Disaster Debris Management
&
Disaster Resilience and Water System

Water & Waste Eng.
2020/07/10

名古屋大学減災連携研究センター
Disaster Mitigation Research Center, NAGOYA UNIVERSITY

The 2011 Tohoku Disaster

- Date-Time; 11 March 2011 14:46 JST
- Magnitude; 9.0 (M8.8 USGS)
- Location; 38.322N 142.369E
- Depth; 24 km
- Distances; 130km East of Sendai, 376km NE of Tokyo

8.8 M - NEAR EAST COAST OF HONSHU, JAPAN

Preliminary Earthquake Report

Magnitude	8.8 M
Date-Time	11 Mar 2011 05:46:23 UTC 11 Mar 2011 14:46:23 near epicenter 11 Mar 2011 14:46:23 standard time in your timezone
Location	38.322N 142.369E
Depth	24 km
Distances	130 km (81 miles) E (86 degrees) of Sendai, Honshu, Japan 179 km (111 miles) ENE (68 degrees) of Fukushima, Honshu, Japan 188 km (117 miles) SE (145 degrees) of Morioka, Honshu, Japan 376 km (234 miles) NE (37 degrees) of TOKYO, Japan
Location Uncertainty	Horizontal: 13.5 km; Vertical
Parameters	Nph = 351; Dmin = 416.3 km; Rmss = 1.46 seconds; Gp = 28° M-type = M; Version = A
Event ID	US c0001xgp ****This event has been revised.*

Nearby Sendai Airport

Seashore of Sendai City

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Collapsed Housing in Sendai City

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Ishinomaki City （2011.3.31）

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Tsunami Sediment in Ishinomaki City

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Nishiki Town, Kesennuma City

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Damaged Fishing Boat

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Devastated Area in Rikuzentakada City

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Embankment Broken by Tsunami

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Rikuzentakada City Hall

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Tsunami Debris in Rikuzentakada City

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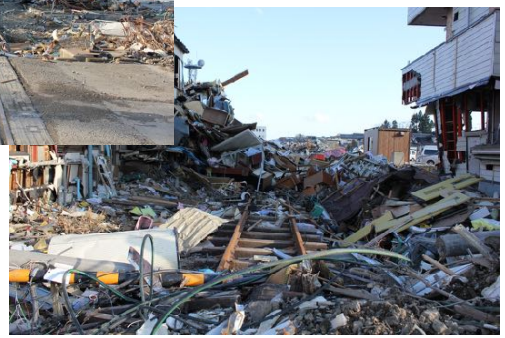
Tsunami Debris Covered Railroad in Ohfunato City



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Sandbar in Nehama Seashore Washed Out

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Tsunami Attacked Area in Ohtsuchi Town

Collapsed House in Yamada Town

Collection Site of Disaster Debris in Sendai City

Temporary Drainage System

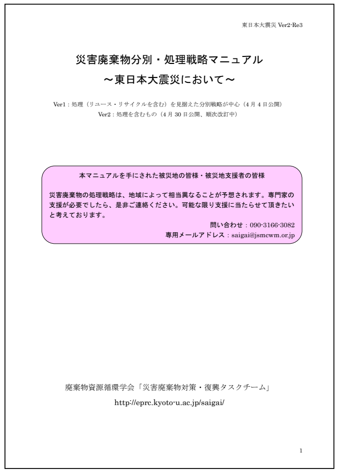
Emergency Response to Embankment

Recovery of Embankment

Japan Society of Material Cycles and Waste Management (JSMCWM)

- Task Team on Disaster Debris and Waste Management and Reconstruction
  - Disclose observations and information reports
  - Strategy Manuals for Disaster Debris and Waste Separation and Disposal
  - Chemical Analyses of the Tsunami Sediment

Strategy Manuals for Disaster Debris and Waste Separation and Disposal (in Japanese)



東日本大震災 Ver2-Re3

災害廃棄物分別・処理戦略マニュアル

～東日本大震災において～

Ver1：処理（リユース・リサイクルを含む）を見据えた分別戦略が中心（4 月 4 日公開）

Ver2：処理を含むもの（4 月 30 日公開、順次改訂中）

本マニュアルを手にされた被災地の皆様・被災地支援者の皆様

災害廃棄物の処理戦略は、地域によって相当異なることが予想されます。専門家の支援が必要でしたら、是非ご連絡ください。可能な限り支援に当たらせて頂きたいと考えております。

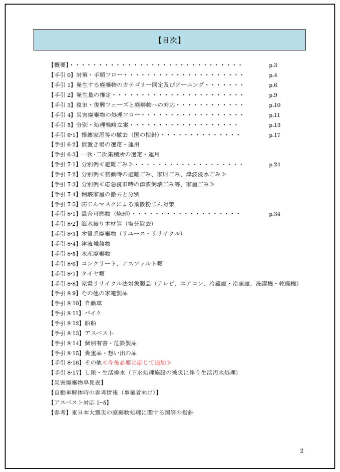
問い合わせ：090-3166-3082

専用メールアドレス：saigai@jsmcwm.or.jp

廃棄物資源循環学会「災害廃棄物対策・復興タスクチーム」

http://eprc.kyoto-u.ac.jp/saigai/

1



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【自動車解体時の参考情報（事業者向け）】
【アスベスト対応 1~5】
【参考】東日本大震災の廃棄物処理に関する国等の指針

2

Before Implementation of Strategy

After the Implementation

Collecting Sites in Sendai City

Tsunami Debris Collecting Sites in Sendai City

White Goods and TVs in Collection Site

Fire Extinguisher and Metals in Collection Site

Tyres and House Hazardous Materials

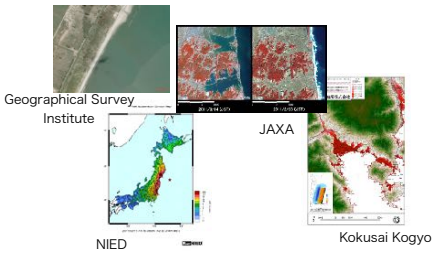
Oil Heaters and Oil Collecting

Temporary Sites after 2016 Kumamoto Earthquake

Temporary Sites after 2016 Kumamoto Earthquake

Quantitative Estimation Procedure for Disaster Debris

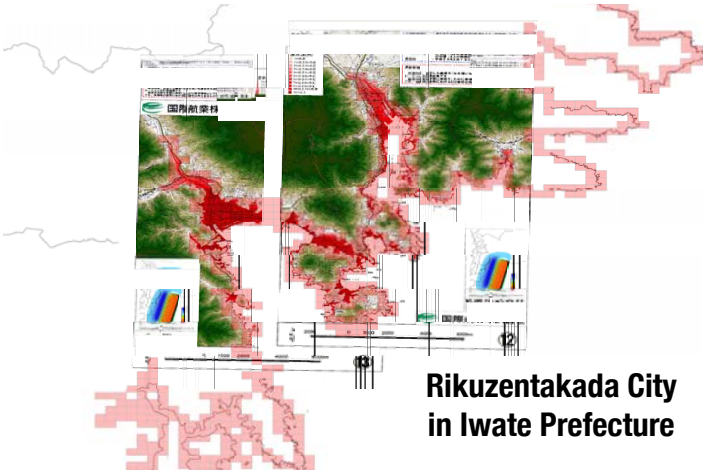
Hazard Information	Damages	Per Unit Generation	Quantitative Estimation
Satellite Image Aerial Photograph Seismic Intensity Tsunami Inundation Area Inundation Depth	Damaged households Damaged buildings	Total Collapse; 113 t/building 61.2t/household Floor Inundation; 4.6t/household	Amount of Disaster Debris



Estimation Procedure for Tsunami Debris

- Identification of Tsunami Inundation Area
  - 500m Grid on GIS (Geographical Information System)
- Number of Damaged Household
  - Census Data
  - Household damaged by tsunami inundation
- Amount of Tsunami Debris
  - Per Unit Generation of Disaster Debris

