



# REFINERIES: HURRICANES & EMERGING TECHNOLOGIES

Leonardo P. Garzon, P.E.

Desimone Consulting Engineers  
Miami, Florida, USA

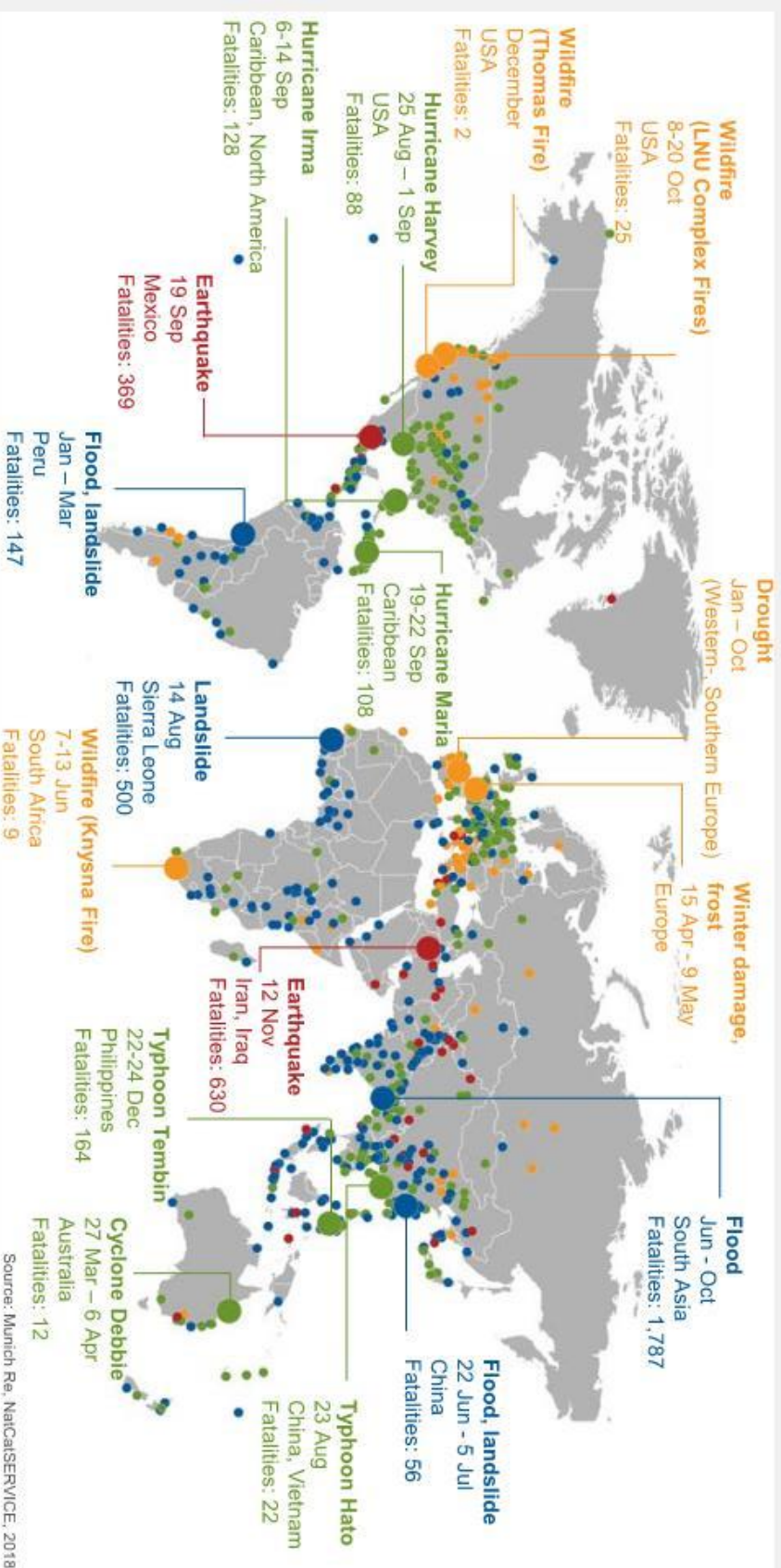
Richard K. Ladroga, P.E.

Desimone Consulting Engineers  
New York, New York, USA

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# Loss events worldwide 2017

## Geographical overview



Source: Munich RE, NatCatSERVICE, 2018

- **Geophysical events**  
(Earthquake, tsunami, volcanic activity)
- **Meteorological events**  
(Tropical storm, extratropical storm, convective storm, local storm)
- **Hydrological events**  
(Flood, mass movement)
- **Climatological events**  
(Extreme temperature, drought, wildfire)
- **Loss events**
- **Selection of catastrophes**





# 2017 Atlantic Hurricane Season YEAR-END SUMMARY

## SEASONAL OUTLOOK

### Named storms

14 - 19

### Hurricanes

5 - 9

### Major Hurricanes

2 - 5

## ACTUAL

### Named storms

17

### Hurricanes

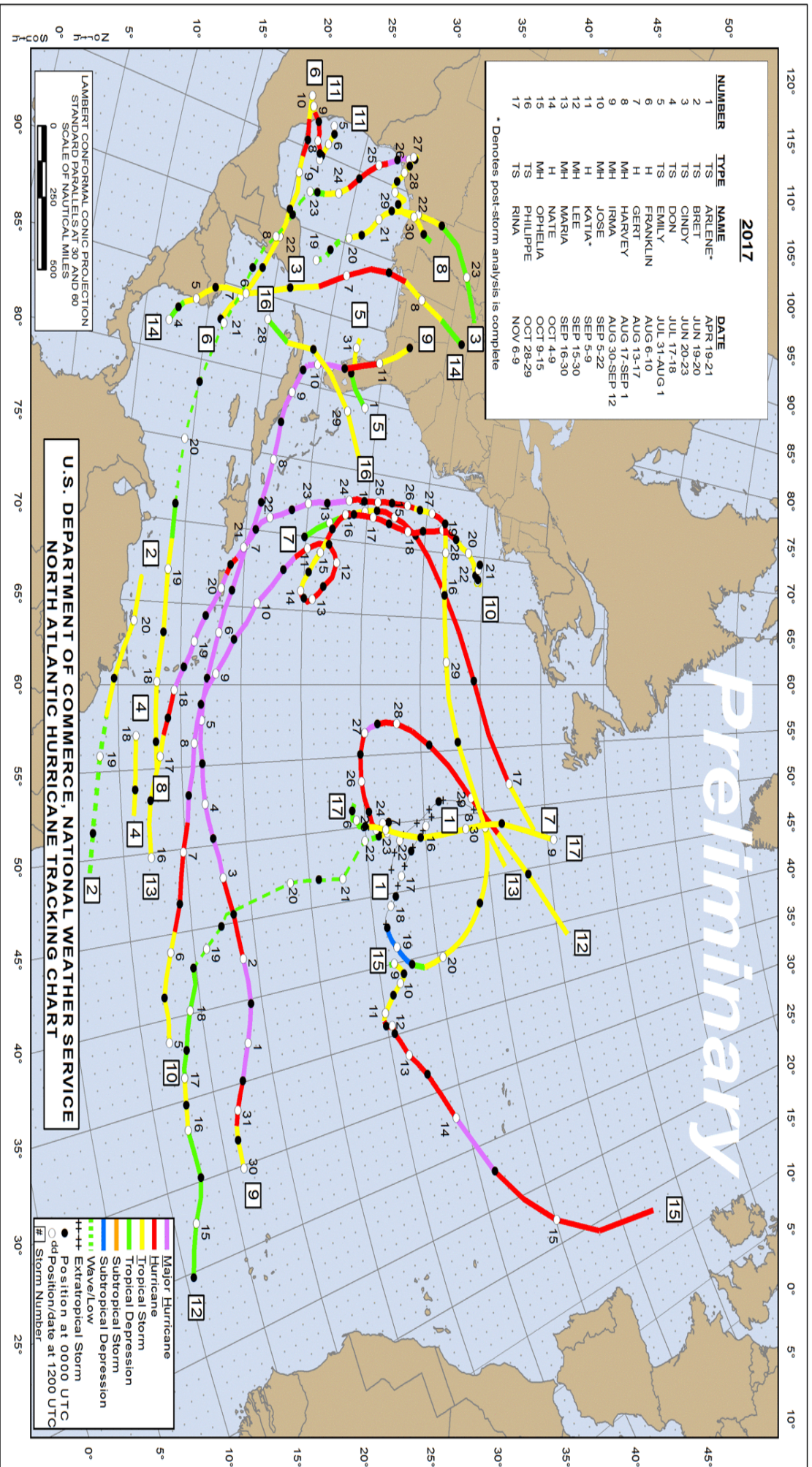
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### Major Hurricanes

6

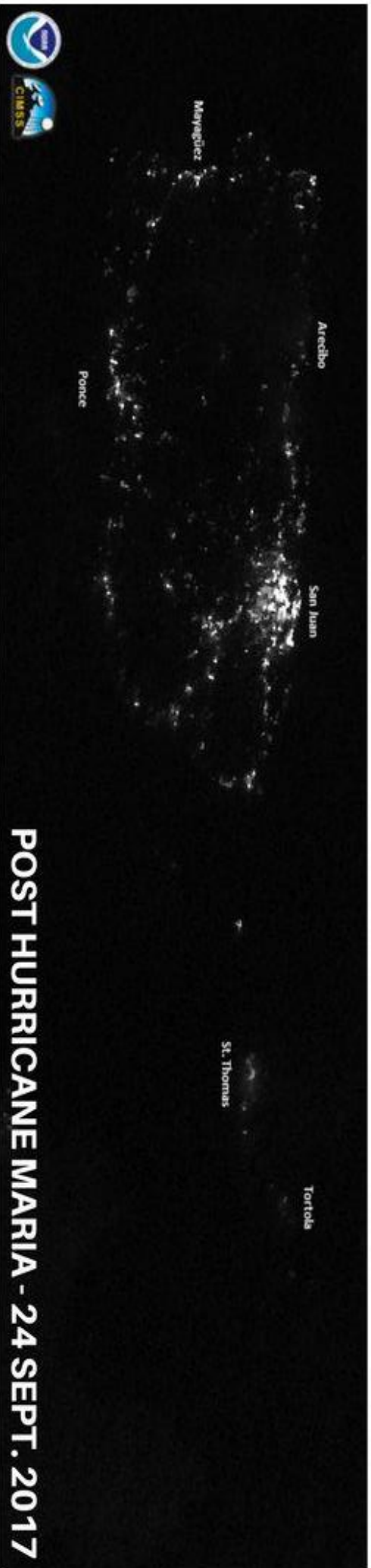
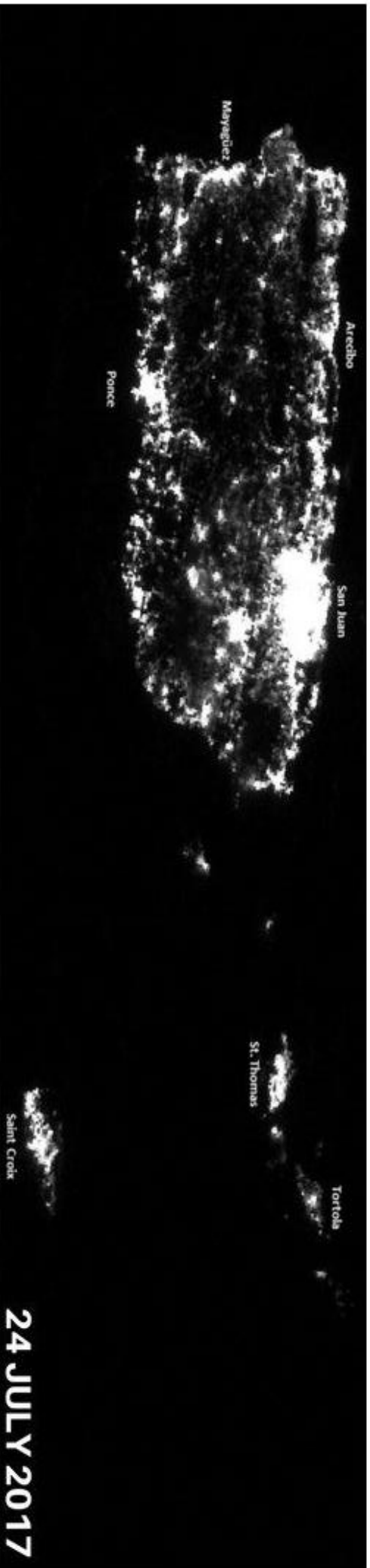
Be prepared: Visit [hurricanes.gov](http://hurricanes.gov) and follow @NWS and @NHC\_Atlantic on Twitter.

