Environmental Health after Critical Infrastructure Failure

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Utah’s Infrastructure Resilience Program

- Earthquake
- Landslide
- Flooding
- Man-Made
- Contamination
- Power Outage
Man-Made Events

- Cyber Attack
- Physical Damage
- Contamination
Contamination

**Chlorine**

- Stored on site
- Potential for great public health and economic effects

**Backflow Contamination**

- Events go largely unreported
- Can occur through multiple access points
EPA 2002

Created a service connection, pumped back through a fire hydrant

Pumped in a non-toxic, food grade solution of potassium chloride for more than 8 hours

Measured resulting levels to detect its flow rate

Residents NEVER questioned the workers

Successfully demonstrated that contaminants could easily be introduced into a system through either direct connection or backflow from a service connection.

In unmarked vehicles

Less than $200
Natural Disaster Events

1994 Northridge Earthquake, California
6.7 Magnitude
Balboa Boulevard
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Natural Disaster Events
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Natural Disaster Events

Haiti Earthquake 2010
Natural Disaster Events

Health and the Environment after Hurricane Katrina
Annals of Internal Medicine
Current Clinical Issues 2006 American College of Physicians
Volume 144 : Number 2
Jennifer Fisher Wilson

“..as the initial crisis has faded, health officials have recognized the potential for continued and lasting health effects from Hurricane Katrina, particularly in the New Orleans area.”

“Threats lie in the mountainous debris; faulty sewage treatment; toxic chemical and oil spills; contaminated water; swirling dust; pesky insects and vermin; and mold, mold, and more mold. The potential severity of these threats remains mostly a mystery that public health officials are trying to resolve.”

“It’s important to get our hands around the science and move rapidly to recovery.”
George Benjamin, MD
Executive Director of the American Public Health Association
February 22, 2011 “Aftershock”
Magnitude 6.3
182 fatalities
$12 billion (U.S.) in damages
Residential areas again hard hit by shaking and liquefaction.

Natural Disaster Events
Christchurch, New Zealand Earthquake
A review and discussion of the physical impact of the 22 Feb earthquake on the water and wastewater networks can be found in: Eidinger and Tang (2011) and Cubrinovski et al. (2011). The TCLEE report (Eidinger and Tang, 2011) also includes impacts of the 4th September 2010 and 13 June 2011 earthquakes.
“Due to the extensive damage to the sewage disposal networks, there was the risk that much of the liquefaction ejecta had been contaminated with raw sewage creating a long-term health risk to the population. During hot and windy conditions the dry, finer portions of silt was mobilised by the wind creating a respiratory health hazard.”

“With thousands of residential properties inundated with liquefaction ejecta, residents were eager to remove it from their properties to restore household functionality, remove the depressing grey deposits and retain a sense of control and normality. Wet or moist silt was also much easier to handle compared to when it had dried, as it became denser, hardened and was more difficult to remove. However, with hundreds of thousands of tonnes of sediment to clear, many residents lacked the capacity (time or resources) to clean up their properties without external assistance.”

Piles of liquefaction ejecta cleaned from residential properties and roads, ready for removal by heavy earth moving machinery at Bracken Street in the suburb of Avonside. (Photo credit: Jarg Pettinga).
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Natural Disaster Events

“36,000 water and wastewater service requests were received and addressed by Christchurch City Council in 5 months following the earthquake.”

“Christchurch City Council set a target of returning sewer services to all homes by the end of August and contractors have been working 24 hours a day, seven days a week since early March to achieve this goal. Work has been completed on all public sewer pipes, however as at 31 August there are still around 800 houses with damage to their private sewer pipes which needs to be addressed before full service is returned.”

“Raw sewage continues to be disposed in the rivers and estuaries due to the inability to treat the waste as a result of significant liquefaction induced damage at the Bromley Waste Water Treatment Plant. The treatment plant has been unable to perform any more then partial primary treatment since the February 22 earthquake. Some sewage is bypassed directly to the lagoons and other pumped directly into rivers. Concerns abound about the lagoons going anaerobic and emitting a stench across the city. The treatment plant was also repeatedly damaged by sand and silt, which flowed into broken sewage pipes when the ground liquefied, continually washed into the basins. The plant was not designed for such heavy solids. Water and wastewater services continue to be impacted by significant aftershocks that liquefy the soils, including significant damages caused by the June 13 aftershock. It will take years to return the water and wastewater systems to pre-earthquake functions.”
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Natural Disaster Events
“The damaged water supply network created a pathway by which pathogens in the wastewater could reach the city’s residents.”
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Natural Disaster Events
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Natural Disaster Events