Identification of Tsunami Inundation Area



Rikuzentakada City in Iwate Prefecture

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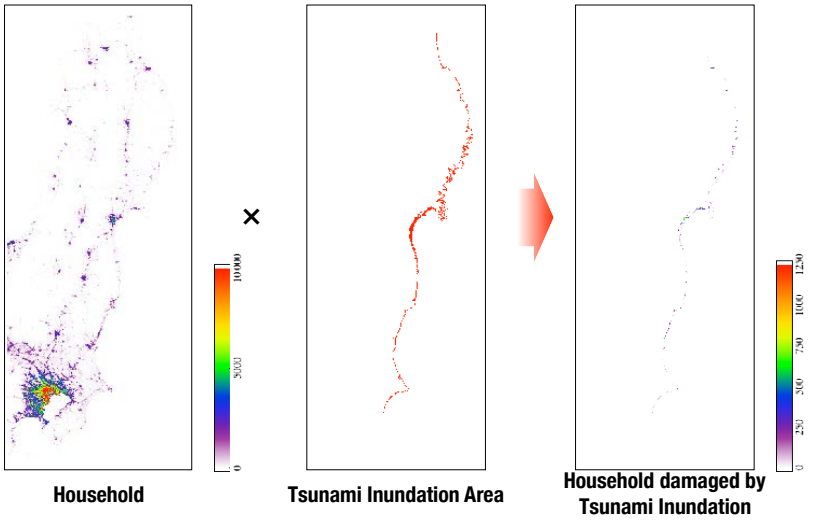
Household Damaged by Tsunami Inundation



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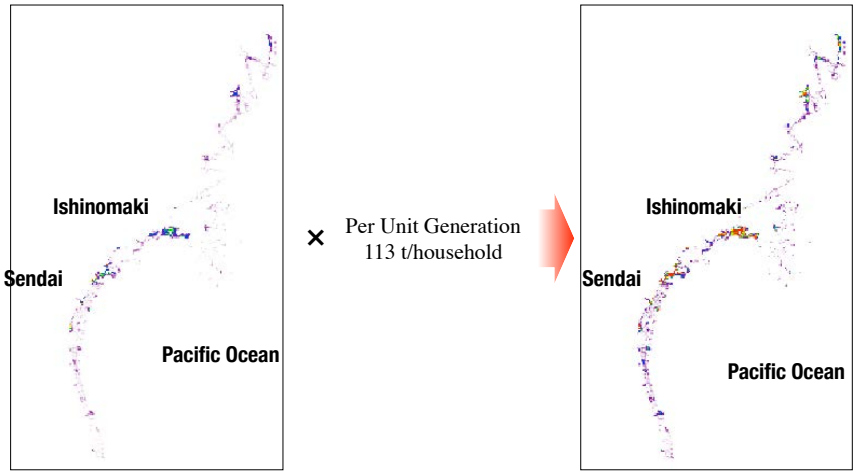
Estimation Results of Amount of Tsunami Debris in Miyagi Prefecture



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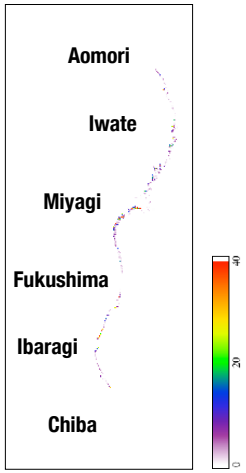
Estimation Results of Amount of Tsunami Debris



Prefecture	Tsunami Debris (10^4t)
Aomori	86.0
Iwate	532.8
Miyagi	1,381.7
Fukushima	239.7
Ibaragi	302.1
Chiba	165.3
Total	**2,707.6**

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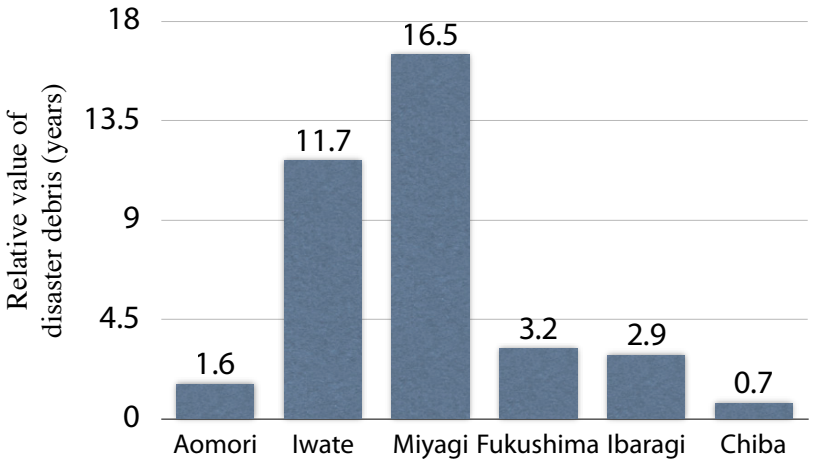
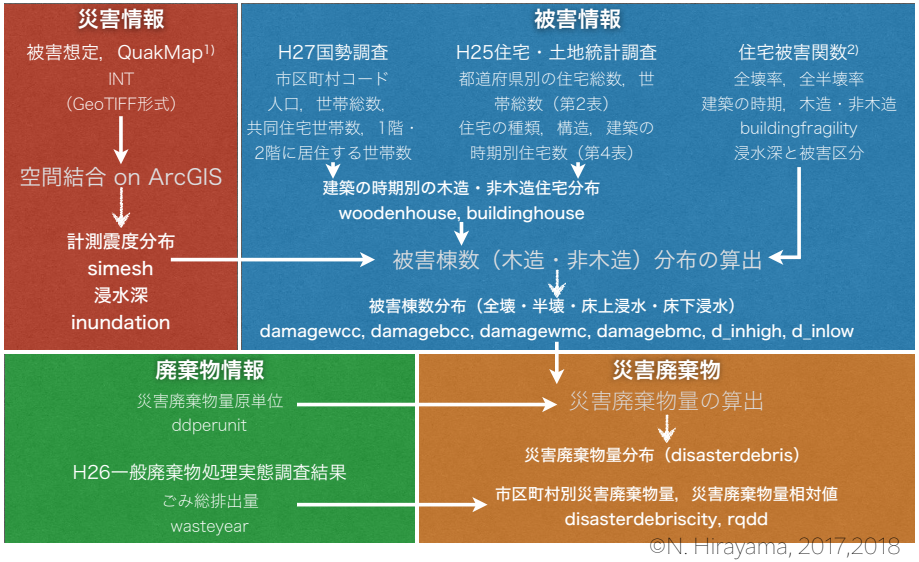
Tsunami debris operation would be not only Local Governments but also National Government



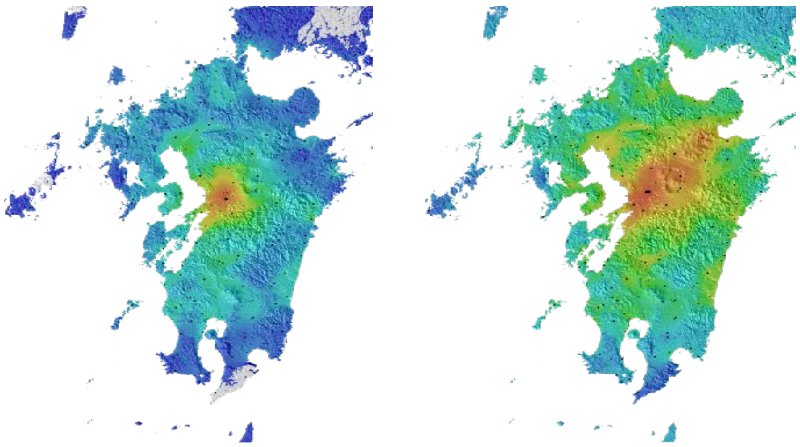
Per Unit Generation of Disaster Debris

- **1995 Kobe Earthquake, 2004 Niigata Earthquake, 2011 Tohoku Disaster**
  - Complete collapse: 116.9 t/dwellings
  - Moderate collapse: 23.4 t/dwellings
- **2004 Niigata Flooding, Fukui Flooding**
  - Inundation damage beyond floor level: 4.6 t/household
  - Inundation damage below flood level: 0.62 t/household

