



# Resilience Planning – Dependencies and Cascading Effects

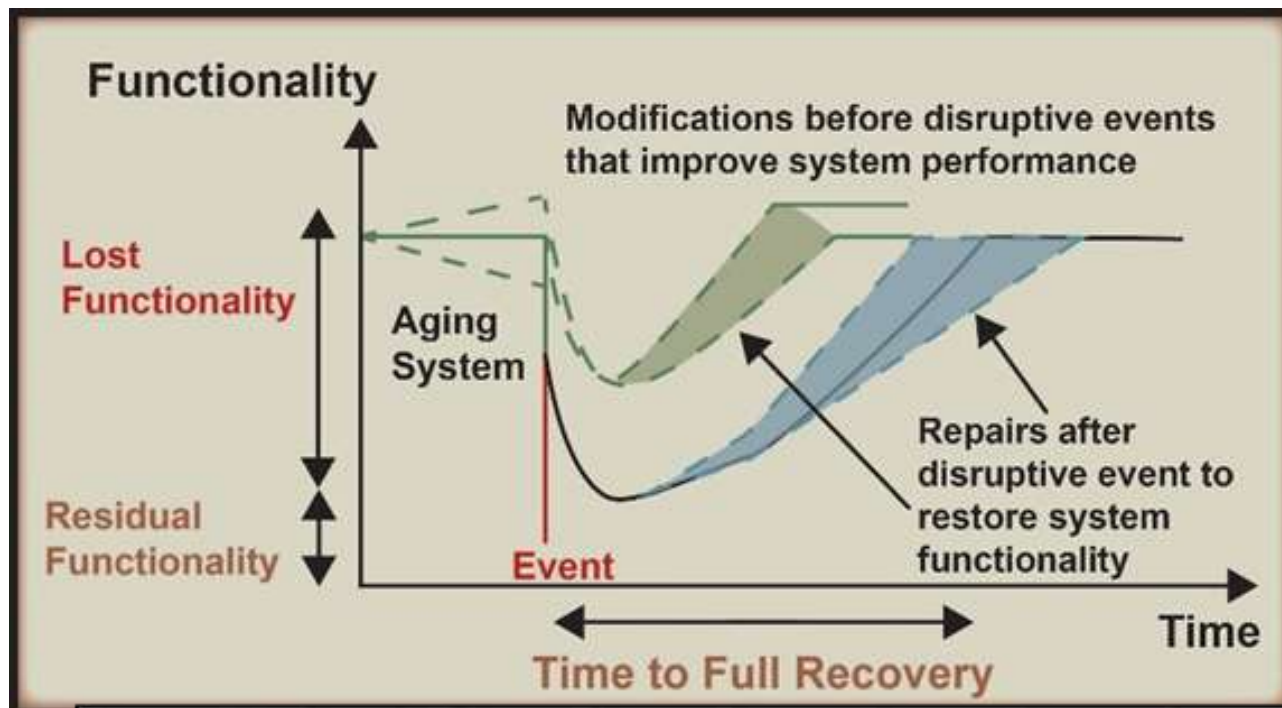


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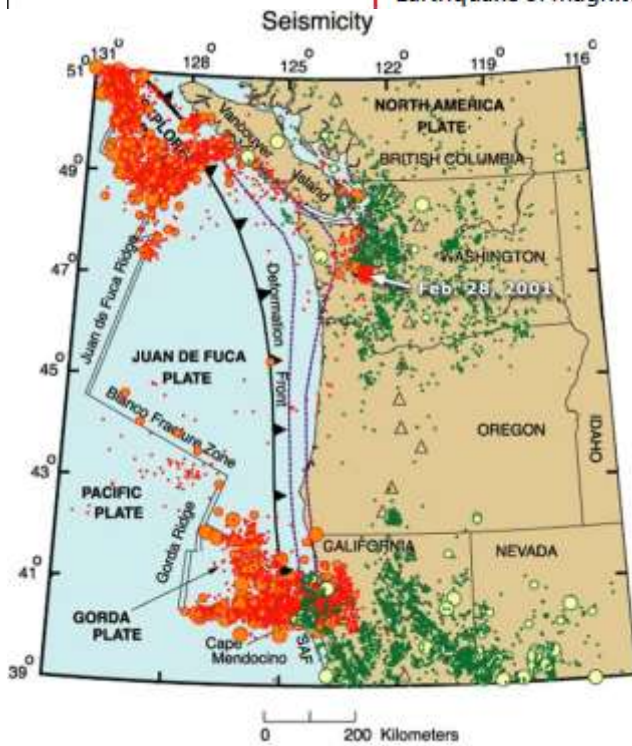
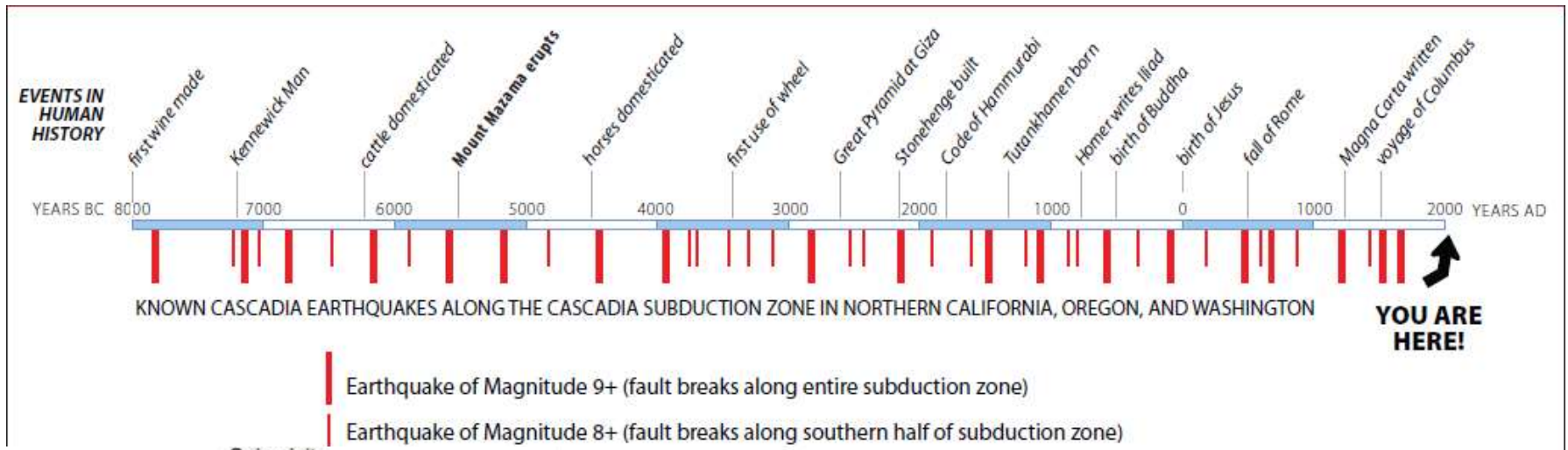
# Resilience Concept

