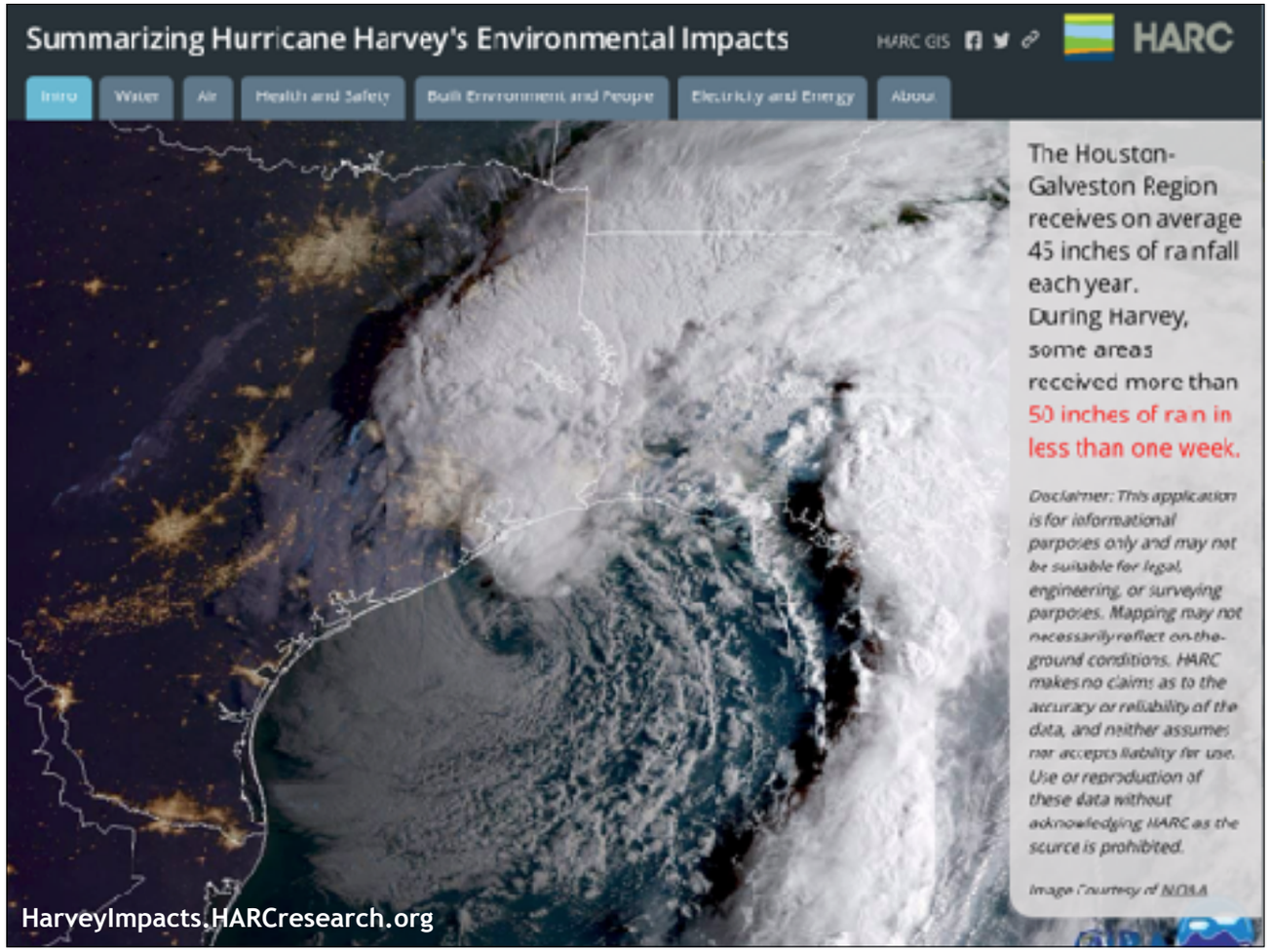
Hurricane Harvey brought record rainfall to Houston; the resulting flooding led to regional devastation, impacting lives, homes and livelihoods. The storm also had numerous environmental impacts. The Houston Advanced Research Center (HARC) mobilized swiftly to acquire and process data and information about the flooding and related environmental impacts, such as storm-related spills, pollutants, Superfund site impacts, water quality, air quality, and power generation. The resulting analysis is shown through narrative summaries, maps, and infographics in the story map, “Summarizing Hurricane Harvey’s Environmental Impacts”. To view the story map, visit http://HarveyImpacts.HARCresearch.org.

HARC is a nonprofit research hub providing independent analysis on energy, air, and water issues to people seeking scientific answers. We are focused on building a sustainable future that helps people thrive and nature flourish.

Bill Bass is a Senior Manager and certified GIS professional (GISP) at HARC (Houston Advanced Research Center), responsible for Geographic Information Systems (GIS), analytics, and enterprise technology. He has extensive experience in geospatial technologies, project management, analytics, and enterprise solutions, including platforms such as ESRI ArcGIS and SAS. Prior to joining HARC, Bill was the Geospatial Program Manager for the Houston-Galveston Area Council (H-GAC), a regional planning agency for the 13-county region surrounding the Houston metropolitan area. Bill has over 10 years consulting experience for global management consulting firms, and has a master’s degree in Geography from Texas State University, and a bachelor’s degree in Management Systems form Arizona State University. Professional interests include geospatial enterprise architecture, data science, analytics, environmental research using geospatial technologies, and delivery of information through interactive mapping and analytical applications. Bill is a native Houstonian having grown up in the Clear Lake and Galveston Bay part of the region. He is a member of Bayou Land Conservancy's Board of Directors and their Spring Creek Ambassador program. Bill is also an avid wildlife, landscape, and conservation photographer.



- Hurricane Harvey dropped more than 50 inches of rain in some areas.
- Region receives approximately 45 inches of rainfall per year.
- You can view the Hurricane Harvey story map at http://HarveyImpacts.HARCresearch.org
- The purpose of our story map was to communicate environmental and infrastructure issues to the general public and key decision makers.
- Our analysis revolved around five key areas:
    - Water quality
    - Air quality
    - Health & Safety
    - Built environment
    - Electricity & energy infrastructure

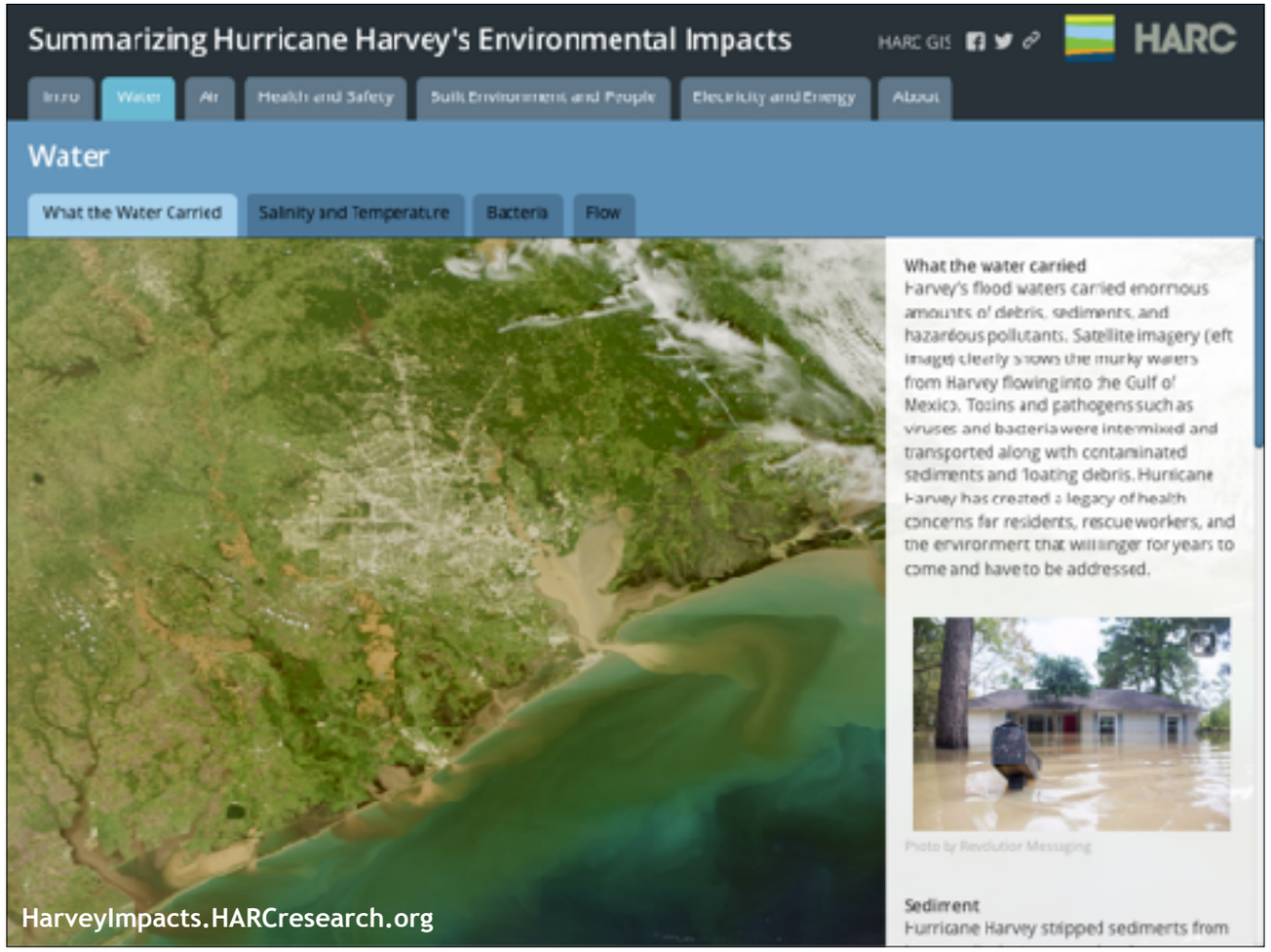
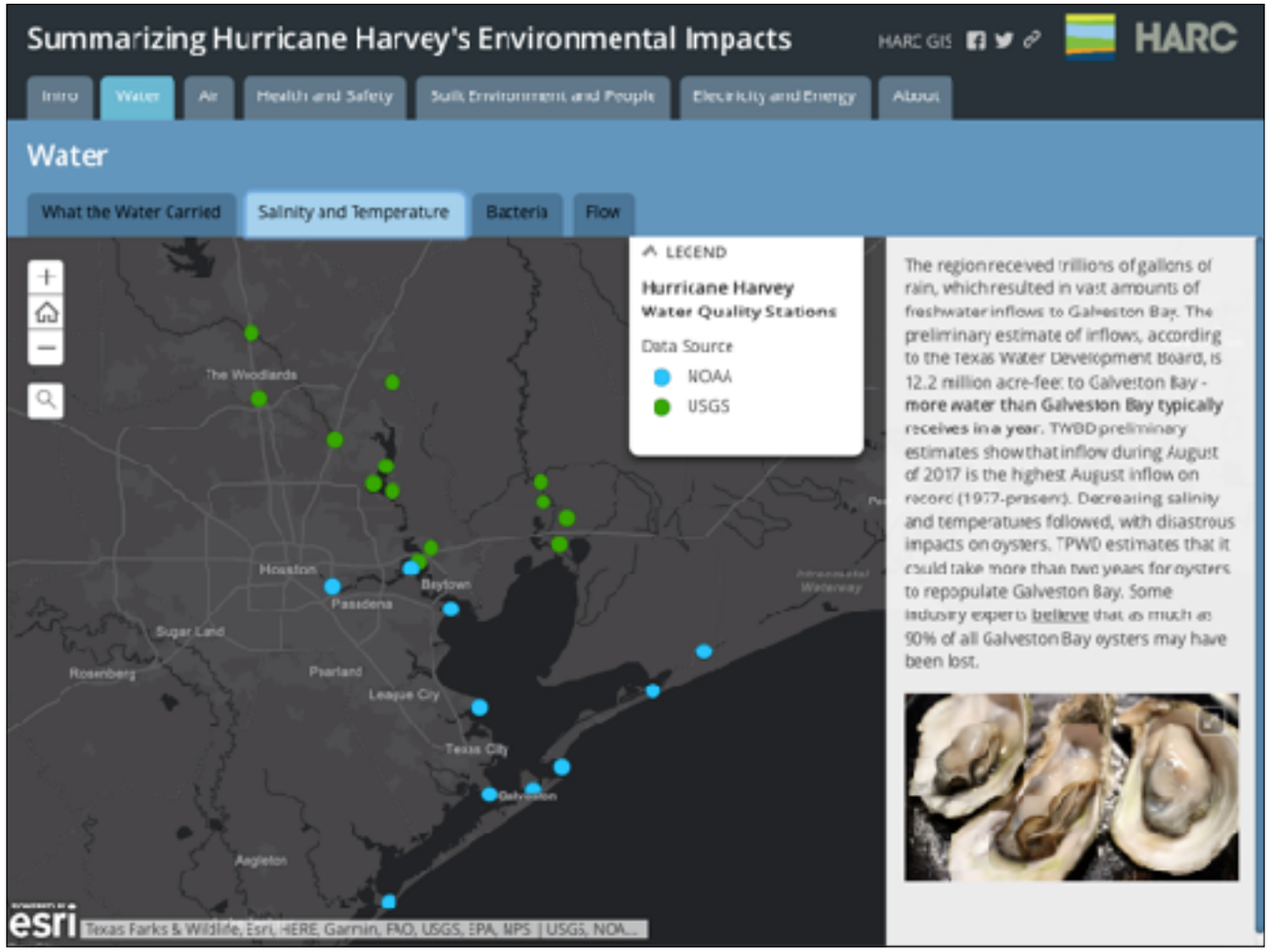