Quantitative Estimation for Disaster Debris

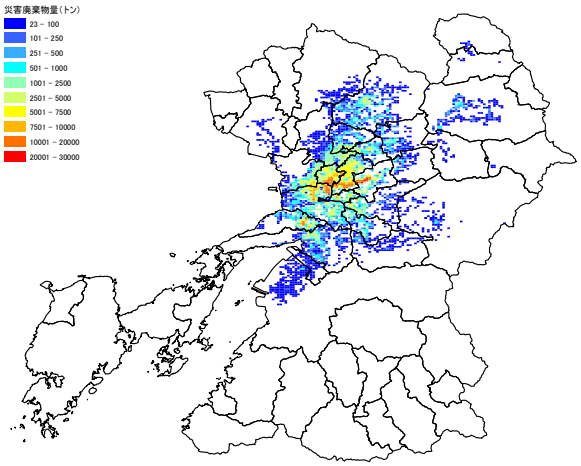


2016 Kumamoto Earthquake Seismic Intensity

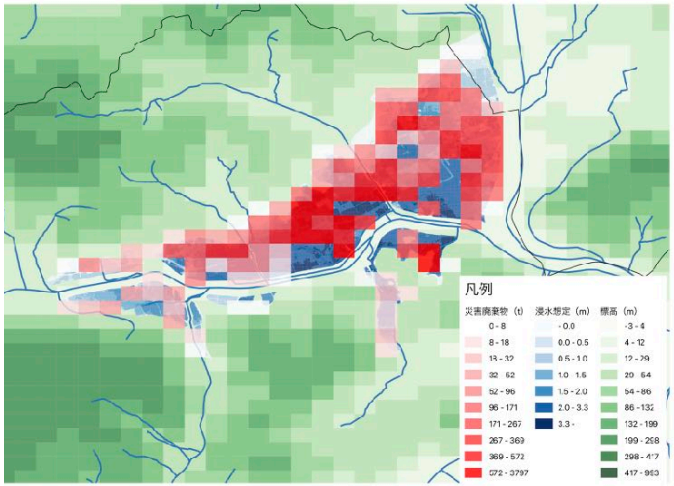


2016年4月14日21:26 Mj6.5　　2016年4月16日01:25 Mj7.3

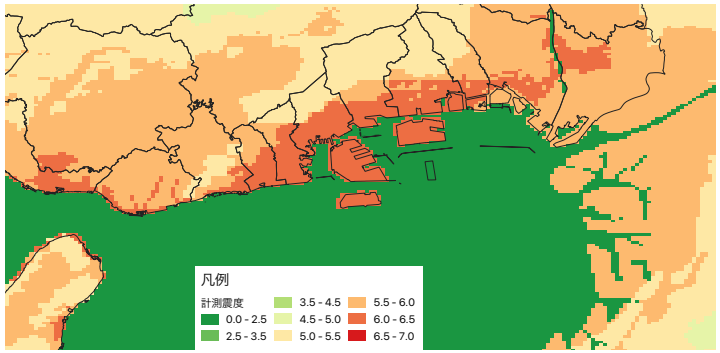
Estimation Result of Disaster Debris



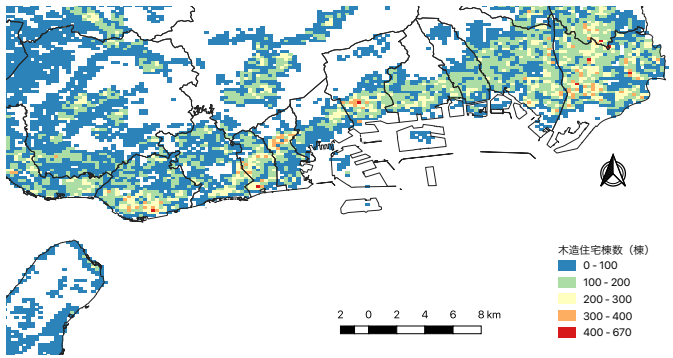
Estimation Result of Flooding Disaster 2018 Mabi town. Okavama Prefecture



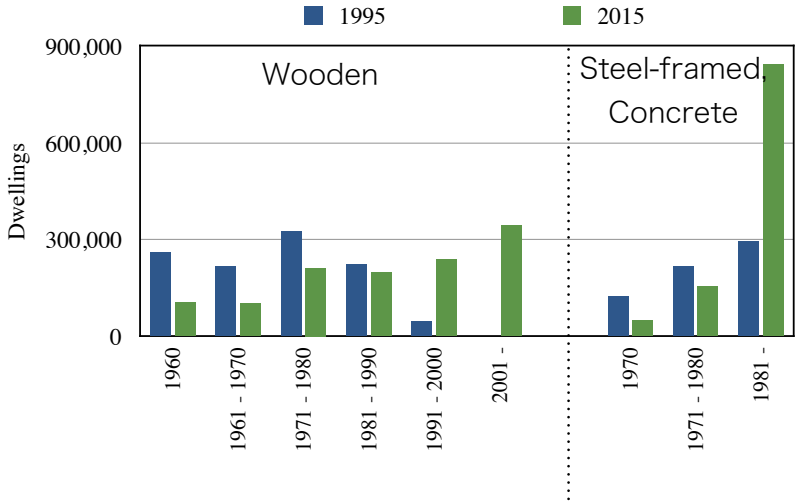
1995 Kobe Earthquake Seismic Intensity



Wooden dwelling in 2015



Dwelling and Year of Construction



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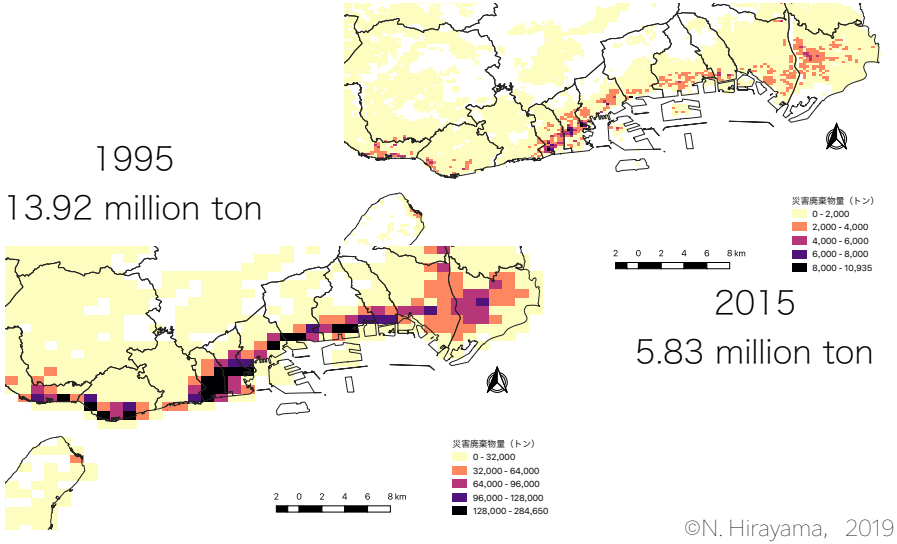
Change of Amount of Disaster Debris



