



U.S. Chemical Safety and Hazard Investigation Board



## Driving Chemical Safety Change: The First 20 Years

Kristen M. Kulinowski, Ph.D.  
Board Member & Interim Executive

Texas Tech University  
October 3, 2018



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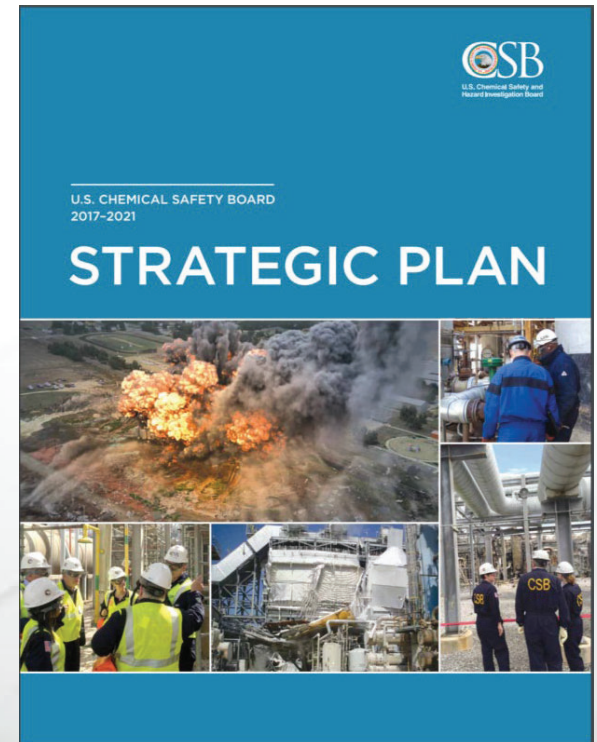
# Vision:

A nation safe from chemical disasters.

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# Mission:

Drive chemical safety change through independent investigations to protect people and the environment.





# Types of Incidents That We Investigate



Arkema Inc. Fire  
Crosby, TX  
August 29, 2017



Freedom Industries  
Charleston, WV  
January 9, 2014



Deepwater Horizon  
Gulf of Mexico  
April 20, 2010

Provided to the New York Times

Jurisdiction: Release of hazardous substance into the ambient air from a fixed facility



