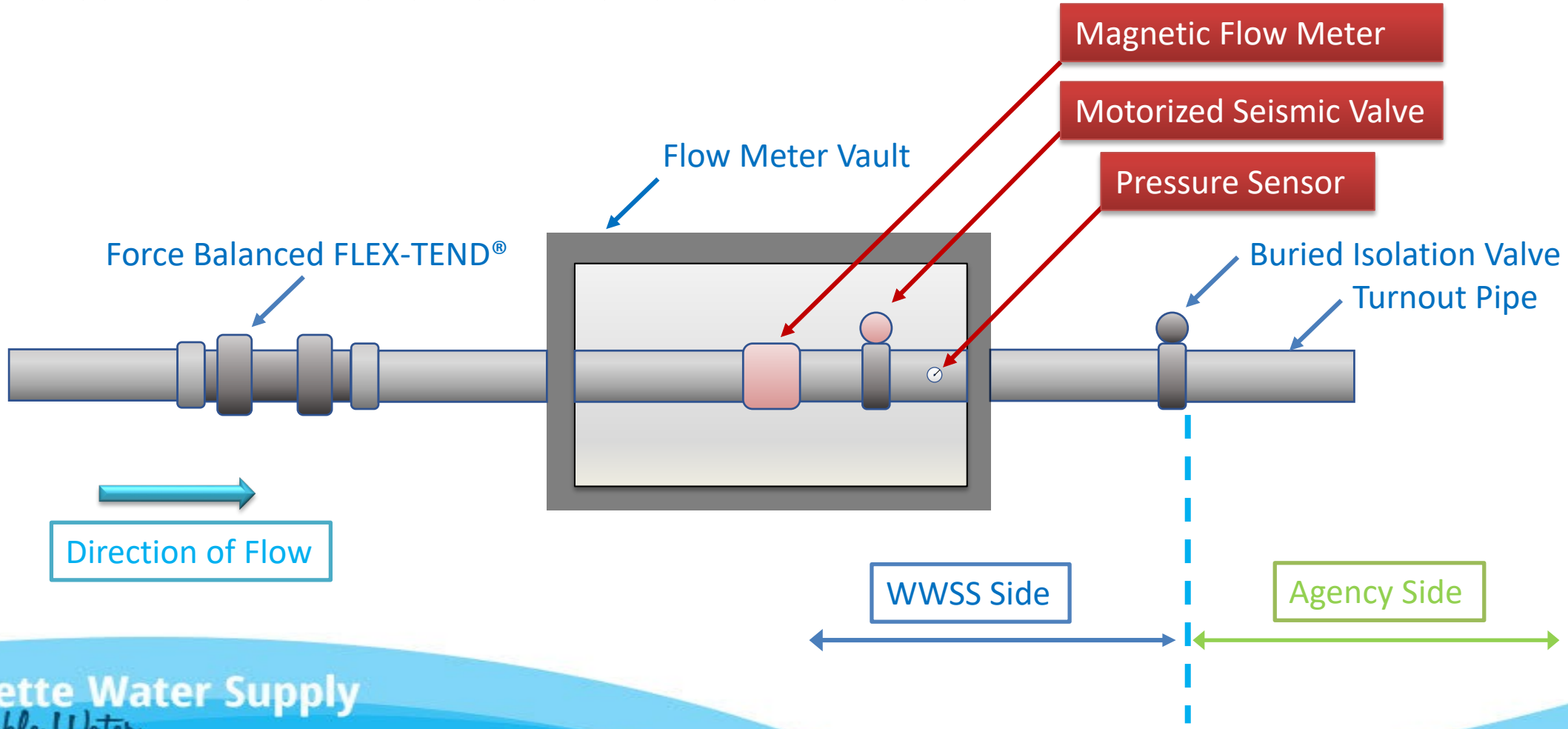
# Timeline After Event – System Controls

Automated Control Actions – Seismic Valves at Turnouts



# Timeline After Event – System Controls

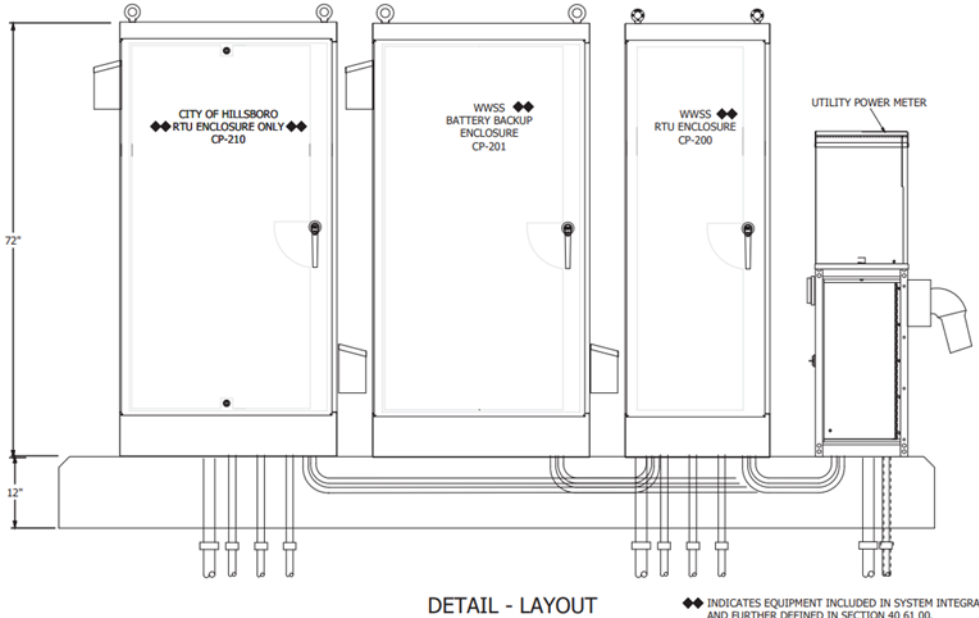
Automated Control Actions – Seismic Valves at Turnouts



# Timeline After Event – System Controls

Automated Control Actions – Seismic Valves at Turnouts

- PLC
- RTUs
- Accelerometer
- Battery Backup
  - 5 days for SCADA
  - 5 valve turns
- Hookup for temp power
- Information for control logic:
  - Communications from WTP
  - Local accelerometer
  - Local flow
  - Local downstream pressure



# Timeline After Event – System Controls

## Automated Control Actions – Seismic Valves at Turnouts

- Vital part of overall system operation:
  - Throttle flow
  - Maintain pressurized system
  - Preserve system storage
  - Continuity of system communications & control through SCADA with battery backup

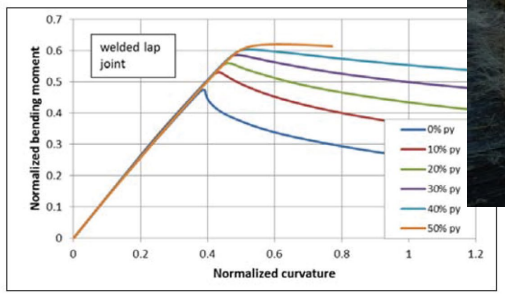
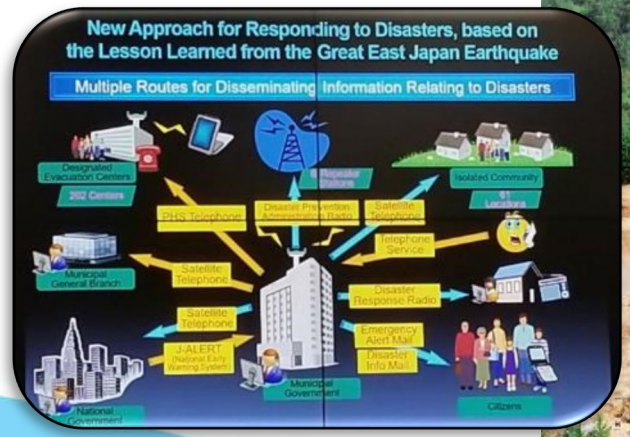




Figure 9. Effect of internal pressure on the bending response of double-welded lap joints ($D/t$ = 191).

