



# Remedy Resiliency

to extreme  
weather events

**Roy I. Thun** | GHD

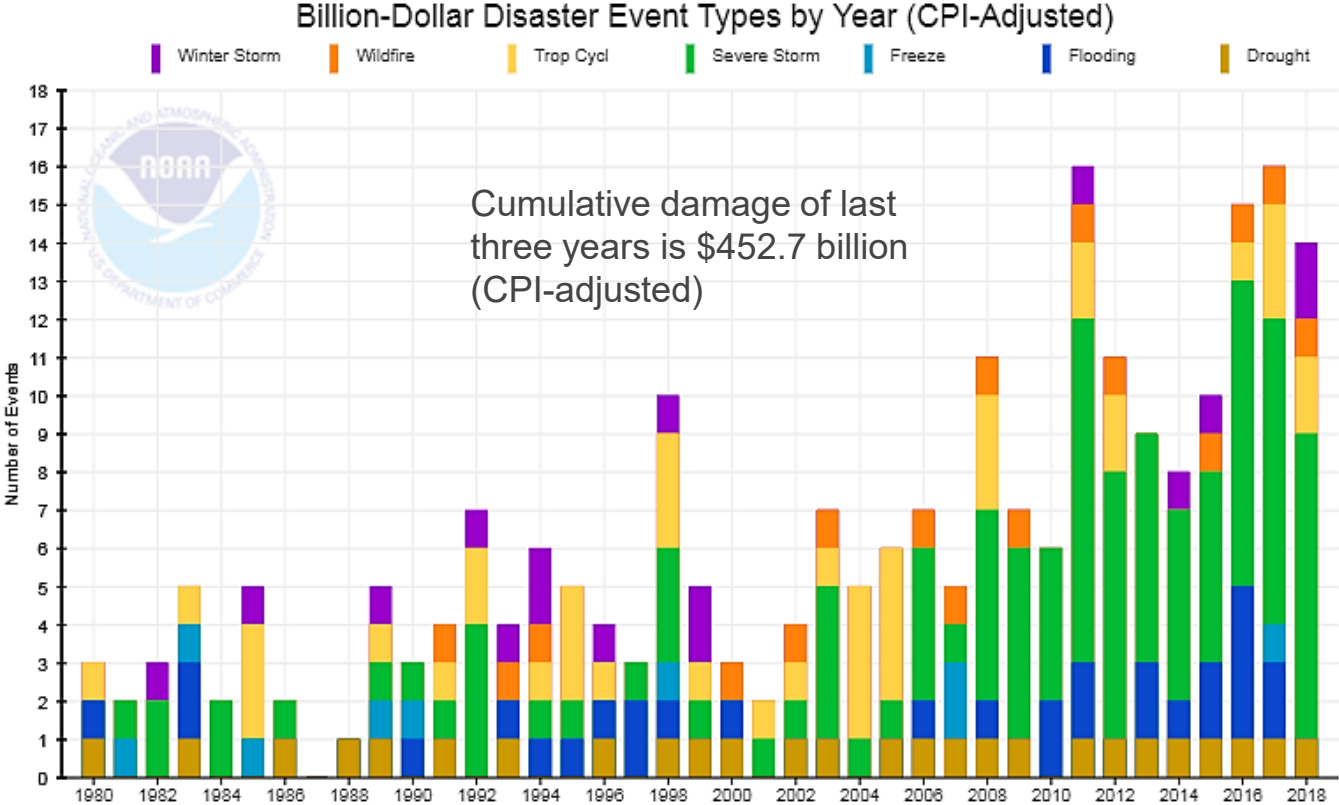
Senior Environmental Specialist

T: +1 661 287 3855

E: [roy.thun@ghd.com](mailto:roy.thun@ghd.com)



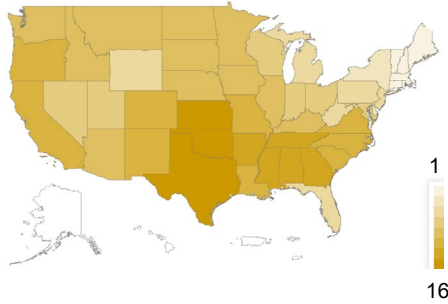
# Billion-Dollar Disaster Event Types: 1980 – 2018