***Learning from the past***

***Anticipating the future***



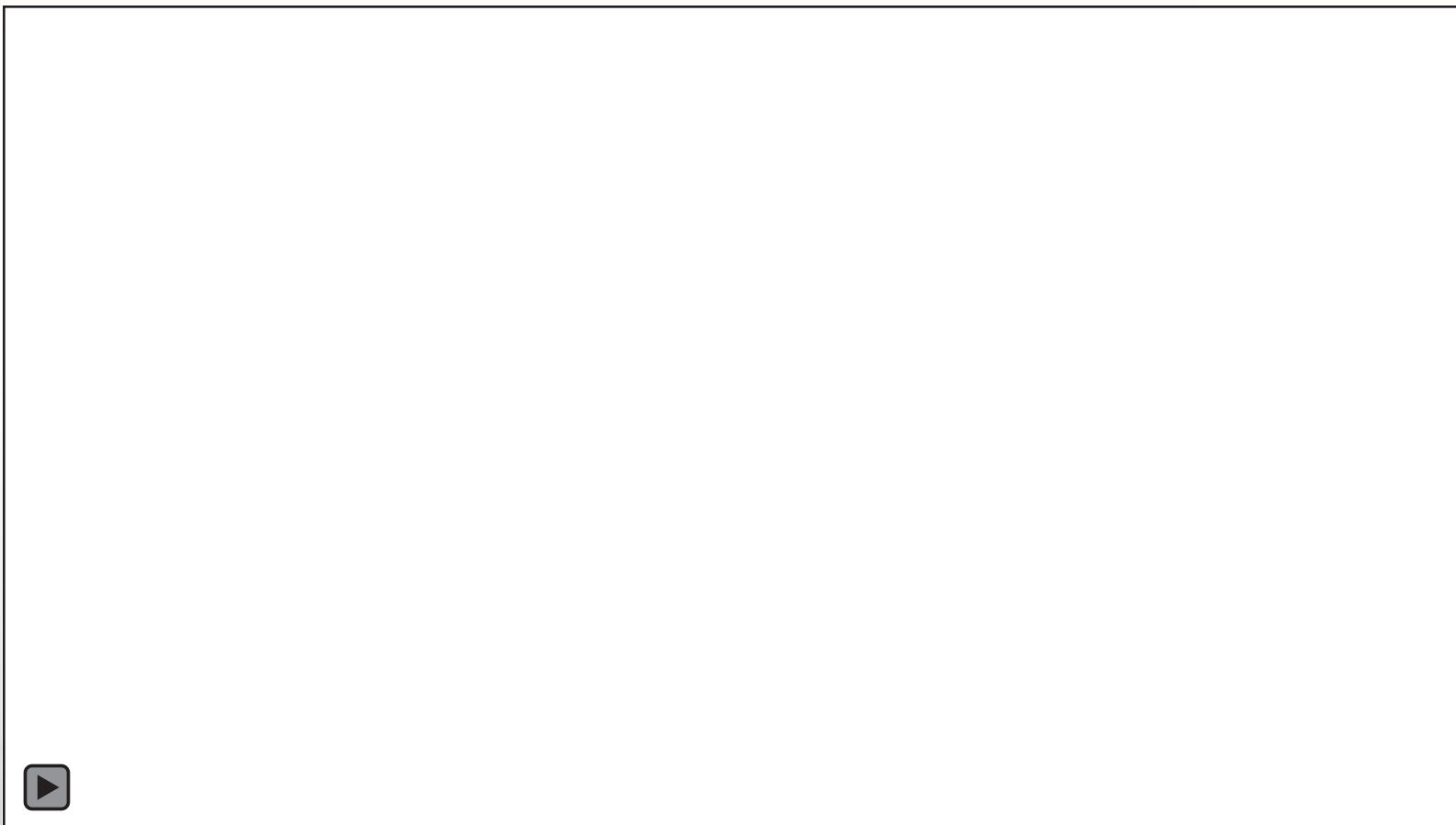


# *Learning from the past*





## West Fertilizer Company Fire and Explosion (2013)





# Texas City Explosion (1947)



Second ship blown ashore



Dock with debris



Destroyed Monsanto plant



# Historical Ammonium Nitrate Explosions

- 32 incidents dating back to 1916
- Most explosions resulted from a massive fire
- Occurred within 20 min. to 1 hour from the initial report of the fire
- Slight variations in storage conditions can impact AN detonability during fires