November 30, 2017







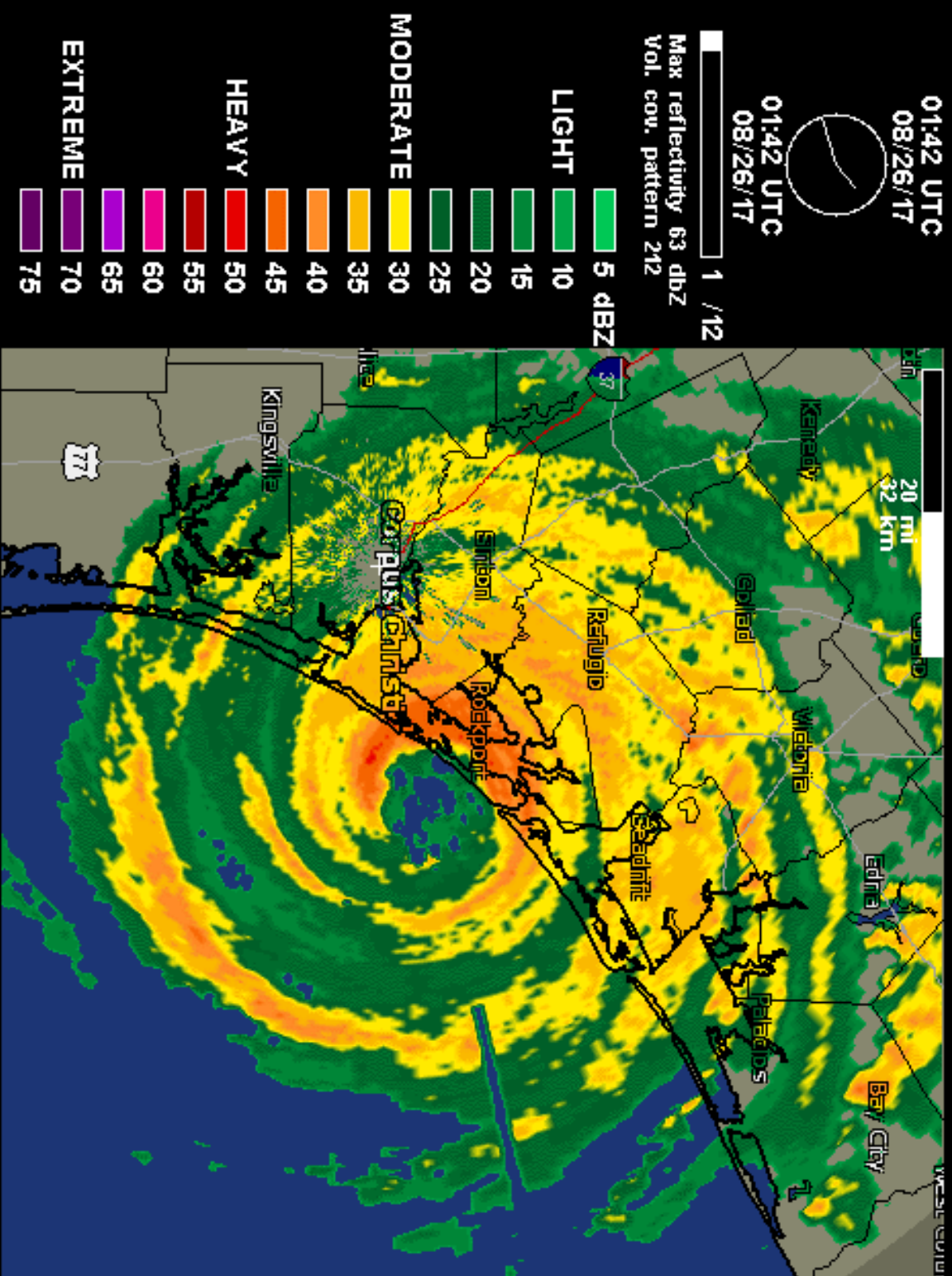


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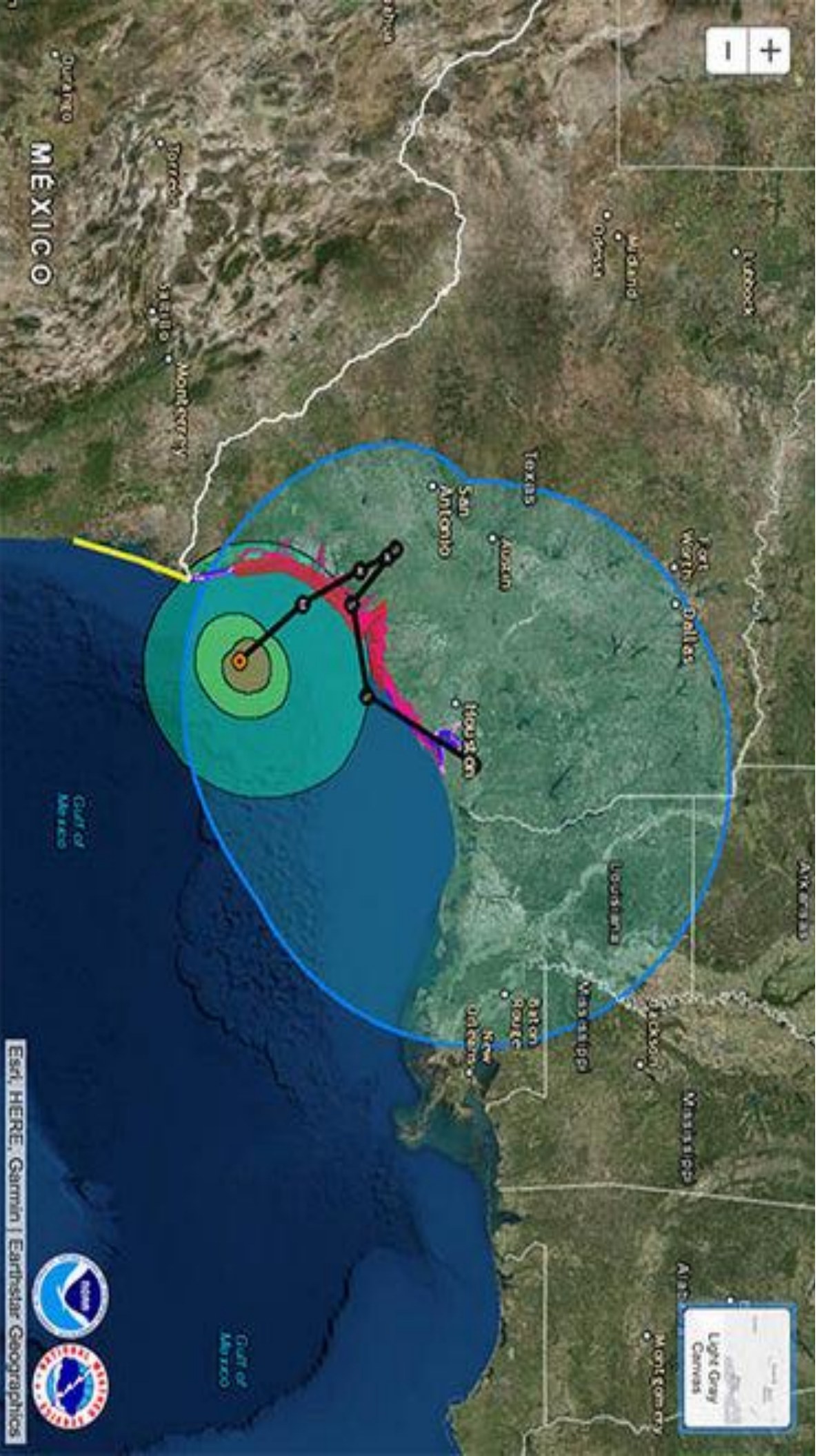


Hurricane Harvey  
August 26, 2017

Landfall: Port Aransas  
and Port O'Connor,  
Texas, as a Category 4  
storm with winds of  
130 mph.

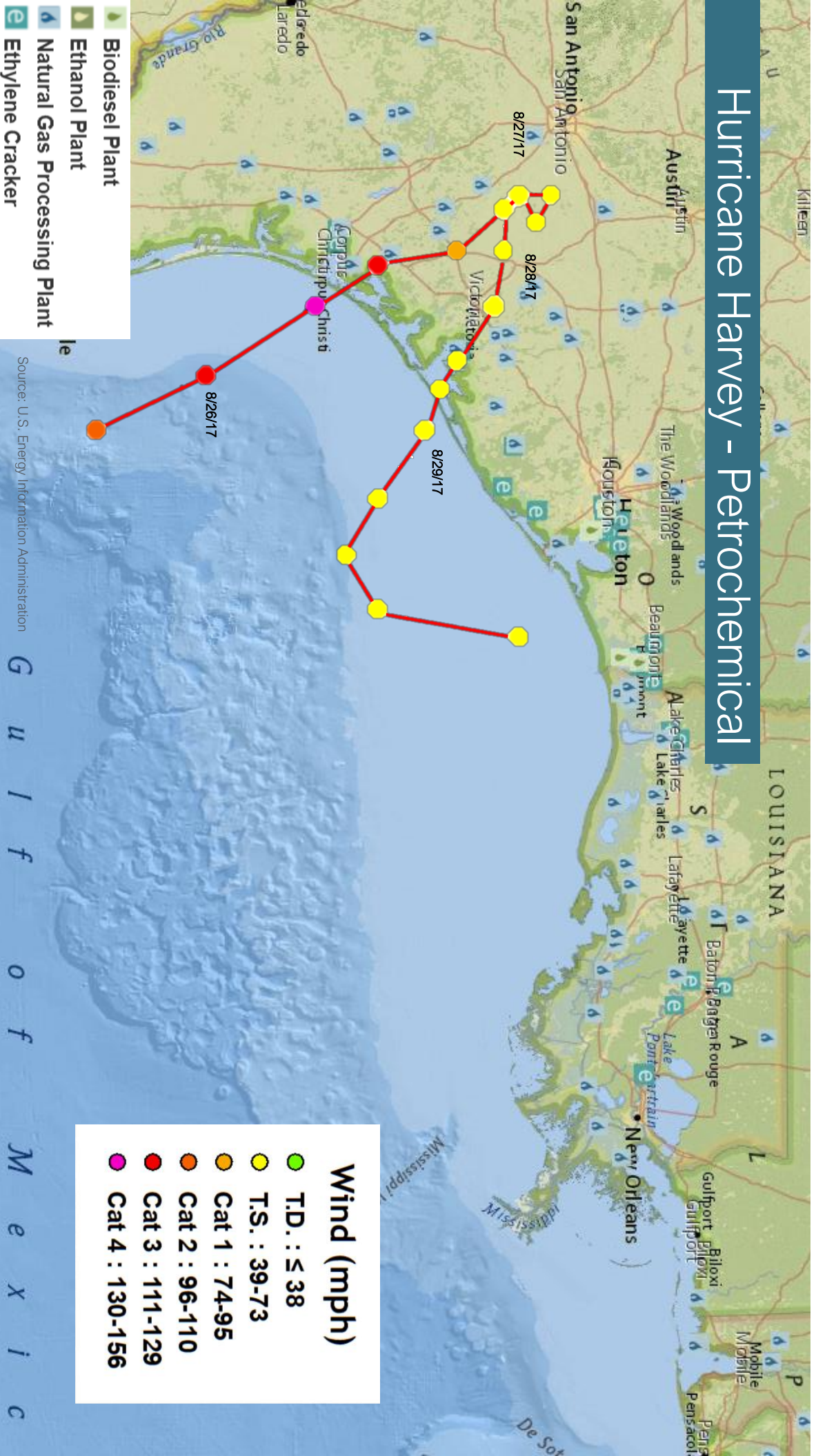
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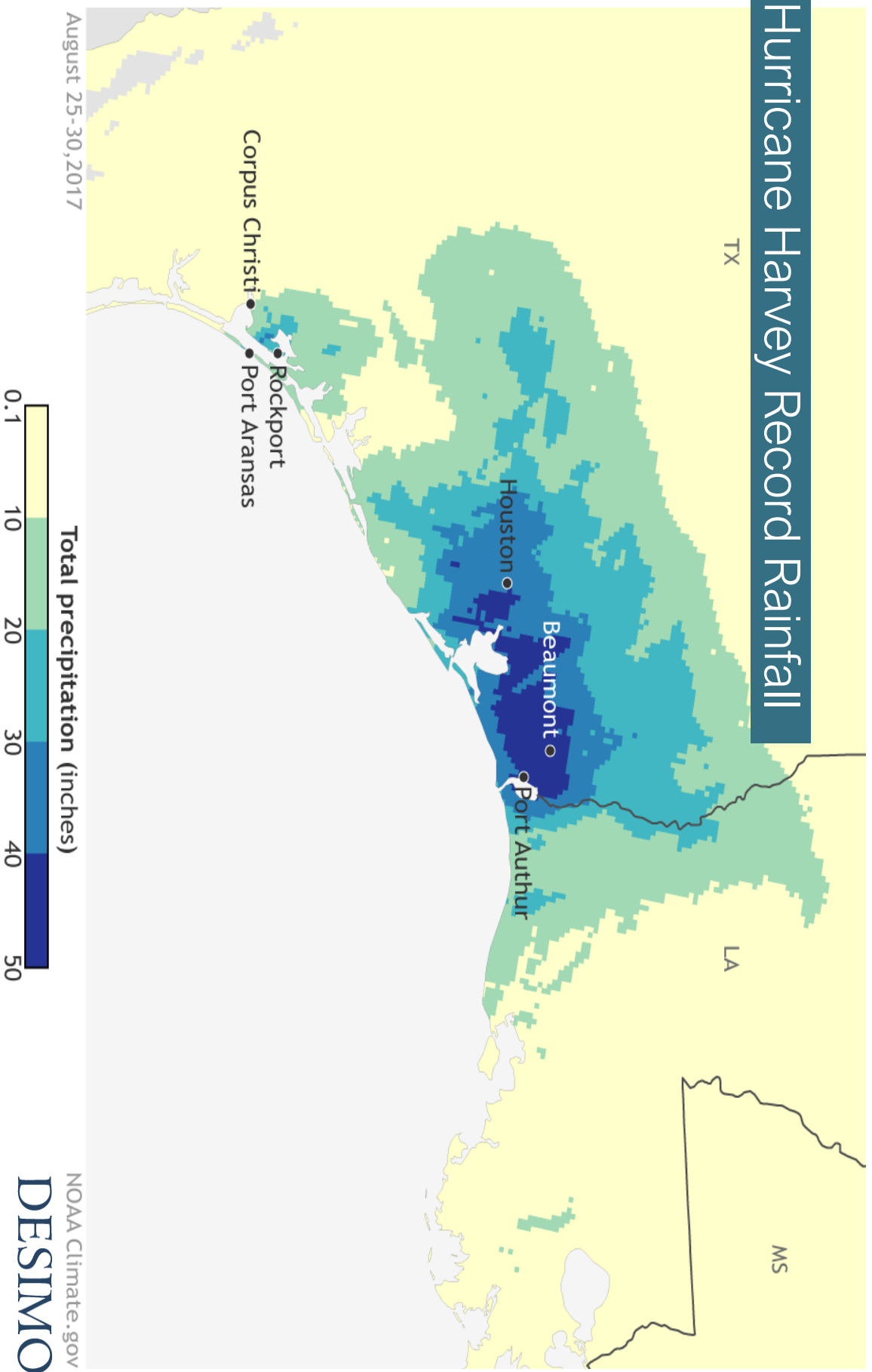