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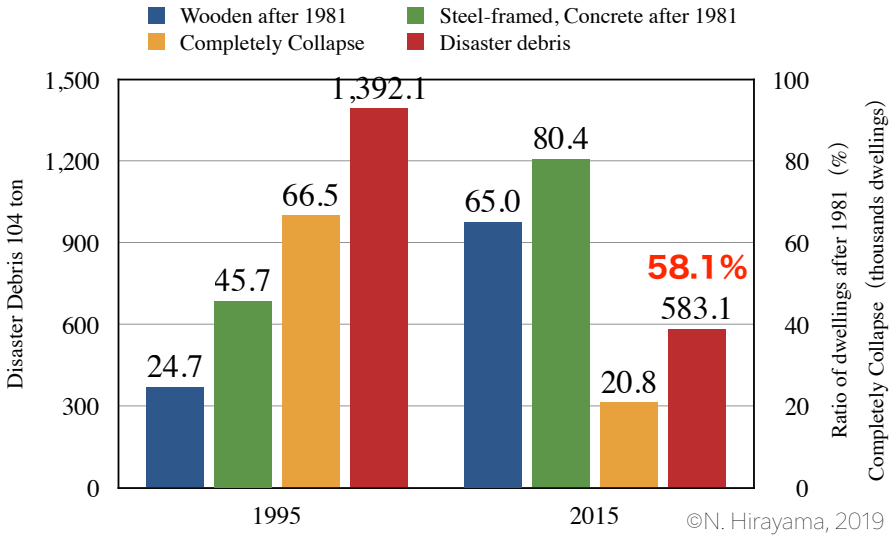
Reduction of Disaster Debris



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Damages to Water Distribution System in 1995

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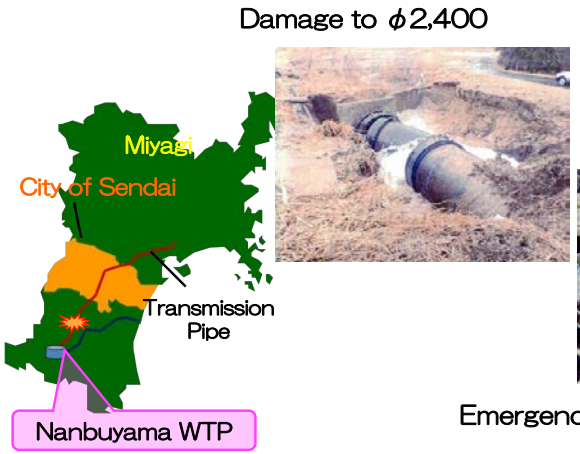
Damage to Facilities in City of Sendai

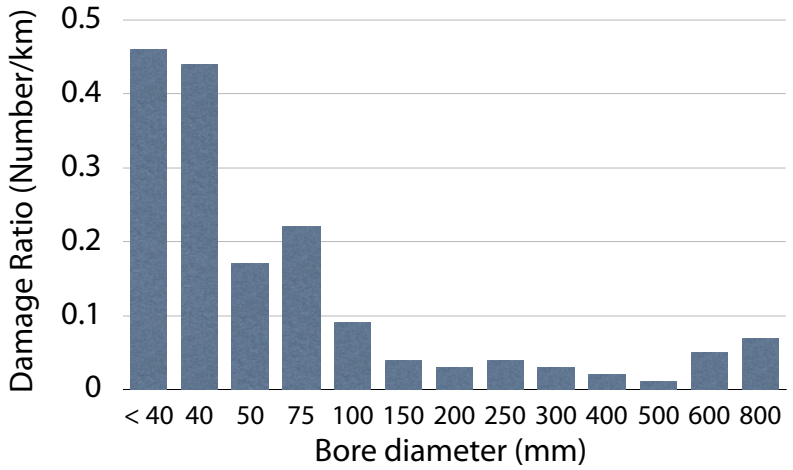
Damage to Water Transmission Pipe



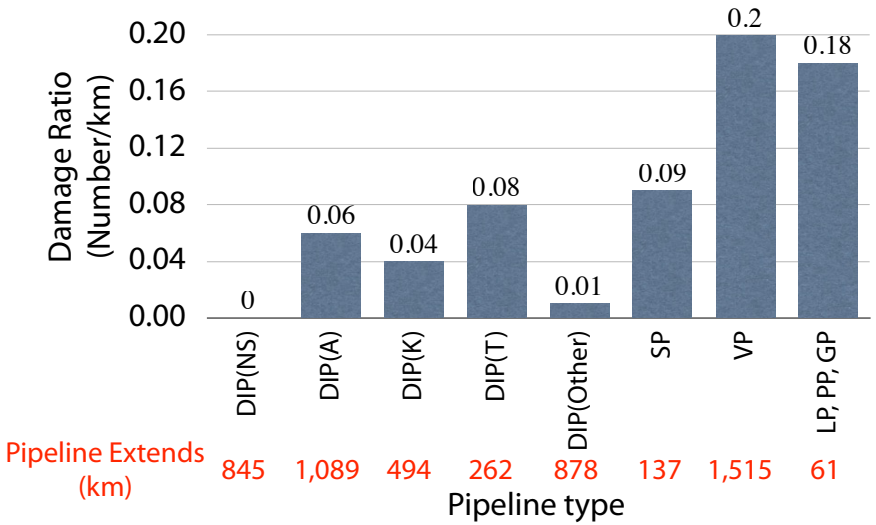
Damage to ϕ2,400

Emergency Recovery of ϕ2,400

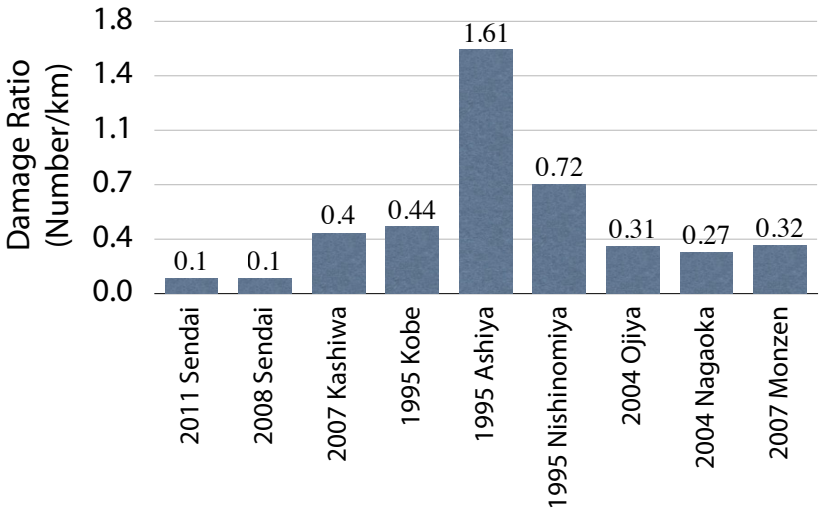
Damage Ratio in Each Bore Diameter in City of Sendai



Damage Ratio of Pipeline in City of Sendai



Comparison Results of Damage Ratio in Japanese Experiences



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Earthquake-Resistant Ductile Iron Pipe (DRDIP)

Property	Performance
Amount of expansion/contraction	±1% of nominal pipe length
Pull-out resistance	3 DkN
Maximum deflection angle	6 – 8˚

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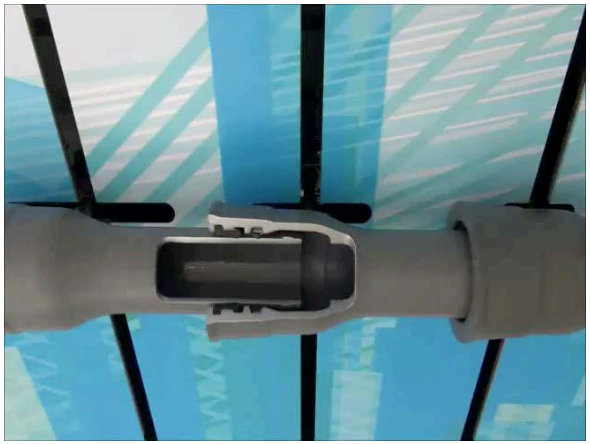
Earthquake Resistant DIP



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Emergency water supply station

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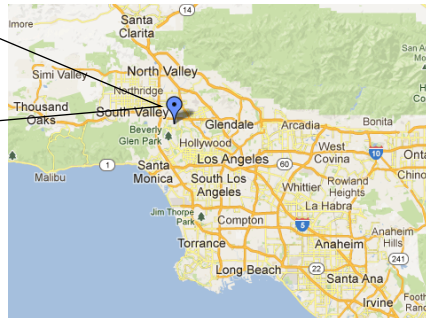
Disaster Community Training at KOBE primary school

Disaster Assistant Cooperation System

US-JP International Research:

Implementation of Earthquake Resistant Ductile Iron Pipe (ERDIP) in U.S.