July 30, 2009

El Dorado Chemical Company,  
Bryan, TX



The Eagle/Stuart Villanueva





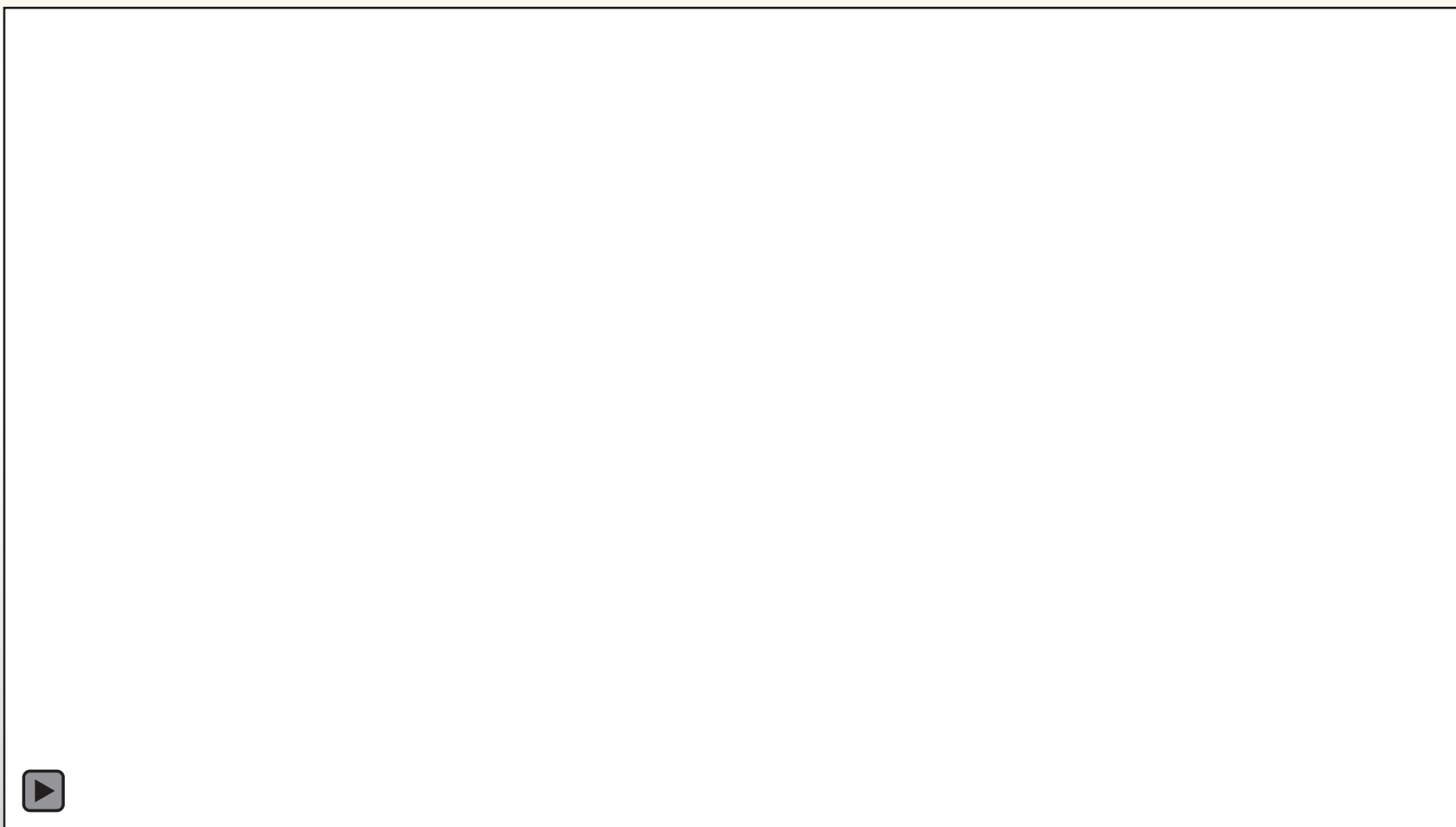
# Contributing Causes of West Incident



Storage of other combustible materials near fertilizer



Facility and storage bins constructed of combustible materials



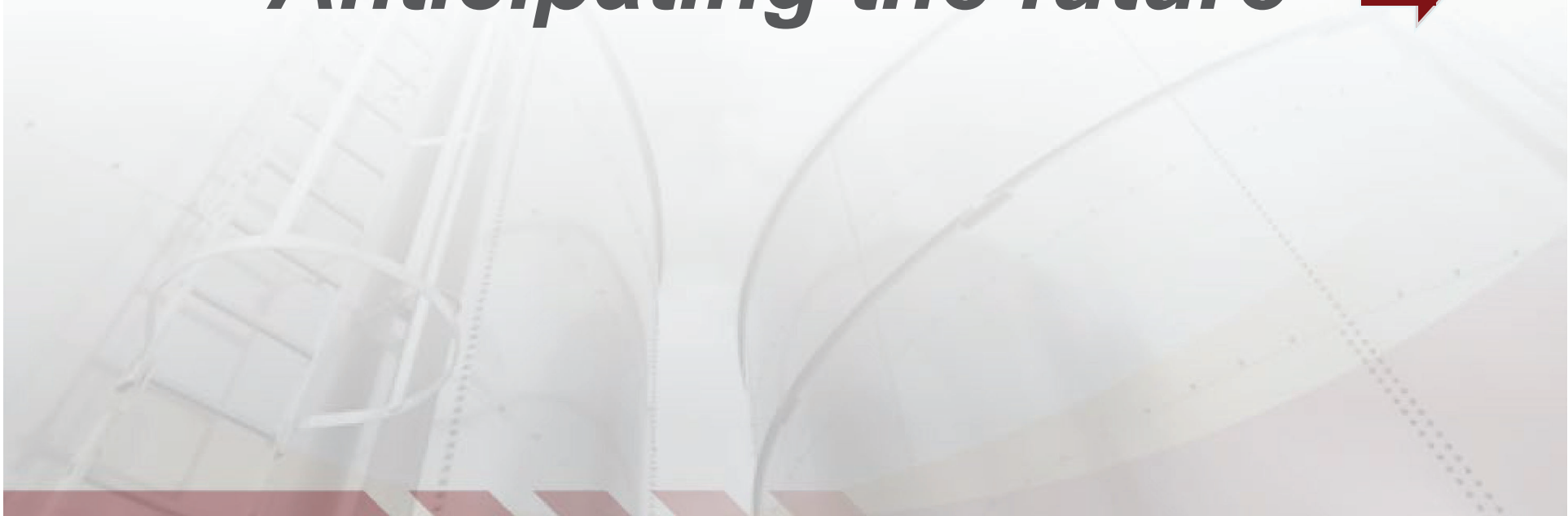
Winnsboro, TX

September 27, 2018



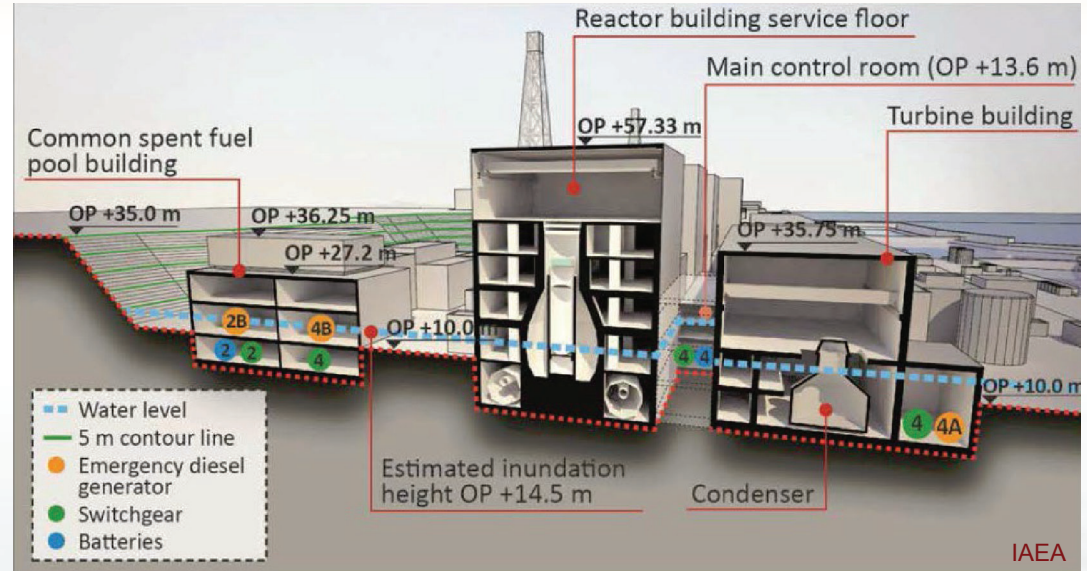
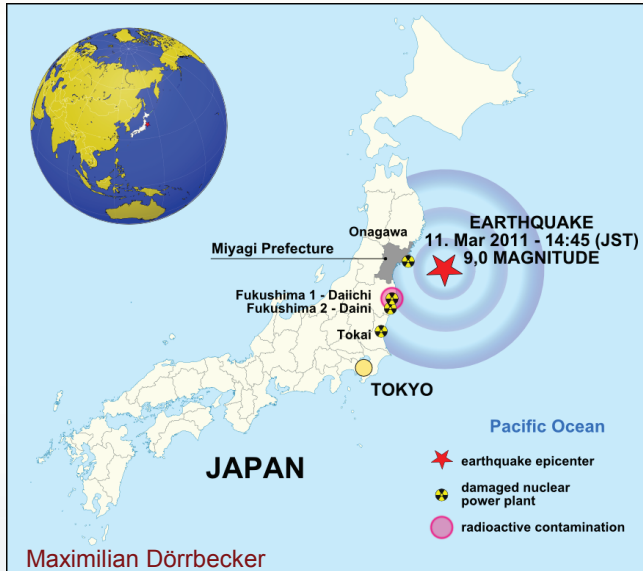
***Learning from the past***