# Hurricane Harvey - Petrochemical



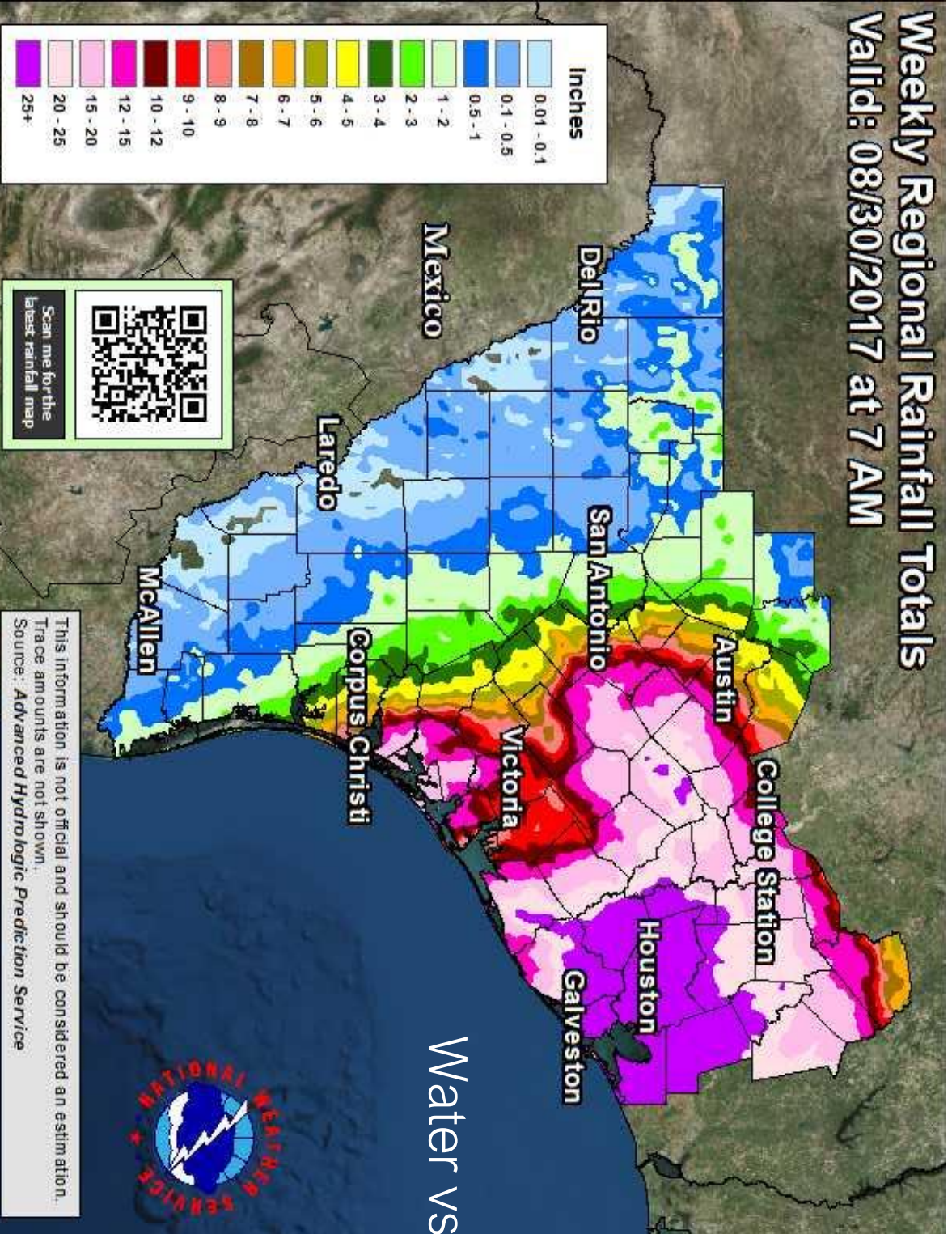


# Hurricane Harvey Record Rainfall



# Weekly Regional Rainfall Totals

Valid: 08/30/2017 at 7 AM

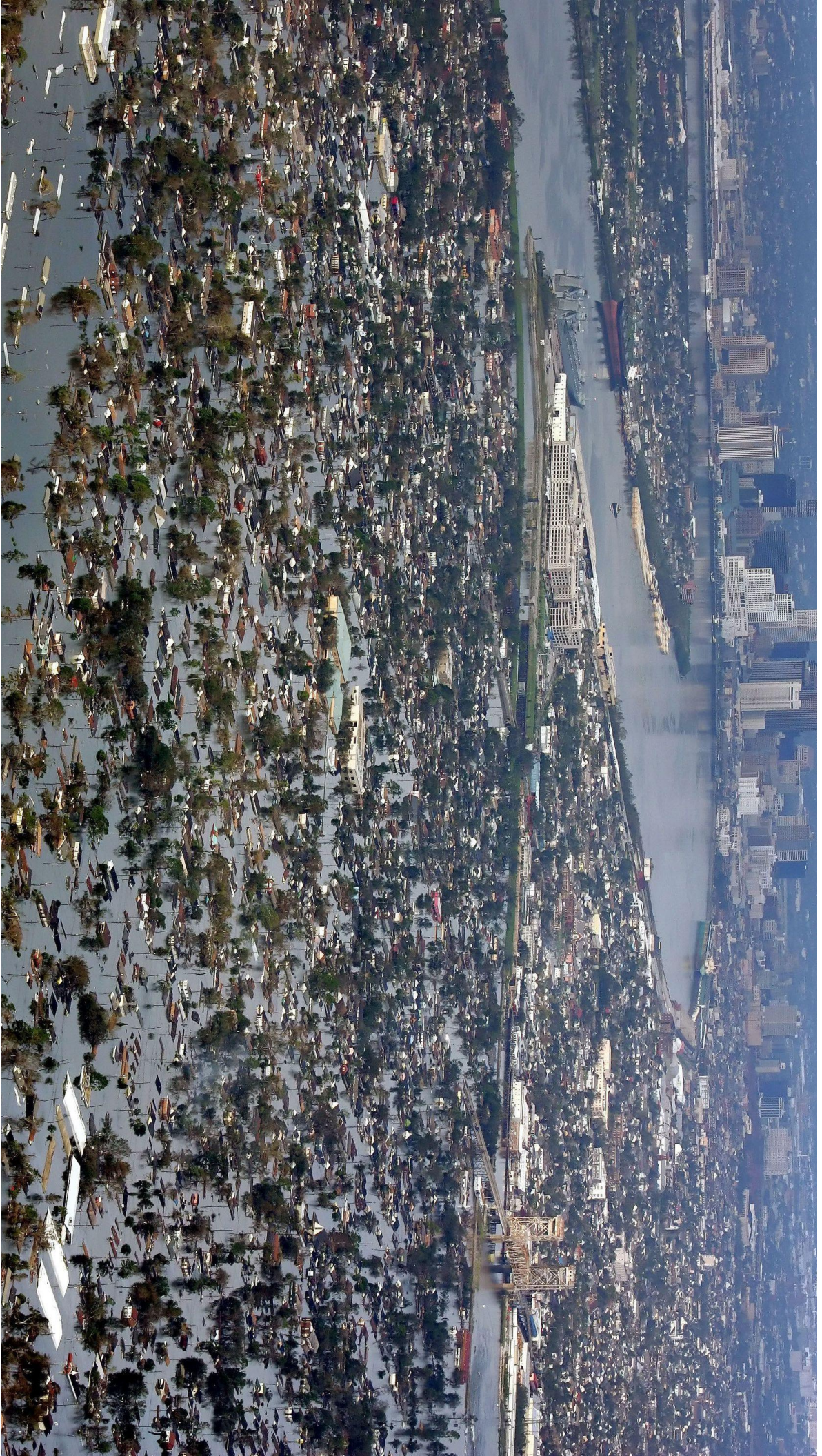


## Water vs. Wind Events

In Houston, dams and reservoirs opened their flood gates due to the heavy rainfall leading to flash flood.