- Resilience can be expressed in terms of
  - system functionality
  - time to recover functionality following a disruptive hazard event

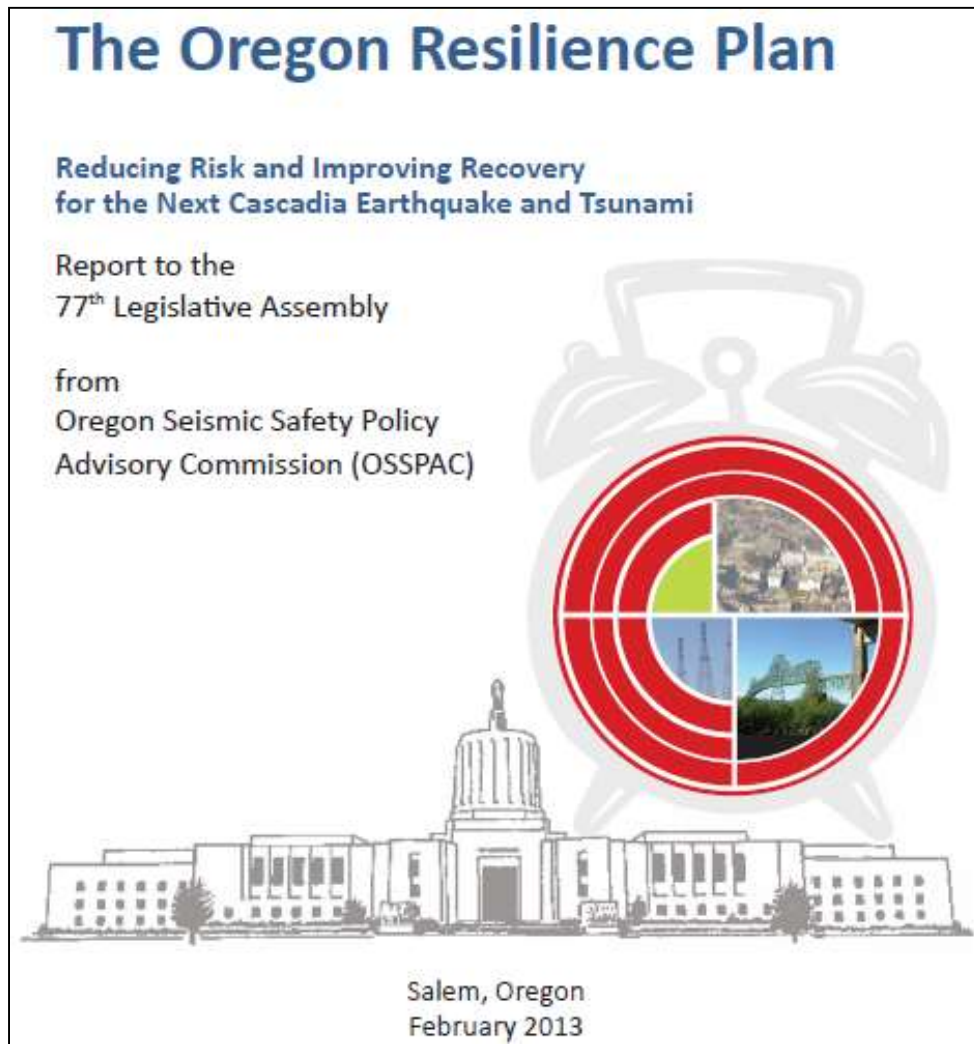


- Definition of Resilience: The ability to *prepare for* and *adapt to* changing conditions and *withstand* and *recover rapidly* from disruptions

