Leveraging Relationships and Agency Products

Date: 29 August 2019

Audience: TFMA Fall Technical Summit
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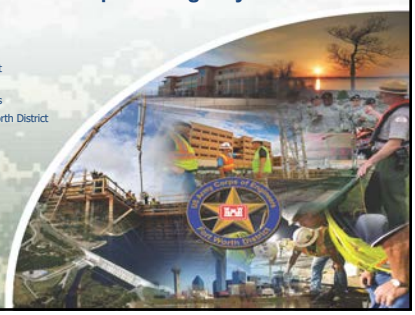


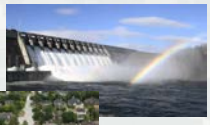
USACE Is Really Its People

- 37,000 professionals
- 130+ countries
- Characteristics
  - ►Dedication, we care!
  - ►Selfless service
  - ►Brilliance
  - ►High ethical standards – honesty
  - ►Adaptive

Yesterday

Today

Flood Damage Reduction Operations



- Did you know?
  - ► USACE operates 410 reservoirs with flood storage
  - ► $1.1 trillion damages prevented to date
  - ► $150 billion expenditure
  - ► 8:1 B/C ratio nationally
  - ► $18 billion in one state (TX) in a single year (2015)

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USACE Dallas-Fort Worth - Flood Reduction and Water Supply System

- 4th largest urban area in the U.S.
- Devastating floods, 1908, 1942, 1949
- 6 multi-purpose reservoirs (1952-1987)
- 2 federal levee systems
- DFW Flood Control System
  - ► 7.4 million people
  - ► $100+ billion in damages prevented
  - ► $2 - $3 billion annually
- Water supply system
- Total cost $2.5 billion
- ***Must be operated as a system***

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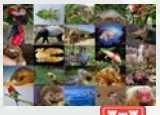
Additional USACE Civil Works Missions

- Navigation
  - ► 41 waterways totaling = 25,000 miles
  - ► 236 lock chambers at 191 sites
  - ► Dredging for rivers and harbors
  - ► $16 B benefits annually
- Water supply
  - ► 10 M acre-feet of water supply
  - ► 85 M people in 115 cities
  - ► irrigate over 2.5 M acres
  - ► $9 B in annual benefits, with $60 M revenue
- Hydroelectric power generation
  - ► 375 hydropower generating units at 75 projects
  - ► 100 B kilowatt-hours annually
  - ► 24% of U.S. hydropower generating capacity
  - ► $2.15 B annual benefits
- Biological operations (BiOps)
- Federal levee systems
  - ► 14,500 miles
  - ► $120 B annual benefits



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Surface Water Gage Network

- Did you know?
  - ► USGS operating partner
    - Shared across federal, state and local governments
    - $170M national surface water network
    - USACE funds about $19.2M
  - ► Provides
    - Real-time streamflow and precipitation observations ++
  - ► Highly important for water resources
    - Critical for USACE dam operations
    - Water Supply
    - Flood risk
    - Flood operations and public flood warnings
    - Trends
    - Climate variability and change
    - Forms the ***BASIS*** of any regional or national water resources study and many climate studies

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Leveraging Other Programs - USACE CWMS Development

- USACE CWMS implementation
  - ***Full suite of engineering scale models***
  - ***$8 mil+ investment for Texas***
  - ***Shared with federal, state and local governments***
  - ***Updates required for new LIDAR***
- Engineering Models
  - Meteorology – how much rain?
  - Hydrology – how will the watersheds respond?
  - River hydraulics – how deep will it get?
  - Reservoir systems – what effect do the reservoirs have?
  - Impacts – who gets wet?

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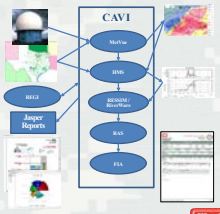
USACE Technologies CAVI & WAT Technologies

- HEC
  - CWMS, WAT, RAS, HMS, FIA, RESSIM/RiverWare
- ERDIC & many other labs
- Stochastic modeling techniques
- RMC
  - State-of-the-art dam safety program



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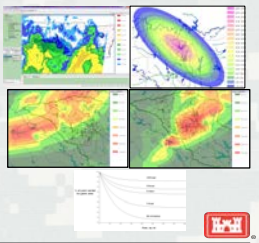
USACE Technologies – HEC-MetVue

- **MetVue Meteorological Tool**
- Response
  - Real-time precipitation
- Mitigation
  - Storm transposition
- Design & planning
  - Storm analysis
  - Design storms
- Dam safety
  - PMP analysis
  - HMR52, HMR55a



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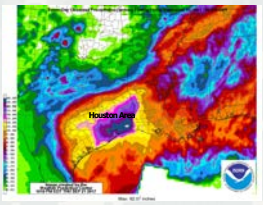
Hurricane Harvey Storm

- Rainfall totals up to 60”
- Approaching or exceeding maximum rainfall possible
- 23,000 + mi^2 (CT, RI, DE, NJ)
- One of the largest storms in continental US history
- Blocking factors
- OFF THE CHARTS!