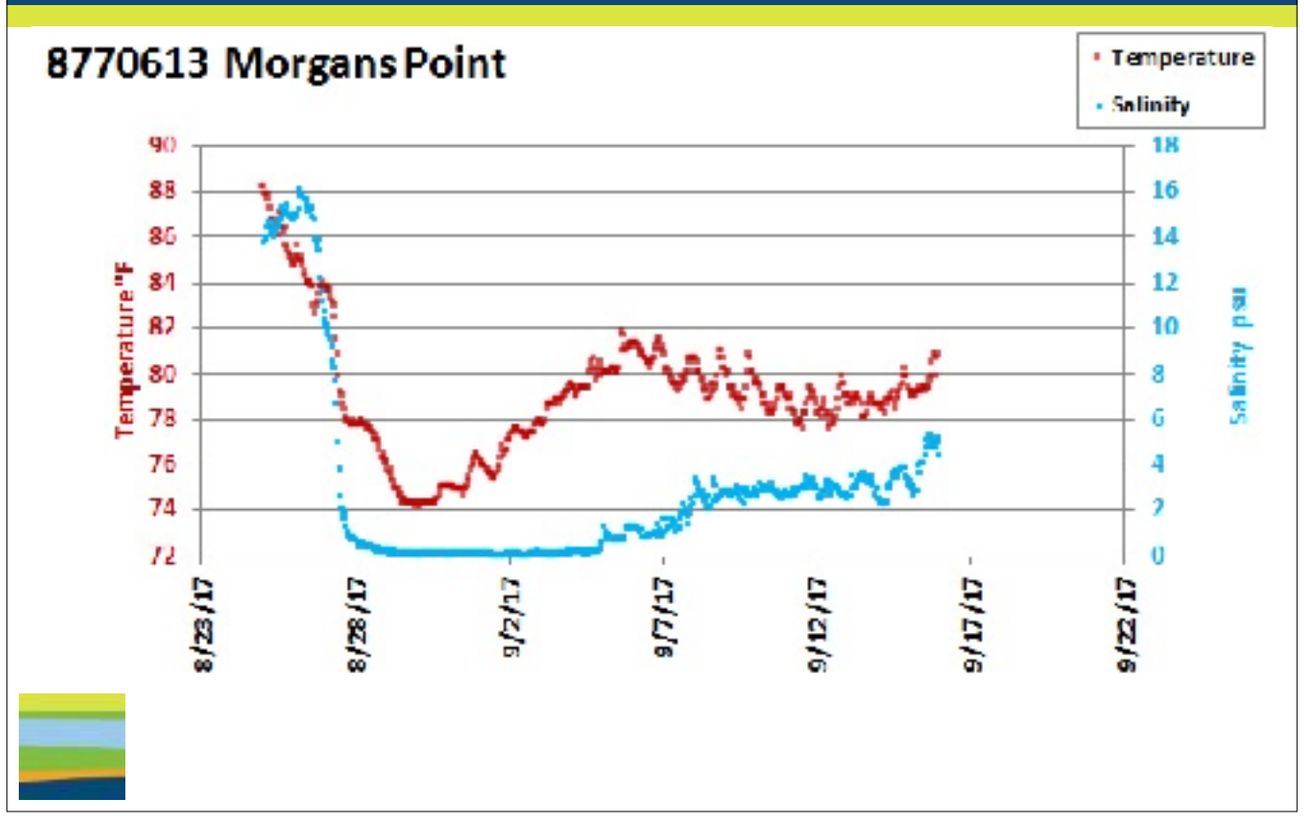
Image by: NASA

- Runoff from Galveston Bay and smaller rivers to the south.
- Ejection plumes: Wasn’t just sediment; debris and hazardous pollutants from spills and wastewater overflows.

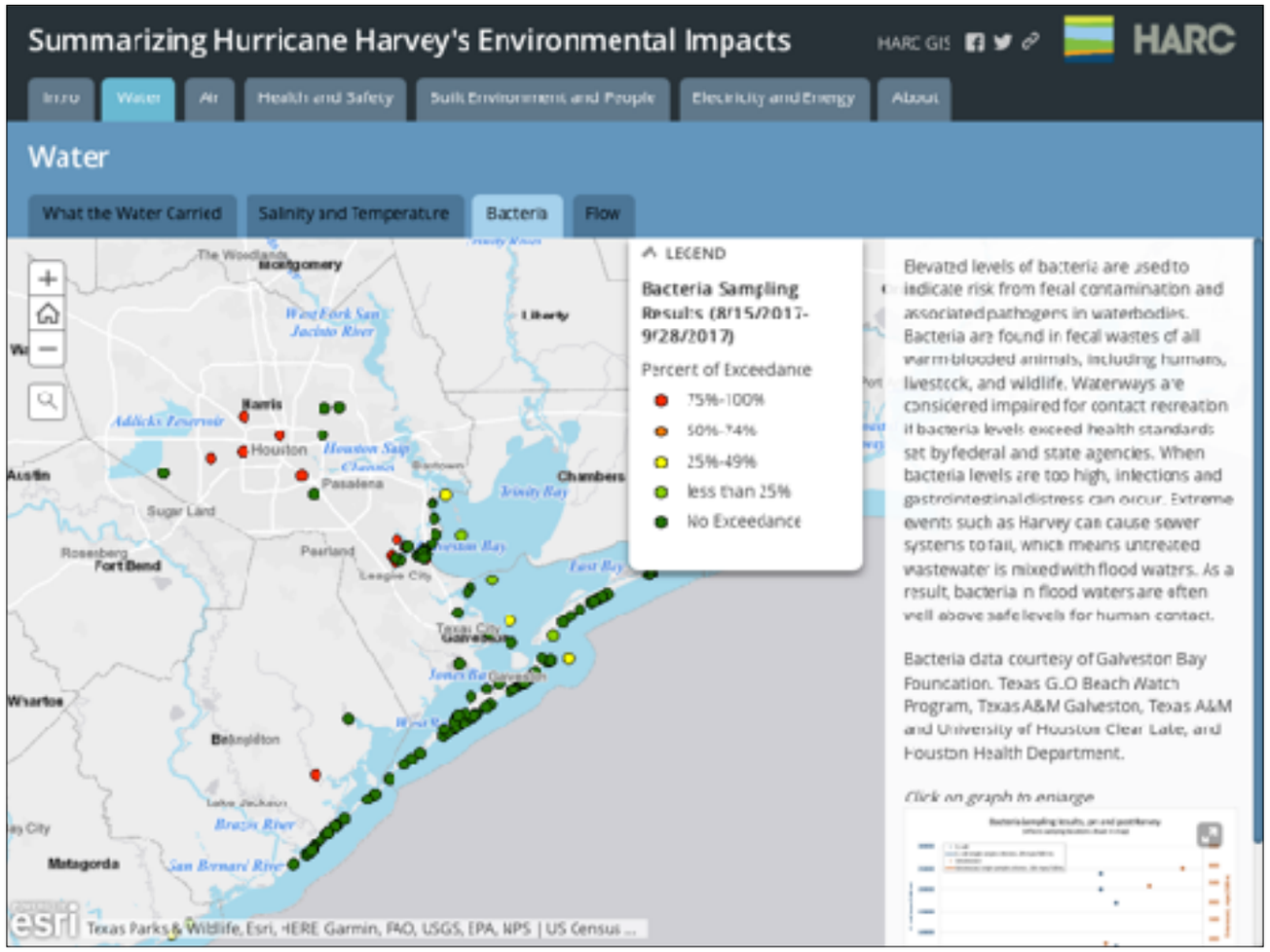


- HARC undertakes an annual research project called the Galveston Bay Report Card (www.GalvBayGrade.org) that assesses the health of Galveston Bay across a number of key indicators.
- Before Harvey, were seeing pressures on oyster reefs from droughts, over-harvesting, and 3 major freshwater inflows in as many years. Will be monitoring closely to see where indicators go from here.
- During Harvey temperatures fell from mid-80's to the low 70's.
- Salinity fell from the 14-16 range to low end of 0.09 to 0.01 range.