***Requires 5 days of battery backup (or alternate power supply) as part of overall "System Operations"***

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# Timeline After Event – System Controls

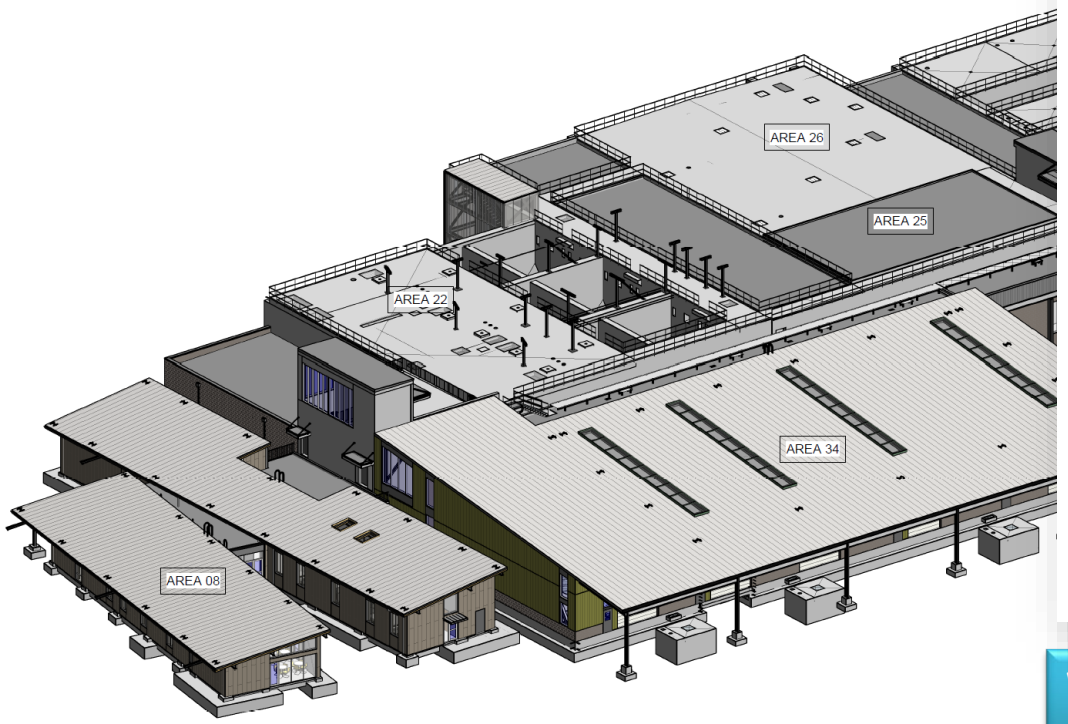
Automated Control Actions – Seismic Valves at Water Treatment Plant

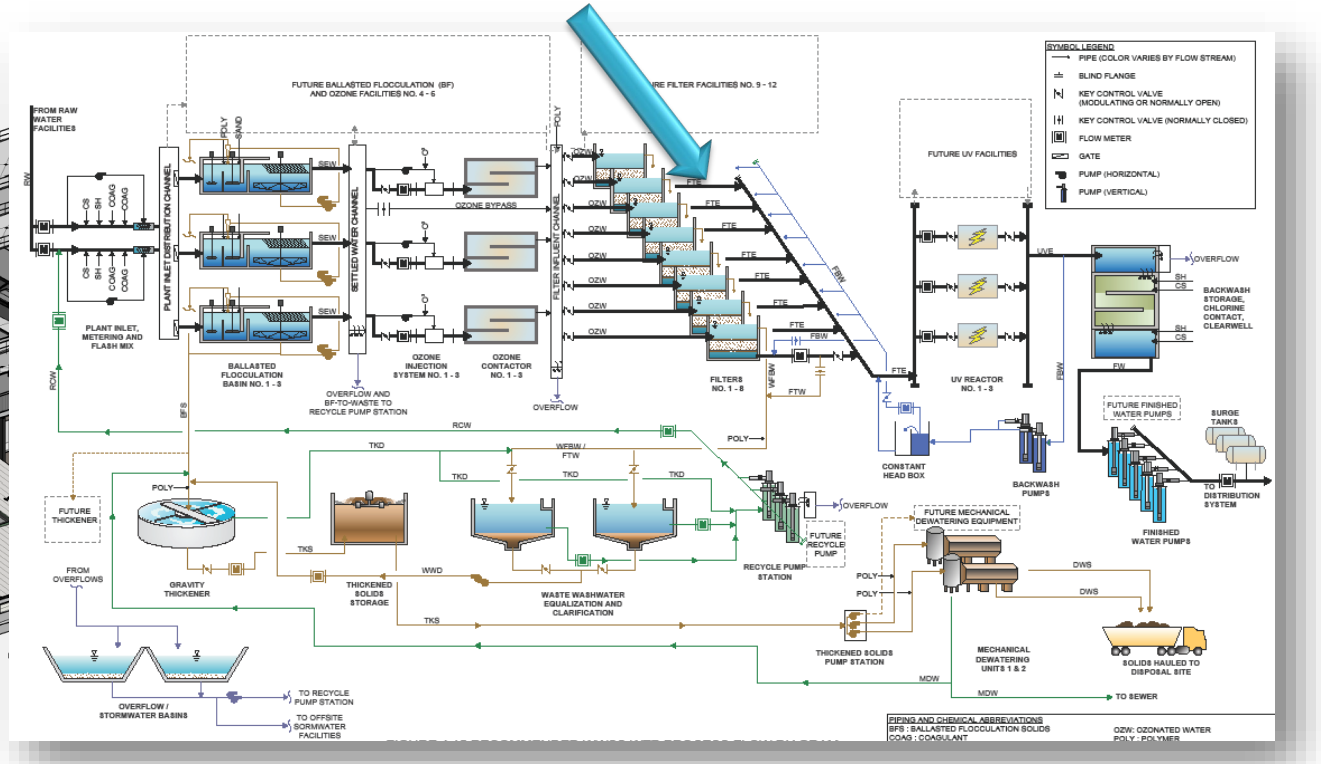
10 MG Clearwell and Finished Water Pump Station Under Construction

Tower Crane by UV Structure

# Timeline After Event – System Controls

Automated Control Actions – Seismic Valves at Water Treatment Plant

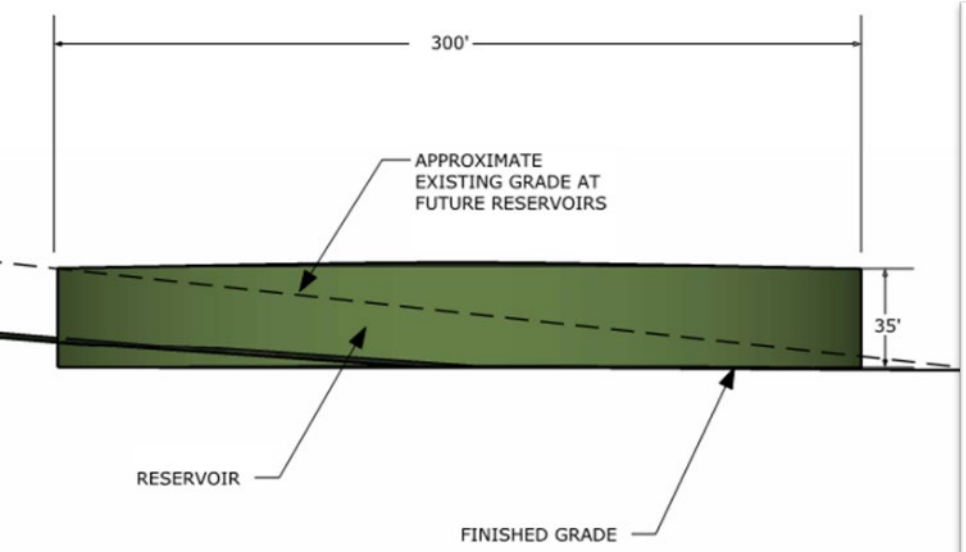



**Within the main treatment process, seismic valves uses on the downstream side of the filters to keep them full of water on shutdown**

# Timeline After Event – System Controls

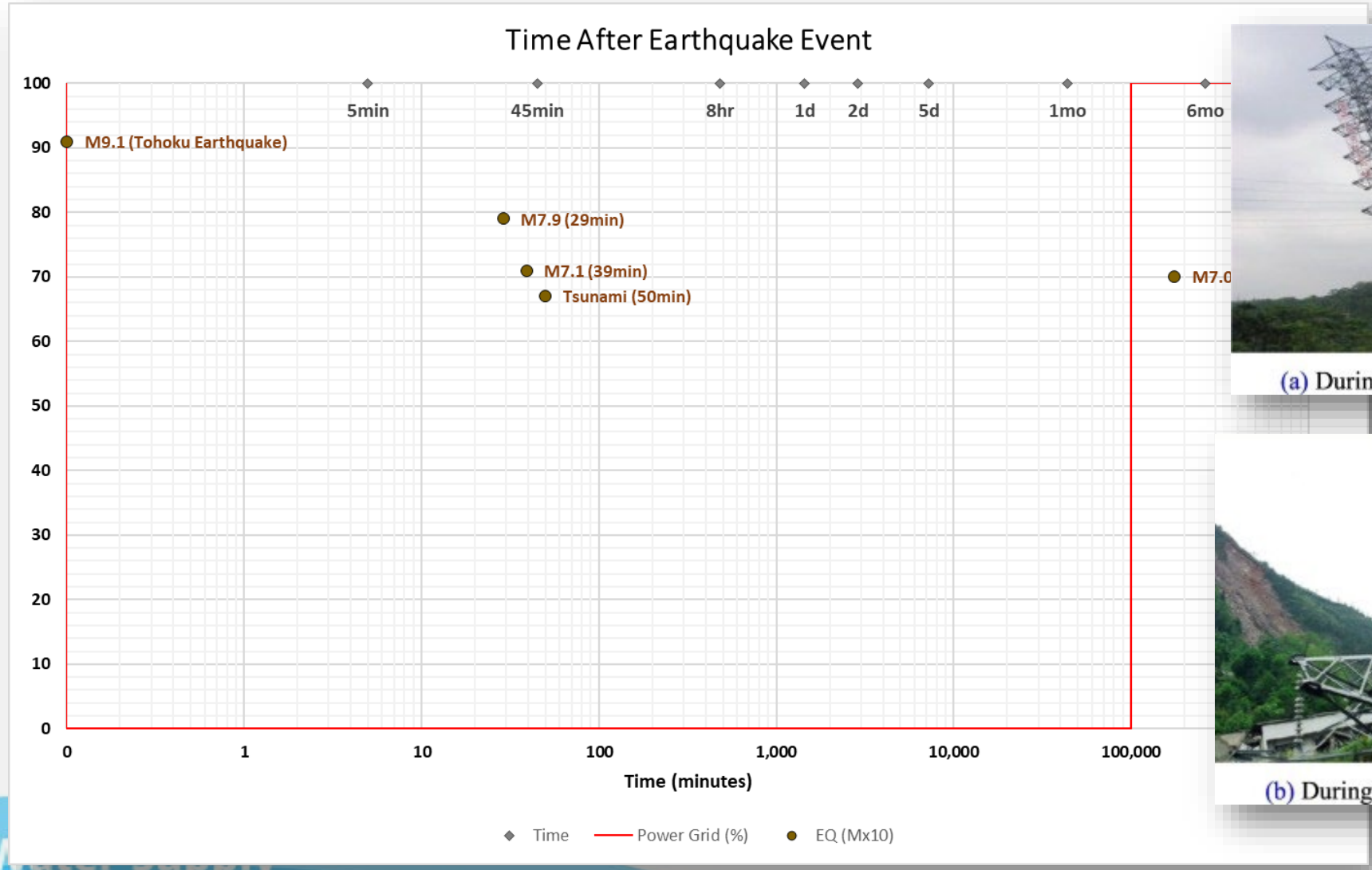
## Automated Control Actions – Seismic Valves at Terminal Reservoirs