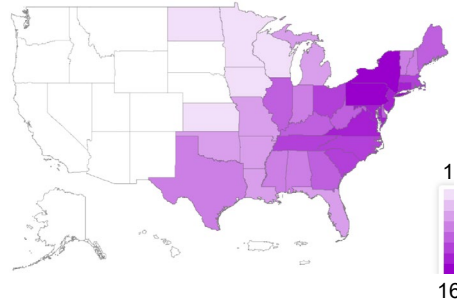
Retrieved from: <https://www.nodc.noaa.gov/billions/>

# U.S. Billion-Dollar Weather and Climate Disasters 1980 – 2018

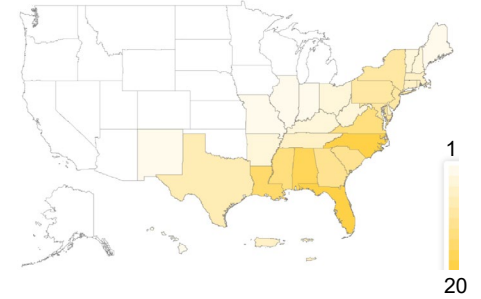
## Droughts



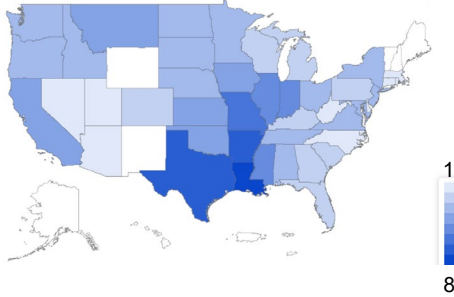
## Winter Storms



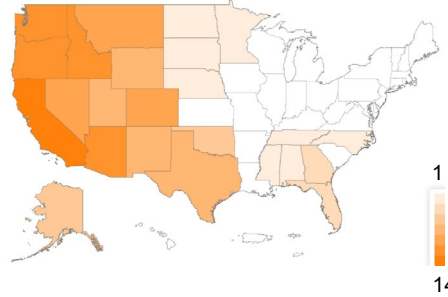