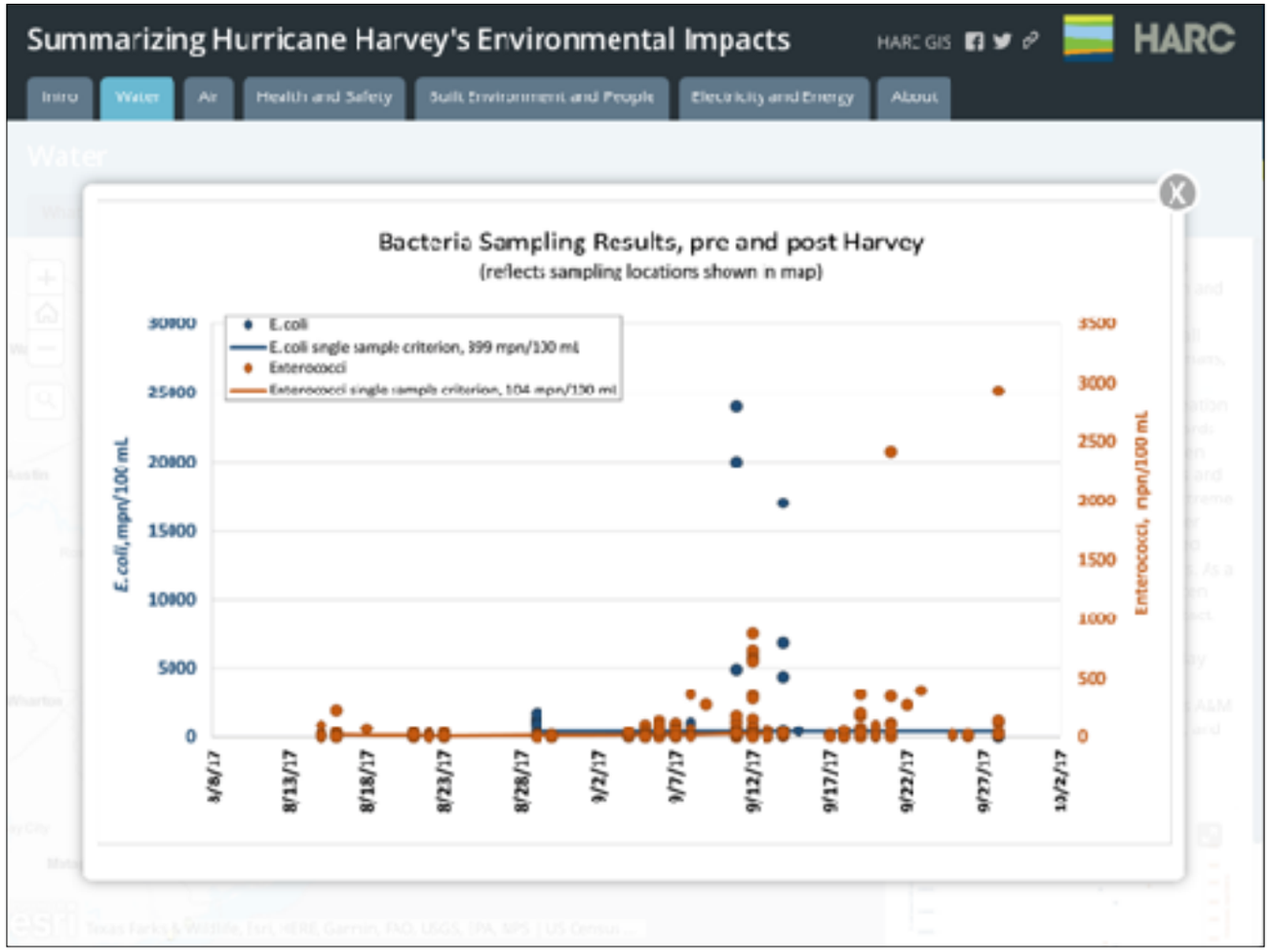
Temperature & Salinity



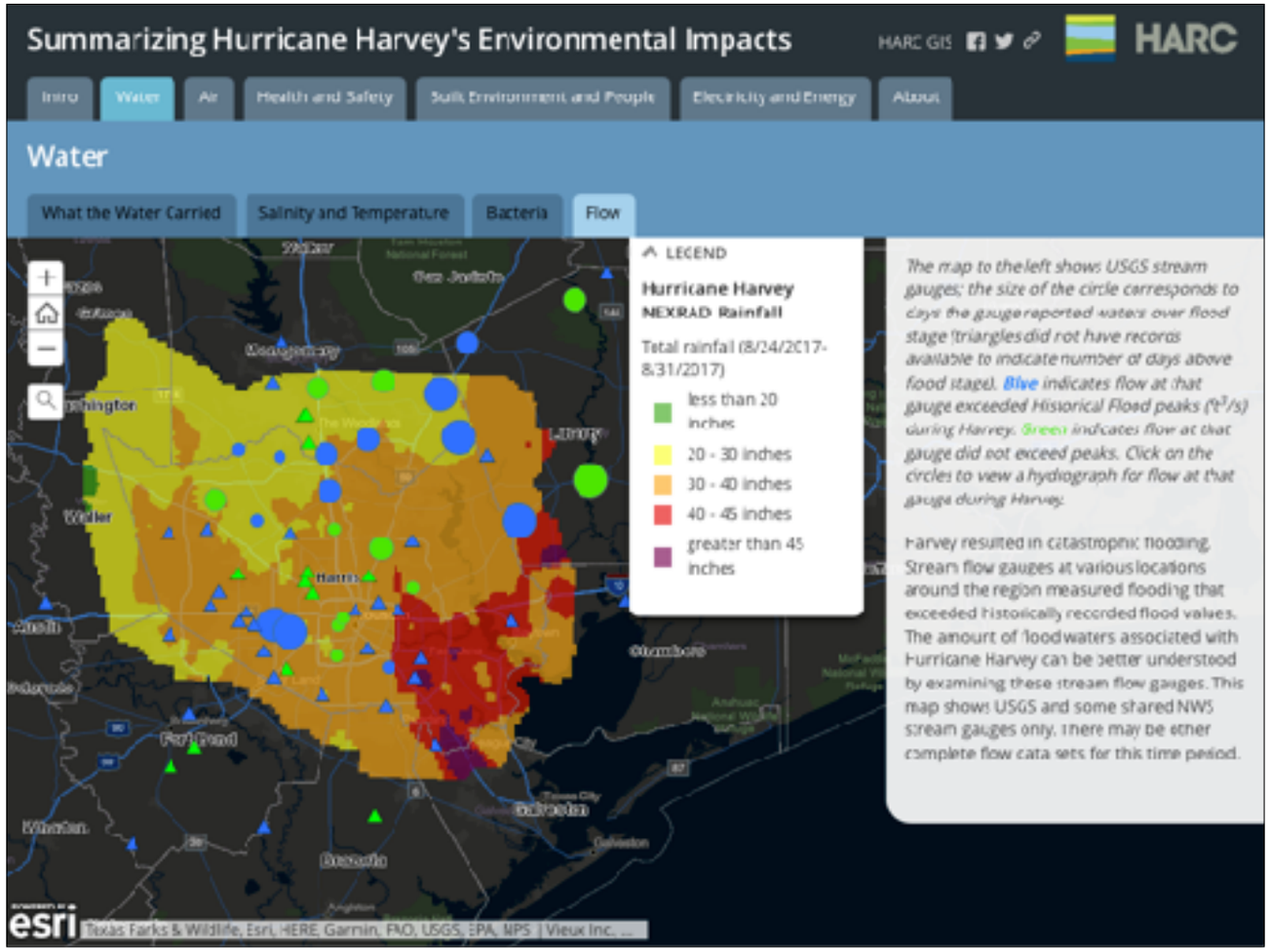
- Time series graph of the Morgan Point sampling station.
- Drop in temperature and salinity before, during, and after Harvey.



- Water quality sampling points and percentage of samples that exceeded acceptable levels.
- Inland water quality issues included eColi and Enterococci bacterium.

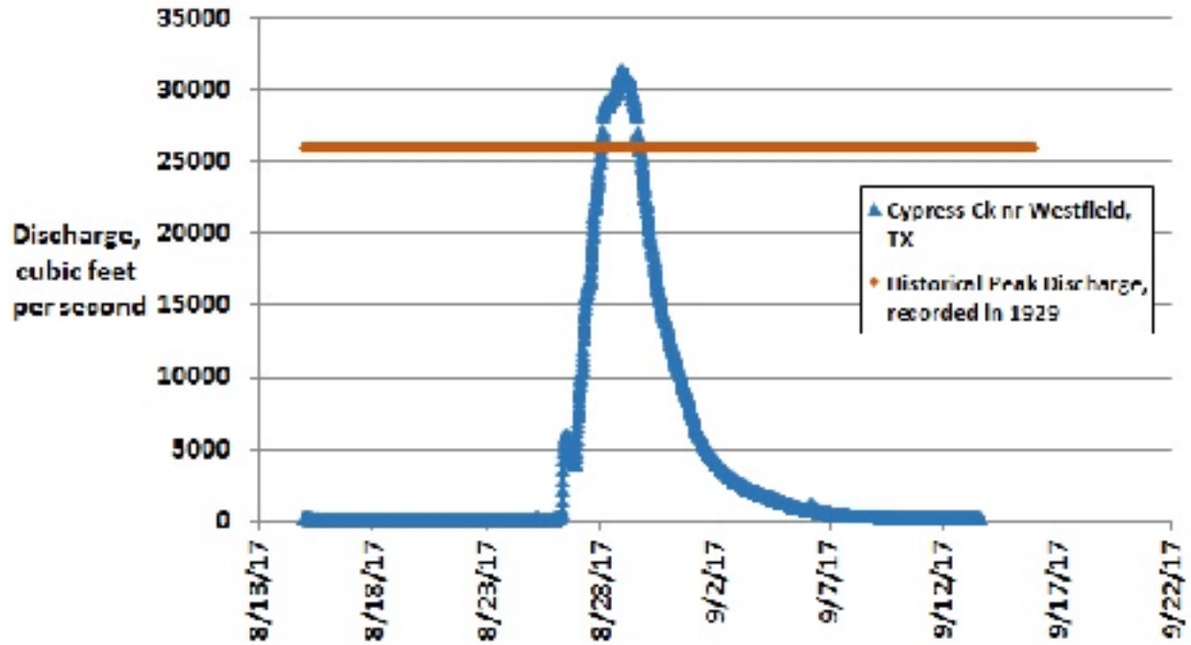


- Blue and orange lines at bottom represent criteria for sampling.