- Closure of seismic valves at turnouts need to be coordinated with remaining supply
- Seismic valve at reservoir closure driven by hydraulic transients

# Timeline After Event – Power Supply

Grid Power

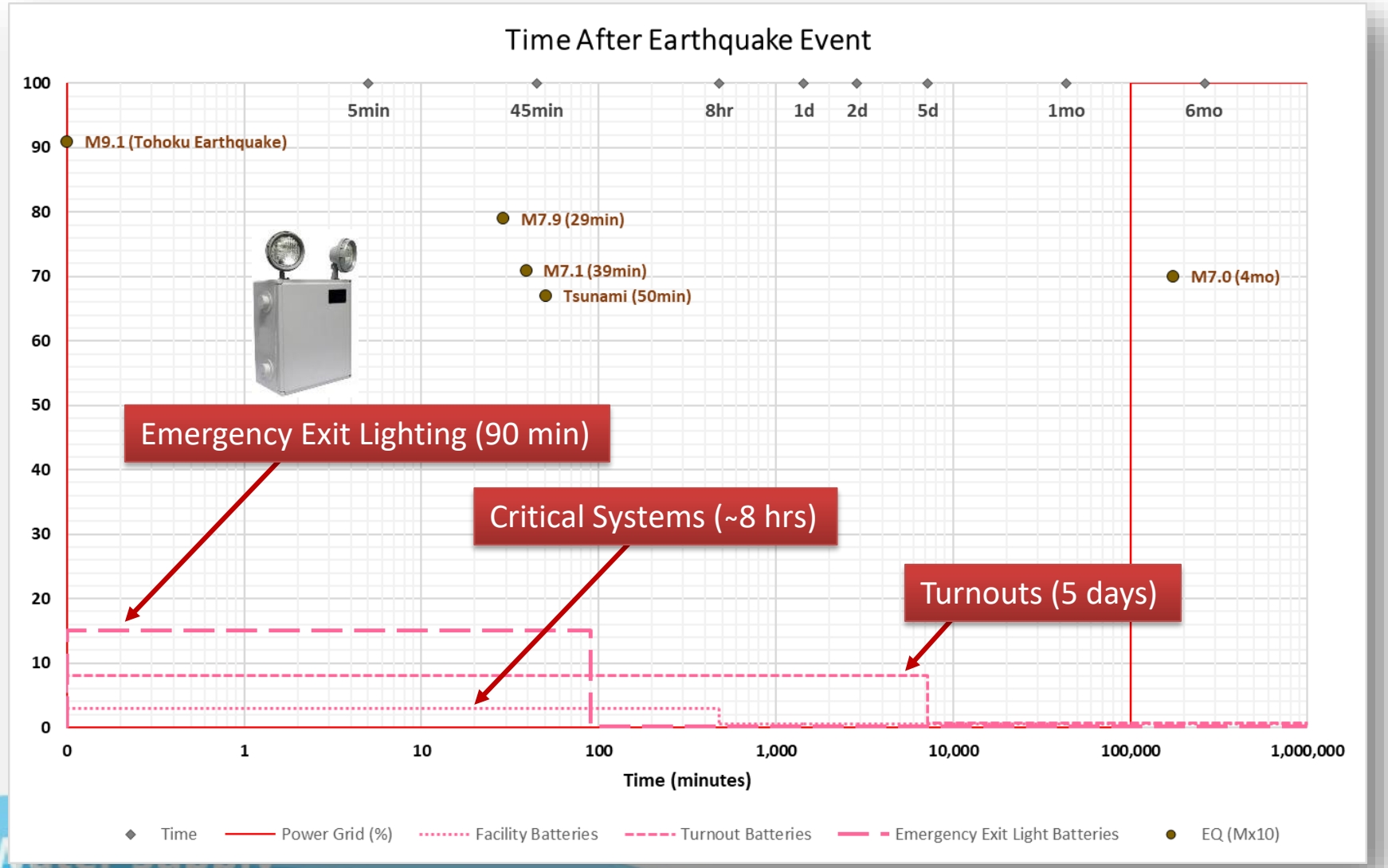



(a) During the Chi-Chi earthquake

(b) During the Wenchuan earthquake