## Tropical Cyclones



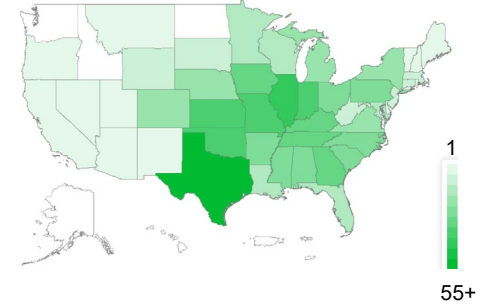
## Flooding



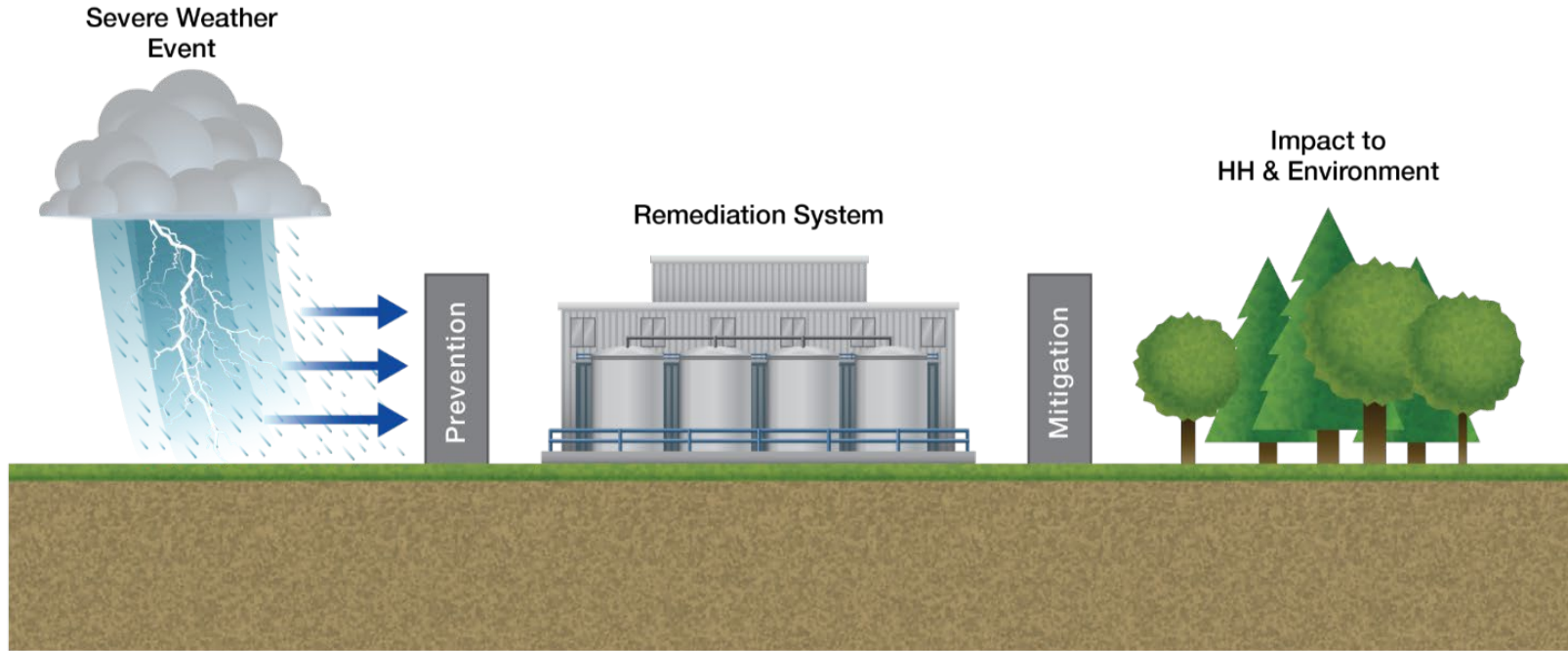
## Wildfires



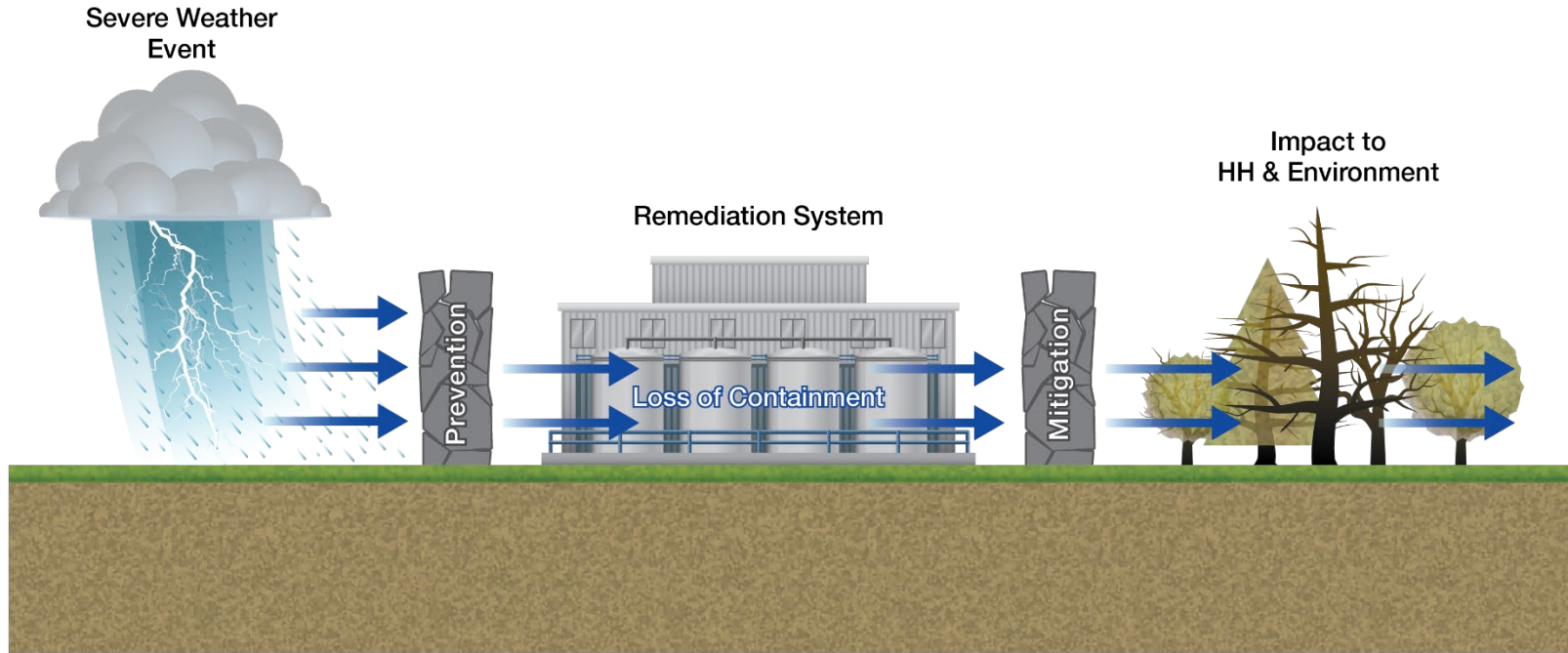
## Severe Storms



# Why do we care about REMEDY RESILIENCY?



# Why do we care about REMEDY RESILIENCY?



# Resiliency Danger Signs

## Murphy Oil, New Orleans, LA

**Threat:** Hurricane