LADWP 1st Pilot Project



(1) Contour Dr. **(Installed on January – March 2013)**

- Pipeline Length: 1800’
- Pipe diameter: 6” (150mm)
- Hillside area (Sloped and curvy roads)
- Landslide risk

LADWP ERDIP Installation

LADWP Pilot Project on the Wall Street Journal

THE WALL STREET JOURNAL.

DOW JONES

MONDAY, APRIL 15, 2013 - VOL. CCLXI NO. 87

Los Angeles Tests Water Pipes That Stand Up to Quakes

Business Continuity (ISO22301)

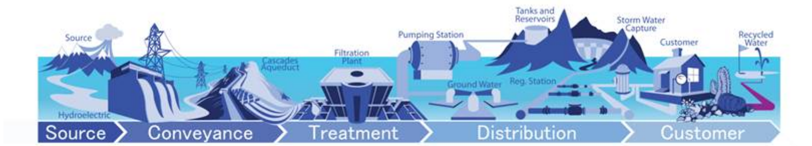
- **Business Continuity**: capability of an organization to continue delivery of products or services at acceptable pre-defined levels following disruptive incidents
- **Business Continuity Management**: process identifying potential threats to an organization and potential business impacts the threats may cause, which provides a framework for building organizational resilience with the capacity of an effective response that safeguards the interests …
- **Business Continuity Plan**: documented procedures that guide organizations to respond, recover, resume, and restore to pre-defined level of operation following disruption
- **Business Continuity Management System**: part of overall management system that establishes, implements, operates, monitors, reviews, maintains, and improves business continuity

Need for Business Continuity

- **Existing Emergency Management Systems have serious gaps to ensure business can continue to function following disruptive events**
  - ✓ Financial
  - ✓ Business functions
- **Dis-link between existing plans**
  - ✓ Operating procedures
  - ✓ Preparedness, Response and Recovery plans
  - ✓ Hazard mitigation plans, and etc.
- **Recent disasters have identified need for systemic business improvements**
  - ✓ Great East Japan Disaster, Hurricane Sandy & Katrina

Why Business Continuity for Water Sector?

- Water Systems function as businesses
  - ✓ No matter what size
  - ✓ Even municipal utilities
- A **business process** is a collection of linked tasks which find their end in the delivery of a service or product to a client/customer.



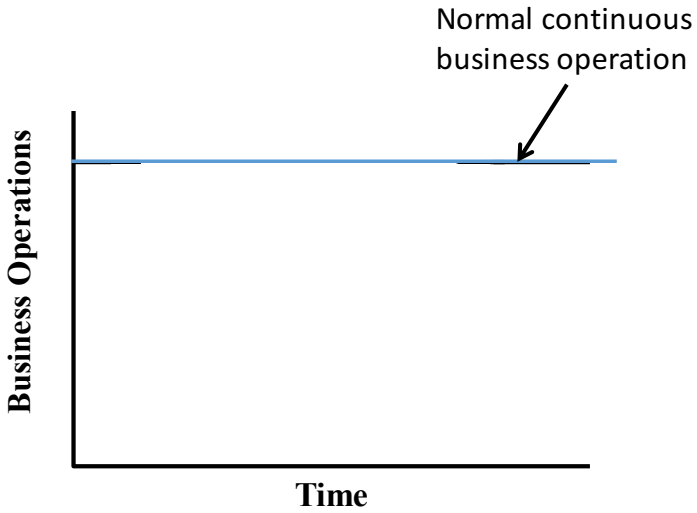
Why Conduct Business Continuity Planning?

- Address gaps in the existing emergency management system (e.g., business functions, administrative facilities, etc.)
- Provide guidance for a business interruption (e.g., power outage)
- Strengthen a utility's ability to continue serving its customers
- Improve resource management and reputation
- Keep employees engaged and employed during event
- Reduce downtime and associated costs
- Improve ability to survive through catastrophic incidents

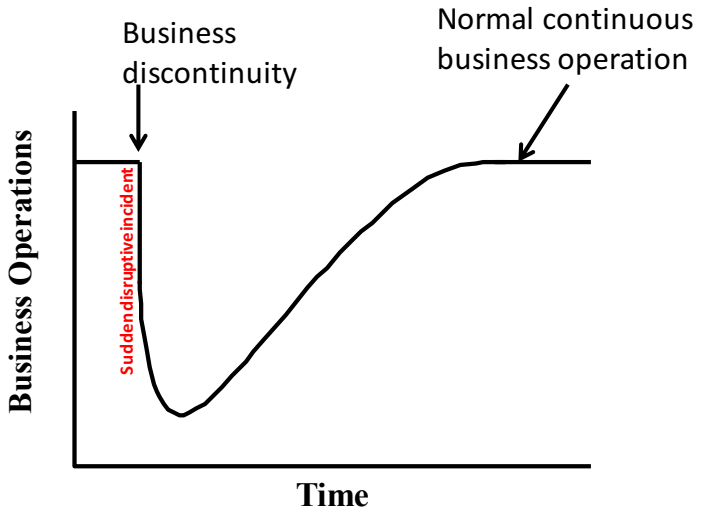
Incidents – natural, man-made

- Fire, flood, hurricane, monsoon, tornado, earthquake, volcanic, landslide, pipe burst(s), etc.
- Plane crashes, vandalism, terrorism, riots, sabotage, loss of personnel, etc.
- Anything that diminishes or destroys normal business processes

Effect of a Significant Incident on Business Operations



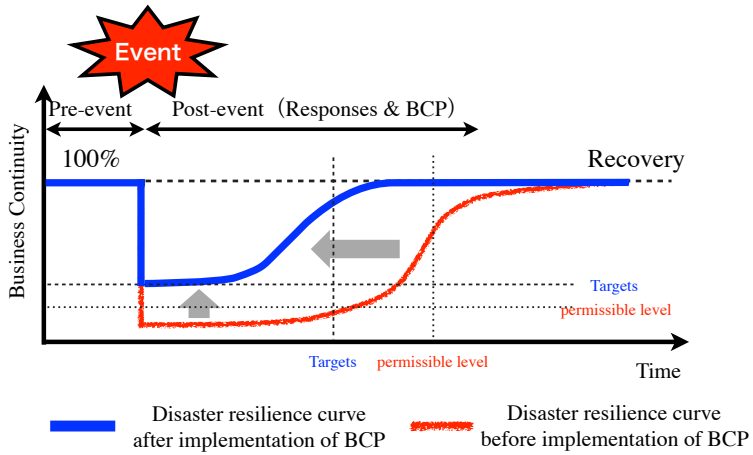
Effect of a Significant Incident on Business Operations



Business Continuity Management

- **Business Continuity Management** (BCM) provides the guidance and control to coordinate the efforts of people and systems to accomplish goals and objectives of mission essential functions using available resources efficiently and effectively.
- In effect, BCM prepares and coordinates all the essential functions of all other water business management activities for employment, or reinstatement, once an incident occurs and a Business Continuity Plan is activated.
- BCM is important to ensure a resilient organization