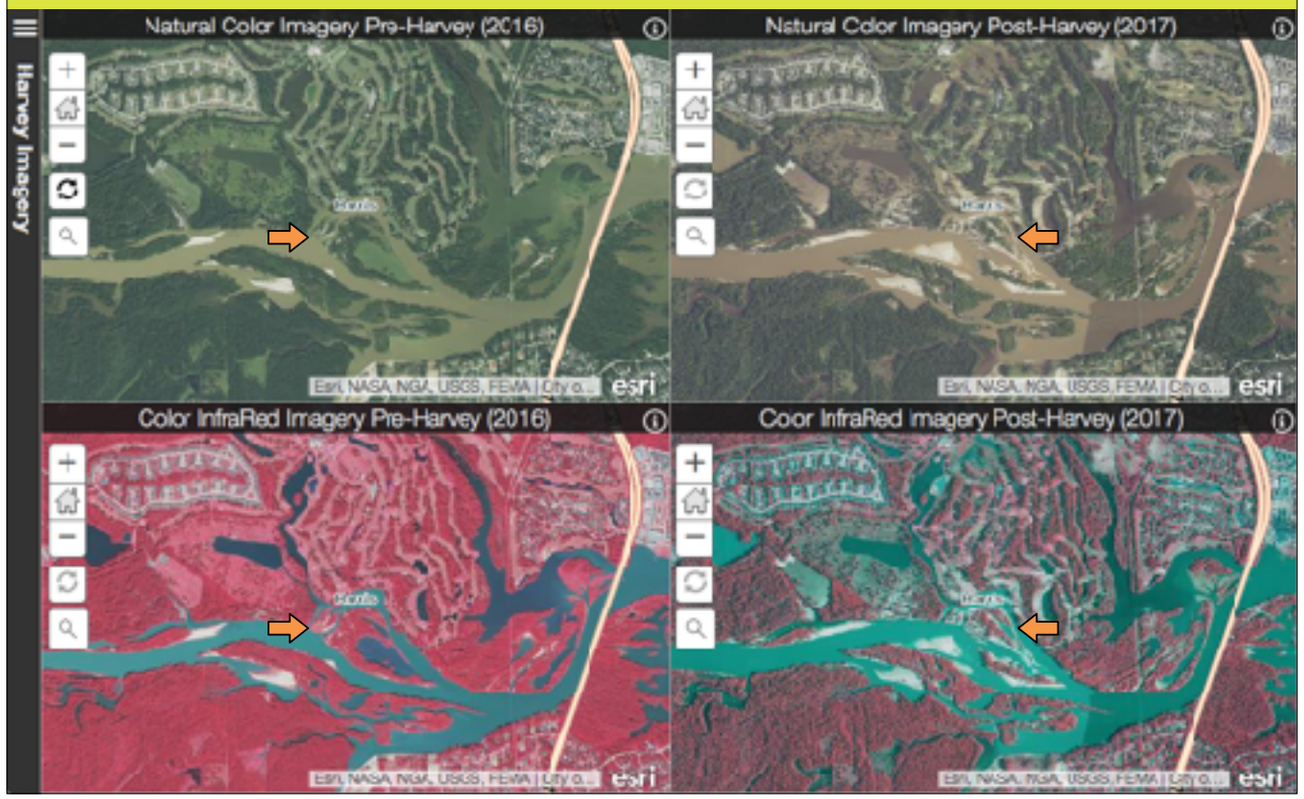


- Background: Nexrad data grids showing rainfall (grid is 1 KM^2).
- Circles: Stream gauges measuring flood levels (ft^3/s) over time.
    - Blue: Exceeded historical flood peak.
    - Green: Did not exceed historical flood peak.
    - Larger the circle the more number of days gauge was over flood stage.
- Triangles: Stream gauges where we did not have time series data.
    - Blue: Exceeded historical peak.
    - Green: Did not exceed historical flood peak.

Historical & Harvey Flows
Cypress Creek & I-45



Erosion & Sand Deposits
West Fork San Jacinto River & Kingwood



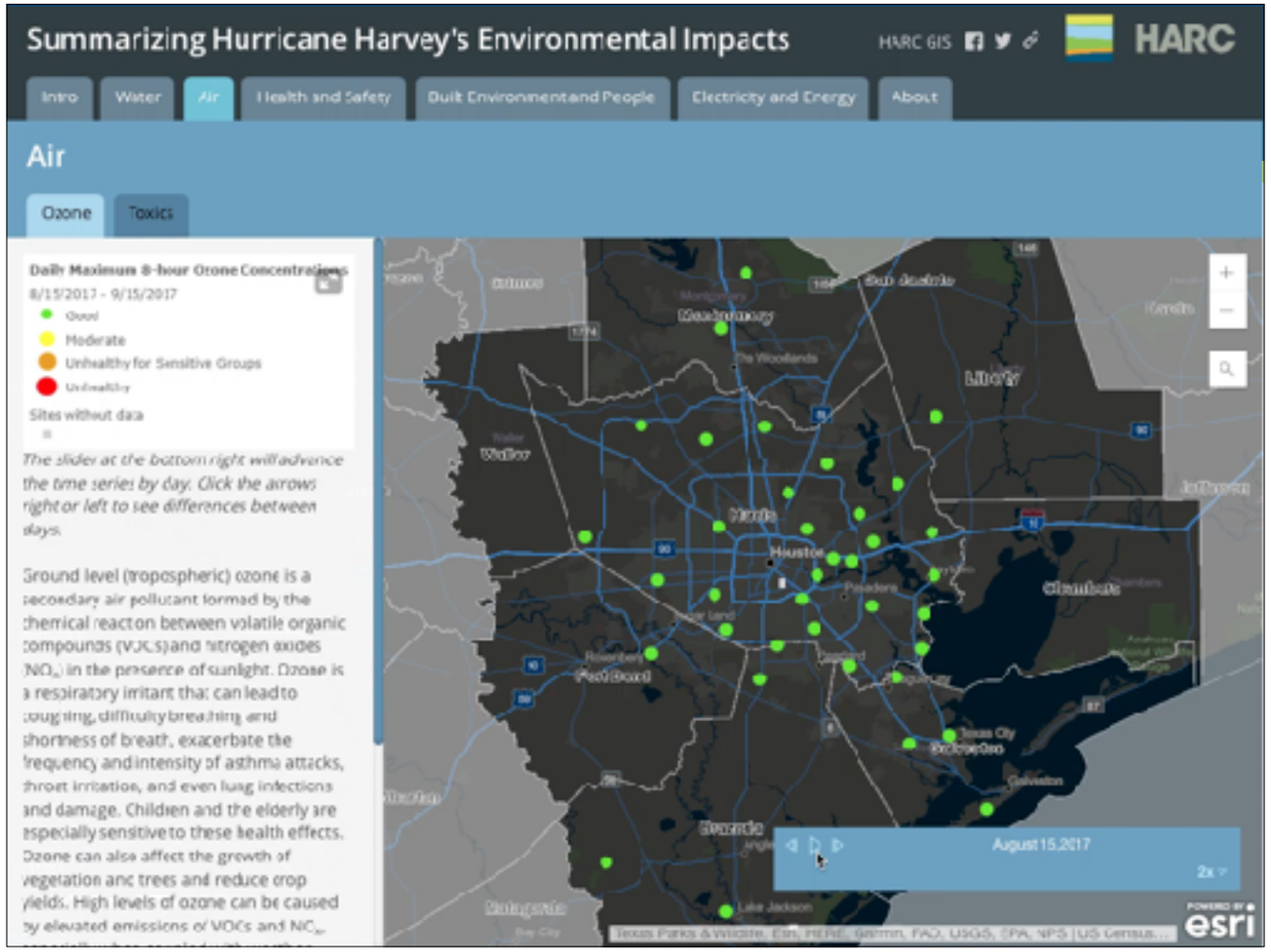
- Orange arrow indicates area of major erosion and sedimentary deposit.
- Becoming a concern as upstream are sand pit operations that may have contributed to sedimentation.

Eco-Logical Damage
Cypress Creek & Hardy Toll Road

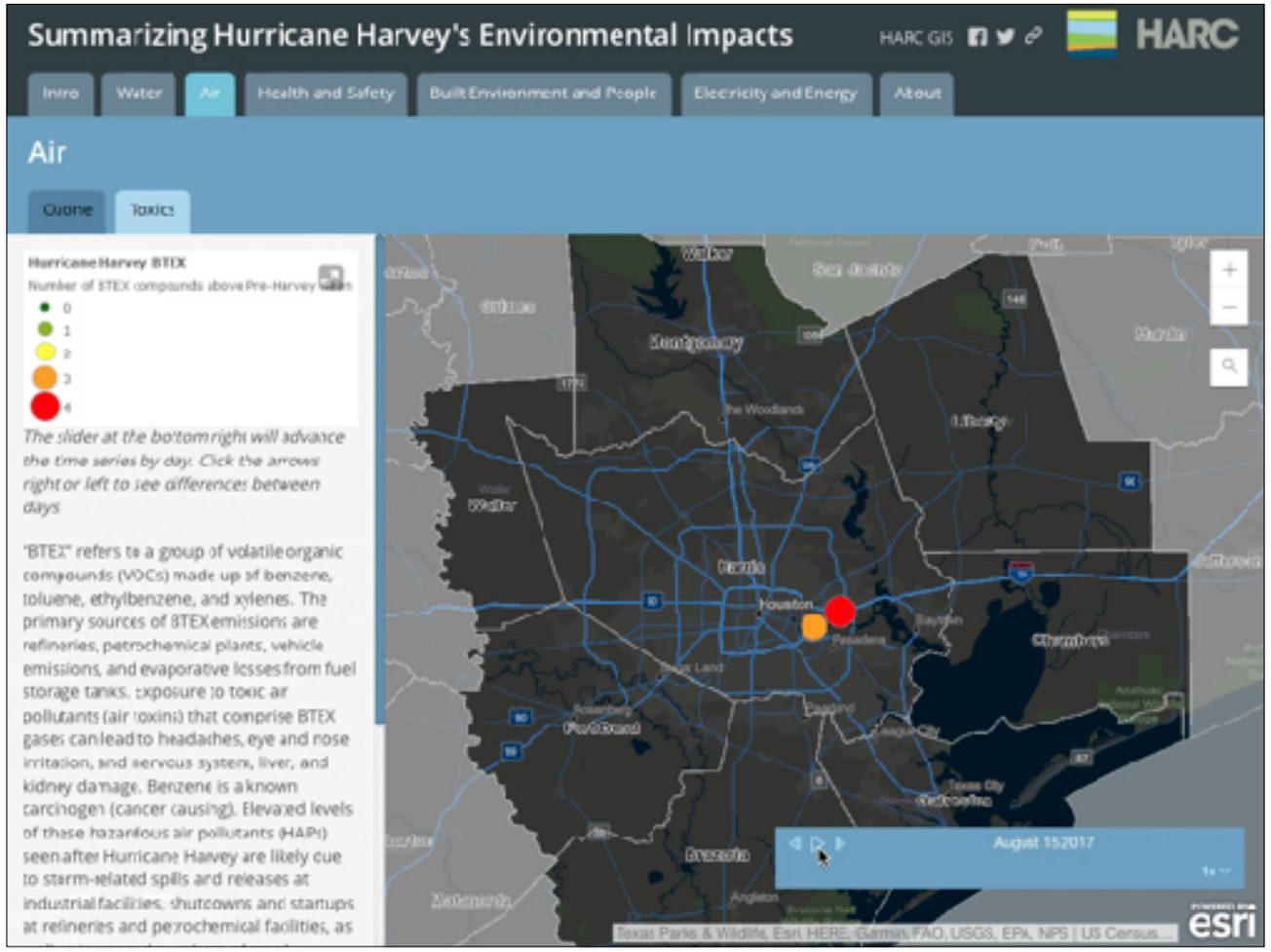
- Extensive damage to valuable riparian areas.
- Ashton Gardens Preserve under management by Bayou Land Conservancy. http://www.bayoulandconservancy.org