Katrina 2005 → **Event:** Storage Tank Failure →

**Consequence:** Million gallons of oil released

## Iron Mountain Mine Superfund Site, Redding, CA

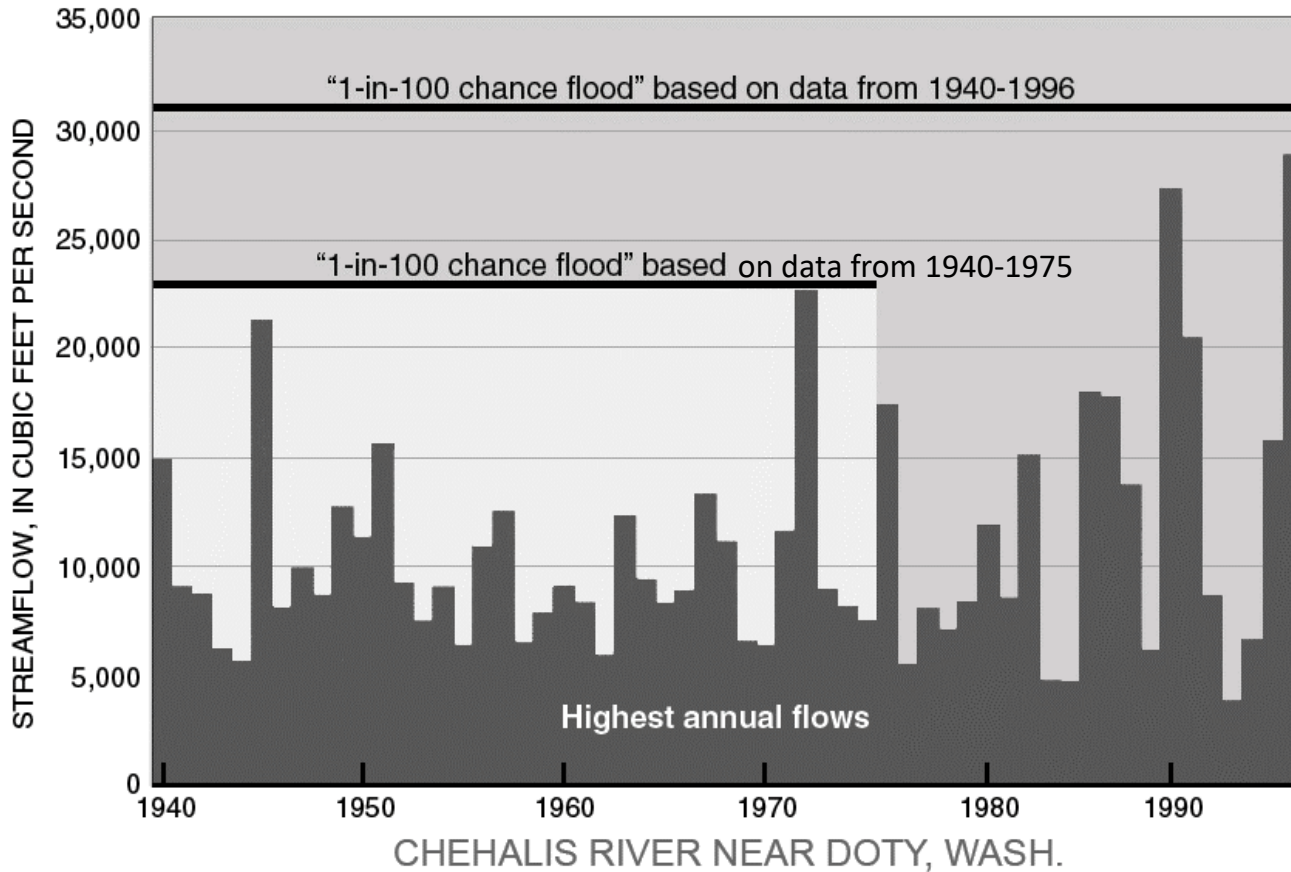
**Threat:** Carr Fire 2018 → **Event:** Loss of power → **Consequence:** Acid mine drainage treatment plant shut down (no off-site release)