# Cascadia Subduction Zone



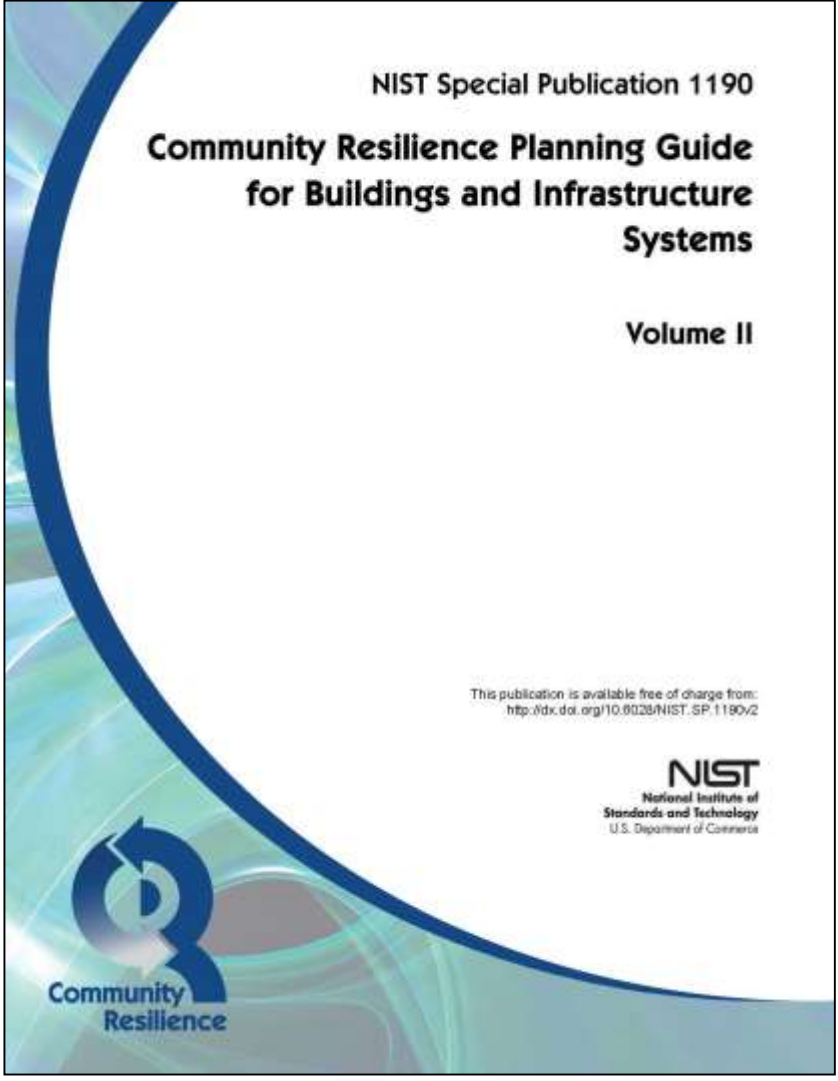
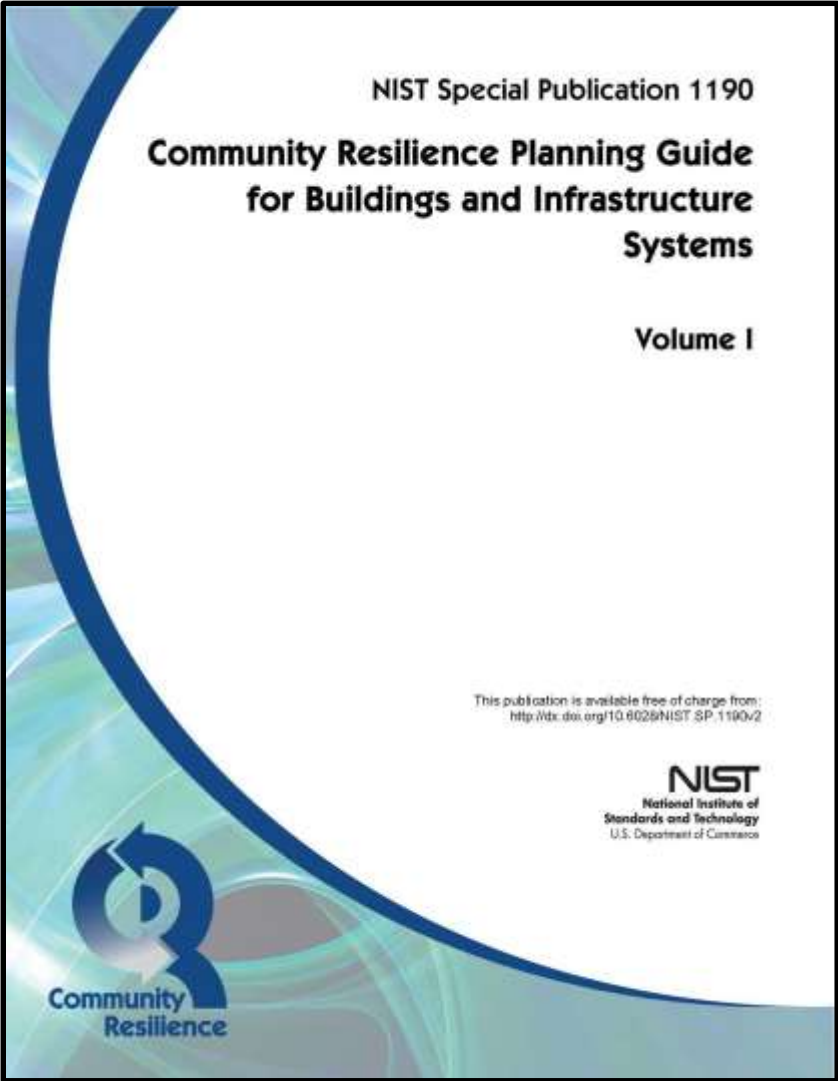
# The Oregon Resilience Plan



(download it from

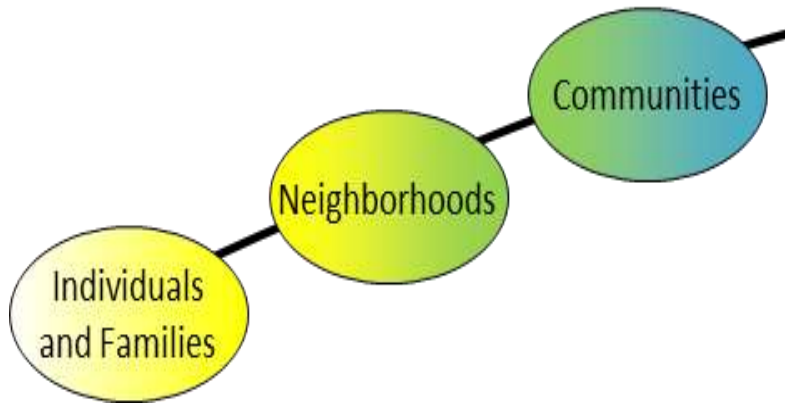
[http://www.oregon.gov/OMD/OEM/ossnac/docs/Oregon\\_Resilience\\_Plan\\_Final.pdf](http://www.oregon.gov/OMD/OEM/ossnac/docs/Oregon_Resilience_Plan_Final.pdf) )