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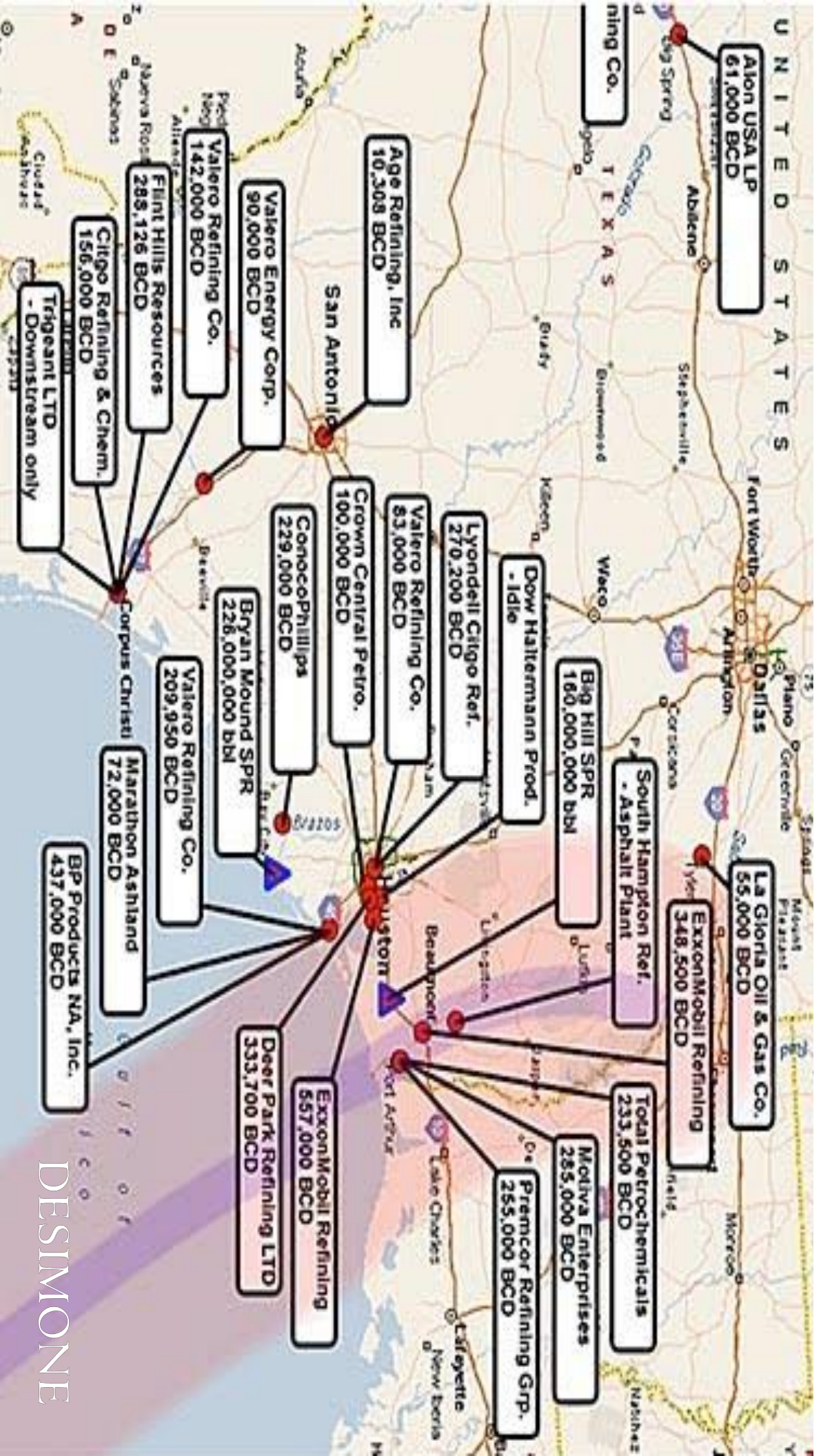
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# Hurricanes & Flood Protection

## Component of Risk

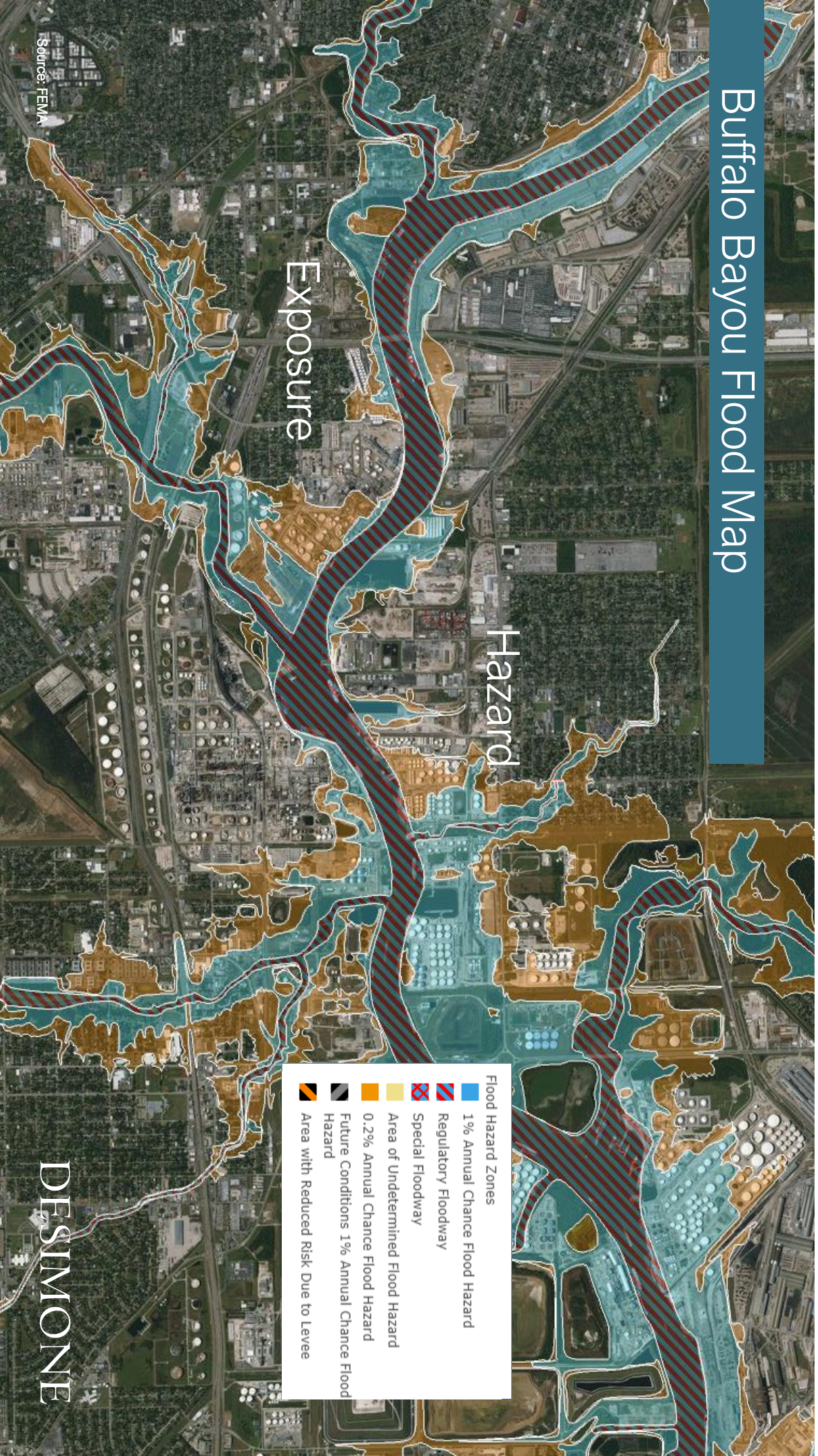
- Hazard
- Exposure
- Vulnerability

## Flood Mitigation

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# Buffalo Bayou Flood Map

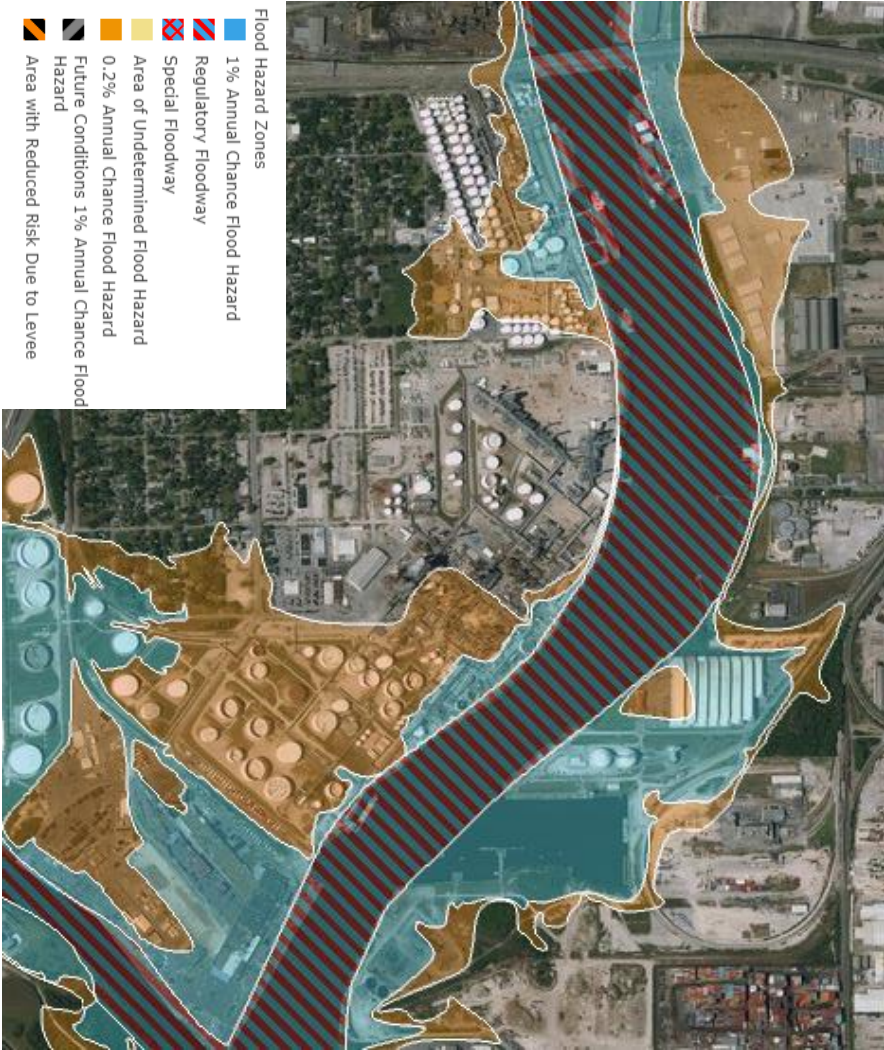




# Houston Refinery Example



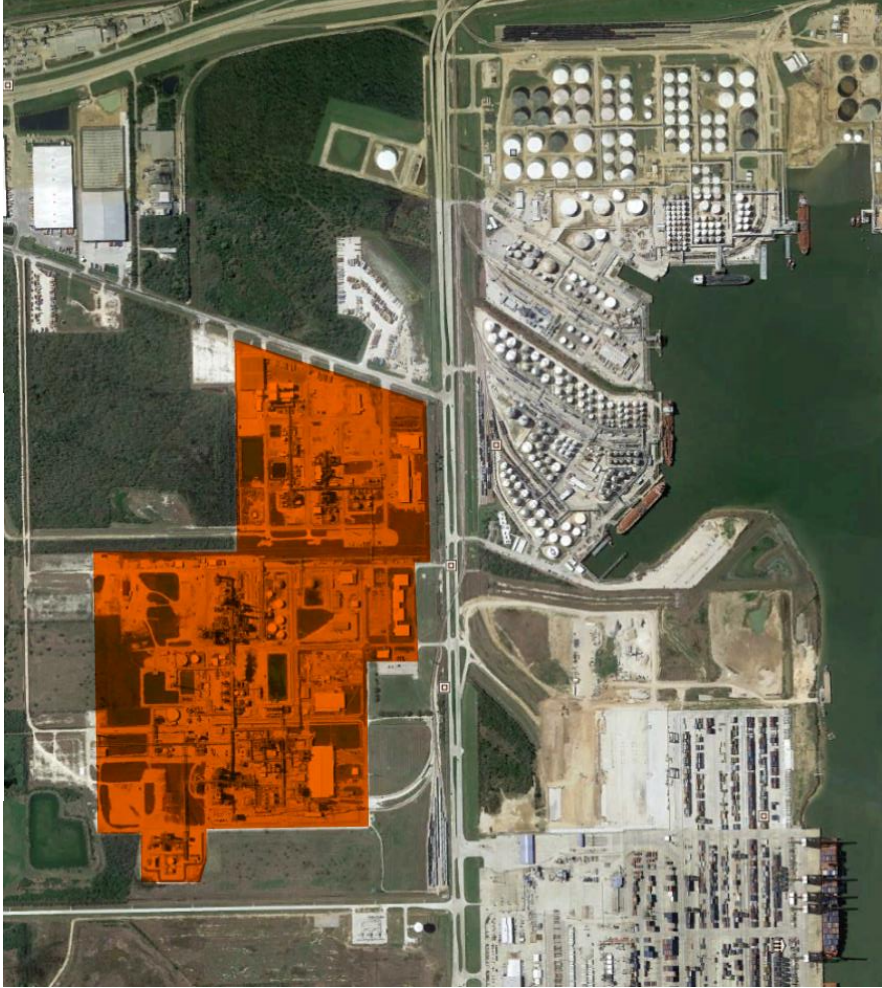
Source: Google Earth & FEMA



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# Houston Petrochemical Industry Example