Ashton Gardens Preserve
(Cypress Creek & Hardy Toll Road)

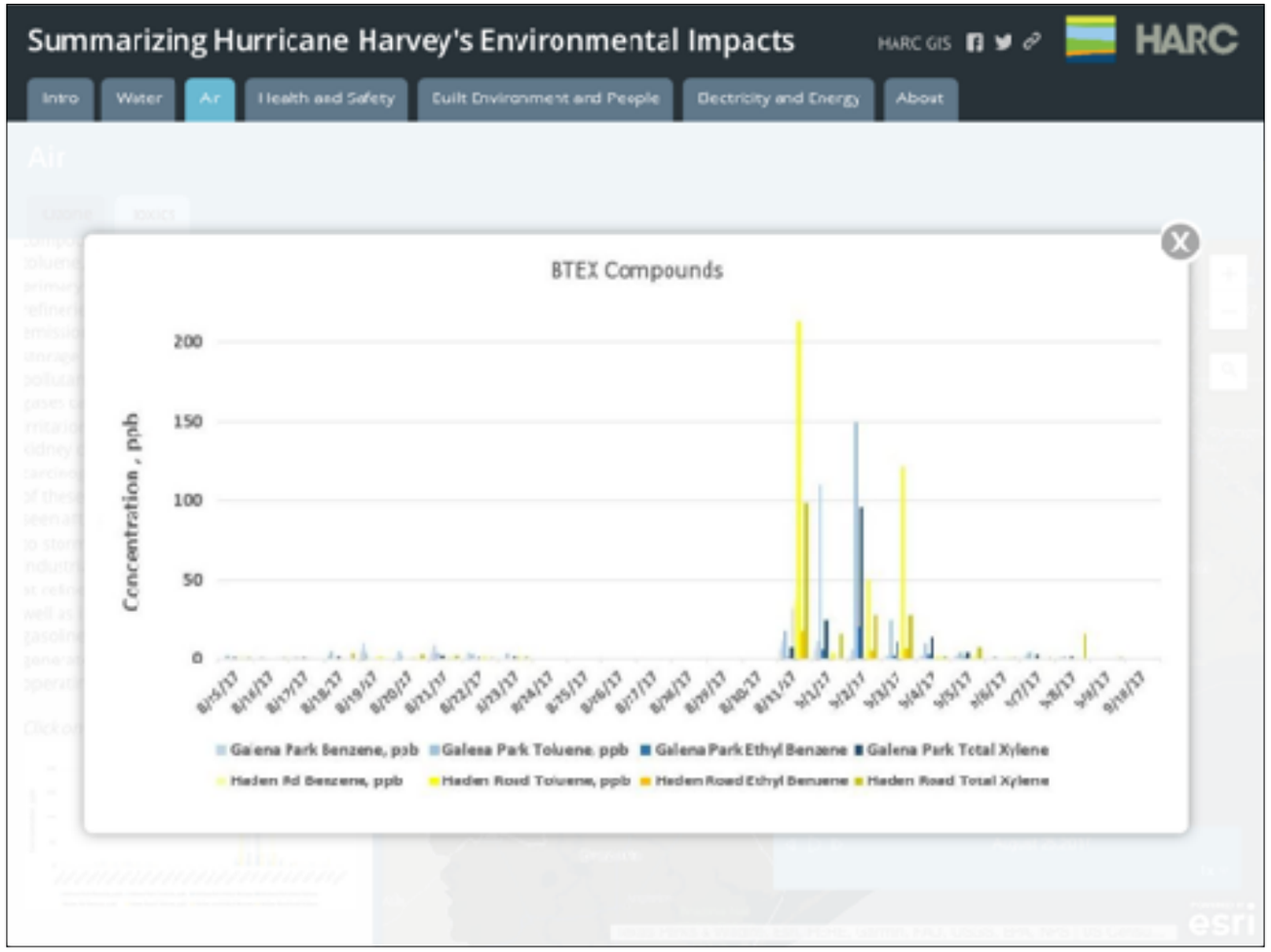
Ashton Gardens Preserve
(Cypress Creek & Hardy Toll Road)



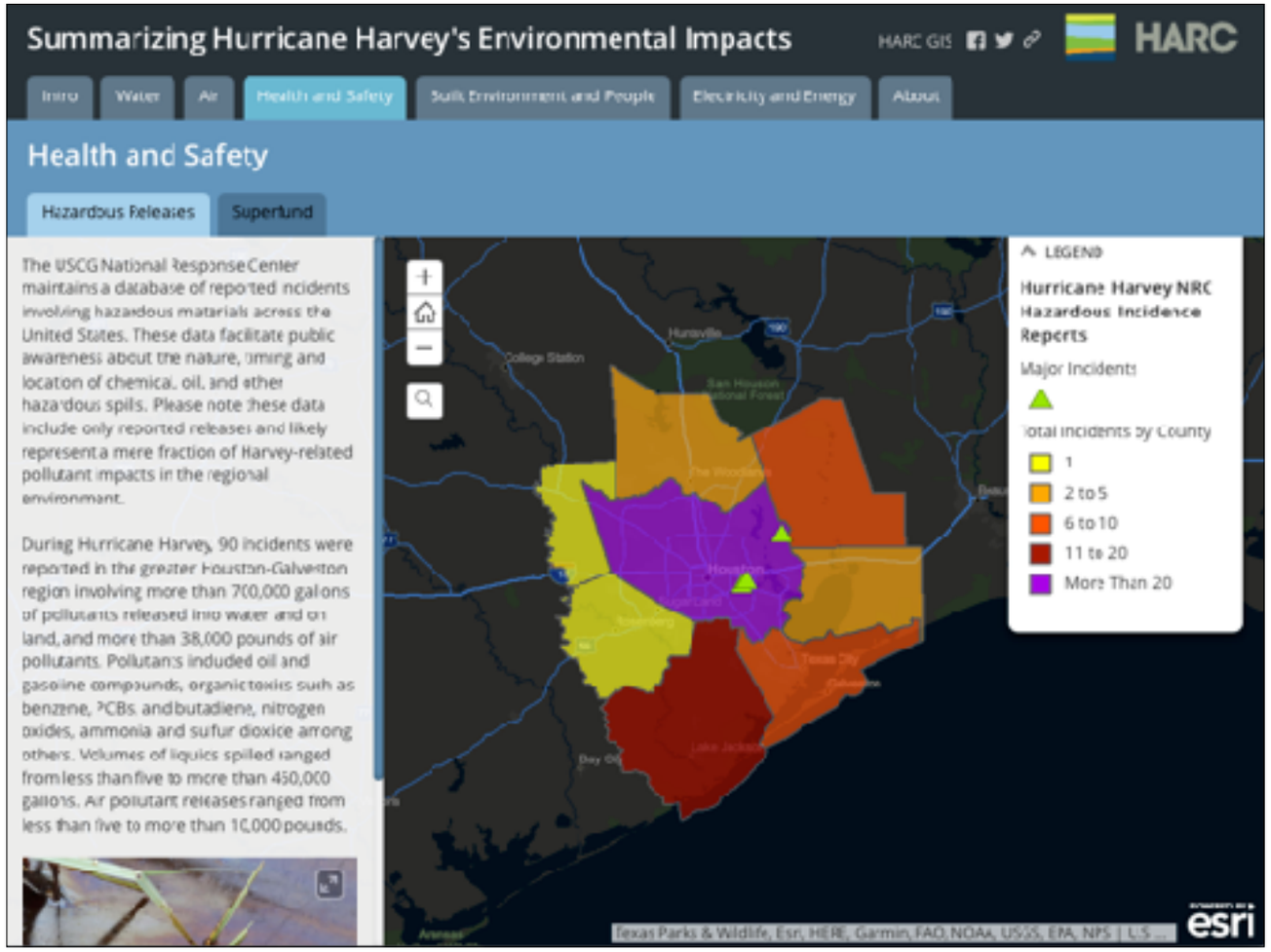
- Stationary ozone monitors that operate year round. (TCEQ https://www.tceq.texas.gov)
- Ozone is created by the reaction of Volatile Organic Compounds (VOCs) and Nitrogen Oxides (NO_x) with sunlight.