# NIST Community Resilience Planning Guide for Buildings and Infrastructure Systems



Google *NIST Resilience Planning Guide* for a free down load

# Community Member Needs



Adapted from Maslow 1943

# Understand the Situation

Link Social Dimensions and Built Environment



# Recovery of the Built Environment

Organize around restoring functionality over time



***When is each cluster and system needed for recovery?***

*Survival*

*Safety and Security*

*Belonging*

*Growth and Achievement*



# Functionality Needs For Recovery

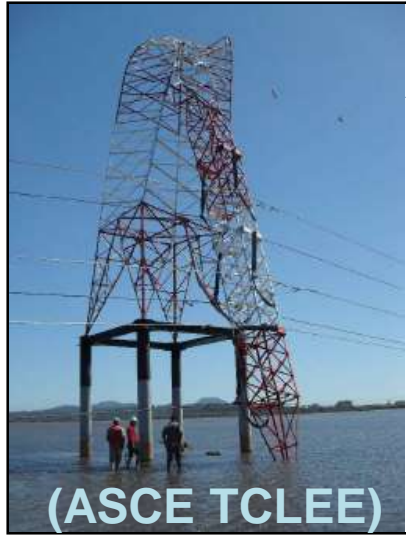
- **Short-Term:** Secure, Rescue, Stabilize, Clear Routes
  - Clusters: Critical Facilities, Emergency Housing  
Related Infrastructure Systems
- **Intermediate:** Restore Neighborhoods, meet social needs
  - Clusters: Housing, healthcare, main street, schools, Churches
  - Related Infrastructure Systems
- **Long-Term:** Community Social and Economic Recovery
  - Clusters: Commercial and Industrial Businesses
  - Related Infrastructure Systems



# Lifeline Dependencies

Interdependencies will make disaster recovery much more difficult. The earthquake will damage all systems at the same time.

To restore electric service, you need to reopen roads



To restore water service, you need electricity



To restore fuel supplies you need electricity

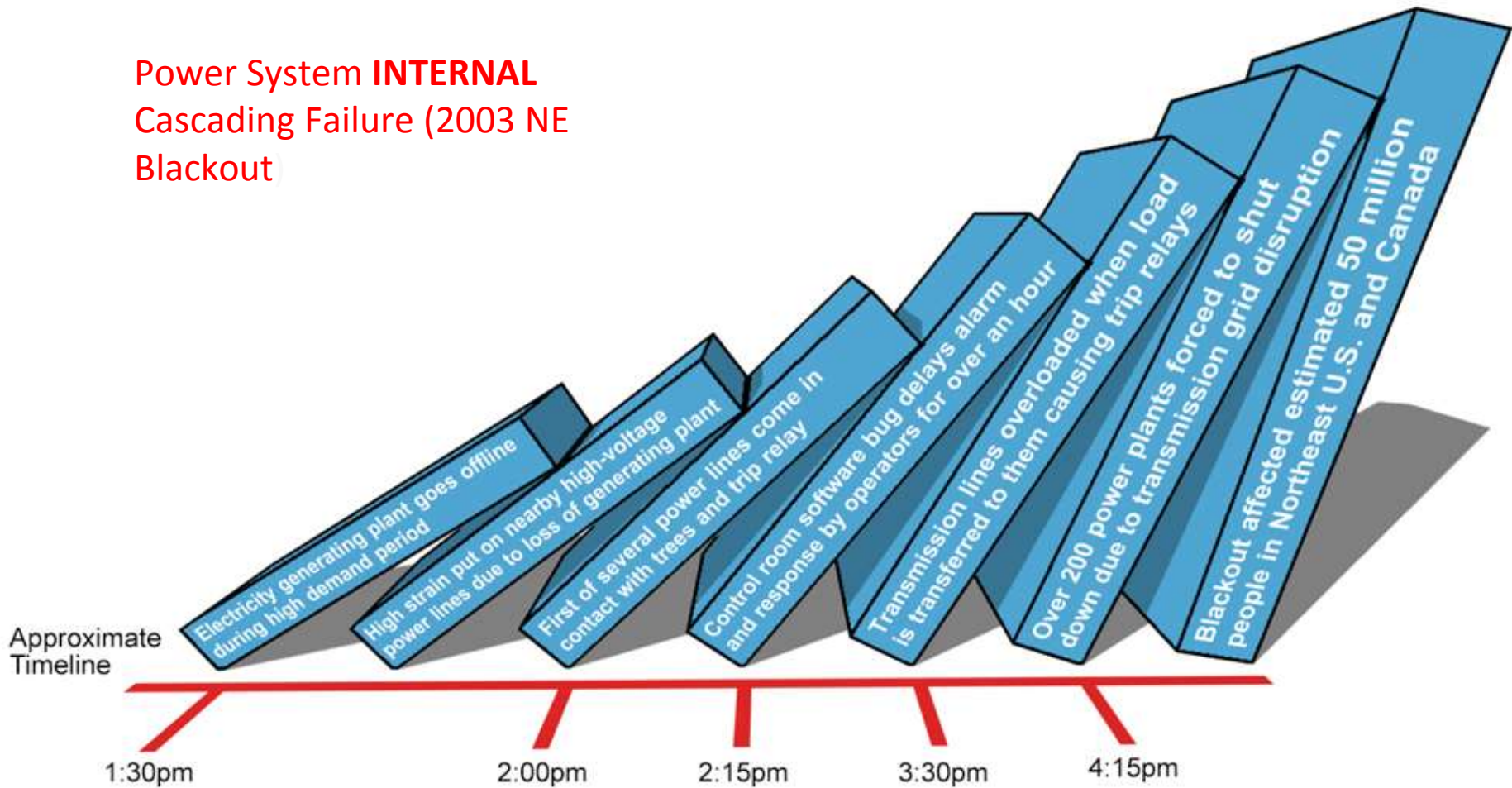


To reopen roads, you need to restore fuel supplies



# Cascading Effects

Power System **INTERNAL**  
Cascading Failure (2003 NE  
Blackout)



# Cascading Effects

Power System  
**EXTERNAL**  
Cascading  
Failure (2003  
NE Blackout)



# Dimensions of Dependencies

- Internal and External
- Time
- Space
- Source

(These dimensions may not be independent)