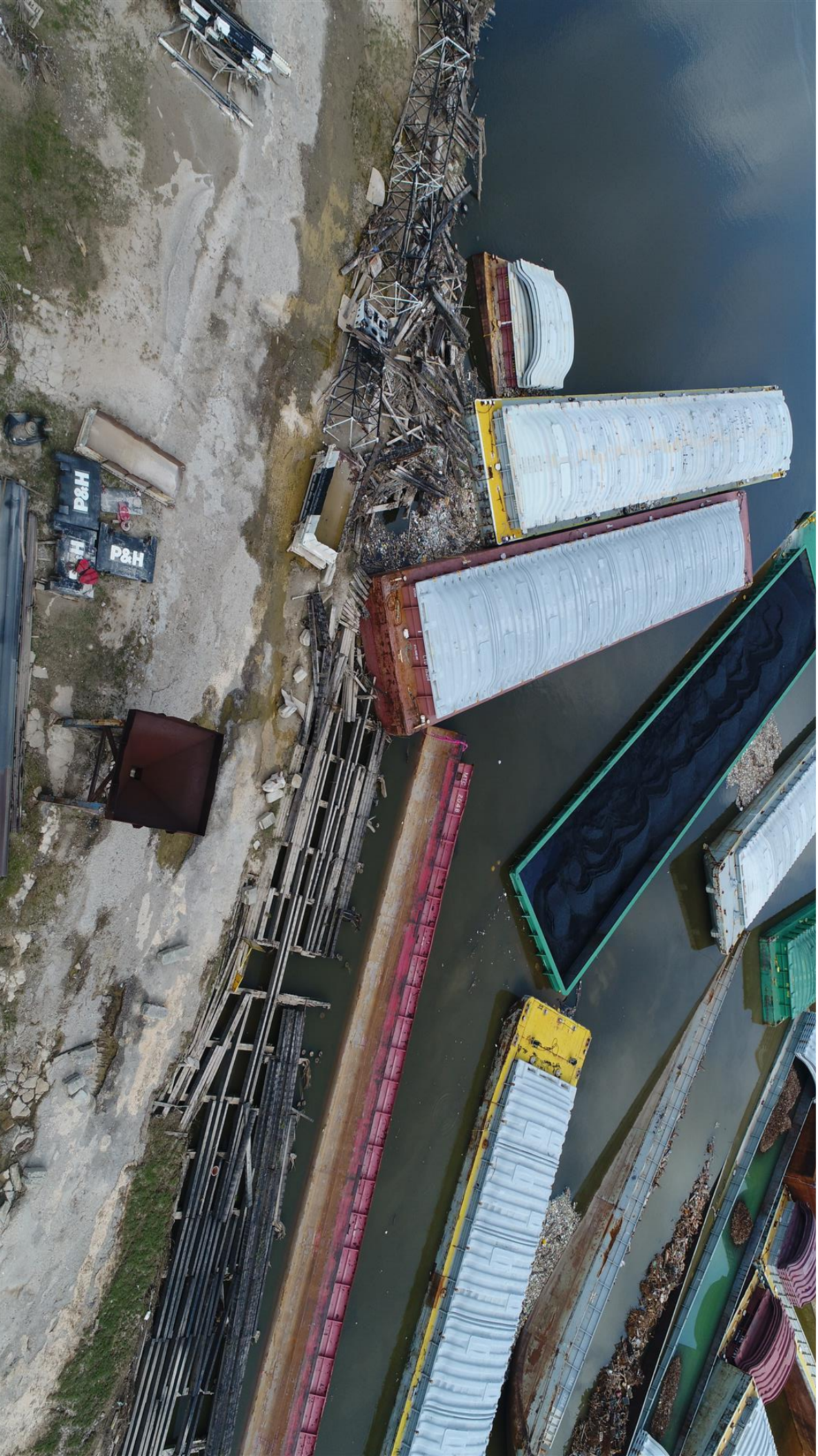
Source: Google Earth & FEMA

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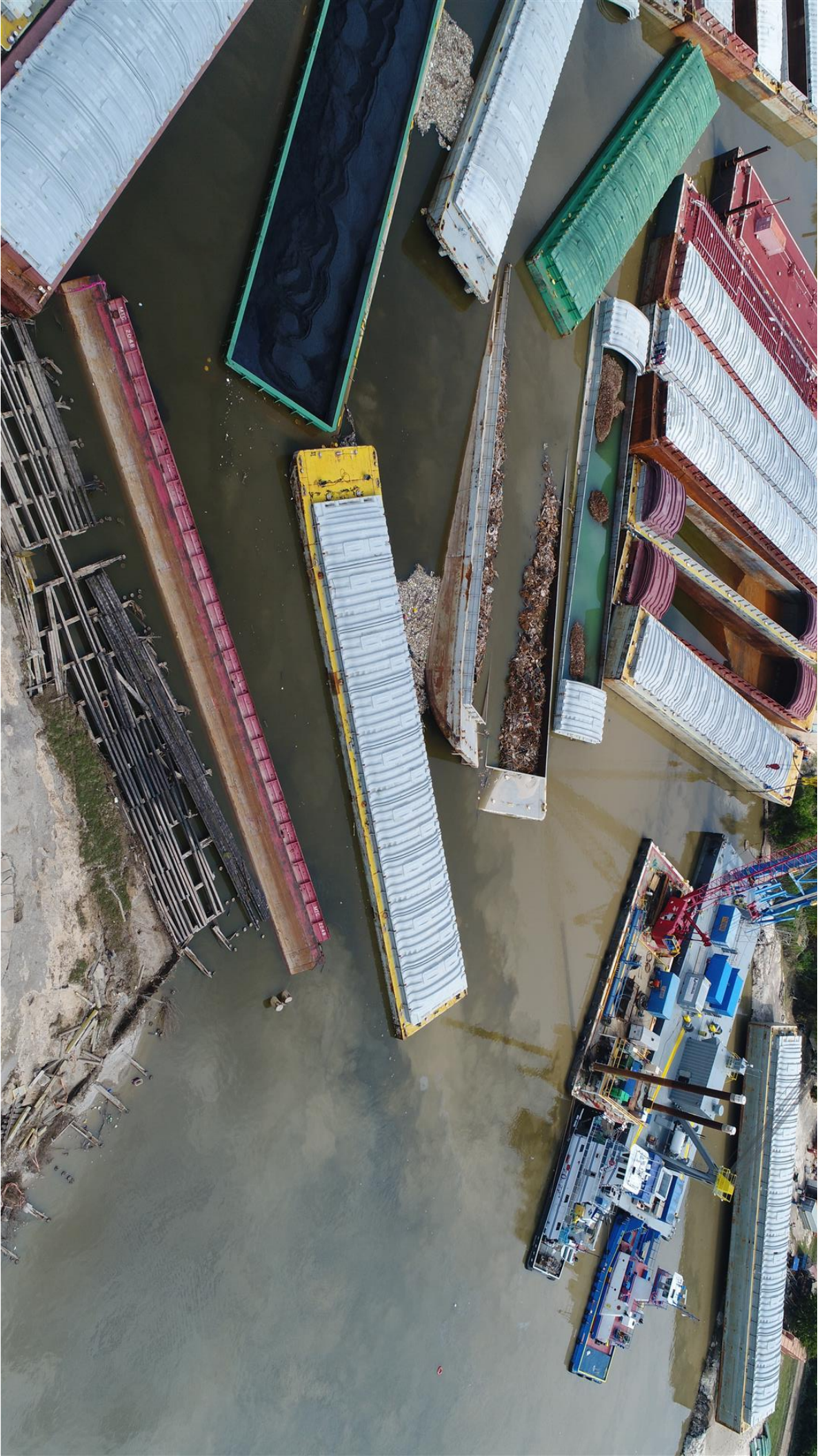
















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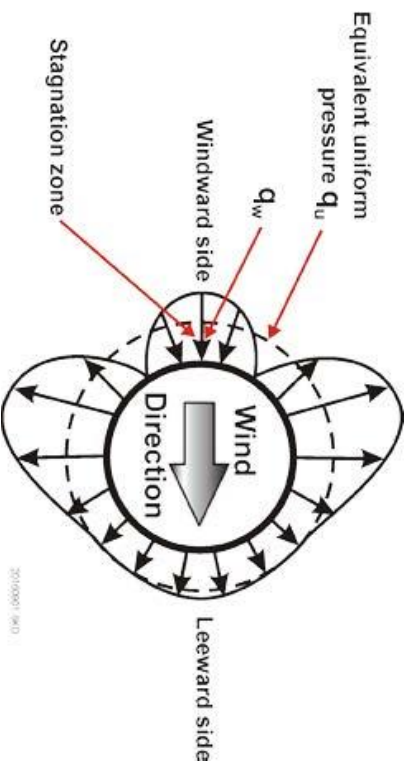




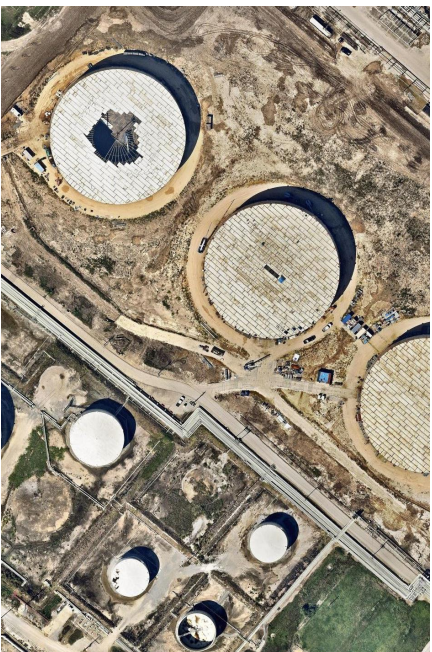
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# Crude Oil and Petrochemical Tanks – Identify Vulnerabilities



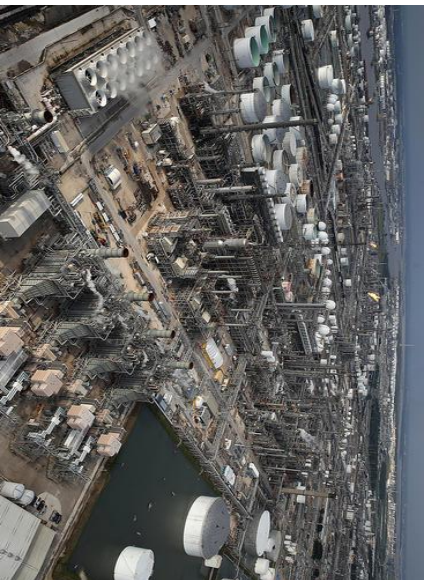
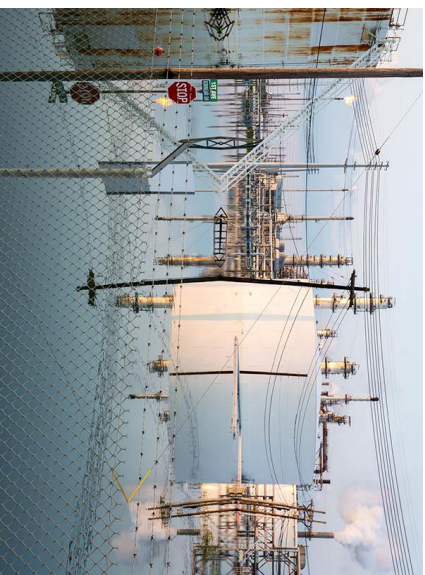
Approximate equivalent wind pressure: 35 to 50 psf  
Number of failed tanks during Harvey: 145,000 gallons  
(24 tanks approximately).