## Duke Energy, Wilmington, NC

**Threat:** Tropical Storm Florence 2018 → **Event:** Coal ash landfill slope failure → **Consequence:** 2000 cyd of coal ash displaced

# The 100-year event failsafe?

- An extreme event (e.g.- storm, flood) that statistically has a 1-percent chance of occurring in any given year.
- Typically calculated using national or regional data.
- Some design models provide default or custom inputs.
- Cumulative impacts from increased frequency of severe events are typically not considered.



Retrieved from: <https://pubs.usgs.gov/fs/FS-229-96/>



# Infrastructure analogue

“...infrastructure planning and engineering models are generally designed to withstand the range of extremes in the 100-year historical record, but that using the past 100-year record will no longer provide an adequate basis for planning and design.”

-2016 NAS Characterizing Risk in Climate Change workshop quote.





# NCP long-term effectiveness and permanence

40CFR300.430(e)(9)(iii)(C) Alternatives shall be assessed for the **long-term effectiveness** and **permanence** they afford, along with the degree of certainty that the alternative will prove successful.

# Remedy Vulnerability to Climate Change

| Common Remedy Types*           | Climate Change Scenarios |                      |                |                |            |         |              |                    |
|--------------------------------|--------------------------|----------------------|----------------|----------------|------------|---------|--------------|--------------------|
|                                | Flooding (Event)         | Inundation (Chronic) | Extreme Storms | Large Snowfall | Wild Fires | Drought | Extreme Heat | Landslide (Precip) |
| <b>Source In Situ</b>          |                          |                      |                |                |            |         |              |                    |
| SVE                            | Major                    | Major                | Major          | Minor          | Minor      | Major   | Minor        | Major              |
| Solidification/Stabilization*  | Major                    | Major                | Minor          | Minor          | Minor      | Minor   | Minor        | Major              |
| In Situ Thermal Treatment      | Major                    | Major                | Minor          | Minor          | Major      | Minor   | Minor        | Major              |
| Multi-phase Extraction         | Major                    | Major                | Major          | Minor          | Minor      | Major   | Minor        | Major              |
| Bioremediation                 | Major                    | Major                | Minor          | Minor          | Minor      | Minor   | Minor        | Major              |
| <b>Source Ex Situ</b>          |                          |                      |                |                |            |         |              |                    |