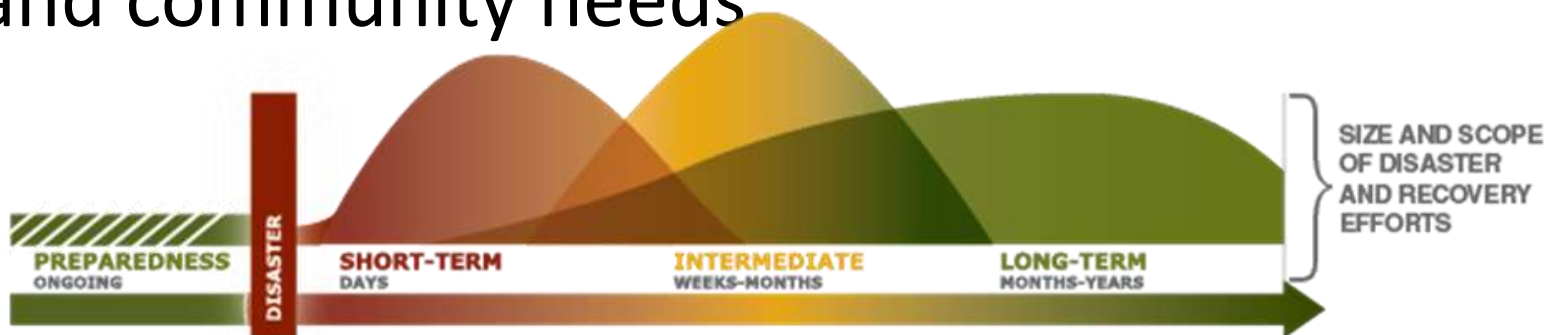
# Internal and External Dependencies

- Internal Dependency (examples)
  - Physical Infrastructure System
  - Equipment and Repair Supplies
  - Operations Center (and more)
  - Employees
- External Dependency (examples)
  - Transportation
  - Power
  - Communication (and more)
  - Financial

(It is also good to consider who may depend on your system)

# Time Dimension

- Recovery Phases
  - Short-Term, Intermediate, and Long-Term
- Dependencies may change from one phase to another
- Performance goals, and restoration sequence and pace are influenced by external dependencies of other infrastructure systems and community needs



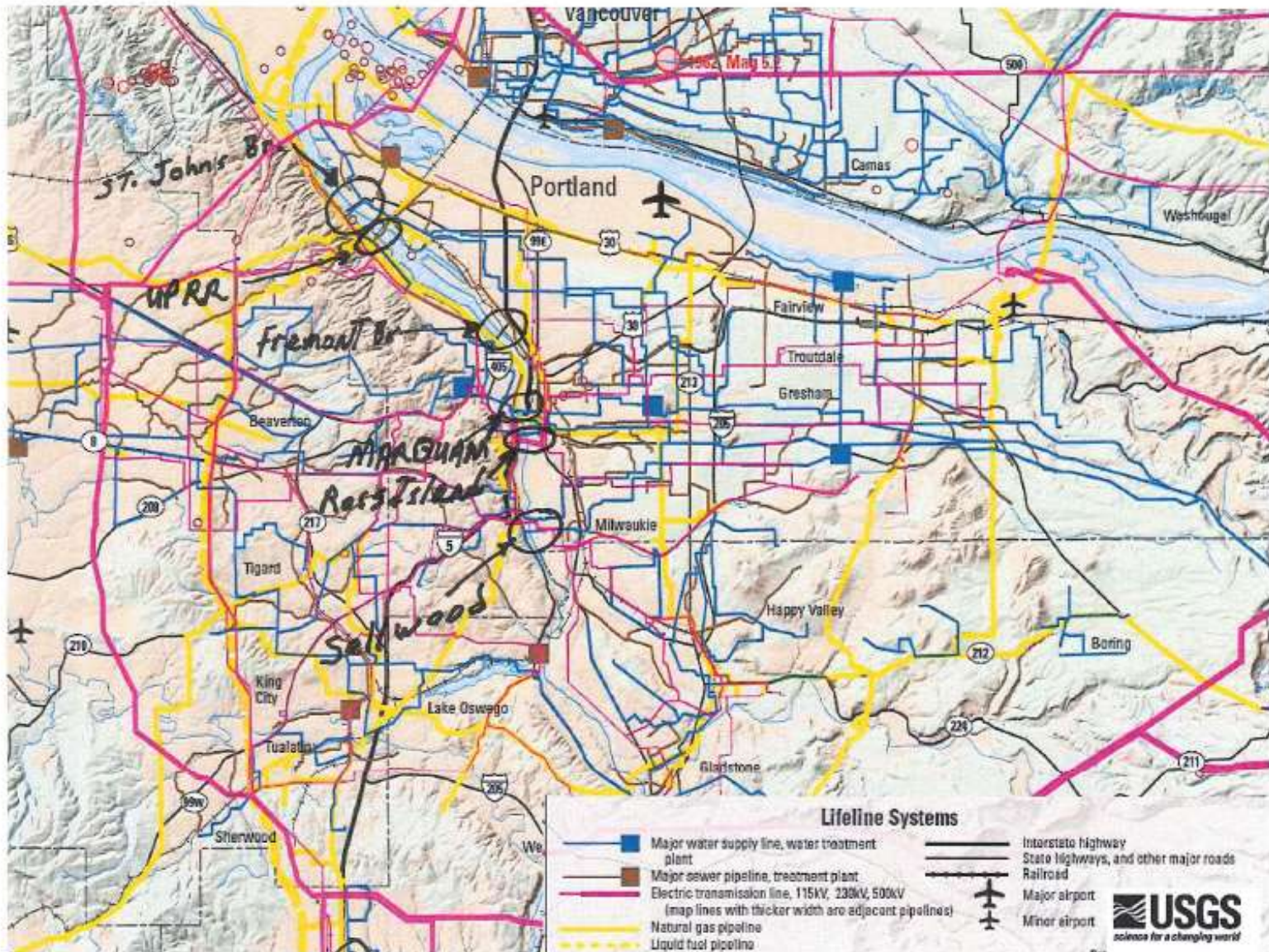
(Source: FEMA, 2014)