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# Tanks – Significant Vulnerability



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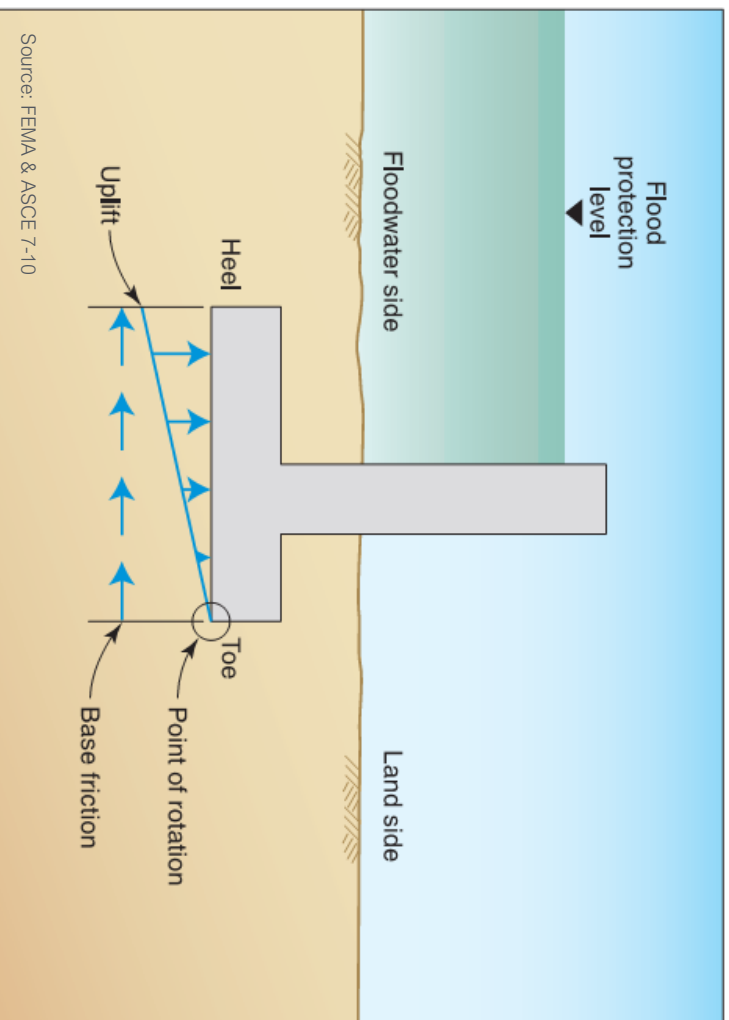




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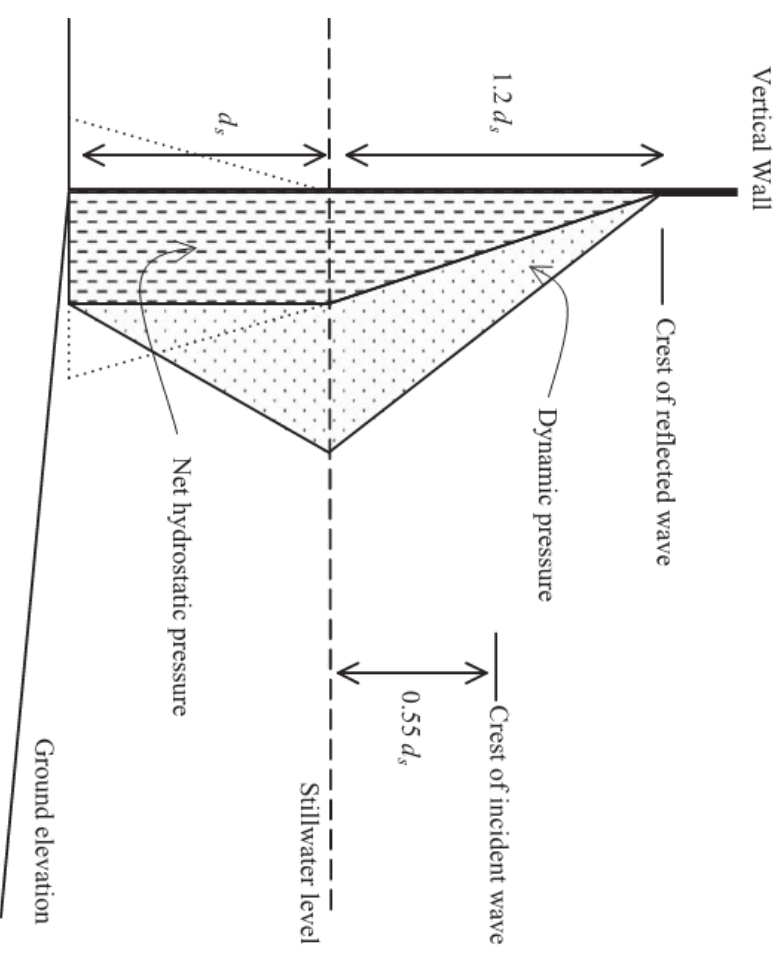


# How to Protect – Flood Walls



## Design Loads:

- Hydrostatic pressure.
- Wind pressure.
- Dynamic pressure (Wave action).
- Debris impact.



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# Flood Walls



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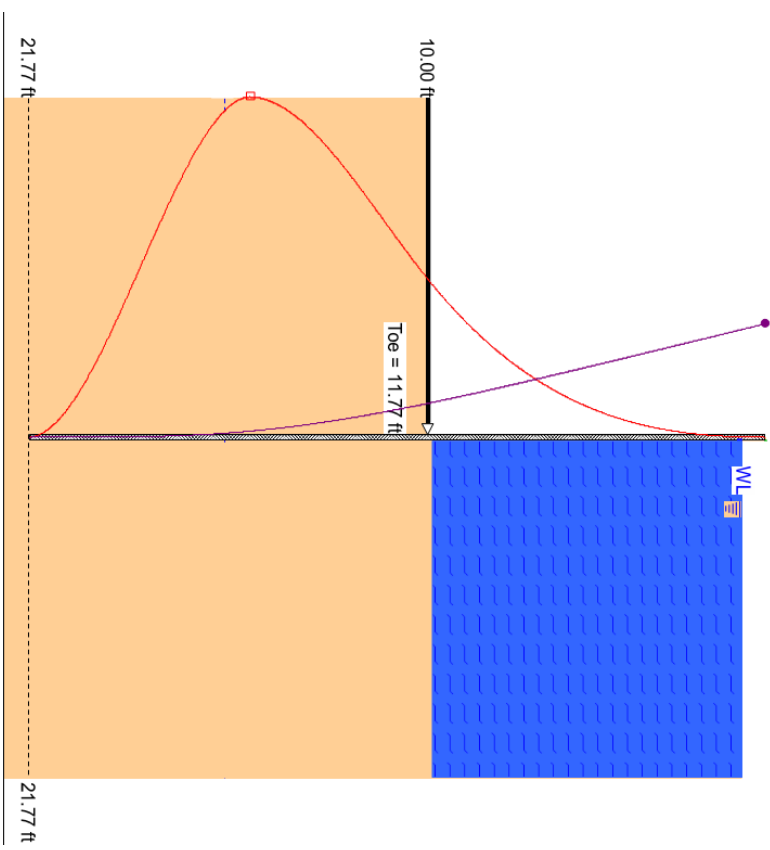
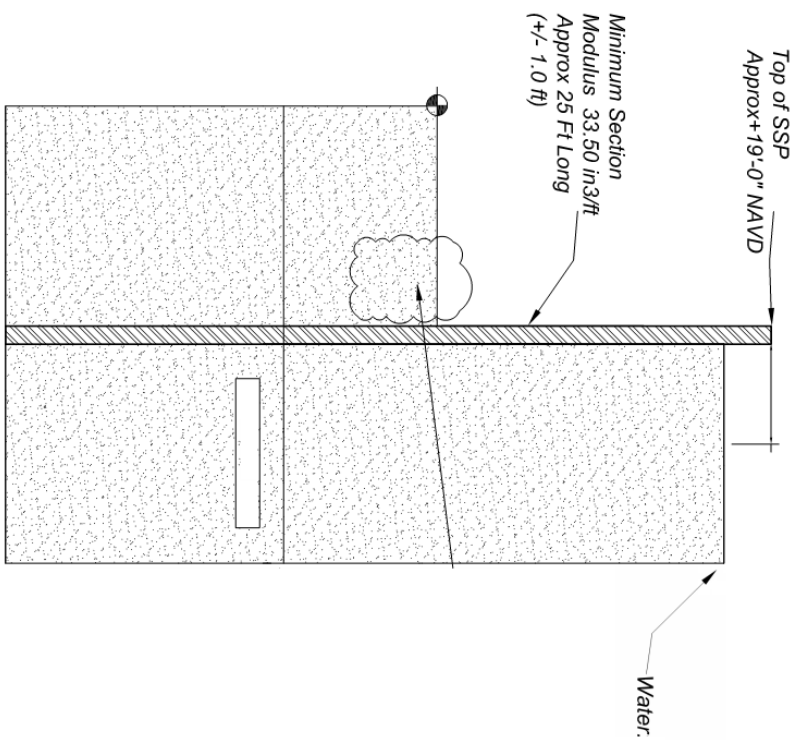
## Flood Walls



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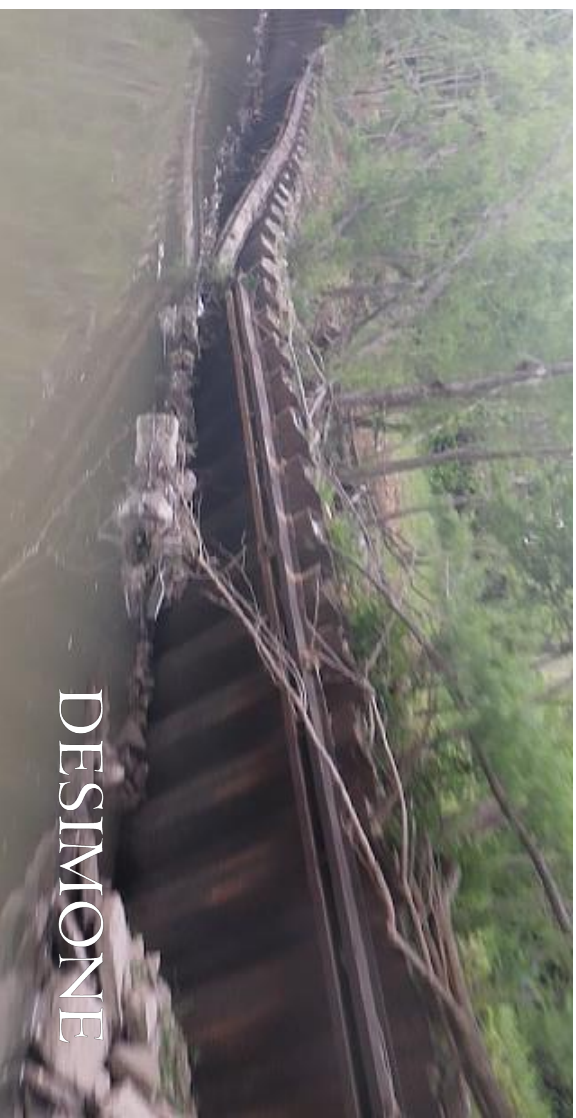
# Sheet Piling