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# Lessons from Fukushima: Beyond Design Basis



Risk analysis failed to consider a tsunami of this magnitude (>2x design basis) despite:

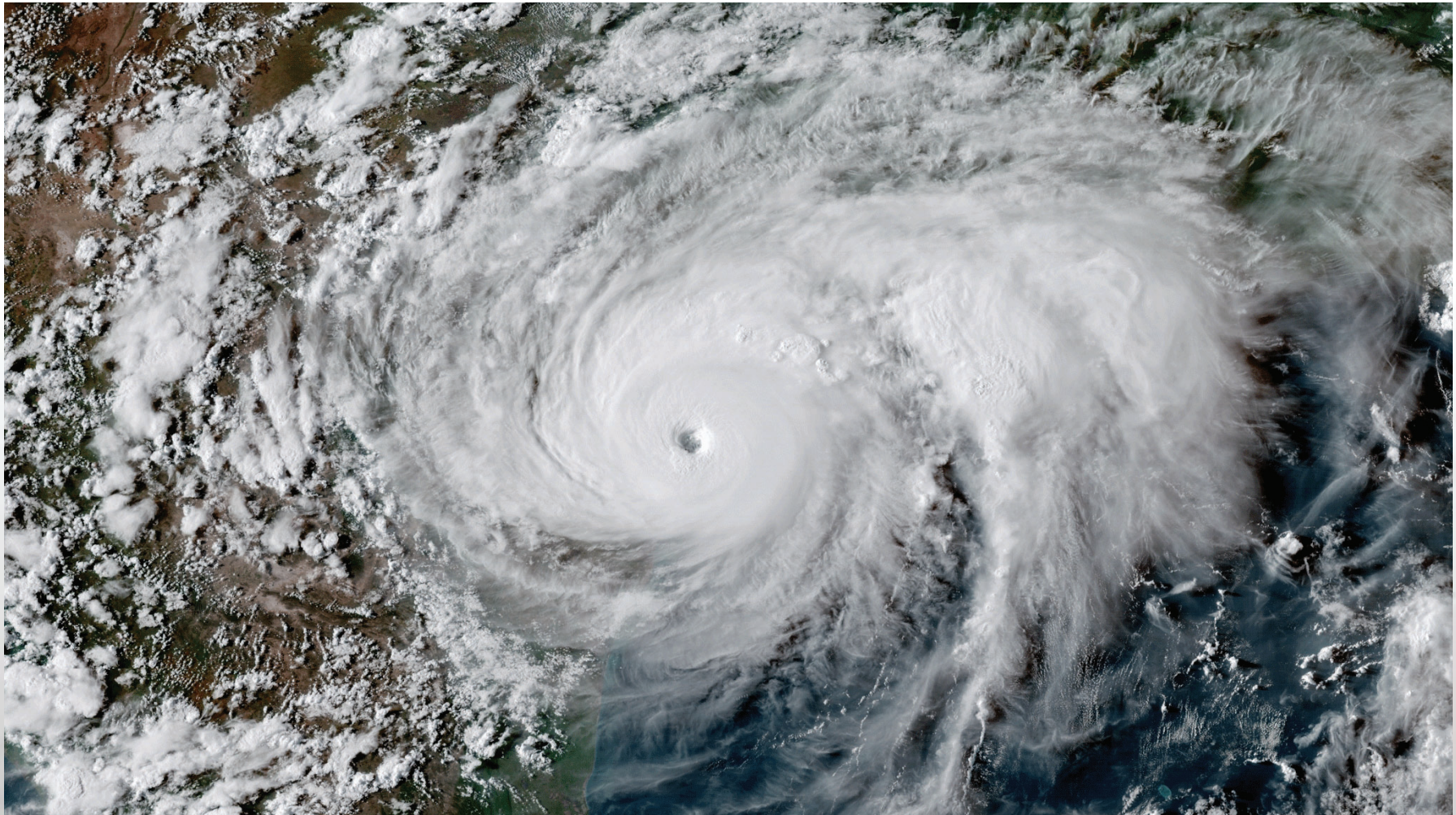
- Evidence of historic 1000-year events
- Computer models showing significant tsunami risk