# Space Dimension





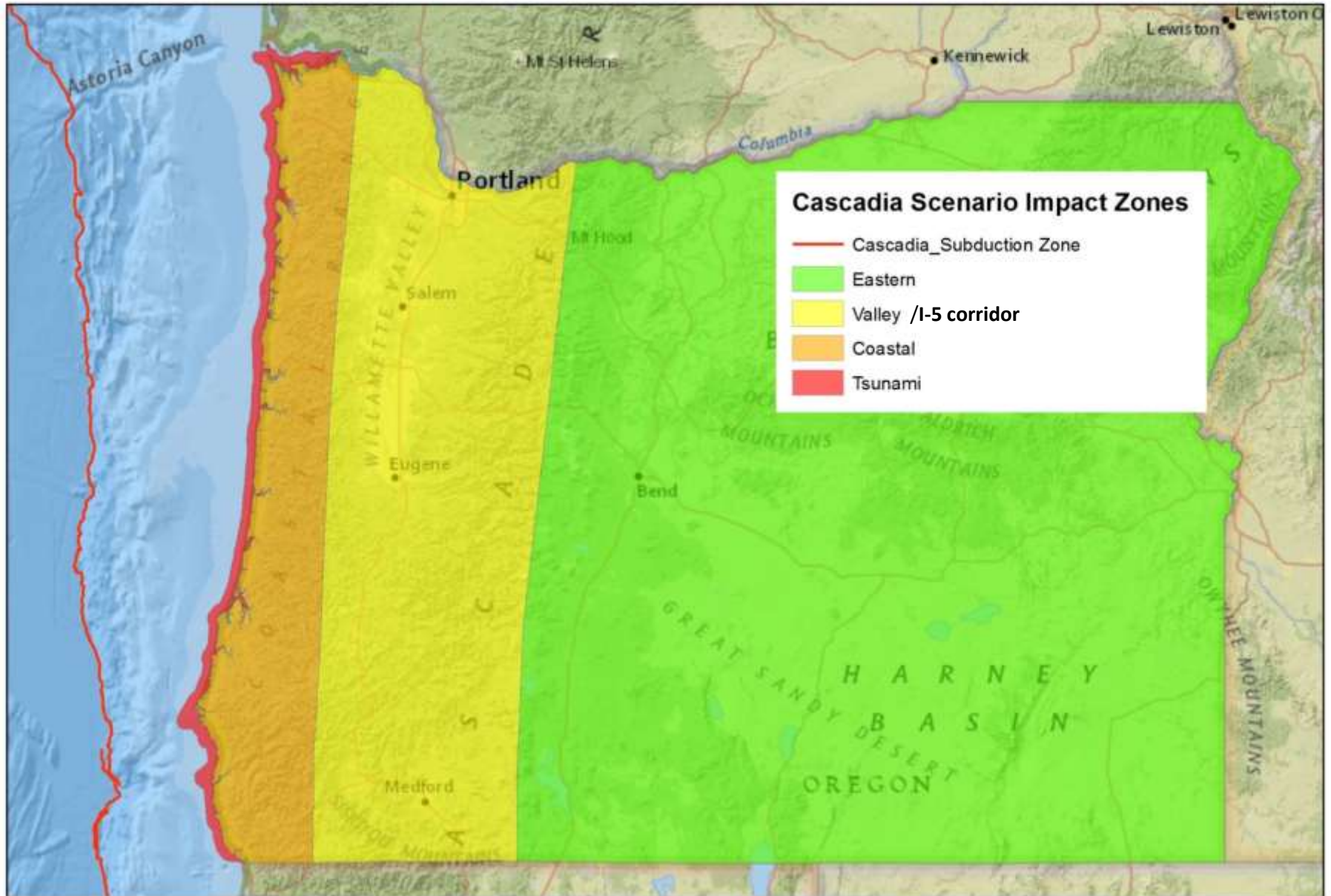
# Space Dimension



Boone Br.

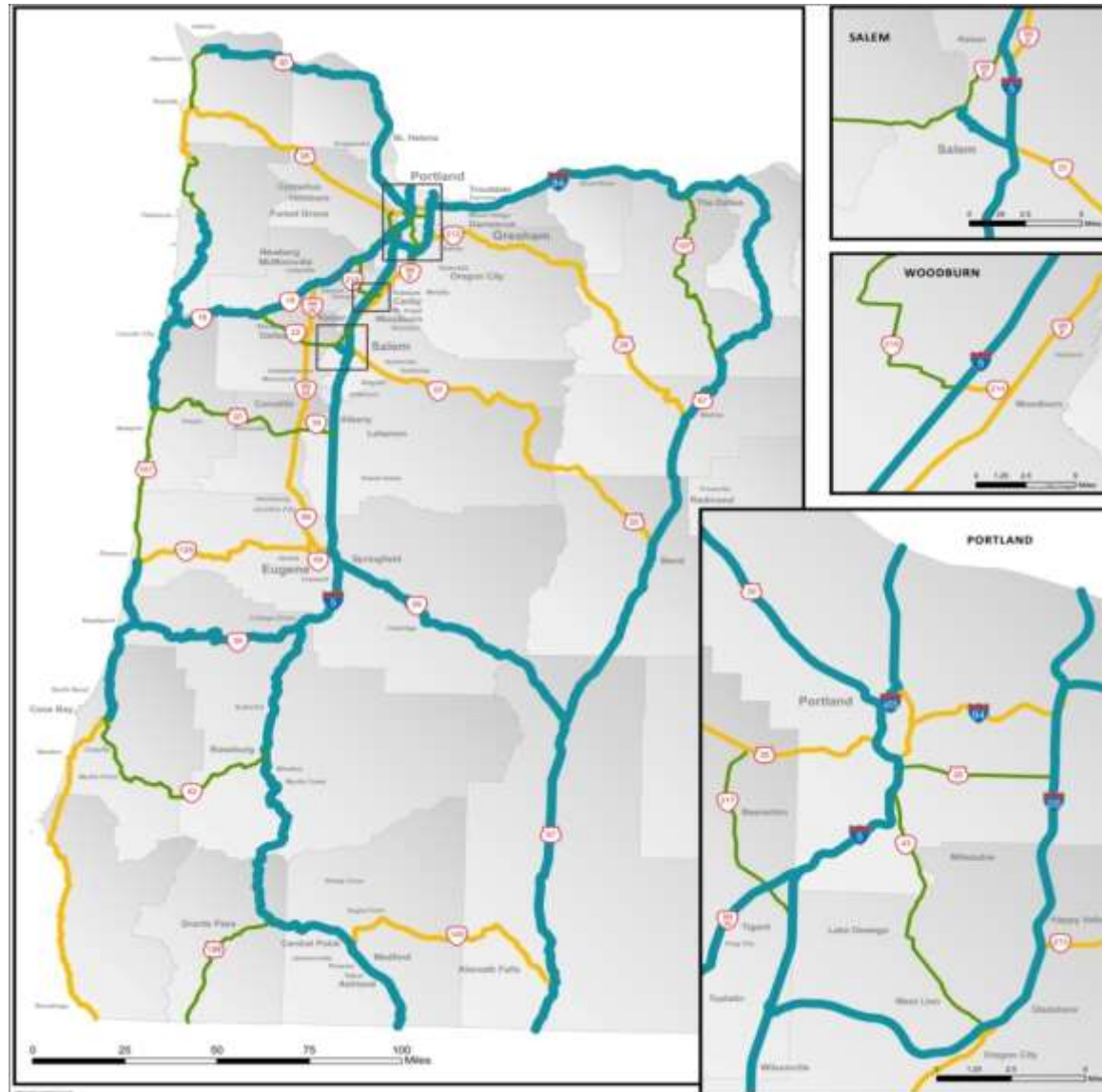
(Source: City of Portland, 2012)