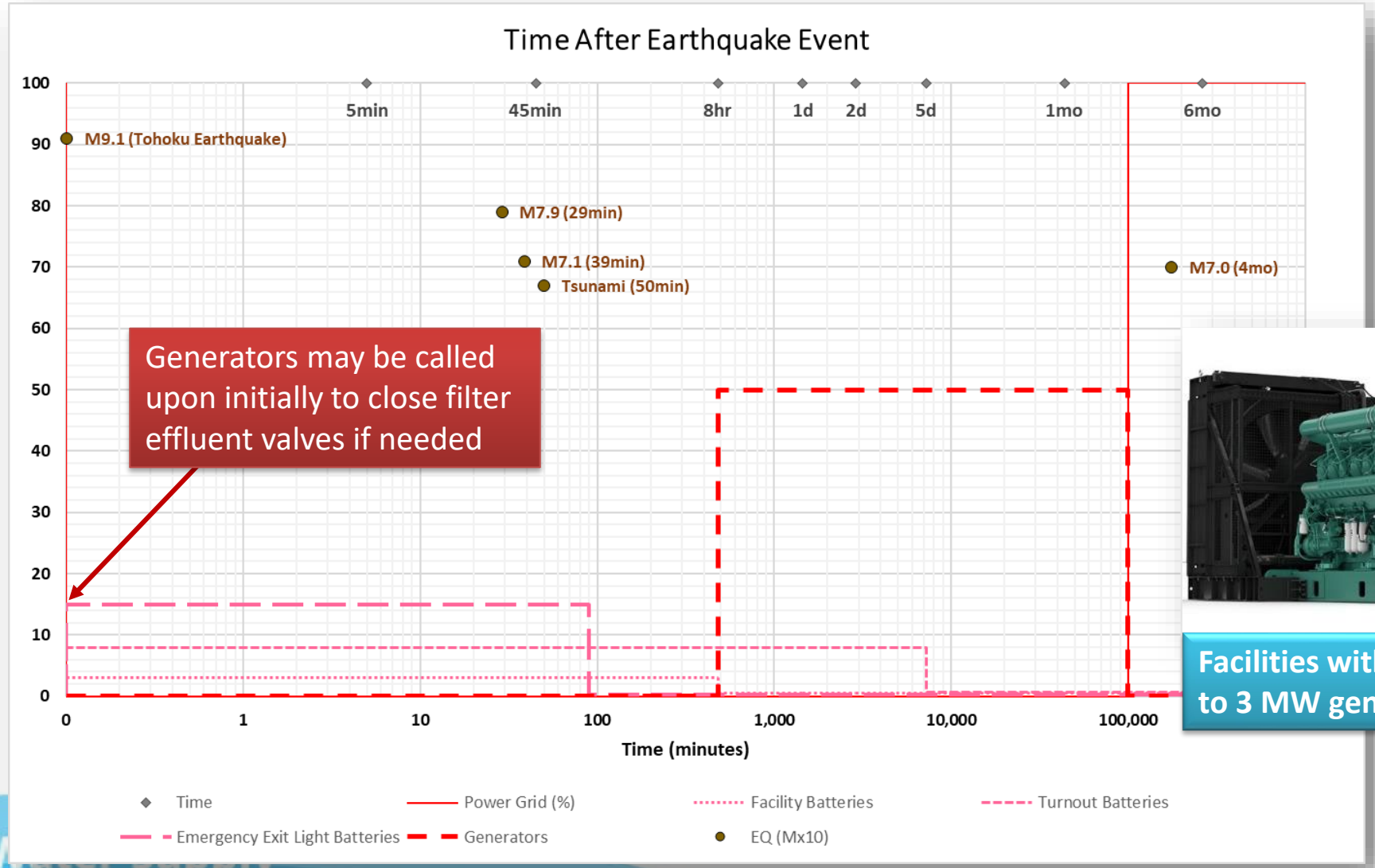
# Timeline After Event – Power Supply

Battery Power



# Timeline After Event – Power Supply

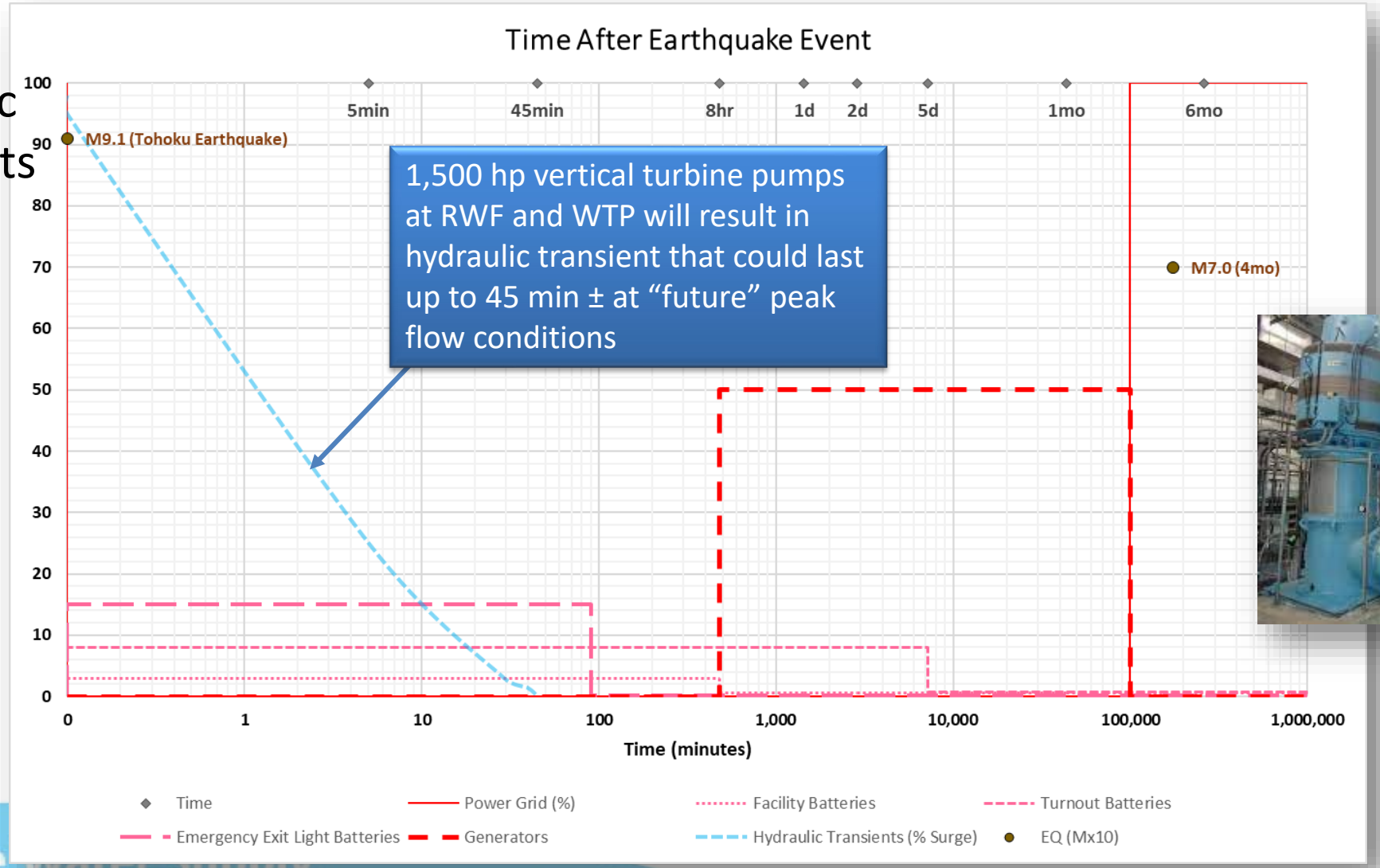
Generator Power




**Facilities with have several 2.5 to 3 MW generators**

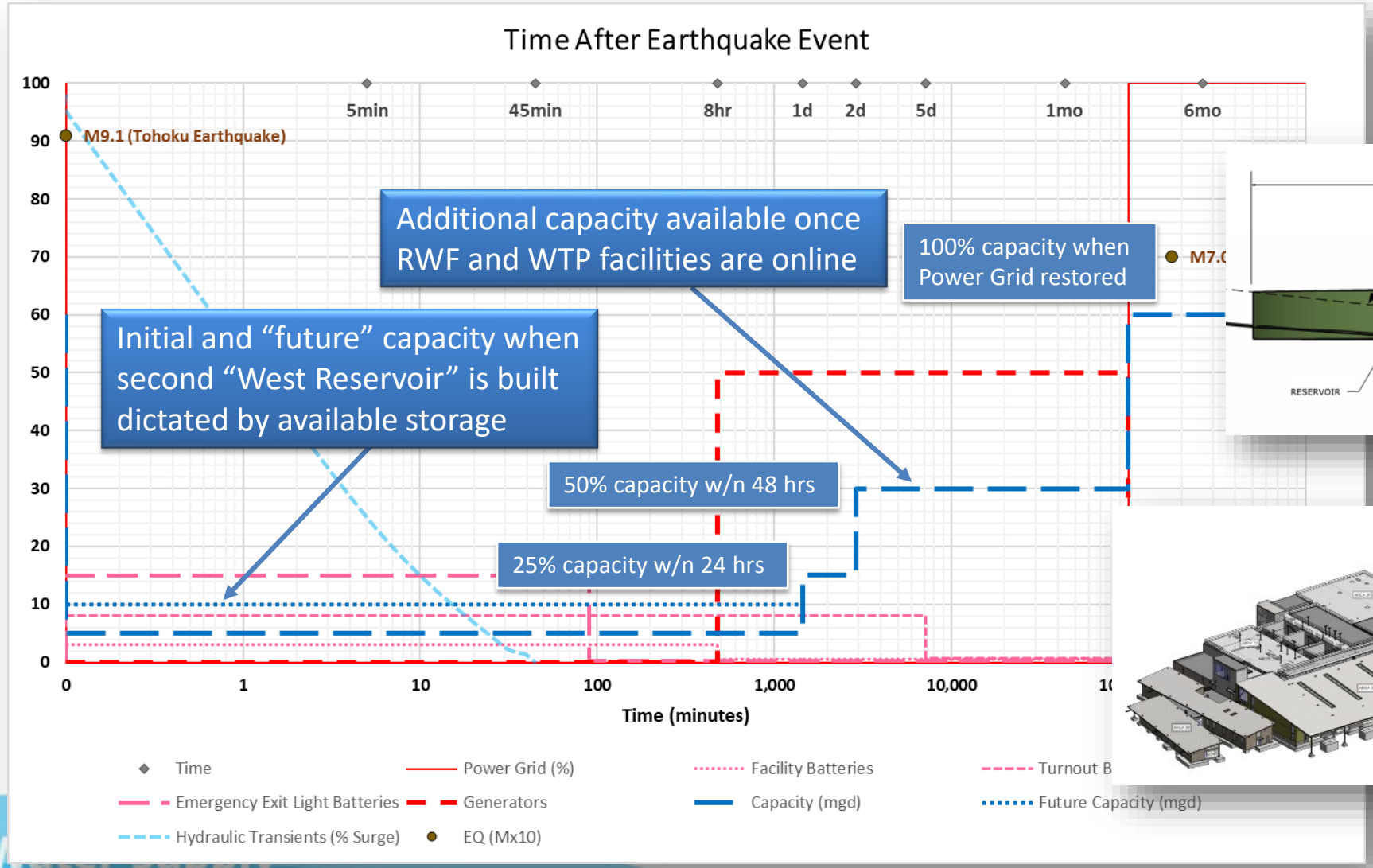
# Timeline After Event - Capacity, Storage, and Hydraulics