Table 1: Summary results 2010-2011 for E.coli testing for Christchurch

<table>
<thead>
<tr>
<th>Supply</th>
<th>Pop</th>
<th>Zone / Plant Code</th>
<th>No. samples</th>
<th>E.coli (+ve)</th>
<th>% (+ve)</th>
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<tbody>
<tr>
<td>Brooklands-Kainga</td>
<td>2300</td>
<td>BKO012BR</td>
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<td>Central Christchurch</td>
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<td>CHR001CE</td>
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<td>Northwest Christchurch</td>
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<tr>
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<td>West Christchurch</td>
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Utah HAZUS

Planning Scenario

- 7.0 M earthquake on Salt Lake Segment of Wasatch Fault in December
- Affects 80% of the population of Utah
- 2,978 Fatalities (▲476)
- Injured:
  - 9,168 require hospitalization (▼248)
  - 29,298 with minor injuries (▲1,774)
- Displaced Population:
  - 88,090 households displaced (▲1,758)
  - 54,514 people seek temporary shelter in public shelters (▲653)
- 55,742 buildings significantly damaged (▼500)
- 331 bridges impassable and/or significantly damaged (▲191)
- 443K households without potable water on day 1 (▲64K); 339K on day 90 (▲52K)
- 251K households without power on day 1 (▼131K); 22K on day 30 (▼8K)
- 29 million tons of debris generated (▲8M); 1.2 million truckloads @ 25 tons/truck (▲369K)

Total economic impact: >$79 billion direct loss (▲$49B)

(increase ▲ or decrease ▼ from 2012 Hazus)
Utah HAZUS

There are 8 WTPs in Salt Lake and Davis counties. System damage will leave 483,638 households out of 751,267 without potable water service. Current water treatment capacity is 625 million gallons of water (MGW) per day.

Assumptions

System Overview (Salt Lake and Davis Counties):
- Three primary potable water providers in Salt Lake and Davis Counties:
  - Metropolitan Water District of Salt Lake City and Sandy
  - Salt Lake City Department of Public Utilities
  - Jordan Valley Water Conservancy District
- Sources of water comes from the Jordan River, Deer Creek Reservoir, Provo River and other Surface Water and are transported via the Salt Lake Aqueduct and the Jordan Valley Aqueduct as well as the backup Point of Mountain Aqueduct.
- System damage will result in the loss of 23% of treatment capacity (145 MGW per day of 625 MGW per day).
- Only one WTP will be extensively damage (Big Cottonwood WTP) which treats 45 MGW per day.
- Surviving infrastructure has the capacity to fulfill treatment demands once damaged facilities are operational as long as the distribution system remains functional.

Transmission and Distribution Systems (12-county region):
- The 12-county region has 56,751 km of water distribution pipelines.
- There will be 7,077 pipeline breaks and 11,328 leaks.
- SCADA System will be disrupted due to loss of electrical power and will contribute to service outages.

Service Outages (12-county region):
- 0-72 Hours: There will be no water service inside the outage zone while the remaining counties will experience a 10% disruption in service.
- 72 Hours (+): 75% of the outage zone will not have water service while the remaining counties will have potable water service.

Bottom Line
- Potable water is unavailable in Salt Lake, Davis, Weber and Utah Counties for weeks or months.
Impact

- Hospitals Shutdown
- Loss of Firefighting Capabilities
- Disease Outbreak
- Psychological Impacts
- Schools, Commercial & Industrial Shutdowns
Immediate dangers without WATER

- Vermin
- Insects
- Cleanliness
- Sustainability
- Disposal
- Vermin
- Insects
- Sustainability
- Groundwater contamination
- Property Damage
- Other Homes
Immediate dangers without WATER
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Training

✓ Develop a work culture centered on preparedness and response.

✓ Incentivize employees to return to work.
Training

✓ Offer employee training to recognize and report suspicious activity.

✓ Investigate unusual system behaviors.

✓ Suspend all access after terminations.

✓ Participate in Local, State & Federal trainings offered.
Great Planning


- Conduct Assessments in collaboration with Local, State Federal DHS Partners.

- Develop Memorandums of Agreement (MOA) with redundant suppliers as well as pre-scripted Mission Specific Assignments (MSAs) for skilled labor support

- Secure Cyber and SCADA networks.

- Ensure that physical restoration plans are stored in secure locations.

- Secure Radio and Wireless transmissions
Collaboration

 ✓ Establish working relationships with local Emergency Managers and involve them in your training & exercises.

 ✓ Share Hazmat info with Fire Officials and Emergency Managers.

 ✓ Discuss interdependencies with other Critical Infrastructure Operators.

 ✓ Understand Re-Entry Protocols and required documentation
Environmental Health after Critical Infrastructure Failure

A Call to Action

- Increase Response Training
- Encourage Agency Collaboration
- Increase Public Outreach

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