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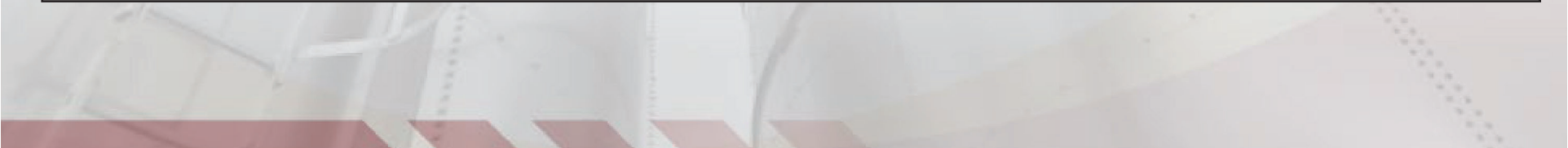
# Arkema Inc. Chemical Fire (August 2017)



NOAA National Environmental Satellite, Data, and Information Service (NESDIS)



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“Certainly, we didn’t anticipate having six feet of water in our plant.”

Arkema President



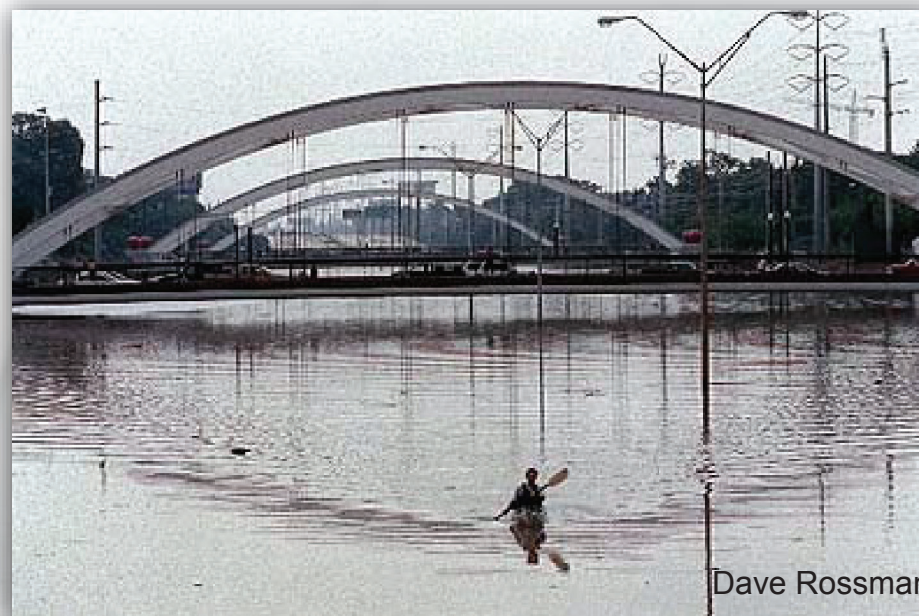


## TS Allison (2001)

**2001**

June – Tropical Storm Allison strikes first on June 5; returns three days later for a second round of storms. Texas Medical Center essentially shut down. North Downtown Houston decimated. Two million people impacted; 22 lives lost. More than 70,000 structures flood. Damages top \$5 billion.

**“ALLISON: A NAME WE’LL NEVER FORGET”**







## Memorial Day Flood (2015)

**2015**

May 25-27 – Memorial Day Flood. More than 6,000 structures flood. Seven fatalities. Highest rainfall recorded in Buffalo and Brays watersheds. Nearly 11 inches in 3 hours on Brays Bayou.



Getty Images

**“HIGHEST RAINFALL RECORDED”**



## Tax Day Flood (2016)

**2016**

April 17-18 - Tax Day Flood. Historic flood over northern and western Harris County results in seven fatalities. Average 12-16 inches of rain in 12 hours countywide; record pool levels in Addicks and Barker reservoirs. Estimated 9,820 structures flood in Harris County.



**“HISTORIC FLOOD”**



# Memorial Day Flood (2016)

## 2016

May 26-27 – Memorial Day Flood. North and northwest Harris County hit with 8-13 inches of rain. Overbank and structural flooding along Spring, Willow, Little Cypress and Cypress creeks, San Jacinto River. More than 400 structures flood in Harris County and more than 900 in the Spring Creek watershed in Montgomery County.





# Houston Floods.

**1900**  
September - Major hurricane hits Galveston. The "Great Galveston Storm" is the worst natural disaster to date in U.S. history. Loss of life reported to be 6,000 to 8,000 citizens. Harris County experiences widespread flooding, with property damage at \$30 to \$40 million.