# Space Dimension

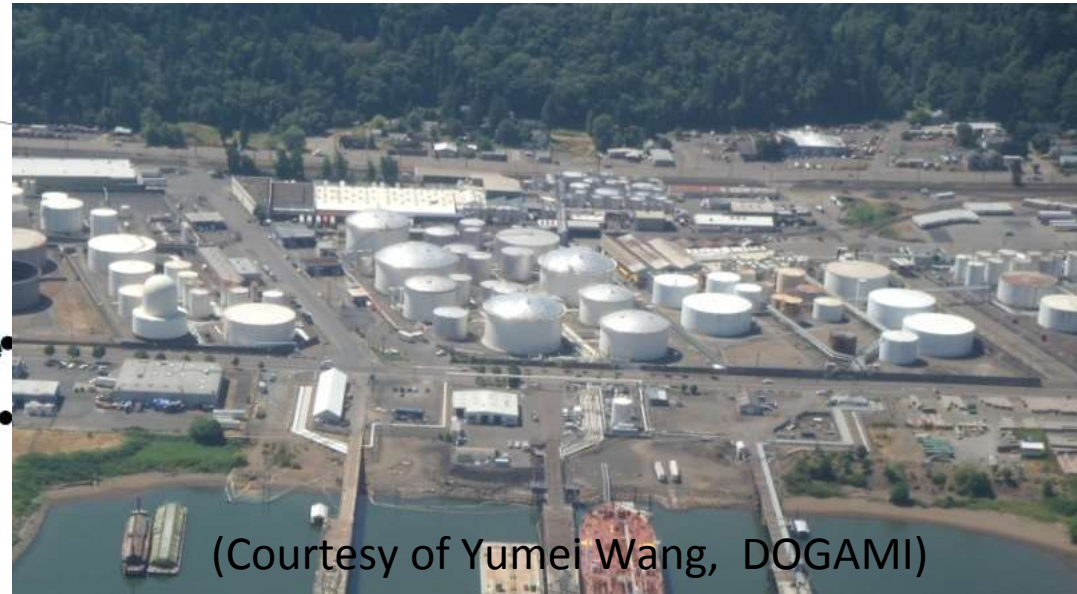


# State Response/Recover Strategy

1<sup>st</sup> tier  
2<sup>nd</sup> tier  
3<sup>rd</sup> tier



# Source Dimension

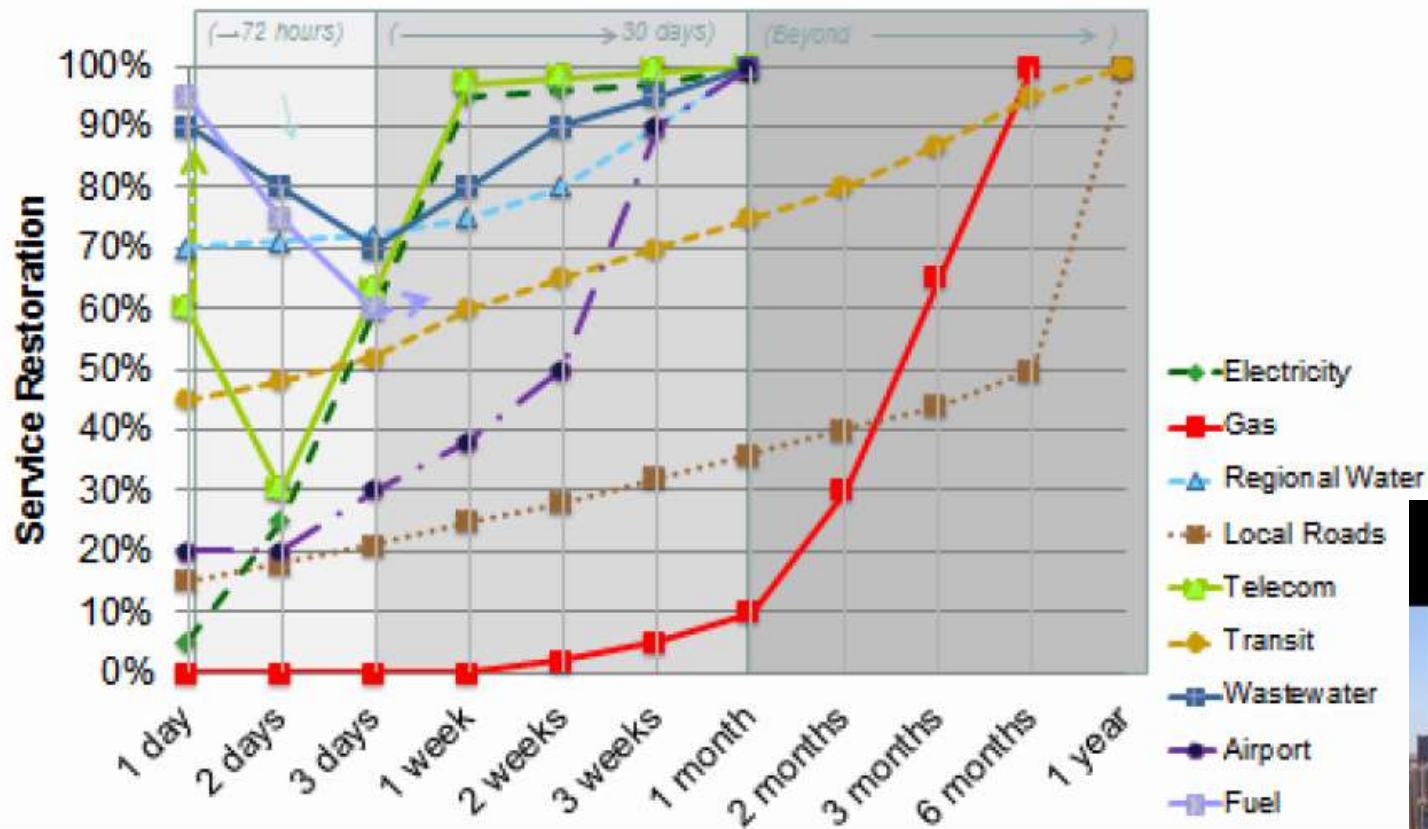


- ### Additional Examples
- Wholesale Water Supplier
  - Wholesale Power supplier
  - Centralized Warehouse of A Healthcare System

Source: <http://www.bppipelines.com/cartoon-maps/olympic.pdf>

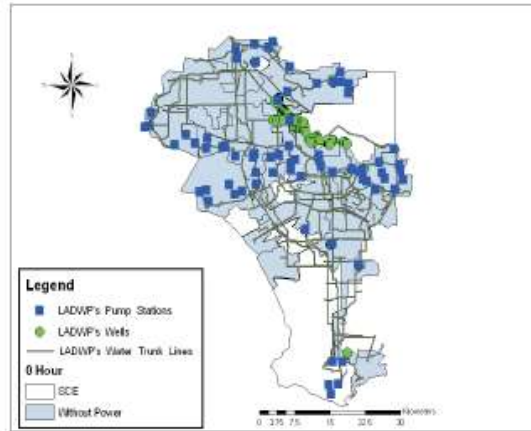
# Dependency Coordination

- SF Lifeline Council

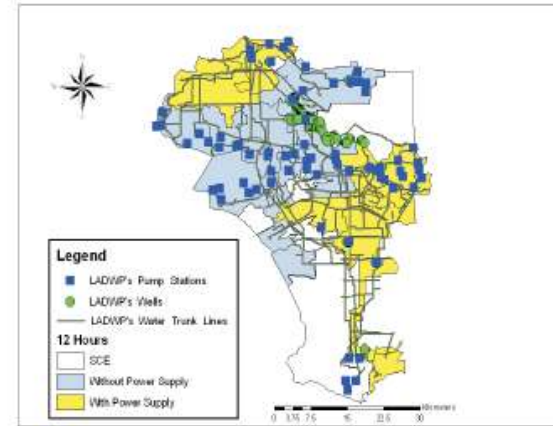