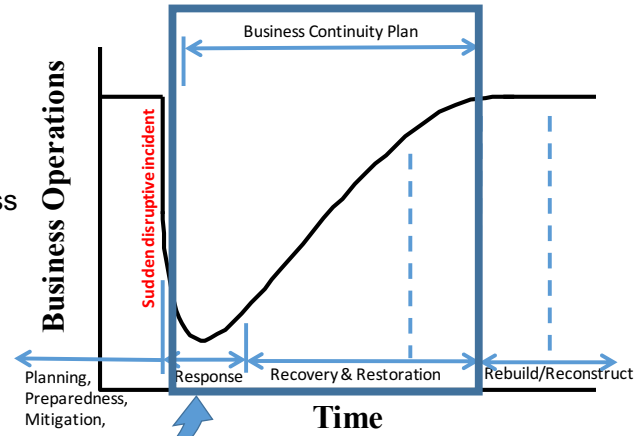
Concept of Business Continuity Planning



Typical Resilience Curve

Plans

- Pre-event
  - Planning process
  - Preparedness
  - Mitigation
- Post-event
  - Response
  - Recovery
  - Restoration
  - Rebuild
  - Reconstruction



Integrating With Other Plans

Water Research Foundation Introduction of BCP

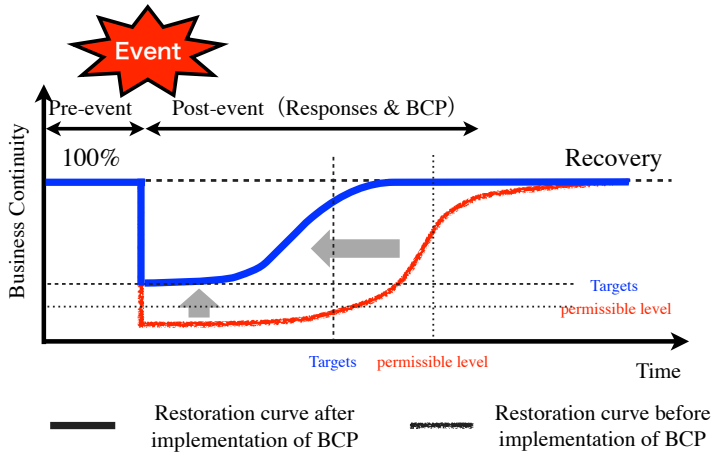
- It is important that business continuity planning be integrated into *a utility's culture* and, as such, consistent with *the utility's mission*.
- The utility's mission includes the provision of a reliable supply of high quality water.
- Does the BCP:
  - Define the scope
  - Establish written policy by the water utility Executives
  - Define the Incident
  - Provide basic assumptions
  - Integrate with other plans

Plan Activation Process

BCM/BCP in Water Sector

- Business Continuity Management is required;
  - Business Continuity Guidelines 3rd (Central Disaster Management Council, Cabinet Office, 2014)
  - New Visions of Water Supply System in Japan (Ministry of Health, Labour and Welfare, 2014)
  - Handbook for emergency response and operation in water sector (Japan Water Works Association, 2008)
  - Business Continuity Planning for Water Utilities (Water Research Foundation, 2014)
  - ISO 22301:2012 Societal security - Business continuity management systems (ISO, 2012)
  - BS25999 Part 1: Code of practice & Part 2: Specification (British Standards Institution, 2006, 2007)

Concept of BCP



Introduction of BCP by WaterRF, US

- It is important that business continuity planning be integrated into ***a utility's culture*** and, as such, consistent with ***the utility's mission***.
- The utility's mission includes the provision of a reliable supply of high quality water.
- Does the BCP:
  - Define the scope
  - Establish written policy by the water utility Executives
  - Define the Incident
  - Provide basic assumptions
  - Integrate with other plans

Water Utility's Missions

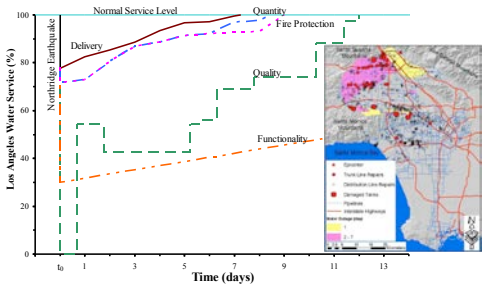
- Confidence with customers and the communities
- Operation to supply safe and portable water steadily
- **Support a civil life and social economic activities**

Performance of Business Continuity in Water Services

- Recently, many researchers and water professionals
  - establishment of BCM/BCP in water sector
- Evaluation method of business continuity in water service
- Evaluation of disaster risk reduction

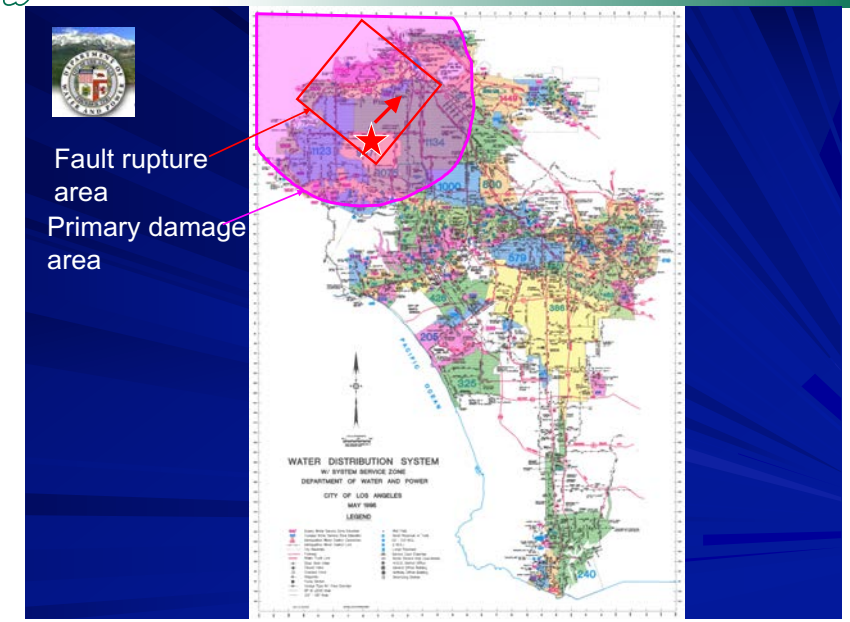
Disaster Resilience Curves in Water Sector

- Water supply ratio
- Available quantity of water
- Opportunity loss
- Water delivery
- Quantity
- Quality
- Fire Protection
- Functionality
- Water accessibility...