**1907**  
Major storm floods much of Houston and Harris County.

1900

**1908**  
First drainage district created in Harris County in Brays Bayou watershed.

**1911-1914**  
Houston Ship Channel construction begins.

**1913**  
December - Major Brazos River storm spreads to Harris County. Entire area is hard hit. Buffalo, White Oak, Brays and Greens Bayous are all out of banks. Many citizens evacuate.

1910

**1914**  
Houston Ship Channel opens.

**1915**  
August - Another Galveston hurricane causes major damages throughout Harris County. Buffalo Bayou and widespread areas of Houston experience heavy flooding. Damage estimated at \$56 million.

**1916**  
The United States Geological Survey publishes topographic maps for Harris County.

**1929**  
April - Enormous gulf storm descends on Houston and Harris County and lasts 14 hours. Many areas of county report rainfall close to 10 inches. Extensive damage sustained to structures in almost all of Harris County. All bayous are reported to be out of banks.

**1929**  
May - As the area is still reeling from the last storm, another major storm hits Harris County. Structural damage, heavy street flooding and widespread crop damage reported. San Jacinto River 30 feet above normal.

1920

**1929**  
May - As the area is still reeling from the last storm, another major storm hits Harris County. Structural damage, heavy street flooding and widespread crop damage reported. San Jacinto River 30 feet above normal.

**1930**  
May - Large rainstorm cell remains stationary over Harris County for 3 days. Rainfall amounts reported as high as 12.5 inches. Entire area averages 8 inches.

**1932**  
August - Hurricane hits Freeport, taking 40 lives. Harris County has widespread flooding on all bayous.

1930

**1935**  
December - Massive storm inundates Houston and Harris County. Buffalo Bayou 52 feet above normal. Overwhelming devastation leads to creation of the Harris County Flood Control District in 1937.

**1940**  
November - Heavy rains last for 5 days in Northeast Harris County. 10,000 head of cattle lost.

1940

**1943**  
July - Hurricane near Galveston creates extensive flooding for Harris County. \$16.5 million in damages.

**1943**  
October - Hurricane near Freeport. More than 11,000 structures flood in Harris County.

**1945**  
August - Area hurricane produces heaviest rainfall ever recorded in Harris County. More than 15 inches in 24 hours. Flooding reported on all bayous.

**1950**  
February - Thunderstorm precedes cold front, resulting in Greens Bayou running out of banks. Area residents evacuate. Baytown also reports flooding.

1950

**1955**  
May - Major thunderstorm hits northern portion of Harris County. Structural flooding reported in the area.

**1957**  
June - Hurricane Audrey crosses the Louisiana/Texas coast. Flooding is reported in Harris County.

**1959**  
October - Thunderstorm floods more than 100 structures in Houston area.

**1960**  
June - Thunderstorm inundates many areas throughout Harris County. Cypress Creek, Spring Creek and San Jacinto River experience flooding. Over 200 families evacuate.

**1961**  
September - Hurricane Carla pounds the Gulf Coast, taking 34 lives. It is the largest hurricane ever recorded, with property damages exceeding \$300 million. Heavy flooding reported in southern Harris County.

1960

**1969**  
February - Thunderstorm precedes cold front, flooding more than 250 area structures. Damages exceed \$3.3 million.

**1972**  
March - Thunderstorm precedes cold front and floods much of northern Harris County. More than 700 families evacuate.

**1973**  
June - Major storm hits Harris County and brings 10-15 inches of rain. Sims and Greens bayous are reported out of banks. 10 lives are lost and damages exceed \$50 million.

1970

**1979**  
July - Tropical Storm Claudette brings record rainfall amounts to the area. A U.S. record of 43 inches of rain in 24 hours falls in Alvin. Total damages exceed \$700 million.

**1983**  
May - Large thunderstorm floods areas along several bayous. Damages exceed \$14 million.

**1983**  
August - Hurricane Alicia strikes Galveston and Harris County. Damages approach \$1 billion, mostly due to wind.

1980

**1983**  
September - Nine inches of rain falls south of downtown. More than 1,000 structures flood along Brays Bayou. Damages top \$38 million.

**1984**  
October - Thunderstorm in northern Harris County floods more than 200 structures. Total damages exceed \$32 million.

**1989**  
May & June - Two separate storms result in two back-to-back presidential disaster declarations.

**1992**  
March - Major storm floods more than 1,500 structures and many bayous are out of banks. Much of I-10 is under water.

**1994**  
October - Major storm hits Harris County. Twice as many structures flood than in the 1992 storm. Most bayous are out of banks.

1990

**1998**  
September - Tropical Storm Frances causes extensive flooding along White Oak Bayou and other bayous. More than 1,300 structures flood.

**1998**  
October & November - Adding insult to injury, two more major storms flood hundreds more structures, mainly in north Harris County.

**2001**  
June - Tropical Storm Allison strikes first on June 5; returns three days later for a second round of storms. Texas Medical Center essentially shut down. North Downtown Houston decimated. Two million people impacted; 22 lives lost. More than 70,000 structures flood. Damages top \$5 billion.

**2006**  
June 19 - Rainfall on already saturated ground floods 3,370 homes, 561 apartments and one nursing home, mostly along Berry and Sims bayous. Rainfall 8-10 inches in three hours.