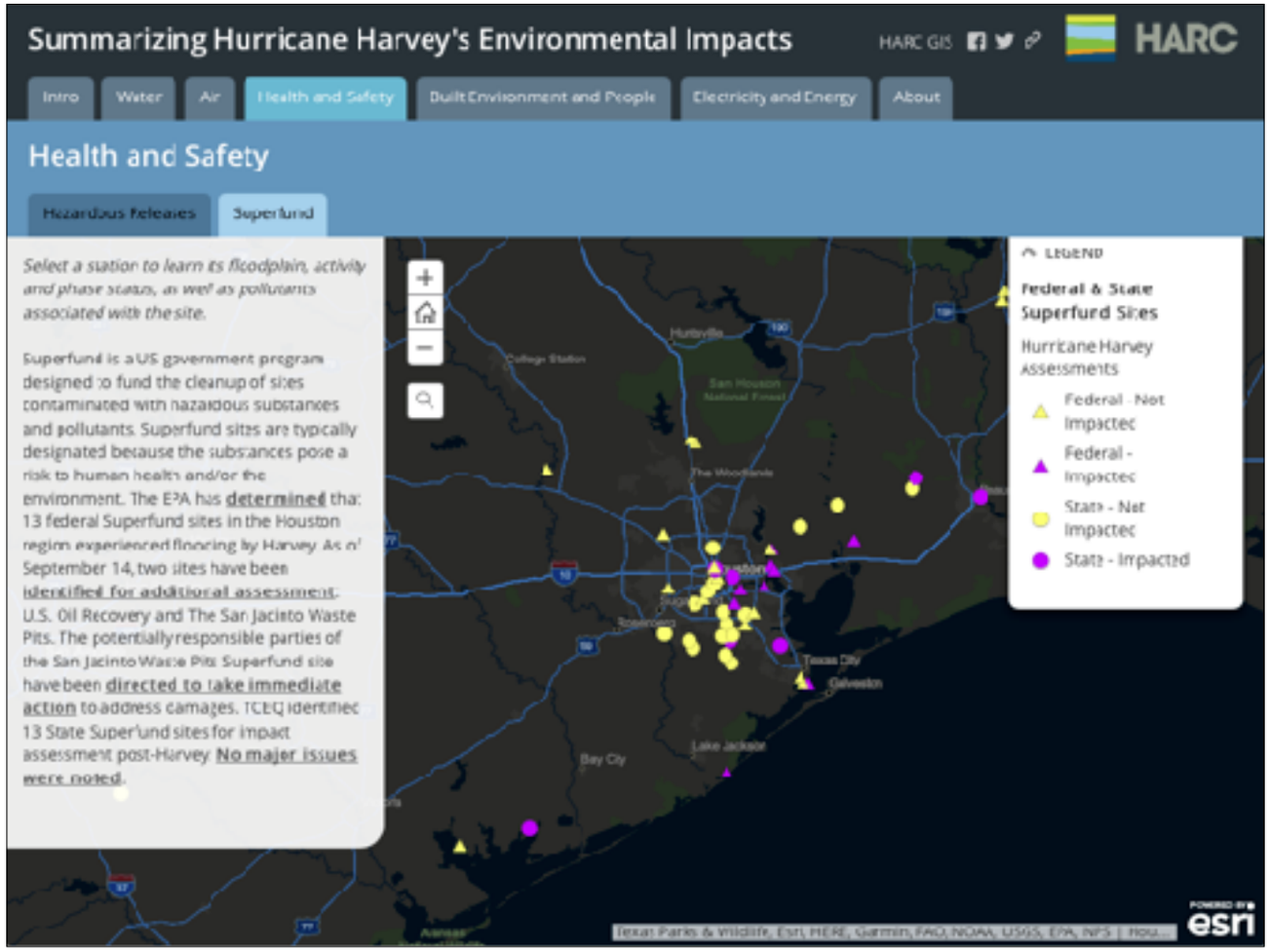
- HARC has a history of measuring and researching BTEX compounds in the region.
- BTEX: Benzene, Toluene, Ethybenzene, and Xylene.
- The initial two points are stationary year-round monitors (TCEQ).
- Subsequent points were from a mobile monitoring vehicle (Environmental Defense Fund (https://www.edf.org) & Air Alliance Houston (http://airalliancehouston.org).



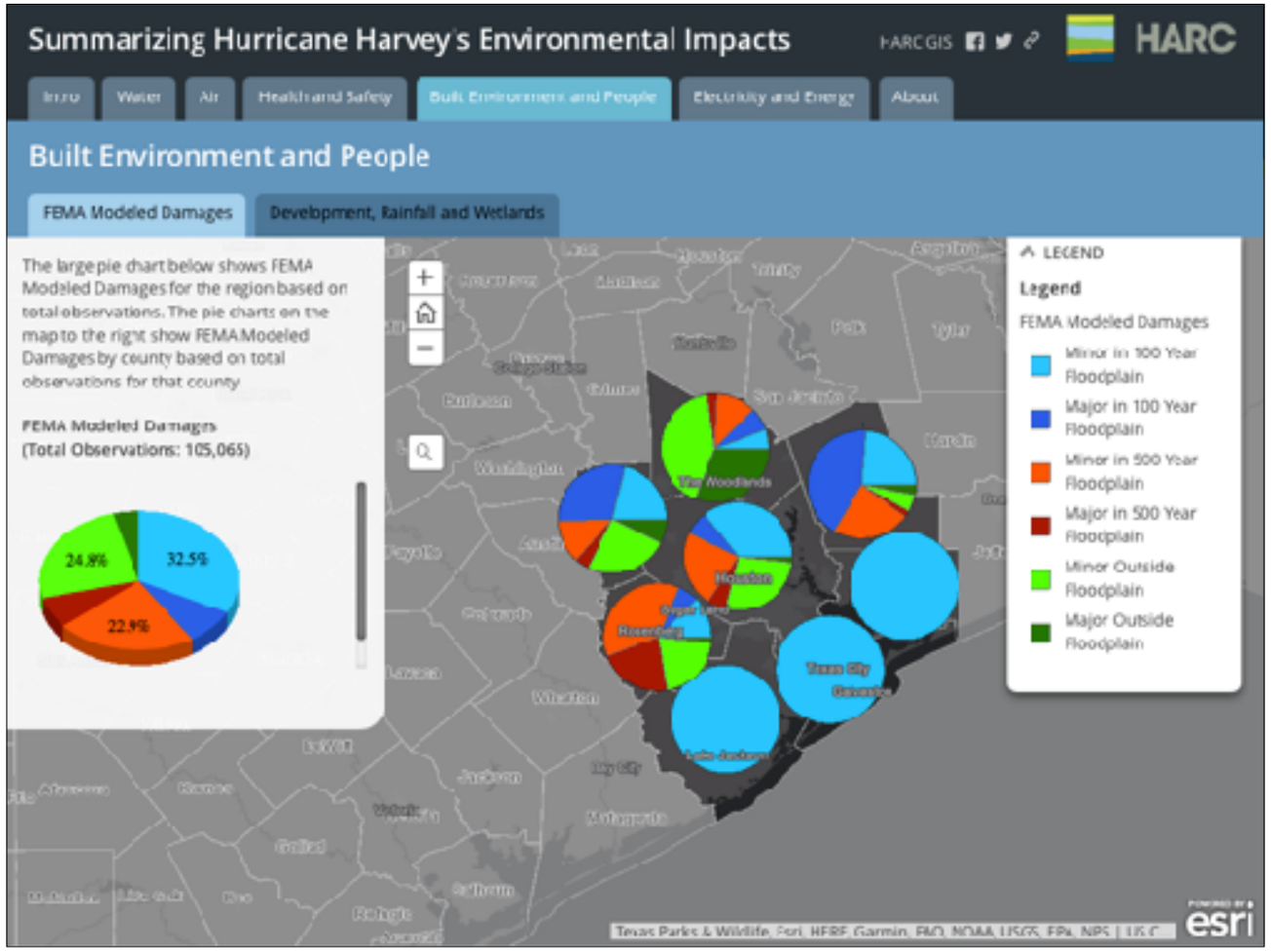
- Two stationary TCEQ BTEX monitors.
- Before & after measures of BTEX compounds.
- Note the drop to zero during Harvey as this was when refineries shut down their operations.
- Raises questions about re-starting refining operations all at once vs. a staggered start following major events like Harvey.



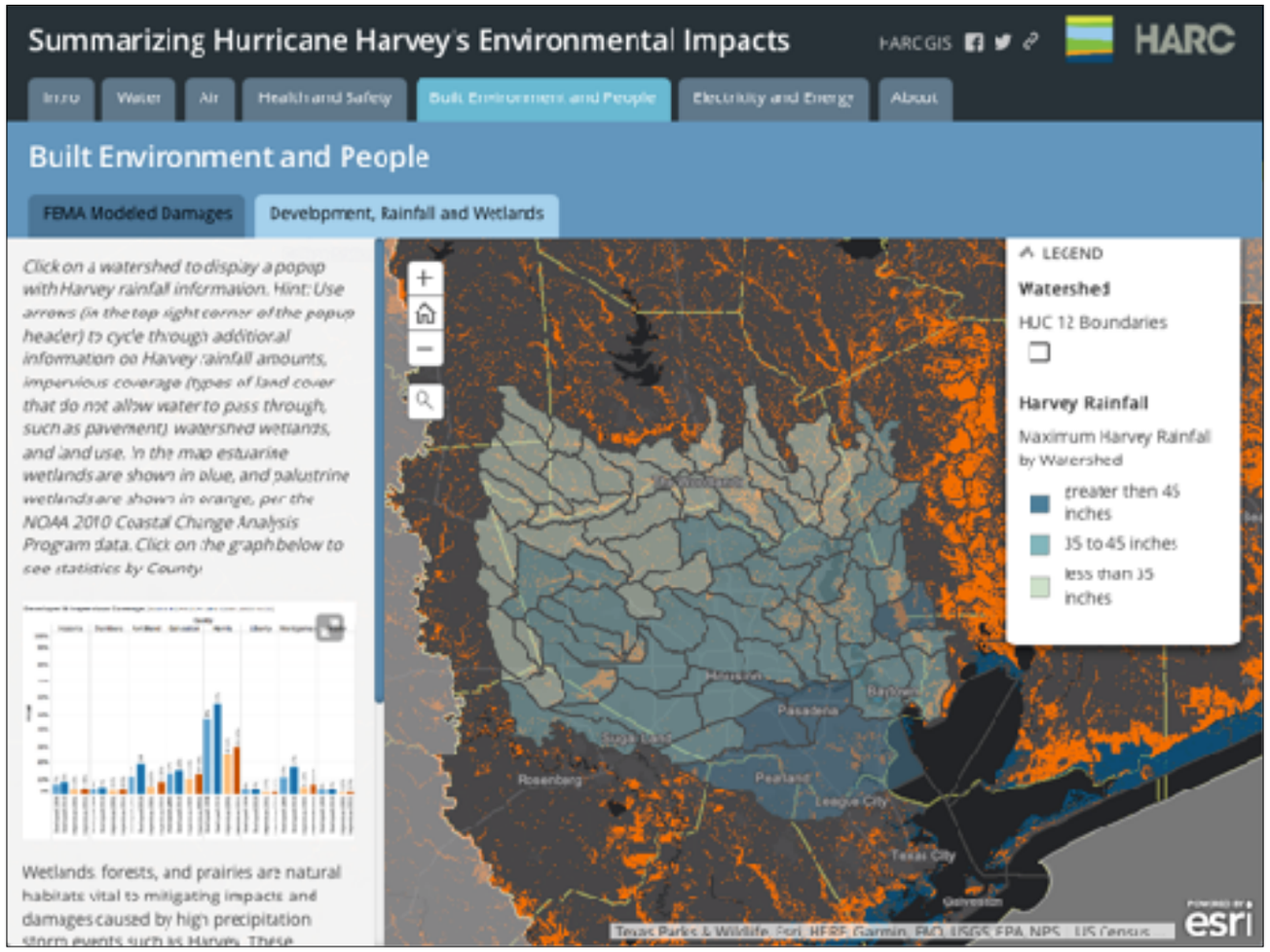
- Collected data from the US Coast Guard National Response Center (http://nrc.uscg.mil).
- More than 90 incidents in the 8-county region.
- Over 700,000 gallons of pollutants released into water or on land.
- Over 38,000 pounds of air pollutants.