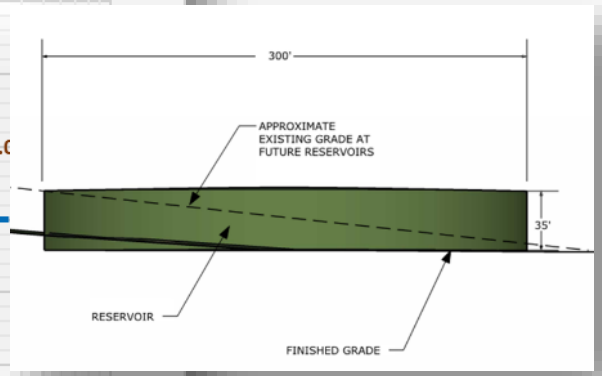
Hydraulic Transients




# Timeline After Event - Capacity, Storage, and Hydraulics

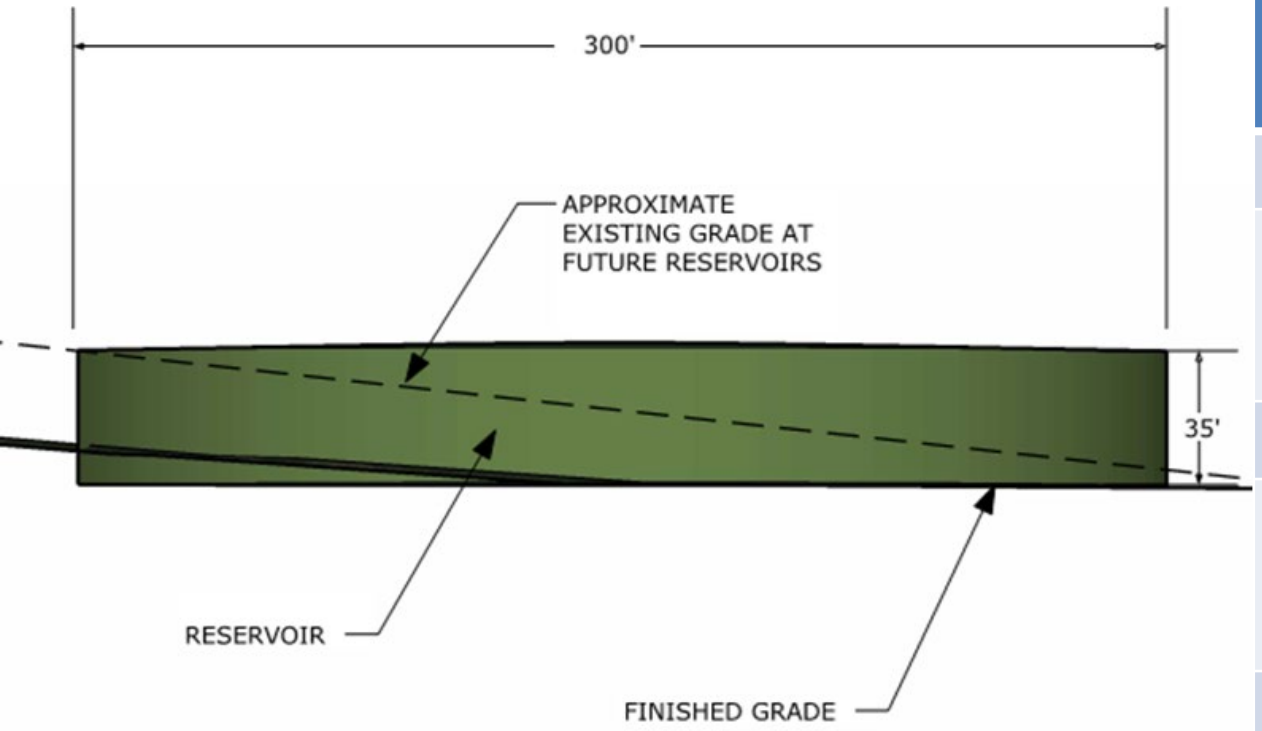
Capacity




# Timeline After Event - Capacity, Storage, and Hydraulics

Initial capacity based on available storage volume




Tentative Operational Levels:

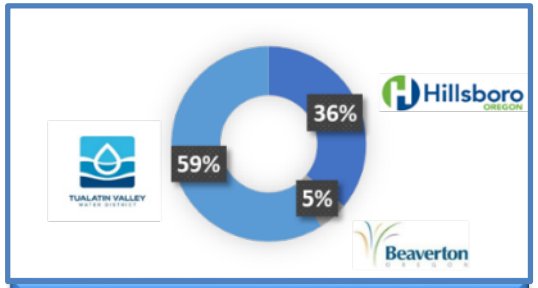
| Height (ft) | Elevation (ft) | Volume 1 Reservoir (MG) | Volume 2 Reservoirs (MG) [Future] | Comments |
|---|---|---|---|---|
| 35 | 525 | N/A | N/a | Roof Height |
| 30 | 520 | 15 | 30 | Top operational level |
| 20 | 510 | 10 | 20 | |
| *10* | *500* | *5* | *10* | *Top emergency storage* |
| 0 | 490 | 0 | 0 | Floor |

# Timeline After Event - Capacity, Storage, and Hydraulics

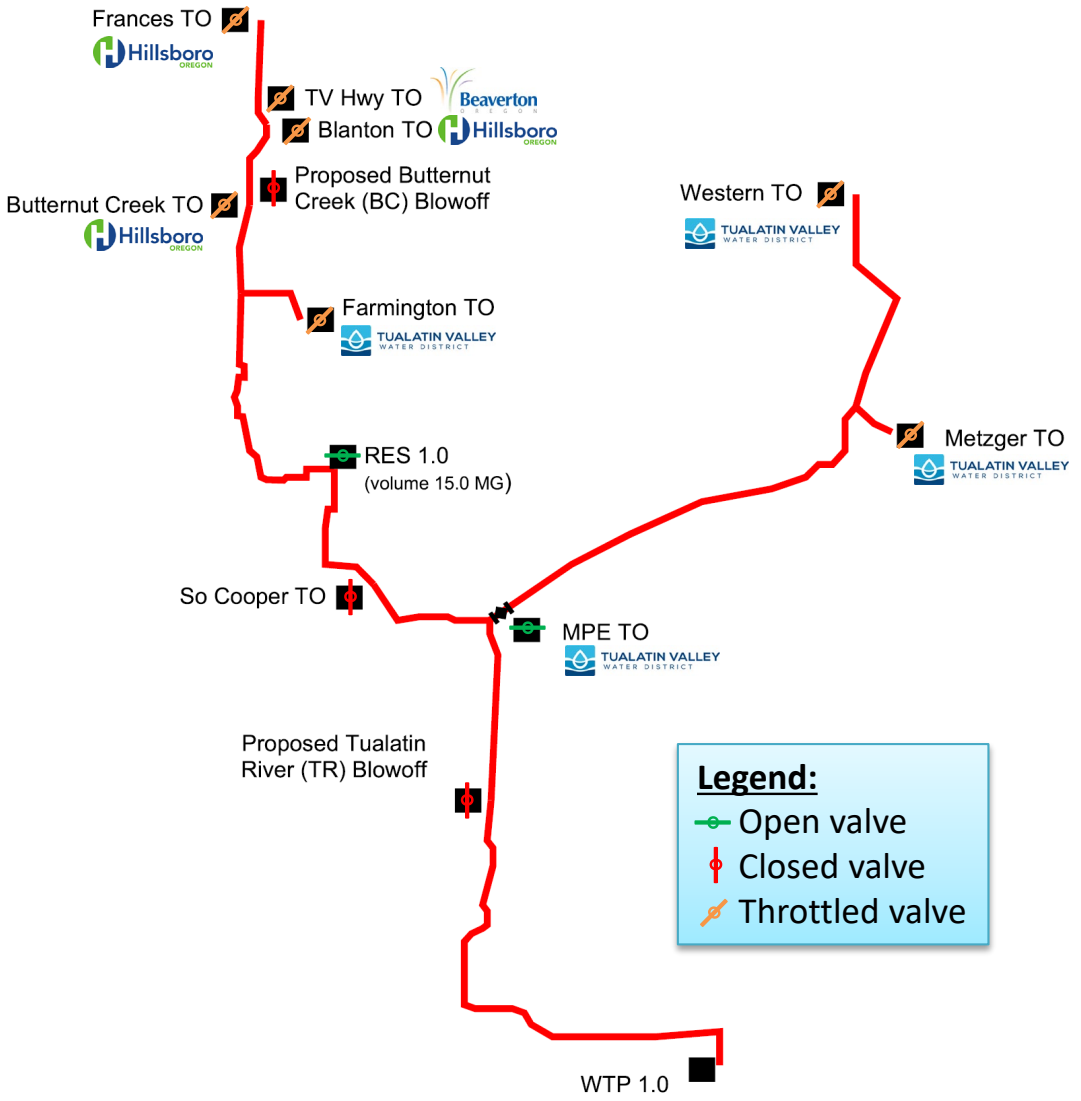
## Available System Capacity

| Time After Event | Capacity with 1 Reservoir* | Capacity with 2 Reservoirs* |
|---|---|---|
| 0 – 24 hrs | 5 mgd | 10 mgd |
| 24 – 48 hrs | 15 mgd | 15 mgd |
| 48 hrs+ | 30 mgd | 30 mgd |
| Power grid restored | 60 mgd | 60 mgd |