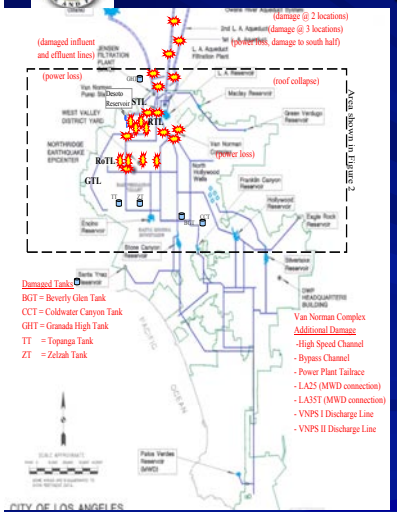


1994 Northridge Earthquake

- January 17, 1994
- Magnitude 6.7 (Mw)
- Thrust Fault (blind/buried)
- Epicenter in Northern Los Angeles
  - ✓ Urban San Fernando Valley
- Millions of people impacted by strong shaking
- 670,000 residents in LA without water
- Another 180,000 people in LA had reduced pressure



LA Water System Damages



- 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
- No outage at pump and chlorine stations

Large Pipe Breaks

Fire and Pipe Break Balboa Boulevard

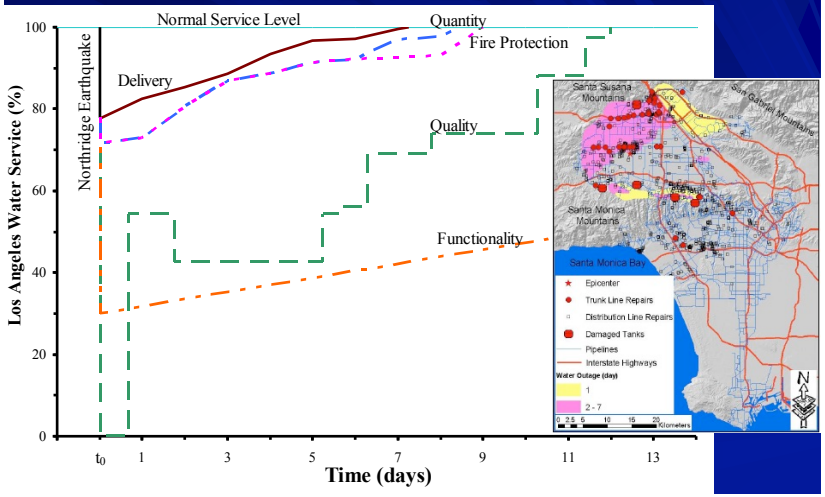
- 5 homes burned here
- 120 mobile homes burned
- 470 fires reported

Water Services

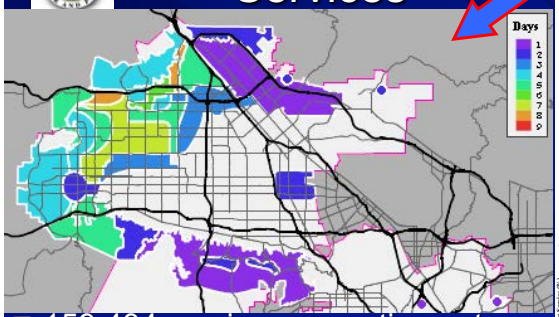
- Service restoration will be presented in the following categories:

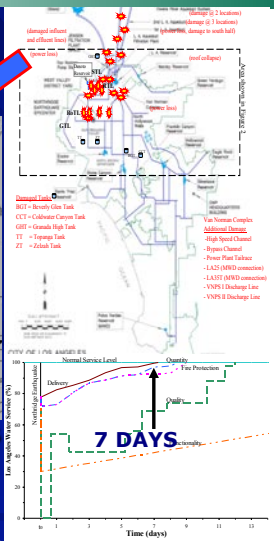
Service Category	Description
Water Delivery	Able to distribute water to customers, but the water delivered may not meet water quality standards (requires water purification notice), pre-disaster volumes (requires water rationing), fire flow requirements (impacting fire fighting capabilities), or pre-disaster functionality (inhibiting system operations).
Quality	Water to customers meets health standards (water purification notices removed). This includes minimum pressure requirements.
Quantity	Water flow to customers meets pre-disaster volumes (water rationing removed).
Fire Protection	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.
Functionality	System restored to meet or exceed pre-disaster functionality and reliability (operational constraints resulting from the disaster have been removed/ resolved) including pressures.

1994 NORTHRIDGE EARTHQUAKE L.A. WATER RESTORATIONS



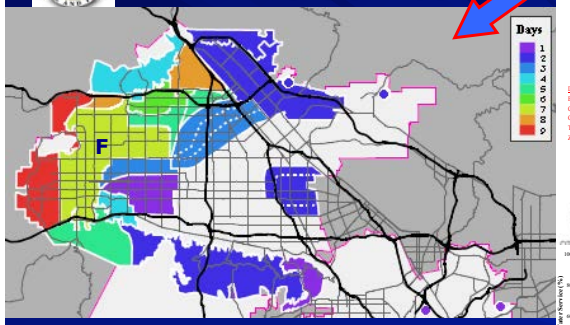
1994 L.A. Delivery Services

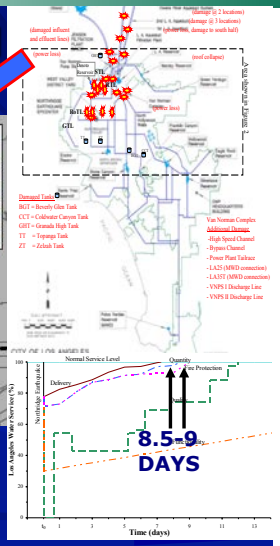




- 159,434 service connection outages
- 22% of all services
- ~670,000 residents
- All delivery service restored in 7 days
- Pipe repairs completed several weeks later

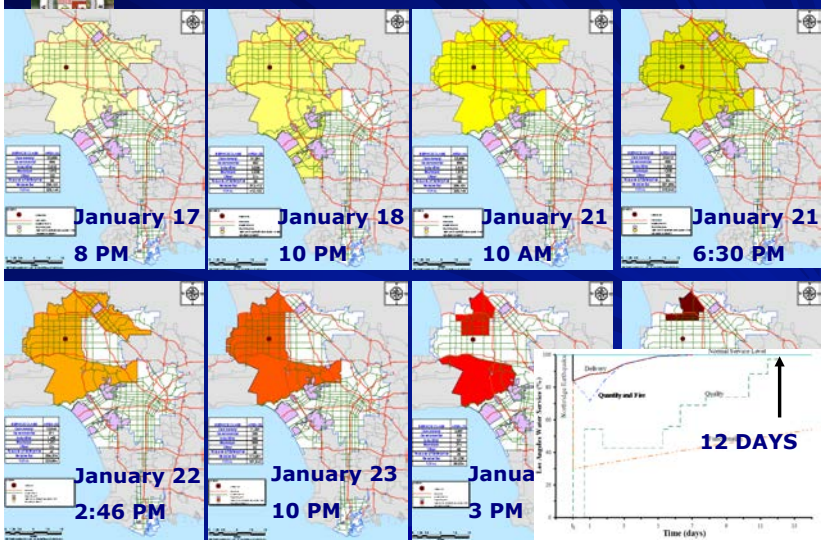
1994 L.A. Quantity and Fire Service





- 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

1994 L.A. QUALITY RESTORATION



1994 L.A. Functional Services

- System functionality dropped to about 30% immediately after the earthquake
- Great redundancy and isolation capabilities in system allowed other services to be restored well in advance of total functionality
  - e.g. 8 of 60 transmission repairs completed to restore delivery
- Full functionality restored over 1-year later
- Functionality increased over next 2 decades by making improvements to vulnerabilities exposed by earthquake

Customer Impacts
Service outage

- No water service
- Reduced fire protection capability
- Flooded streets restricted access
- Commerce and economics impacted for most industrial and restaurant businesses
- More bottled water used
- LADWP supplied emergency water in sanitized tanker trucks (15 locations)
- Beverage companies supplied bottled water

Tanks Delivering Water to Customers

Water Purification Advisory

- Issued throughout system on Jan. 17
- Concern: Potential for contamination from pipe breaks
- Lifted advisory in areas after water testing
- Longest in epicenter area
- Water purification advisory lasted up to 12 days
  - ✓ longer than service outage