# Dependency Coordination

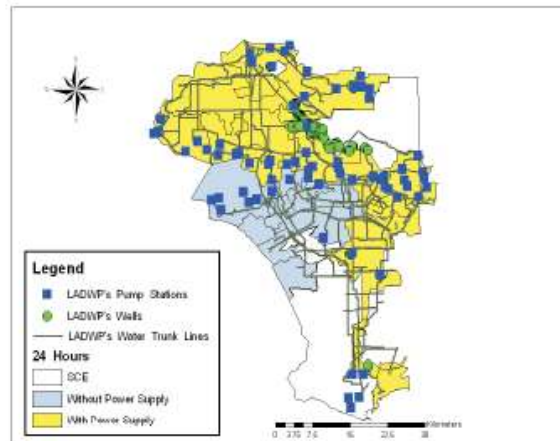
- LA DWP – Integration of Power and Water



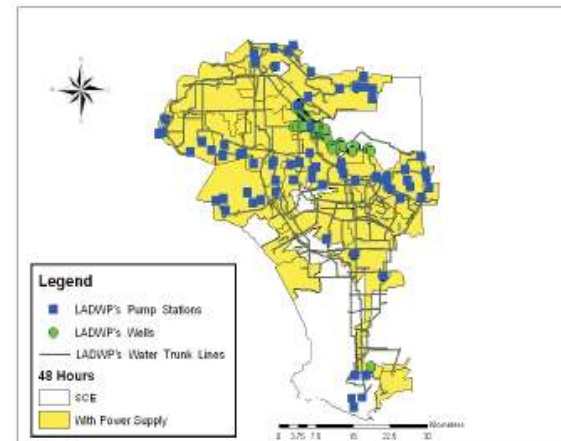
(a) 0 Hours Later



(b) 12 Hours Later



(c) 24 Hours Later



(d) 48 Hours Later

(source: Shinozuka et al. 2004)

# Remarks

- Start from Social Needs (to define performance goal)
- Consider Dependencies (no more silo approach!)
- Dependency relationship is complex and multi-dimensional
- Consider various dimensions of dependencies within each service provider
- Community-wide coordination
- Strategies to reduce dependencies