* Based on initial WTP capacity of 60 mgd




System capacity distributed at turnouts based on ownership percentage

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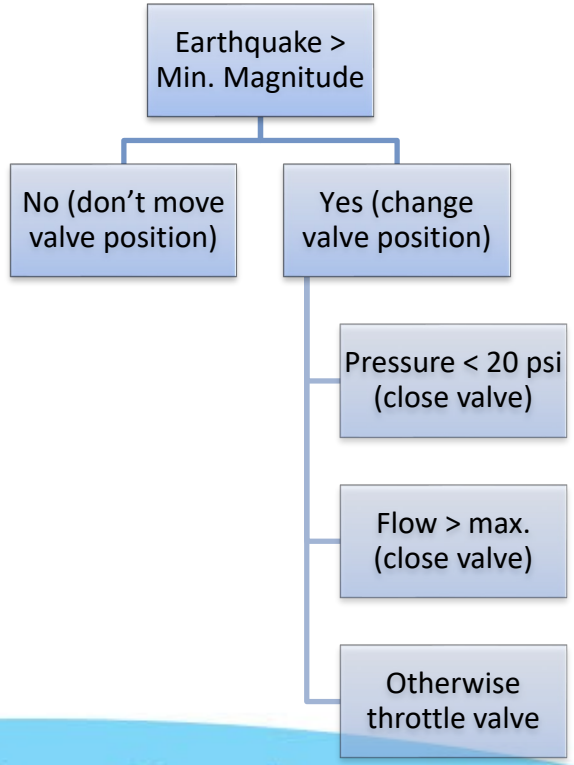
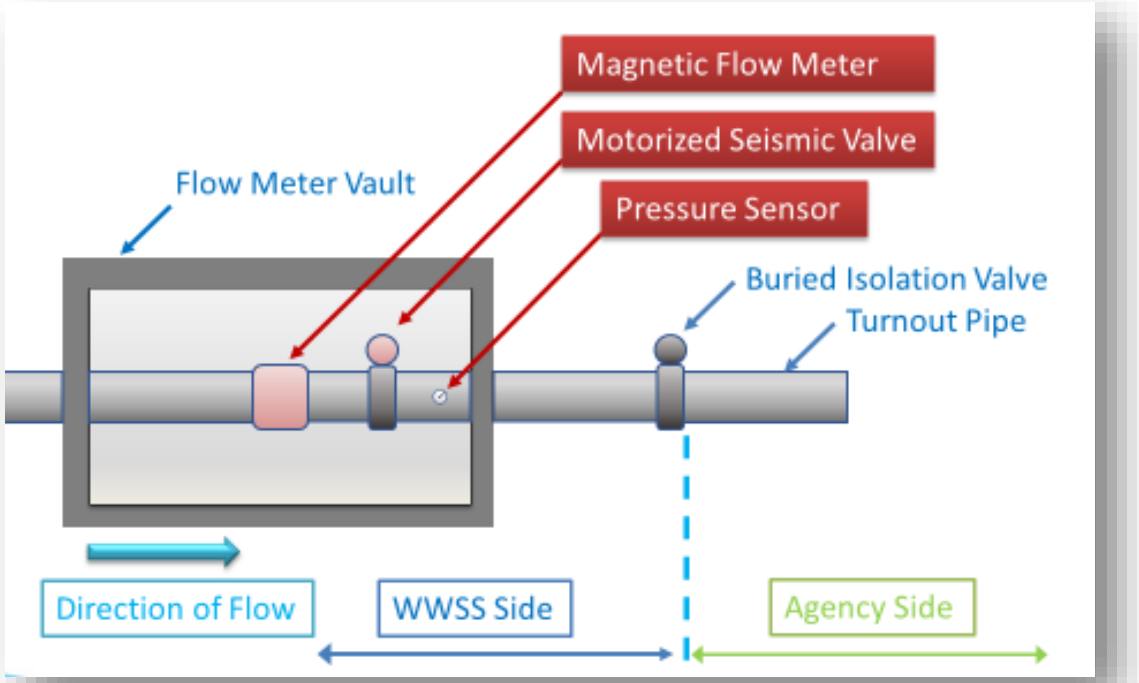
# Timeline After Event – System Controls

Automated Control Actions – Seismic Valves at Turnouts

**Turnout Control Logic (Tentative)**




**Closure of Motorized Seismic Valve in Turnout Flow Meter Vault**



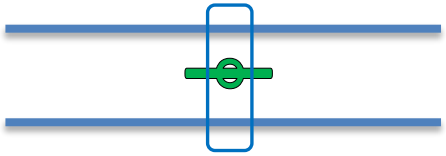
# Timeline After Event – System Controls

Automated Control Actions – Seismic Valves at Turnouts

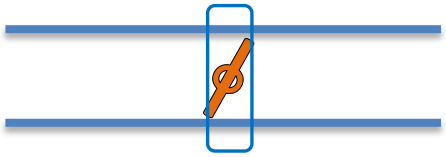
## Longest Valve Closure Time

Butterfly valve starts in *fully* open position

Start position
fully open
(Position A)



End position
(Position B)

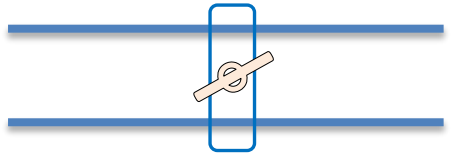


Valve moves almost 90° to nearly closed position

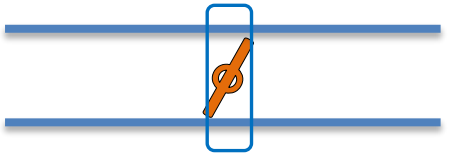
## Optimized Valve Closure Time

Butterfly valve starts in *partially* open position

Start position
partially open
(Position A)

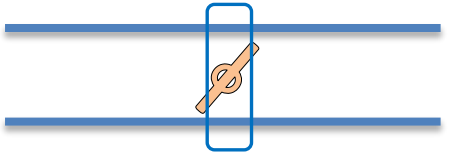


End position
(Position B)



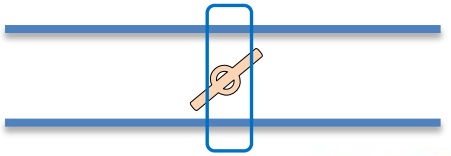
*5 mgd system flow*

24 hr position
(Position C)



*15 mgd system flow*

48 hr position
(Position D)

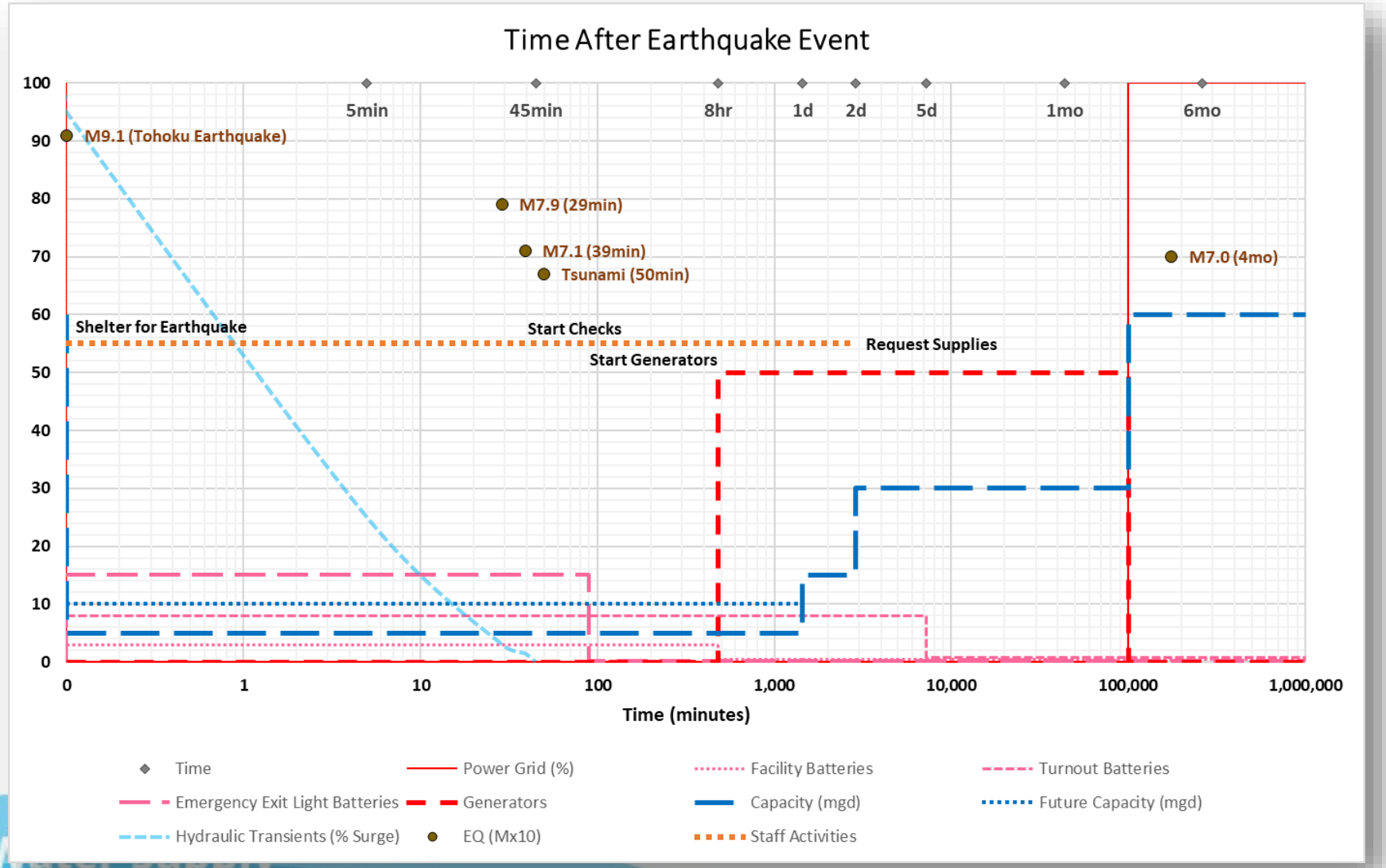


*30 mgd system flow*

Valve closure times need to be coordinated with hydraulic transient response of system