| Solidification/Stabilization*  | Major                    | Major                | Minor          | Minor          | Minor      | Minor   | Minor        | Major              |
| Physical Separation            | Minor                    | Minor                | Minor          | Minor          | Minor      | Minor   | Minor        | Minor              |
| Recycling                      | Minor                    | Minor                | Minor          | Minor          | Minor      | Minor   | Minor        | Minor              |
| Surface Water Treatment        | Major                    | Major                | Minor          | Minor          | Major      | Minor   | Minor        | Major              |
| Unspecified Off Site Treatment | Minor                    | Minor                | Minor          | Minor          | Minor      | Minor   | Minor        | Minor              |
| On-site Containment            | Major                    | Major                | Major          | Minor          | Major      | Minor   | Minor        | Major              |
| <b>Groundwater In Situ</b>     |                          |                      |                |                |            |         |              |                    |
| Bioremediation                 | Minor                    | Major                | Minor          | Minor          | Minor      | Minor   | Minor        | Major              |
| Chemical Treatment             | Minor                    | Major                | Minor          | Minor          | Minor      | Minor   | Minor        | Major              |
| Air Sparging                   | Major                    | Major                | Major          | Minor          | Minor      | Major   | Minor        | Major              |
| Permeable Reactive Barrier     | Minor                    | Major                | Minor          | Minor          | Minor      | Minor   | Minor        | Major              |
| <b>Groundwater Ex Situ</b>     |                          |                      |                |                |            |         |              |                    |
| P&T                            | Major                    | Major                | Major          | Minor          | Major      | Minor   | Minor        | Major              |
| Vertical Engineered Barrier    | Minor                    | Major                | Minor          | Minor          | Minor      | Minor   | Minor        | Major              |
| Monitored Natural Attenuation  | Minor                    | Major                | Minor          | Minor          | Minor      | Minor   | Minor        | Major              |

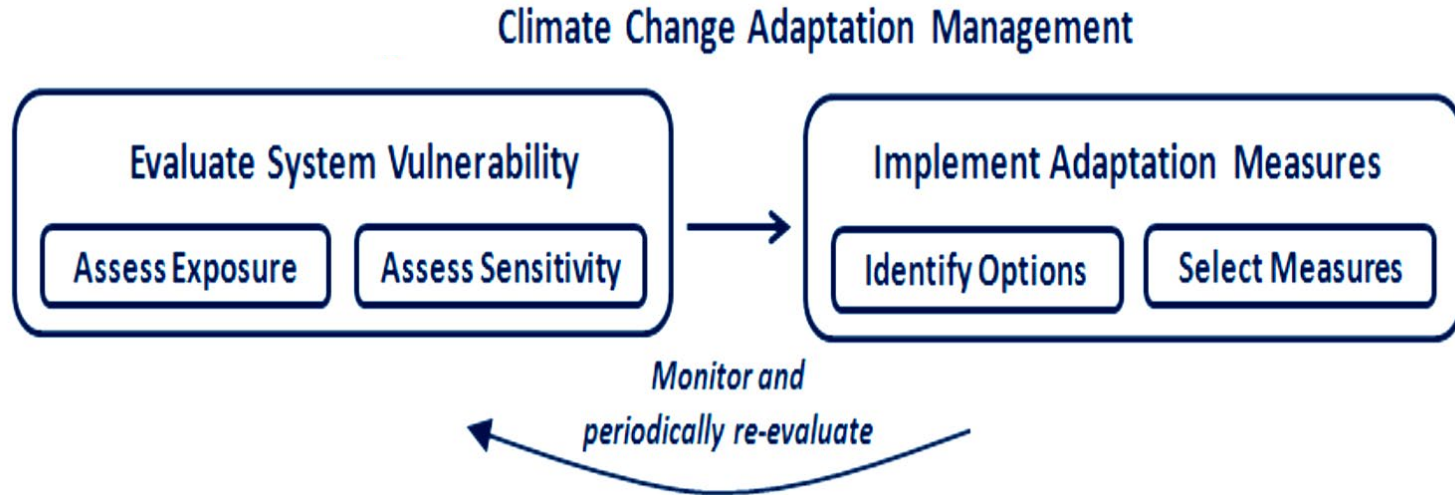
## Qualitative Vulnerability Analysis

-  No known potential impacts
-  Minor impacts: Potential for temporary loss of remedy functionality or effectiveness, contaminant(s) remain contained
-  Moderate impacts: Potential for total loss of remedy functionality and effectiveness indefinitely, contaminant(s) remain contained
-  Major impacts: Potential for total loss of remedy functionality and effectiveness indefinitely, contaminant(s) release