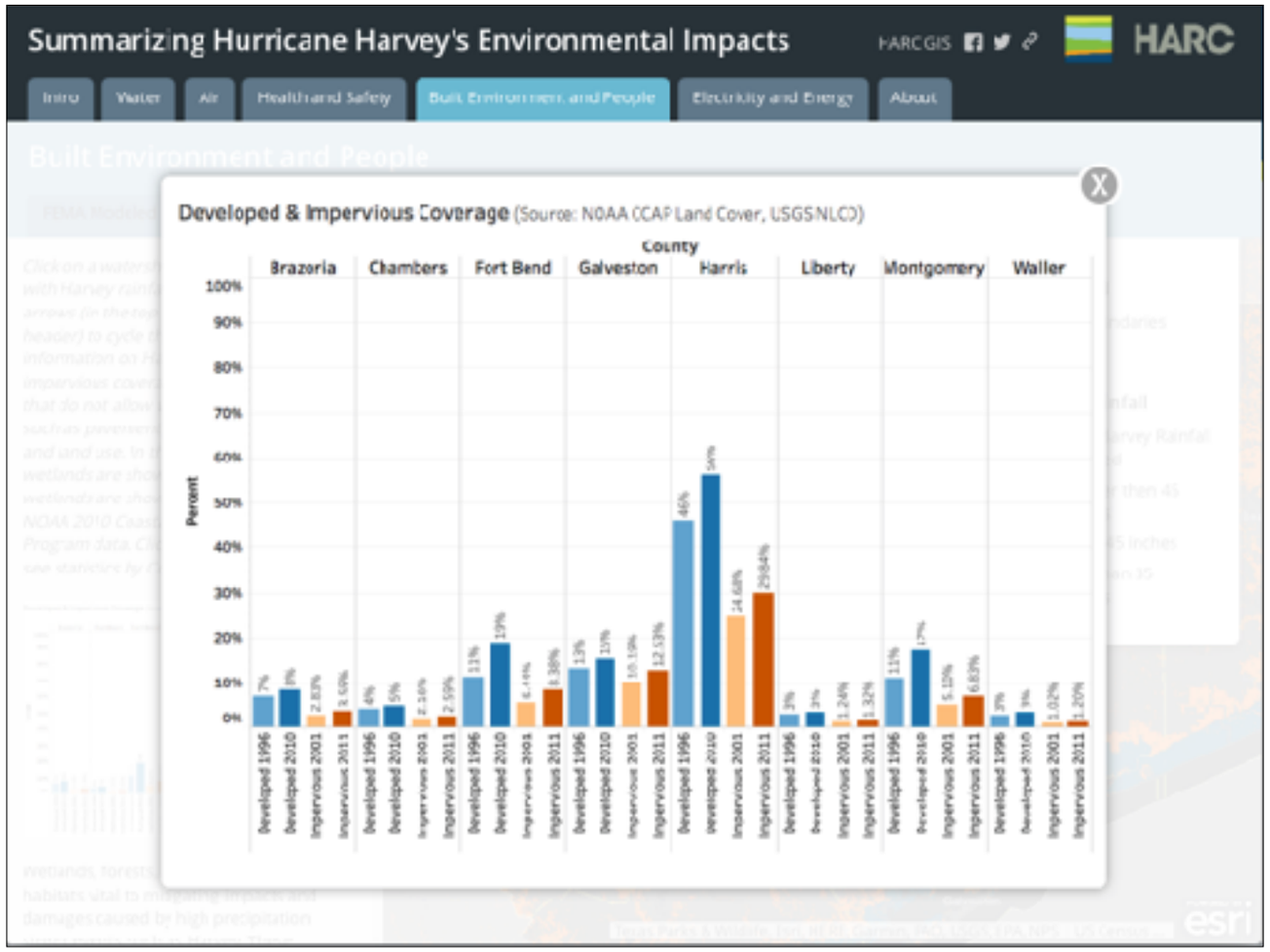
- The state released their assessments of superfund sites that were impacted.
- Most sites weren't impacted.
- Many remediated sites were inundated; good case for cleaning up sites.
- One site in particular was impacted, the San Jacinto River Waste Pits.
- The protective cap was damaged at the site
- Recently announced a plan is being developed for the removal of toxic substances from the site. However, the temporary cap repair that was done following Harvey has not held up and seems to be leaking again based on recent news reports.



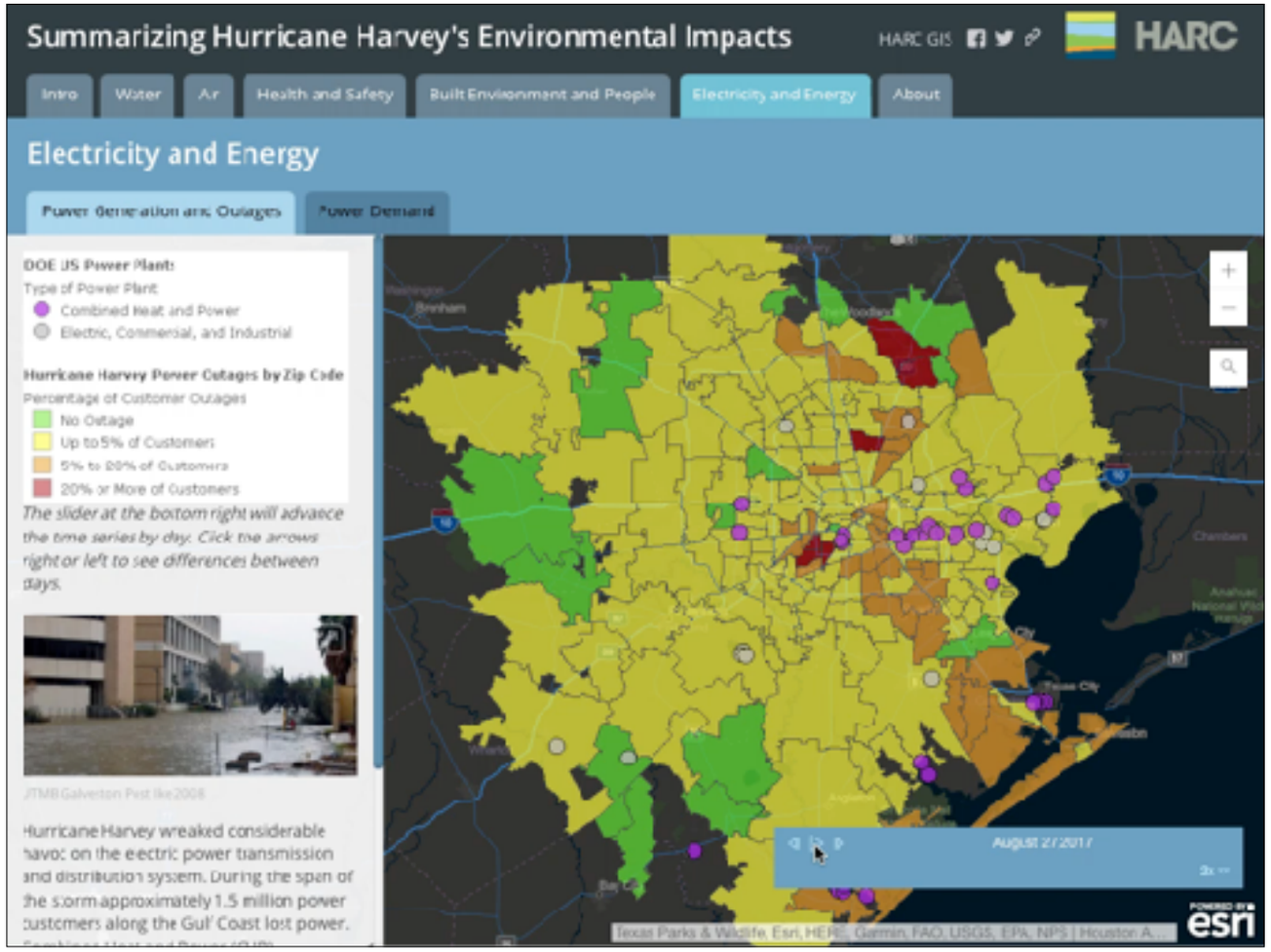
- At the time of our research we only had modeled damage estimates to go by.
- Just recently actual damage assessments are starting to filter out of reliable data collection entities.
- Theme that has persisted: Disproportionate number of homes outside the 100 and 500 year floodplains that were damaged.
- Pop-up apps like Trulio (sp?) were used to identify people in need to recuses. Not sure where the data is now.
- In the past month more current damage assessment data has begun to be released.



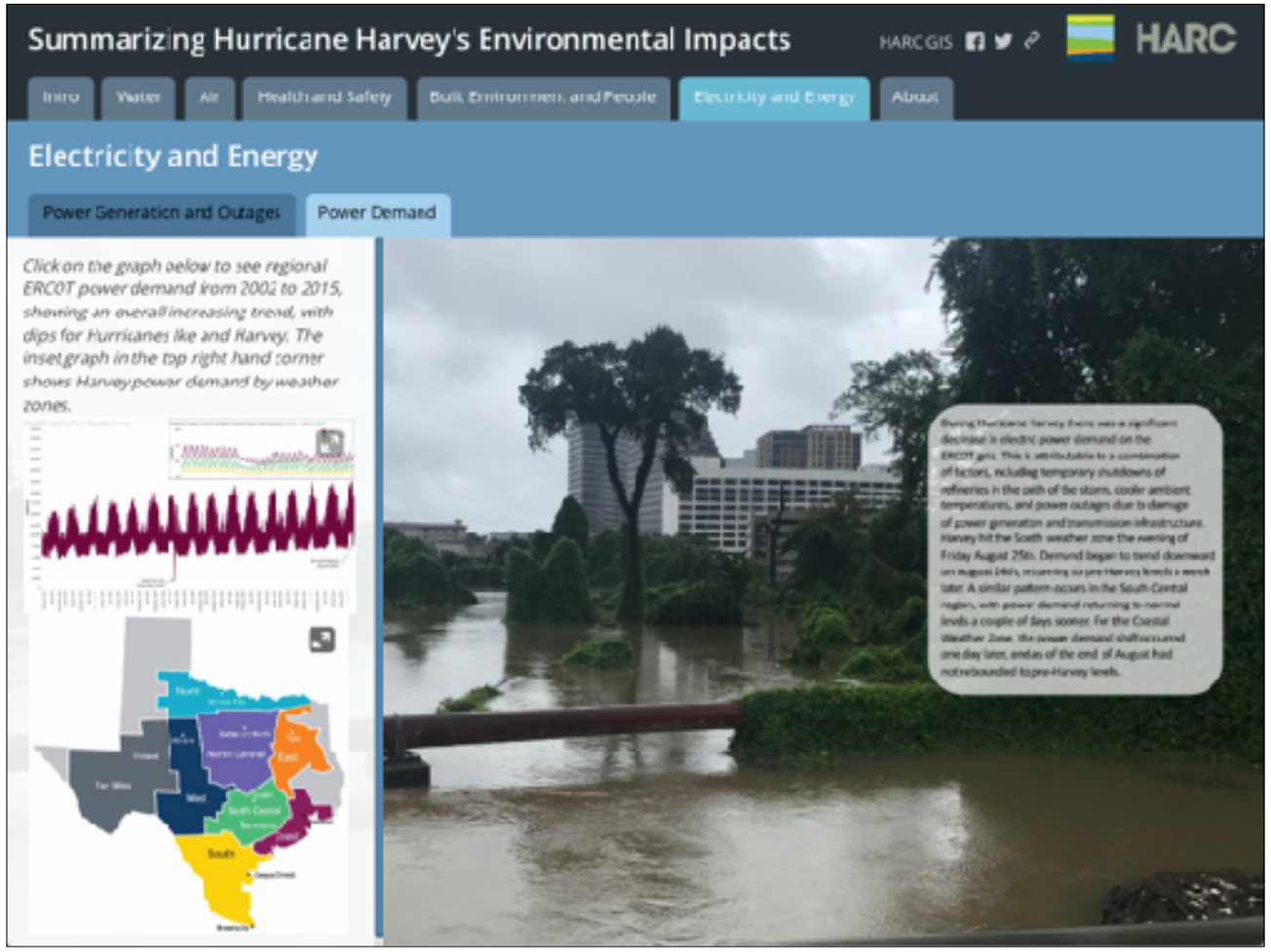
- Background: The orange ad blue represent fresh and saltwater wetlands.
- Many of the areas that experienced the most rainfall has the least green infrastructure remaining.
- Ensuring resilience will require measures on multiple levels.
    - Engineered solutions
    - Conservation of lands for more green infrastructure
    - Educating homeowners
    - Development standards
- Region clearly cannot continue to operate ‘as is’ going forward.
- Needs to be a concerted effort to look at how we map flood risk.