2000

**2008**  
September - Hurricane Ike, 3rd deadliest in U.S. history, strikes Galveston Island. Eleven deaths in Harris County. Storm surge swamps 2,500 structures; rainfall causes 1,200 more structures to flood. More than \$28 billion in damage.

**2009**  
April 17-28 brings extensive flooding; five children drown when a car goes into a Greens Bayou tributary. Some highways close; record high water on Bear, Langham, Mayde Cypress and Cypress creeks. 2,305 structures flood on Langham Creek and Buffalo Bayou. HCFC records one-hour rainfall of 6.9 inches at Clear Creek.

**2012**  
July - High water rescues along Cypress, Little Cypress and Willow creeks after several days of heavy rainfall beginning July 9. More than 70 structures flood in northern Harris County.

**2014**  
August - Slow-moving rains drench portions of Harris County with 3.5-4.5 inches. In the Greens Bayou watershed, 107 structures flood.

**2015**  
May 25-27 - Memorial Day Flood. More than 6,000 structures flood. Seven fatalities. Highest rainfall recorded in Buffalo and Brays watersheds. Nearly 11 inches in 3 hours on Brays Bayou.

2010

**2016**  
April 17-18 - Tax Day Flood. Historic flood over northern and western Harris County results in seven fatalities. Average 12-16 inches of rain in 12 hours countywide; record pool levels in Addicks and Barker reservoirs. Estimated 9,820 structures flood in Harris County.

**2016**  
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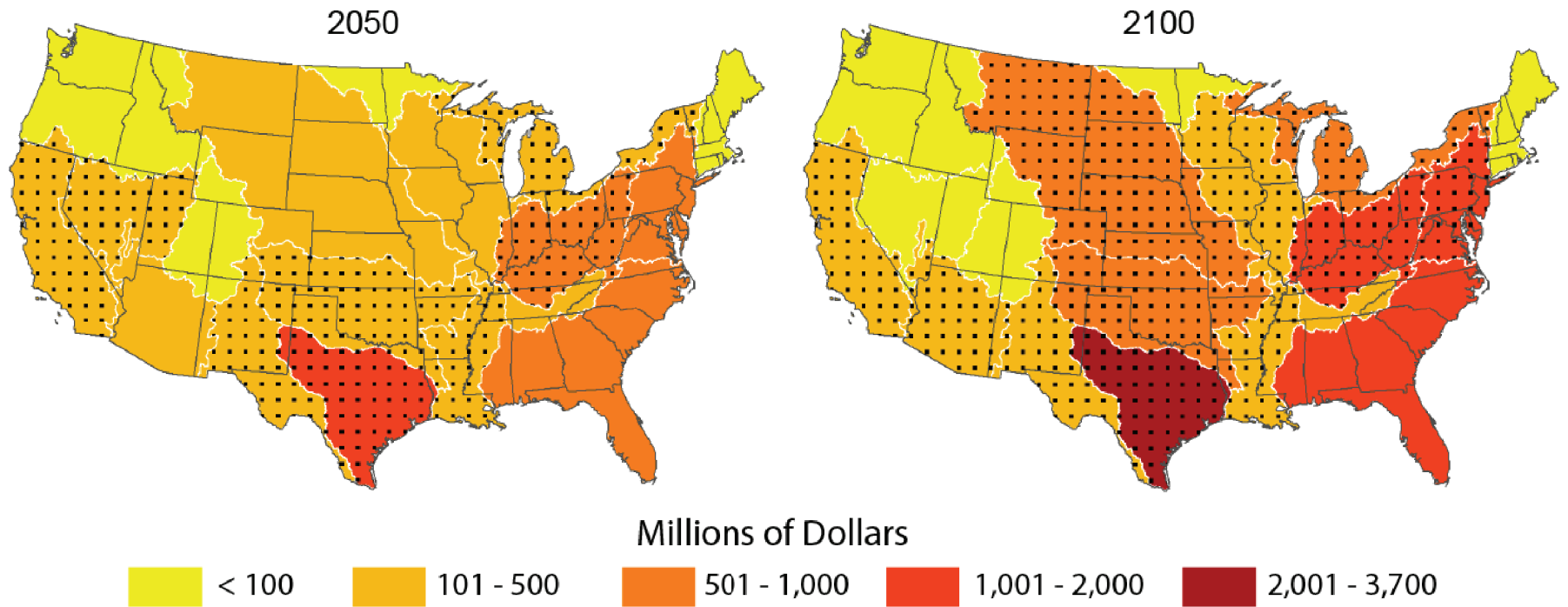
***Anticipating the future***





### Figure 1. Estimated Flood Damages Due to Unmitigated Climate Change

Estimated flood damages under the Reference scenario in 2050 and 2100 for the IGSM-CAM climate model (millions 2014\$). Results are presented for the 18 2-digit hydrologic unit codes (HUCs) of the contiguous U.S. Stippled areas indicate regions where the projected damages are significantly different from the historic period (at a 90% confidence interval).



For more information, visit EPA's "Climate Change in the United States: Benefits of Global Action" at [www.epa.gov/cira](http://www.epa.gov/cira).