\* Most common remedy types based on Superfund Remedy Report

Retrieved from: [https://clu-in.org/conf/tio/climatechange\\_040115/slides/CCA-Pachon-Opening%20Final.pdf](https://clu-in.org/conf/tio/climatechange_040115/slides/CCA-Pachon-Opening%20Final.pdf)

# USEPA Adaptation Approach



# CERCLA 5-year Review

## Assessing The Protectiveness Of The Remedy

### QUESTION C: Has any other information come to light that could call into question the protectiveness of the remedy?

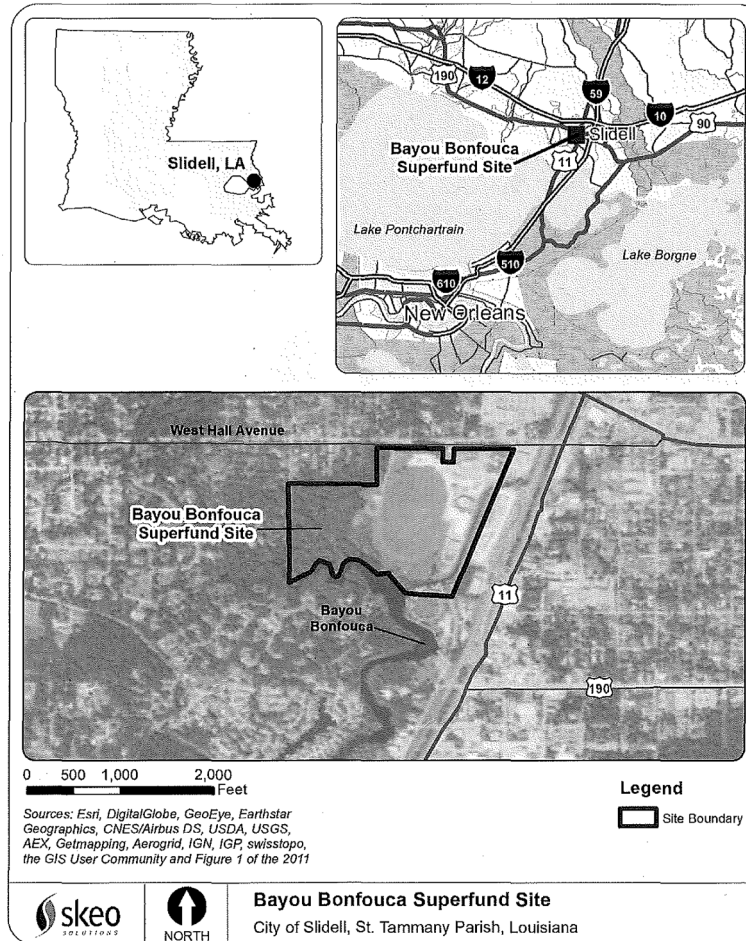
- The site is/was subject to natural disasters, such as a 100-year flood. (USEPA 2001)
- This question may address site changes or vulnerabilities that may be related to climate change impacts not apparent during remedy selection, remedy implementation or O&M (e.g., sea level rise, changes in precipitation, increasing risk of floods, changes in temperature, increasing intensity of hurricanes and increasing wildfires, melting permafrost in northern regions, etc.). (USEPA 2016)

# Bayou Bonfouca Superfund Site

## Third Five-Year Review

### June 2006

The 54-acre site was impacted by Hurricane Katrina resulting in loss of power and containment systems for three weeks.



Retrieved from: <https://semspub.epa.gov/work/06/205145.pdf>

# Bayou Bonfouca Site

## Third Five-Year Review, June 2006

### **Question A: Is the Remedy Functioning as Intended by the Decision Documents?**

“There were no observed indicators of potential problems that would impact the protectiveness of the remedy.”