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# Sheet Piling



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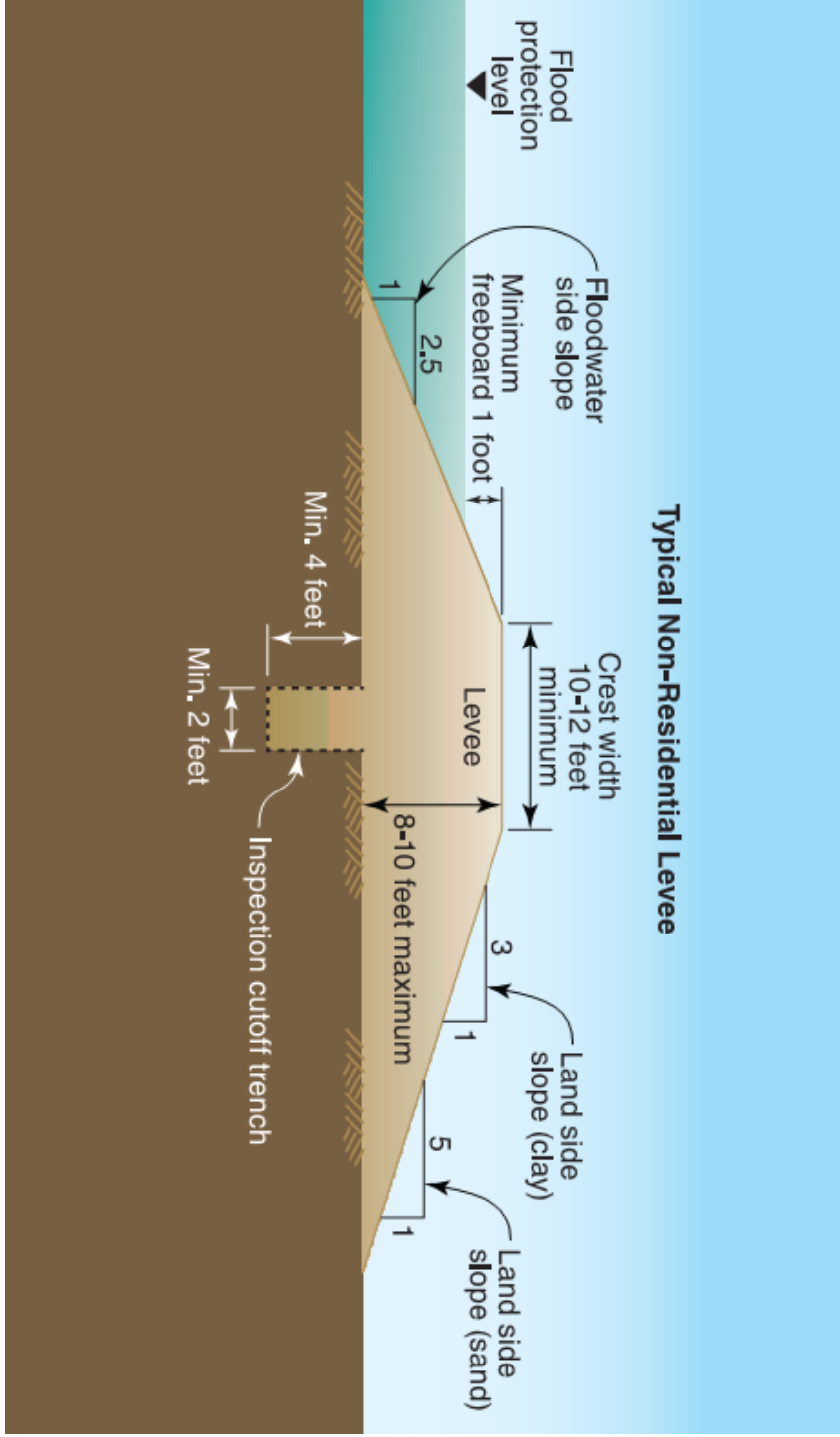
## Flood Walls



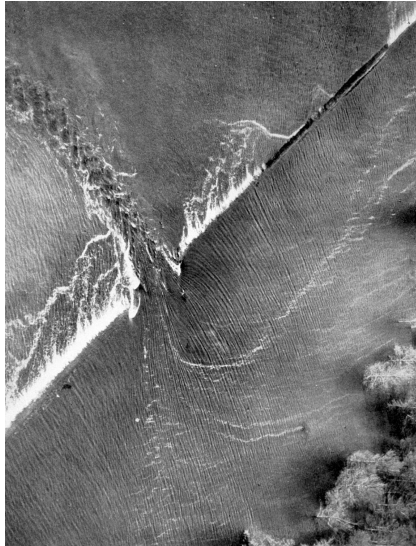
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# Levees



Source: FEMA



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# Top Refinery Technologies

- DIGITAL SYSTEMS
- ARTIFICIAL INTELLIGENCE
- DRONES



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## Digital Technologies - 5 Major Trends\*

- TREND NO. 1: Only 19% recognize digital systems as one of their top 3 priorities.
- 57% stated that current levels of investment are greater than they were 12 months previous.
- 62% indicated they intend to invest “more” or “significantly more” over the course of the next 3-5 years.

\* Based on survey of over 200 refinery professionals worldwide

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## Digital Technologies - 5 Major Trends\*

- TREND NO. 2: Analytics is number one for performance followed by cyber security
- Analytics (including big data) is overwhelming choice for digital technology that will impact performance.
- Cybersecurity viewed as one of the top digital technologies affecting operational performance. (Necessary to offset increased network connectivity supporting refinery ops)

\* Based on survey of over 200 refinery professionals worldwide

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## Digital Technologies - 5 Major Trends\*

- TREND NO. 3: National Oil Companies (NOCs) leading the way in digital maturity.
- Roughly 25% making significantly higher investments in past 12 months.
- 89% of refiners consider themselves still digitally immature.
- NOCs rank higher – 20% indicate maturity

\* Based on survey of over 200 refinery professionals worldwide

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## Digital Technologies - 5 Major Trends\*

- TREND NO. 4: It's no longer "Can refiners afford to", but instead "Can they afford not to?"
- 40% of refiners cite operating costs as their top priority – yet half of refiners cite cost as predominant barrier to digital implementation.

\* Based on survey of over 200 refinery professionals worldwide

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## Digital Technologies - 5 Major Trends\*

- TREND NO. 5: Digital benefits are clear; the ability to realize them is not.
- 38% of refiners cite lack of digital strategy as barrier.
- Value-add proposition difficult to develop without solid business case.

\* Based on survey of over 200 refinery professionals worldwide

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# Cultural Paradox Paradigm

- Digital requires senior executive leadership, vision, and proof of concepts that quickly lead to scaled programs focused on maximizing return on investment.
- Companies need to drive a culture of innovation and technology adoption — a parallel focus on OT & IT.
- Investment in human capital and development programs are needed to promote new, digital thinking and new ways of working.
- Digital strategy required for solid business case. Decision matrices, profitability increase, risk reduction, increased output, etc. Is the cost worth the gain?

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# DIGITAL TECHNOLOGIES - EXAMPLES

Sensors – Continuous monitoring vs scheduled monitoring

- Moisture
- Dissolved Gas Analysis - Chromatography
- Pressure
- Temperature
- Electrical
- Hysteresis
- Position
- Flow
- Molecular Composition

## Digital Technologies - Summary

- The current state of the oil and gas market is forcing companies to reinvent themselves to improve productivity and profitability.
- Investing in digital technologies is a sound move that can significantly increase efficiency and production with existing operations, reduce operating costs, increase revenue generation, while also increasing reliability and minimizing risk.

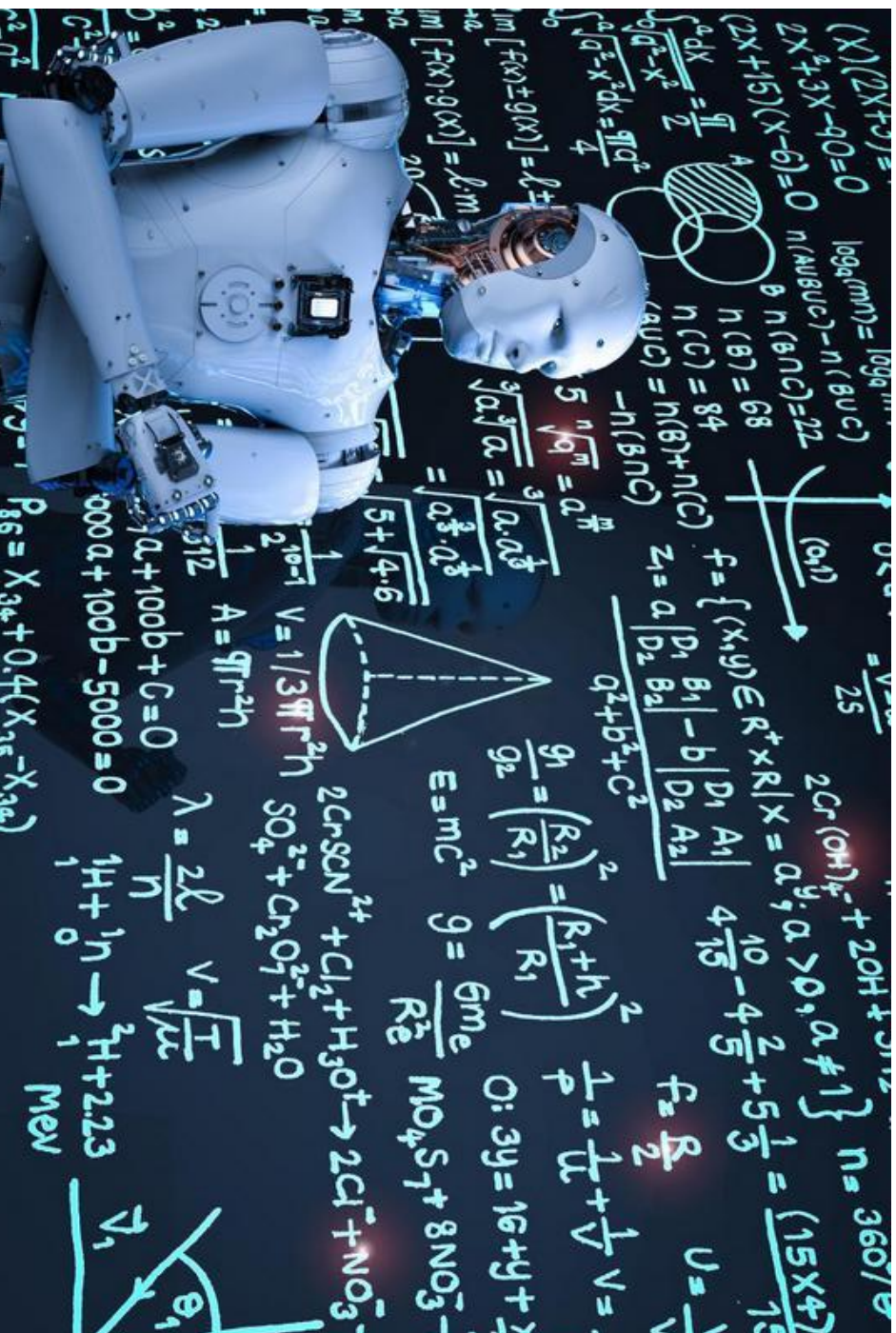
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# ARTIFICIAL INTELLIGENCE



# The Future is Already Here



PANDORA

NETFLIX

AMAZON

SIRI

ALEXA

TESLA

FACEBOOK

GOOGLE

TWITTER

SALESFORCE

INTEL

APPLE

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## Artificial Intelligence Technologies - Downstream

- AI on target to eclipse human intelligence by 2029 – The future is here
- Predictive maintenance models used to avoid failure and unplanned outages
- Massive productivity gains attributed to plant & process optimization
- Optimize processing cycles and transportation
- Analyze weather patterns, economic dispatch

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# Artificial Intelligence in Oil & Gas - Upstream

- Equipment Ratings
- Seismic Vibrations
- Strata Permeability
- Thermal Gradients
- All can be layered and used to determine optimal drill direction, depth, and rate.
- Identify new well locations – AI used to assess historical well performance data – production increase 30%
- Billions in revenues at stake

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# Impact of Artificial Intelligence on Oil & Gas Industry

In upstream only, there is around USD 50bn at stake



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# Drone Technology



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## Drone Technologies - Refineries

- Tank roof inspections
- Vessel inspections
- Tower inspections.
- Thermographic inspections
- Flare stack inspections
- Flare re-ignition
- Contamination area inspections

## Drone Usage at Refineries



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# Drone Usage at Refineries



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# WIND FARM – PUNTA LIMA, PUERTO RICO