# Timeline After Event – People/Staff

Initially Shelter in Place



# Timeline After Event – People/Staff

System Checks

- Through SCADA and control systems
- Though instrumentation
- Visual
  - "Rapid" inspection (OrSAP training – June 7)
  - Remote through video cameras

*Raw Water Facilities will have an instrument to assess tilt in the caisson*

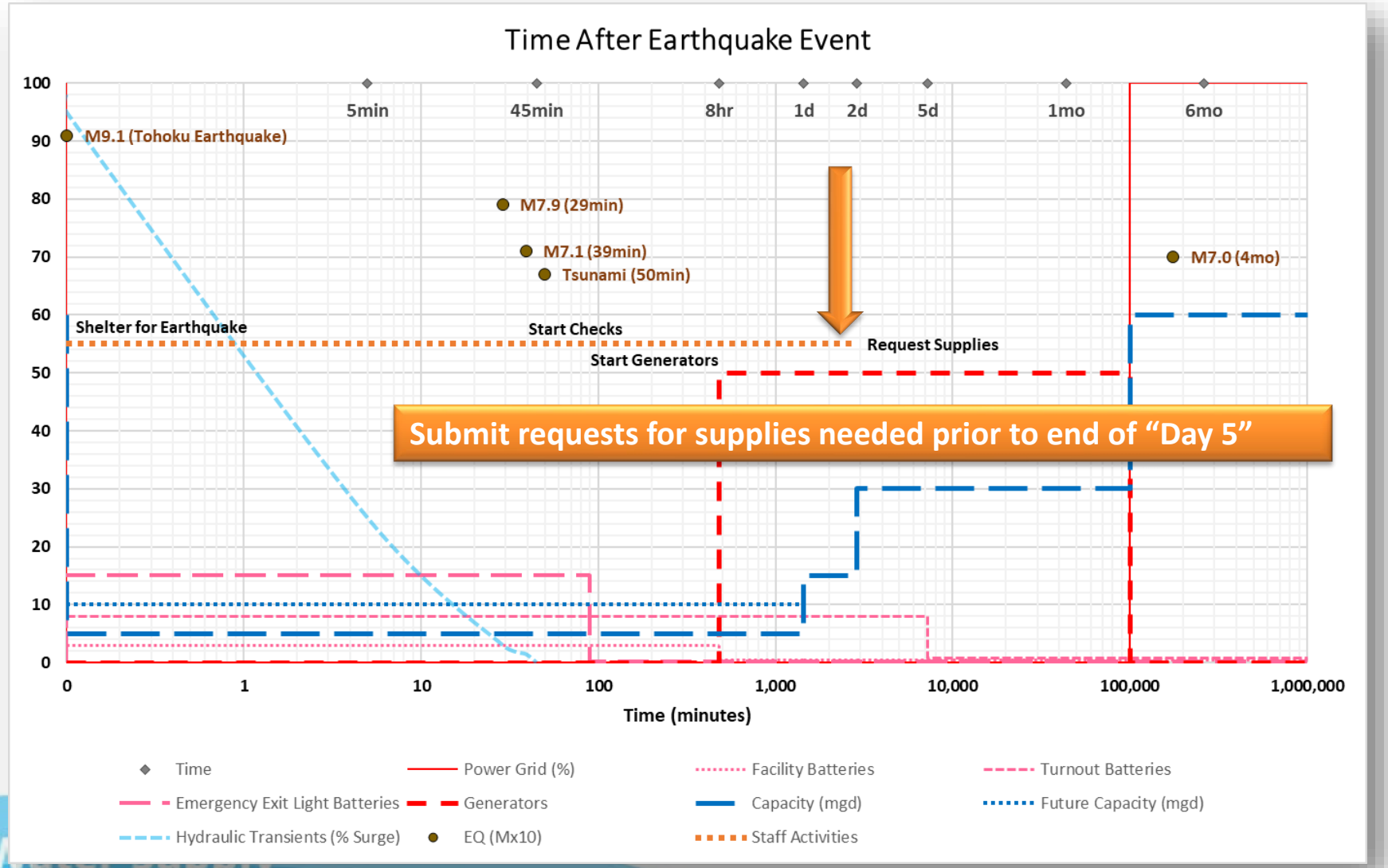
*RWF will have cameras for video inspection*

# Timeline After Event – People/Staff

Request Supplies

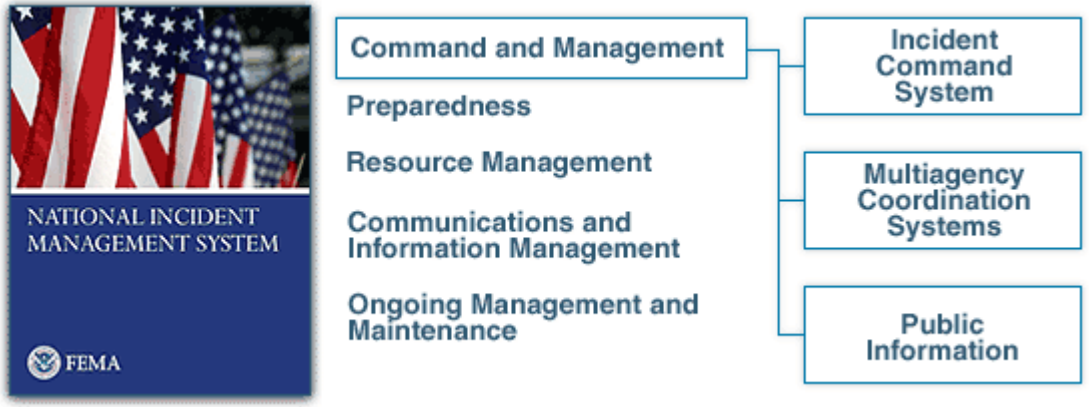
&

Emergency Response Coordination



# Timeline After Event – People/Staff

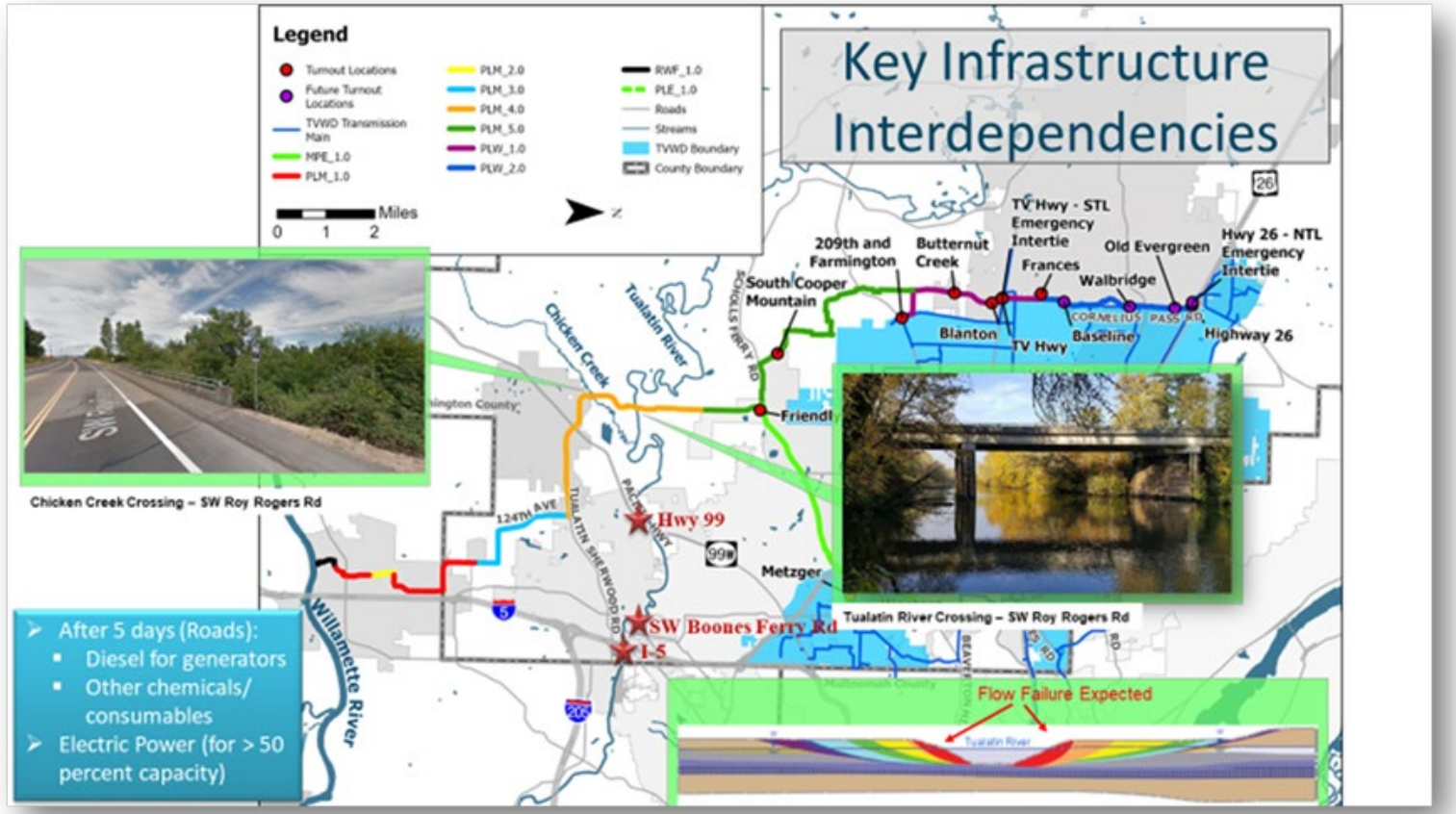
- Coordination and reporting out to Partner Agencies and coordination with other emergency response activities