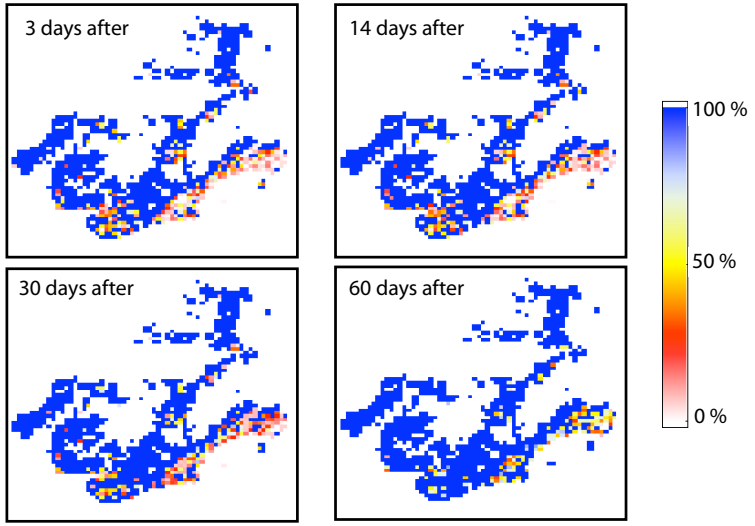
Customer Impacts Water Purification Advisory

- Boil or disinfect before using
- Customer concern with water quality
- More bottled water used
- Restaurants
  - ✓ Impacted serving and cooking food
  - ✓ Impacted cleaning
- Los Angeles Airport
  - ✓ Commercial airlines threatened to be grounded
- Flush pipes and water heaters in buildings following advisory removal

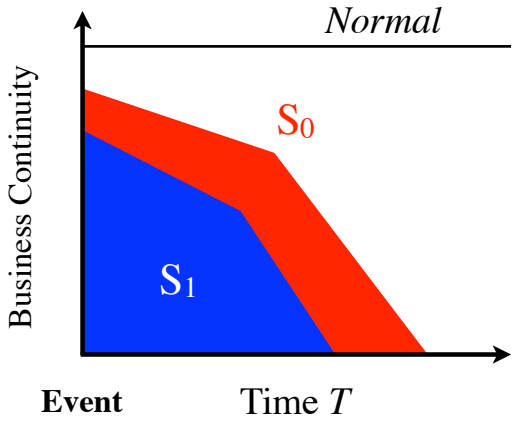
Conclusions: water

- 1994 Northridge Earthquake affected:
  - ✓ Entire city with boil water advisory
  - ✓ 159,434 service connections without water
  - ✓ 670,000 people + businesses
- All customers had pre-earthquake services restored in 12 days
- Took many more months to return system back to pre-earthquake functionality

Water System Service Categories Map (Quantity)



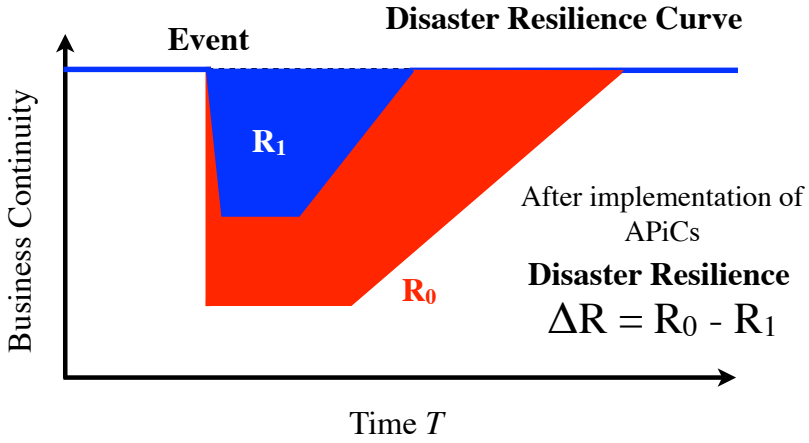
Concept of Performance Evaluation



Risk Reduction

$\Delta S = S_0 - S_1$

Evaluation of Disaster Risk Reduction Performance

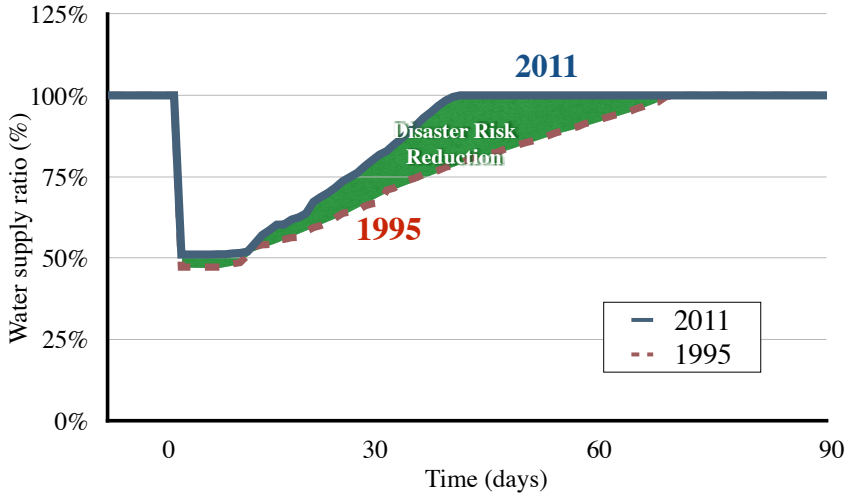


After implementation of APiCs

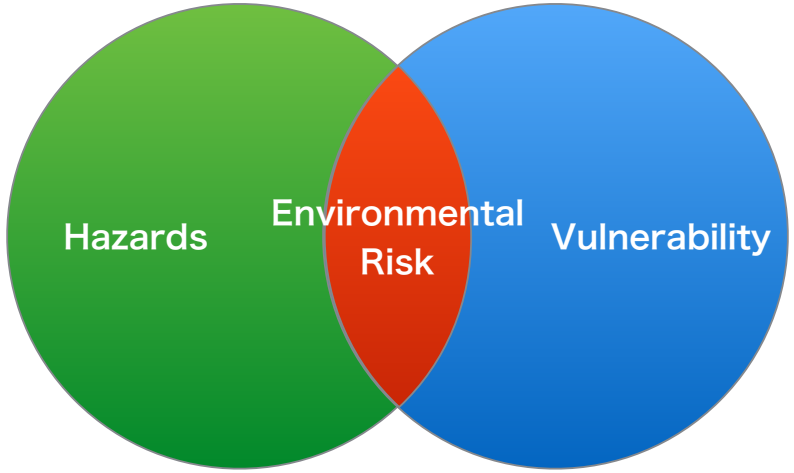
Disaster Resilience

$\Delta R = R_0 - R_1$

Comparison Results in Business Continuity; Water Supply Ratio in Kobe Case



Disaster and Environment



Disaster and Society

- $D = f(H, E, V, A, T)$
  - **D**isaster
  - **H**azard
  - **E**ffect
  - **V**ulnerability
  - **A**ctivity
  - **T**iming

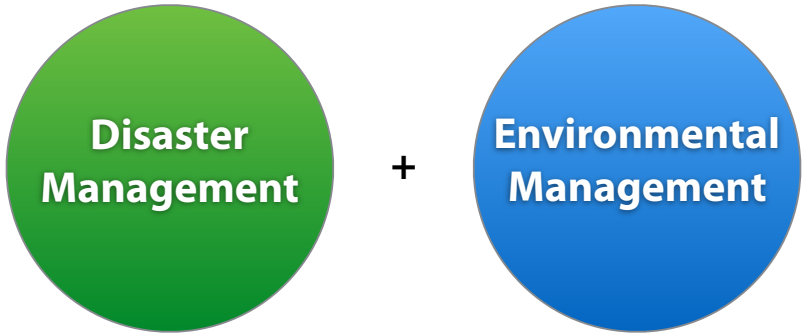
H.Hayashi, 2014

Disaster and Environment

- $D = f(H, E, V_E, A, T)$
  - **D**isaster
  - **H**azard
  - **E**ffect
  - **V**ulnerability in **E**nvironment
  - **A**ctivity
  - **T**iming

N. Hirayama, 2015

Disaster Management and Environment Management



Safety and Security of Society = Sustainable Society

Resilient Society, Community