## CSB Guidance to Industry

- Perform an analysis to determine susceptibility to extreme weather events and other natural disasters
- Apply a conservative risk management approach when evaluating and mitigating the potential effects of extreme scenarios
- Ensure that critical safeguards and equipment are not susceptible to common mode failures



# CSB Work on Lab Safety

## Texas Tech University Laboratory Explosion

No. 2010-05-I-TX

### ISSUES

- Laboratory safety management for physical hazards
- Hazard evaluation of experimental work in research laboratories
- Organizational accountability and oversight of safety



Experimenting with Danger

### Experimenting with Danger

10/20/2011 4:00:00 AM

Hazards associated with conducting research at chemical laboratories in academic institutions. [read more](#)

October 2014

### Key Lessons for Preventing Incidents from Flammable Chemicals in Educational Demonstrations

Eliminating Flash Fire Hazards by Substituting or Minimizing the use of Flammable  
Chemicals and Performing an Effective Hazard Review Will Prevent Injuries

#### Key Lessons Summarized:

- Due to flash fire hazards and the potential for serious injuries, do not use bulk containers of flammable chemicals in educational demonstrations when small quantities are sufficient
- Employers should implement strict safety controls when demonstrations necessitate handling hazardous chemicals — including written procedures, effective training, and the required use of appropriate personal protective equipment for all participants
- Conduct a comprehensive hazard review prior to performing any educational demonstration
- Provide a safety barrier between the demonstration and the audience







# Post-doc Loses Arm in U Hawaii Lab Explosion

March 16, 2016



Honolulu Fire Department



“Weeks before the accident the postdoctoral researcher had also reported to her PI being electrically shocked when touching the pressure vessel and the gas storage tank.”

“One day before the accident, the postdoctoral researcher reported a “cracking sound” within the 1 gallon pressure vessel to her PI. Based on the pressure changes, visual observations, and smell, a combustion had occurred. Yet the researchers apparently dismissed the event as an anomaly...”

Source: UC Center for Laboratory Safety *Report to the University of Hawaii at Manoa on the Hydrogen/Oxygen Explosion of March 16, 2016*



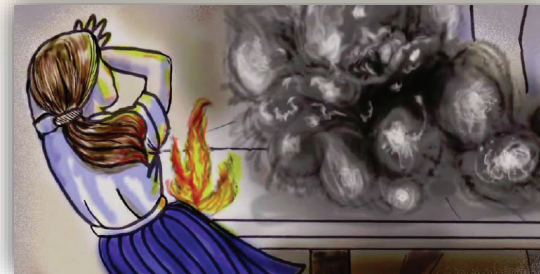
# Incidents in Schools and Informal Educational Settings

Between 2001-July 2017

- 261 incidents in lab, classroom, or demonstration setting
- 130 in higher ed > 185 injuries and 5 fatalities
- 66 in elementary and secondary schools > 170 injured



CSB Safety Bulletin



Washington Post October 30, 2015



TEXAS

## 12 Preschool Kids Burned When Teacher's 'Rainbow Experiment' Goes Wrong

Melissa Chan  
May 17, 2017





## Findings from TTU Incident

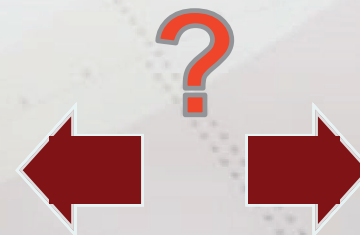


### Findings for TTU

- Physical hazards of chemicals
- Safety management, incl. training
- Prior incidents

### Broader Findings for Research Community

- Guidance on hazard evaluation in academic labs
- OSHA lab standard
- Influence of granting agencies



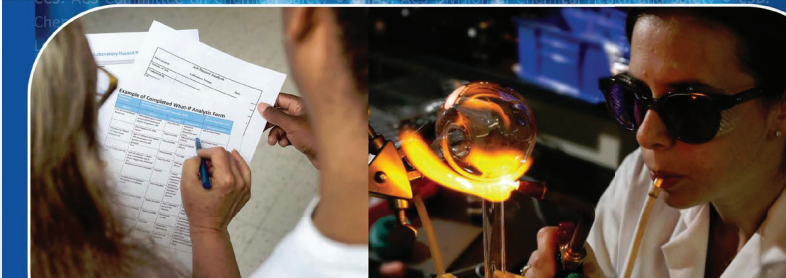


# Lab Safety Resources

ACS, 2015

NAS, 2014

**IDENTIFYING AND EVALUATING HAZARDS IN RESEARCH LABORATORIES**  
 GUIDELINES DEVELOPED BY THE HAZARD IDENTIFICATION AND EVALUATION TASK FORCE OF THE AMERICAN CHEMICAL SOCIETY'S COMMITTEE ON CHEMICAL SAFETY



ACS  
 Chemistry for Life  
 Committee on Chemical Safety • CHAS: ACS Division of Chemical Health and Safety • OSHA: Occupational Safety and Health • PPE: Personal protective equipment • WHO: World Health Organization



**SAFE SCIENCE**  
 Promoting a Culture of Safety in Academic Chemical Research



NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES



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***Anticipating the future*** 



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