# Time After Event - Supplies and Infrastructure Interdependencies

"Action Plan" included in County's Natural Hazard Mitigation Plan (NHMP) related to Seismic Upgrade to Two Bridges on Roy Rogers Road:

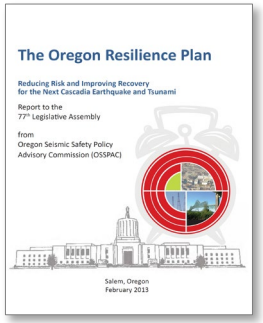
- Serves as a critical transportation link within Washington County to provide supplies for WTP and RWF operations following an earthquake.




Washington County Natural Hazard Mitigation Plan – 2022 Update

# WWSP Seismic Level of Service (LOS) Goals

- Target States of Recovery modeled off the ORP
- Added “5 days of self-sufficiency”




TARGET STATES OF RECOVERY: WATER & WASTEWATER SECTOR (VALLEY)

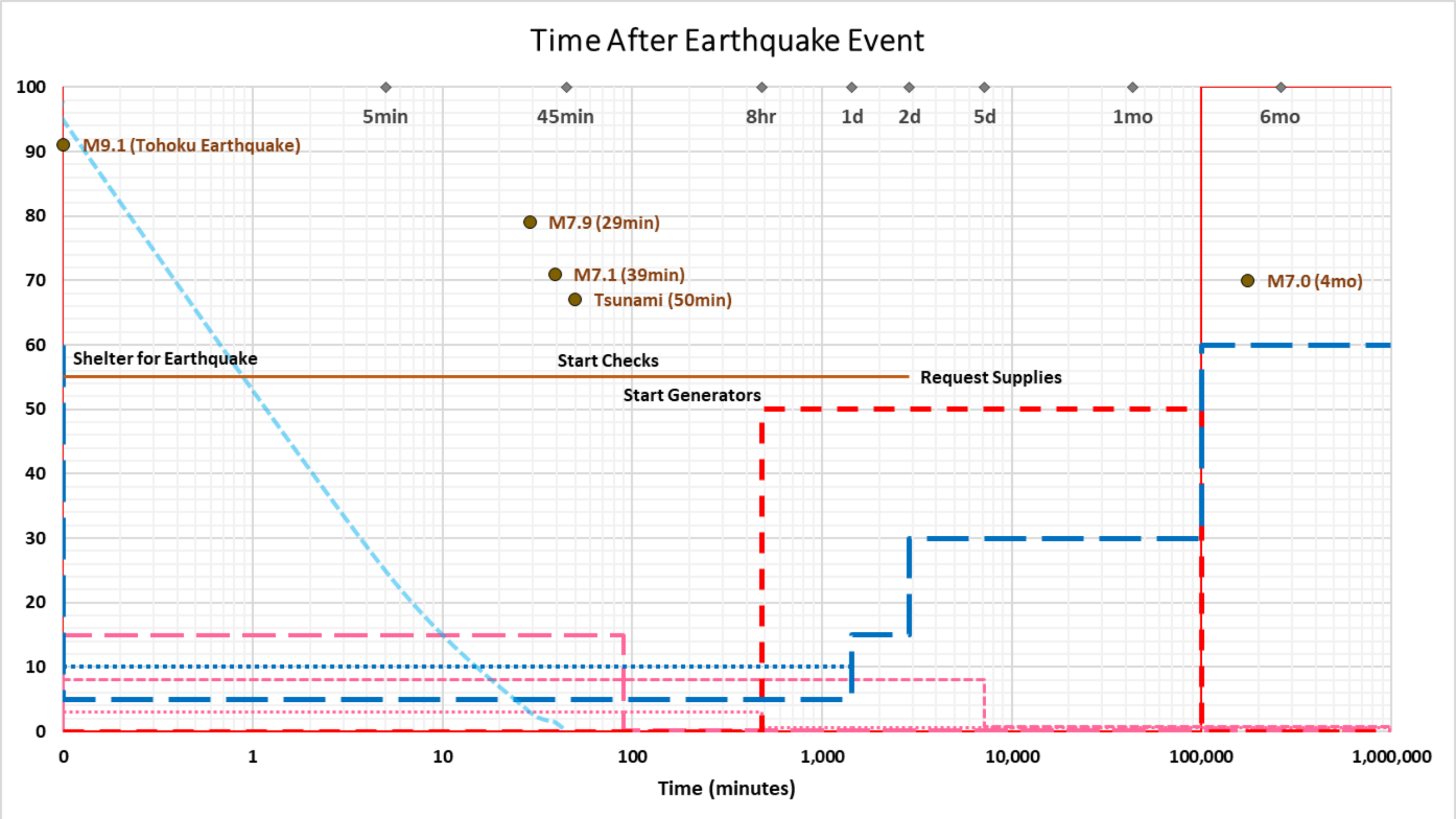
| | Event occurs | 0–24 hours | 1–3 days | 3–7 days | 1–2 weeks | 2 weeks–1 month | 1–3 months | 3–6 months | 6 months –1 year | 1–3 years | 3 + years |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Domestic Water Supply** | | | | | | | | | | | |
| *Potable water available at supply source (WTP, wells, impoundment)* | | R | Y | | G | | | X | | | |
| *Main transmission facilities, pipes, pump stations, and reservoirs (backbone) operational* | | G | | | | | X | | | | |
| *Water supply to critical facilities available* | | Y | G | | | | X | | | | |
| *Water for fire suppression—at key supply points* | | G | | X | | | | | | | |
| *Water for fire suppression—at fire hydrants* | | | | R | Y | G | | | X | | |
| *Water available at community distribution centers/points* | | | Y | G | X | | | | | | |
| *Distribution system operational* | | | R | Y | G | | | | X | | |

***Turnouts also part of maintaining 5 days of operational capacity of the WWSS overall “System Operations”***

Table 4-2 WWSP LOS Goals

| System Components | Proposed |
|---|---|
| Intake and RWF | • 25% capacity within 24 hours<br>• 50% capacity within 48 hours<br>• 90% to full capacity when power transmission and transportation is restored<br>• 5 days of self-sufficiency for all consumables required for operations<br>• Fire suppression systems shall be autonomous and fully operable at 90-100% capacity immediately after a seismic event |
| WTP | • 25% capacity within 24 hours<br>• 50% capacity within 48 hours<br>• Full treatment process available immediately for critical components[7]<br>• 90% to full capacity when power transmission and transportation is restored<br>• 5 days of self-sufficiency for all consumables required for operations<br>• Fire Suppression systems shall be autonomous and fully operable at 90-100% capacity immediately after a seismic event |
| Terminal Storage Reservoir | • Same as ORP, Main Transmission System<br>• RES_1.0 Water Quality Building and related infrastructure shall meet the requirements of other “Facilities” as identified for the “Intake and RWF” and the “WTP” |
| Transmission Lines | • Same as ORP, Main Transmission System |
| Appurtenances | • Same as ORP, Main Transmission System |
| Turnouts | • Same as ORP, Main Transmission System |
| System Communications | • All critical systems to be hardwired<br>• All critical systems must be able to operate independent of Internet (including wireless)<br>• Include cyber security protocols |
| Distributed Control System | • Primary and secondary communication systems to be determined |
| System Infrastructure | • All facilities and transmission system components shall sustain no structural or mechanical damage that impairs system capacity or operability |

Key: ORP = Oregon Resilience Plan; RWF = Raw Water Facilities; WTP = Water Treatment Plant


Time After Earthquake Event
100
90
80
70
60
50
40
30
20
10
0
5min
45min
8hr
1d
2d
5d
1mo
6mo
M9.1 (Tohoku Earthquake)
M7.9 (29min)
M7.1 (39min)
Tsunami (50min)
M7.0 (4mo)
Shelter for Earthquake
Start Checks
Request Supplies
Start Generators
0
1
10
100
1,000
10,000
100,000
1,000,000
Time (minutes)

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# EXTRA SLIDES

# C.A.T.S. System

- https://youtu.be/wmOmIrsZQk0