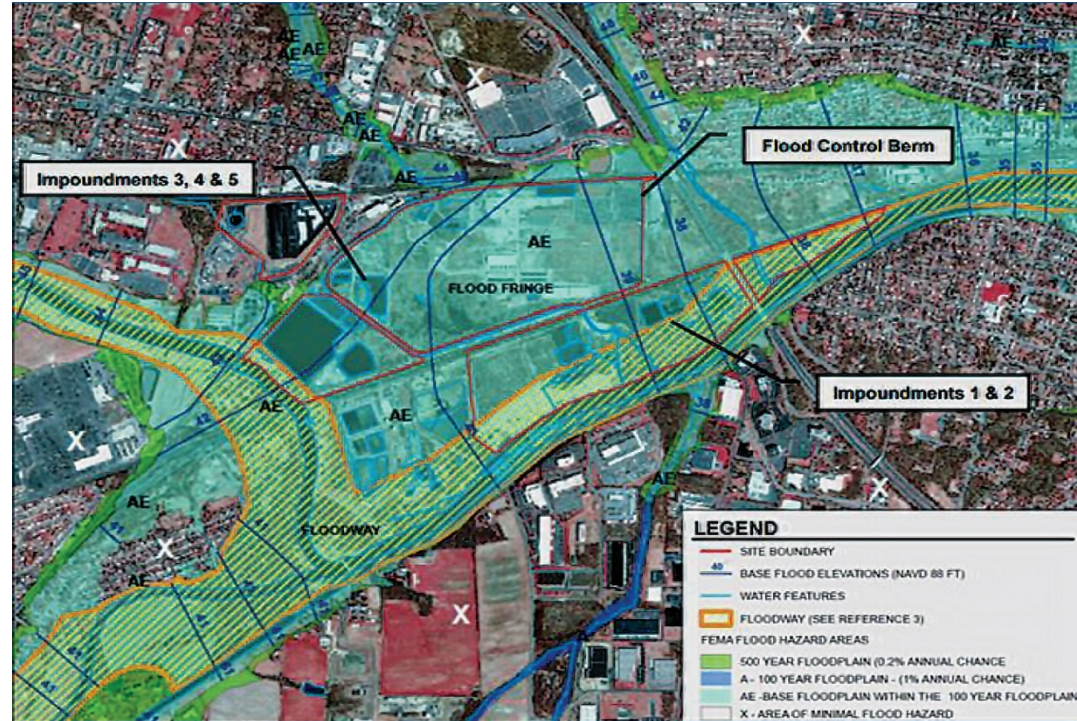
### **Question C: Has any other information come to light that could call into question the protectiveness of the remedy?**

“no such information has come to light as part of this third five-year review for the site.”

# American Cyanamid Superfund Site Fourth Five-Year Review, June 2014

This 435-acre site located along the Raritan River experienced significant flooding in 2011 due to Hurricane Irene

EPA required that all future engineered caps be designed to a 1-in-500 year flood event, at a minimum.





# American Cyanamid Superfund Site Fourth Five-Year Review, June 2014

**Question C: Has any other information come to light that could call into question the protectiveness of the remedy?**

“No other information has come to light that could call into question the protectiveness of the remedy.”

# EPA Review of 2017 Hurricane Season

## What is the overall finding?

- Over 250 sites were impacted by tropical forces winds or greater, and/or inundation
- Only 16 sites across three regions reported minor damage, none at this point indicate impairment to remedy protectiveness
- **The state of the remedies is “Resilient”**

# Summary

- The severity and frequency of extreme weather events is increasing as are the associated costs.
- Be aware of design model weather inputs and the decision basis for the 100-year event.
- The current 5-year review process could do a better job of recording the nature and extent of impacts from extreme weather events.
- More work is needed to understand remedy vulnerabilities to changes in the frequency and severity of extreme weather.

# Thank you



## Contact

If you would like more information regarding this presentation, or are interested in evaluating remedy resiliency at a site, please contact me at:

**Roy I. Thun** | GHD

Senior Environmental Specialist

T: +1 661 287 3855

E: [roy.thun@ghd.com](mailto:roy.thun@ghd.com)

[www.ghd.com](http://www.ghd.com)