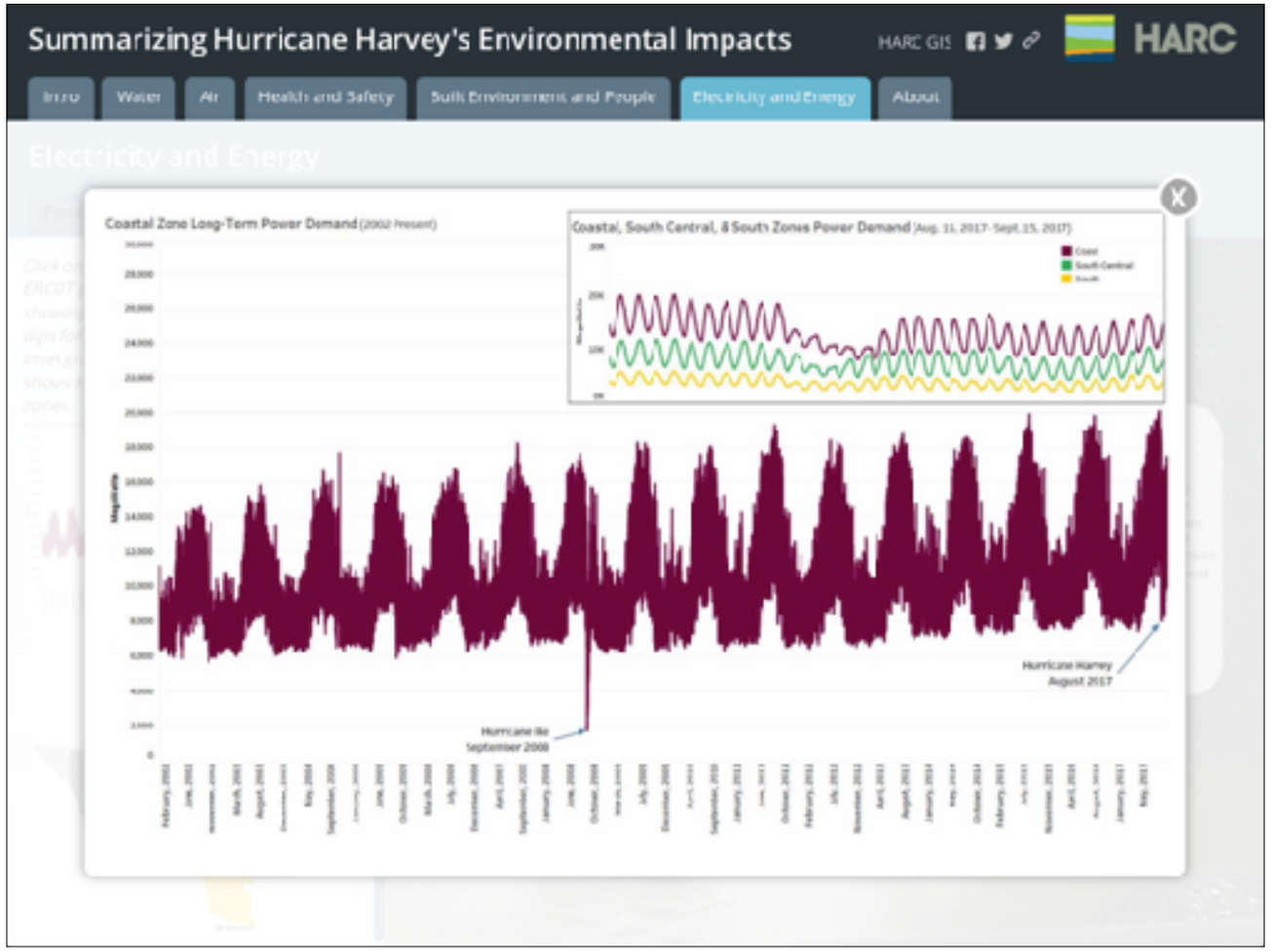


- Currently only have 2010 NOAA CCAP Land Cover data available.
- Hoping to get the 2016 data later this year.
- Don’t expect this trend to change from 2010 to 2016.
- Every county in the region has seen an increase in development and imperviousness, some quite substantially.

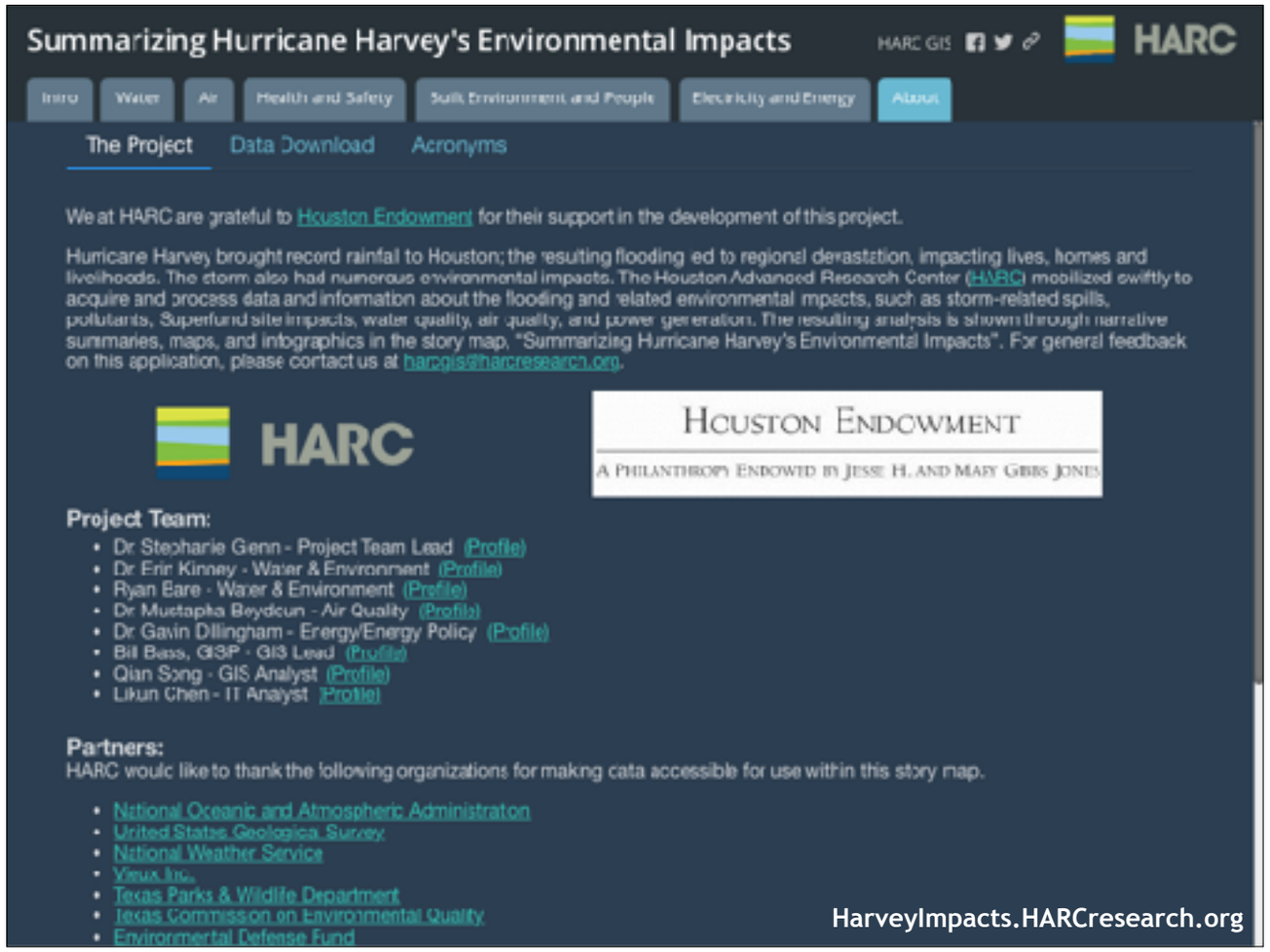


- Following Tropical Storm Allison in 2001 & Hurricane Ike in 2008, areas like the Houston Medical Center made major changes to their power generation and backup capabilities.
- This is one area HARC is very involved in, not only from a power efficiency stand-point, but also helping to build more resilient systems for critical infrastructure.


Summarizing Hurricane Harvey's Environmental Impacts
HARC GIS
HARC
Intro
Water
Air
Health and Safety
Built Environment and People
Electricity and Energy
About
Electricity and Energy
Power Generation and Outages
Power Demand
Click on the graph below to see regional ERCOT power demand from 2002 to 2015, showing an overall increasing trend, with dips for Hurricanes Ike and Harvey. The inset graph in the top right hand corner shows Harvey power demand by weather zones.
North
East
West
South
South Central
Coast
Panhandle
Far West
Coastal
Weather Zone, the power demand shift occurred one day later, and as of the end of August had not rebounded to pre-Harvey levels.



- Remember that Harvey first came ashore as a category 4 hurricane into the Rockport, Tx area.
- From the graph can see the impact on power outages in the Coastal Zone, which the Houston region is a part.
- In the summer of 2017, the coastal zone also hit an all-time high for power generation.



- Effort was a multidisciplinary project with varied expertise.
- Funded by a generous grant from Houston Endowment (https://www.houstonendowment.org).

GIS.HARCresearch.org

Bill Bass, GISP
BBass@HARCresearch.org

Qian Song
QSong@HARCresearch.org

@HARCresearch

HARCresearch.org

Houston Advanced Research Center

@HARCresearch

HARC (härk), *n.*

an independent research hub helping people thrive and nature flourish.

- The Hurricane Harvey story map as well as other applications can be found on our Geospatial websites at GIS.HARCresearch.org.