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# Drone Technologies

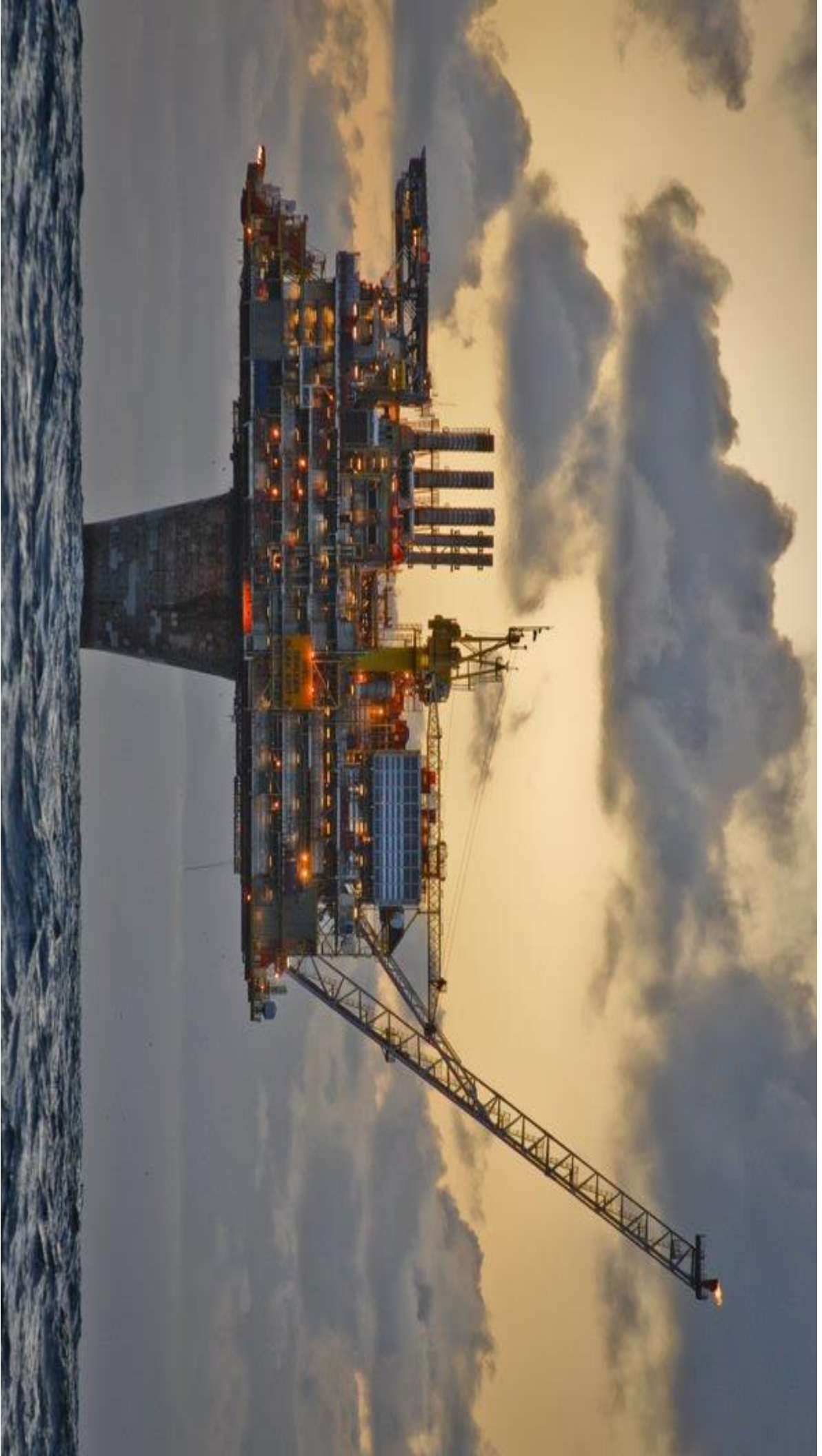
Unmanned Aerial Vehicles (UAVs) usage expanding exponentially

Visually inspect flares tips – Tough locations such as the North Sea – safer than climbing, much less costly than helicopters.

Visually inspect:

- Pipelines
- Tanks
- Electrical Apparatus
- Flares
- Facilities Inspections

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# Technology Advancements

Major players marrying drone technology to AI

- General Electric, Siemens, IBM, ABB, others
- \$100B USD by 2020
- UAVs
- Robot Crawlers
- Thermal Scanning & Imaging
- Laser Measurements
- Pipeline Leakage Sensors
- Electro Magnetic Interference
- Ambulance
- Taxis

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# DRONE TAXI



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## DRONE TAXI



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# DRONE AMBULANCE



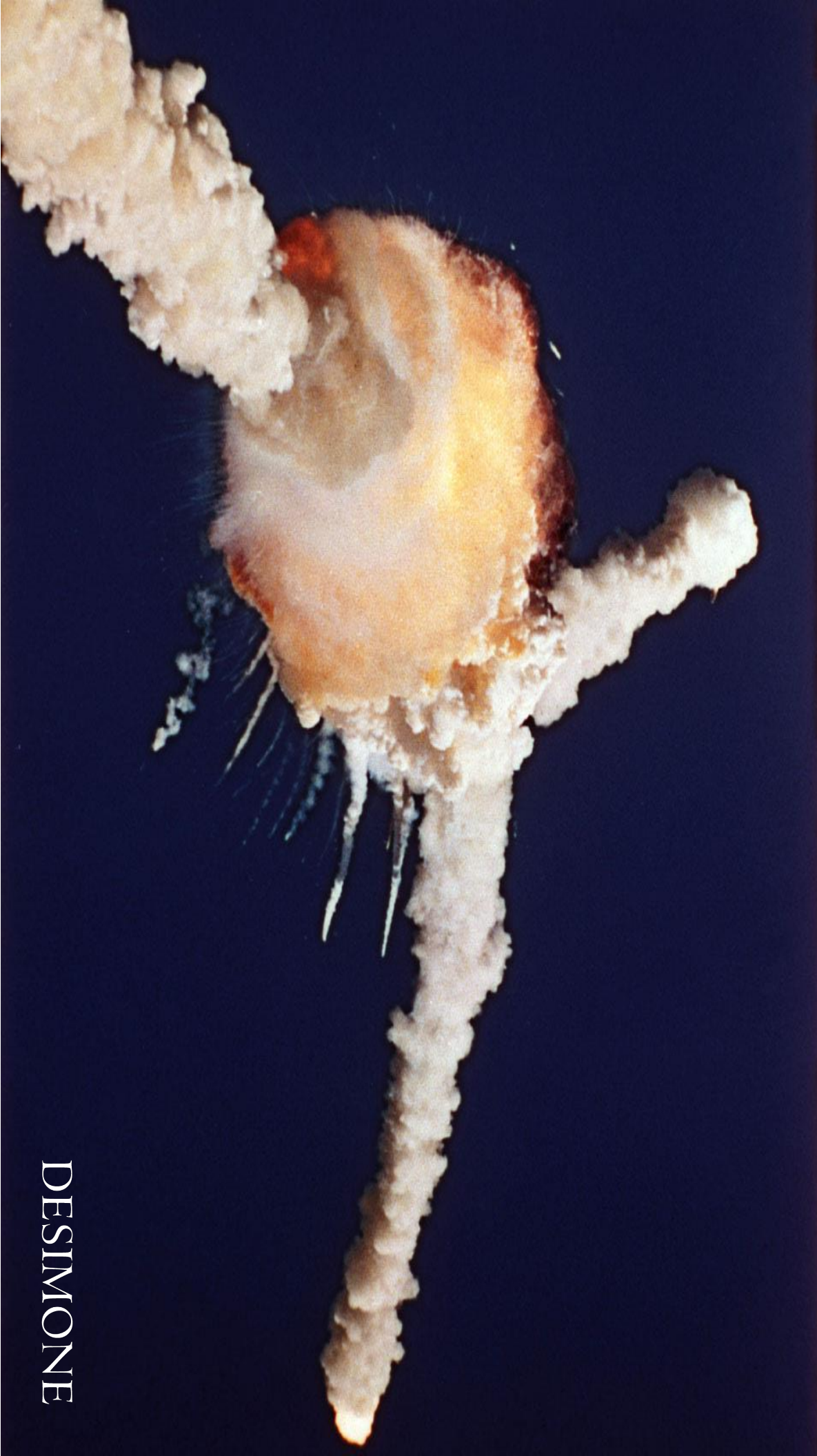
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A photograph of a large industrial building at night. A fire is burning on the roof of the building, with bright orange and yellow flames visible. The building has a light-colored, possibly white, roof. In the foreground, there are some industrial structures and a sign that says "XTRA". The background is dark, suggesting it is nighttime.

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# EXPLOSION AT TEXAS CHEMICAL PLANT

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## Common Mode Failure: Human Factors

- Technology is only effective, safe, and useful if it is managed properly.
- Human Factor Engineering – Improve technology to prevent human error as a causal factor

## Andrew Hopkins (Failure To Learn) “Awful Sameness”

- Corporate cost cutting
- Failure to invest in plant infrastructure
- Lack of corporate oversight
- Lack of process safety
- Inadequate training
- Incompetent supervision
- Poor communications
- Poor decision making
- Aged, broken, or inop controls, gauges, indicators
- Lack of maintenance spending, equipment repair & replacement

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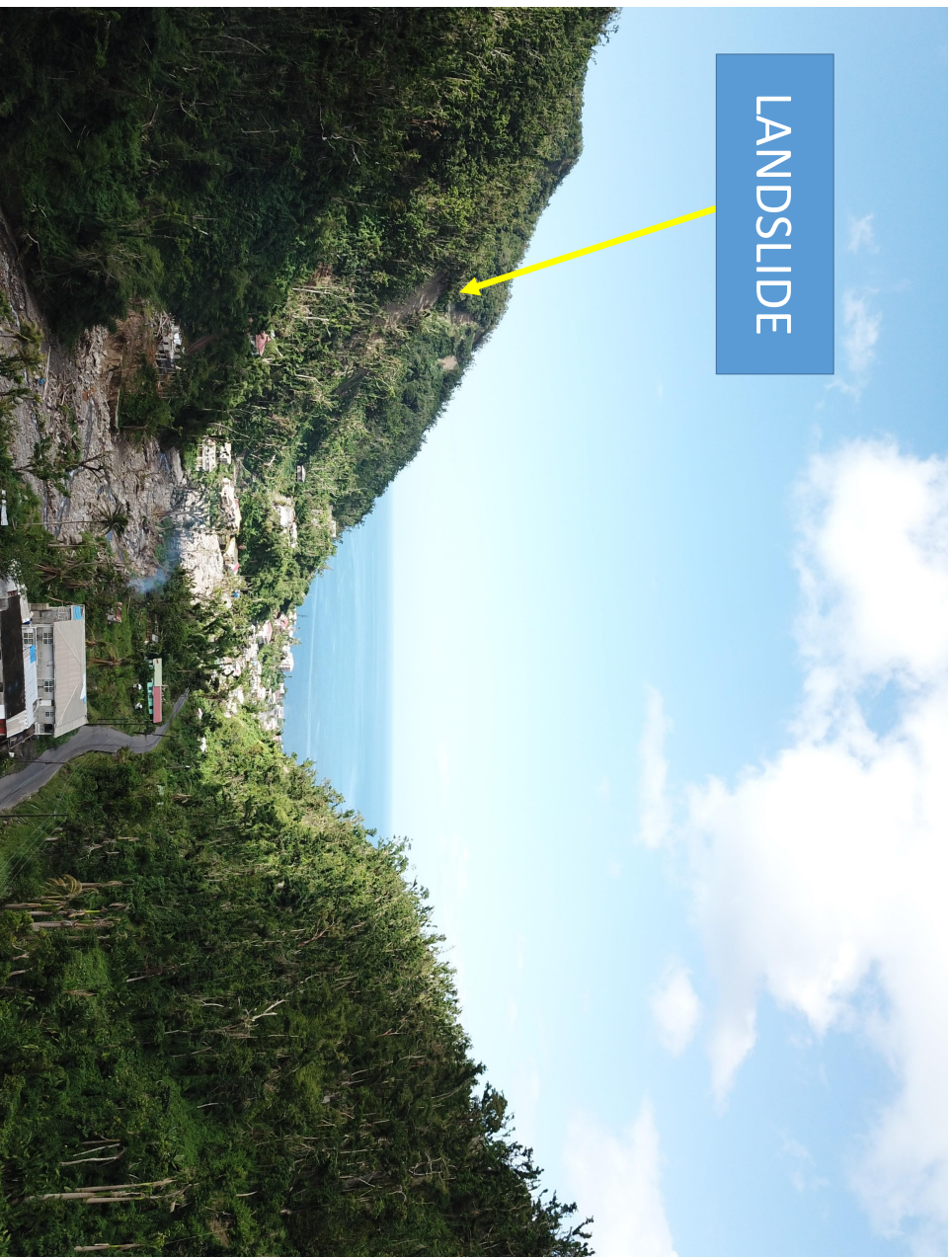
# LANDSLIDES AND FLASH FLOODS



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# FLASH FLOOD TO OCEAN



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# CAR BLOWN OFF MOUNTAIN SIDE



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## STROLL IN THE NEIGHBORHOOD



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## RASTA BUCKET MON



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# CALM AFTER THE STORM



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DeSimone Consulting Engineers      DeSimone Consulting Engineers  
Miami, Florida, USA      New York, New York, USA

March 19, 2018

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