Growing trend toward extreme weather and weather anomalies

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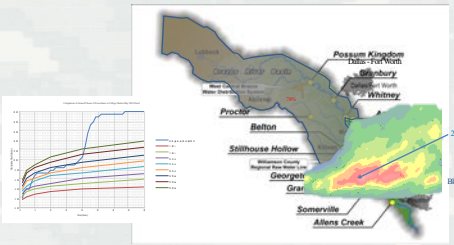
Brenham Storm, May 26-27, 2016 (Not Tropical)



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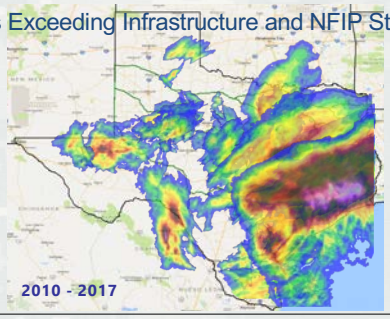
Storms Exceeding Infrastructure and NFIP Standards



2010 - 2017

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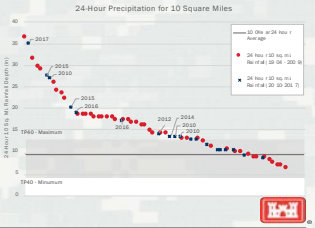
Storms Exceeding Infrastructure and NFIP Standards

- Regional observed storms
  - USACE extreme storm database
- 24-hour rainfall for 10 mi²
- Plotted in descending order
- Grey band is current design standard (100-year) for all of TX
- Blue X's points are 2010-2017 storms that exceed 100-year
- 18 events exceeded the 100-yr design standard



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What Flooding Disasters Do

- Impact existing infrastructure
  - Water systems
  - Waste water systems
  - Transportation
  - Electrical power generation
  - Health and human services
  - Security
- Destroy property (homes, automobiles)
- Take lives (48/29 Texas)
- Loss of pets
- Ruin family photos and heirlooms
- Disconnect people - friends, schools, work, and familiar places
- Alter relationships
- Permanent harm to culture and way of life
- Impact the most socially and financially marginal people
- Long-term consequences to the health (mental) and collective well-being of those effected
- Damage natural ecosystems that are integral parts of communities
- Disrupt populations in ways that are difficult to articulate, let alone assign monetary worth

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Why Focus on Flood Risk?

Floods are the most *common* and the most *costly* natural disaster in the United States.

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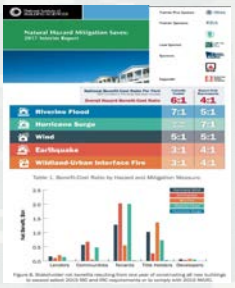
RETURN ON INVESTMENT

2017 "*Natural Hazard Mitigation Saves*" report by: National Institute of Building Sciences Institute, Multi-hazard Mitigation Council (MMC), at the direction of the U.S. Congress

Riverine flooding – for $1 invested in mitigation strategies and higher standards (versus recovery from flooding actions), communities save $5-7



Source: http://www.wbdg.org/files/pdfs/MS2_2017Interim%20Report.pdf

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The Interagency Flood Risk Management (InFRM) Team

Multiple Federal Agencies → One Mission

- *Develop actionable information to reduce long-term flood risk in the region*
- Operates under the umbrella of Integrated Water Resources Science and Services (IWRSS)
- Pilot Program began in Texas in 2014
- Collaboration
- Leverage resources and information
- Limit duplication of
- www.InFRM.us

InFRM Academic Council

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InFRM - Participating Agencies & Offices

- FEMA - Sponsor
- U.S. Army Corps of Engineers (USACE)
  - Fort Worth District
  - Tulsa District
  - Galveston District
  - Albuquerque District
  - Little Rock District
  - Vicksburg District
  - New Orleans District
- U.S. Geological Survey (USGS)
  - Texas
  - Oklahoma
  - Arkansas
  - New Mexico
  - Louisiana
- National Weather Service – River Forecast Centers
  - West Gulf
  - Tulsa
  - Lower Mississippi

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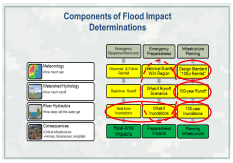
Interagency Flood Risk Management (InFRM) Products and Services

- NOAA Atlas 14 (what is the 100-year rainfall)
- Watershed Hydrology Assessments (what is the 100-year flow)
- Flood Inundation Map Library & Scenario viewer
- Base Level Engineering BFE Viewer (what is the BFE at my location)
- WEB services @ www.InFRM.US



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NOAA Atlas 14, Precipitation Frequency Estimates (Planning and Mitigation)

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InFRM – Meteorology Research Initiatives, NOAA Atlas 14

- **What is it:**
  - Precipitation frequency estimates
  - Informs us of how much rain to expect in a 100-yr storm event
  - Non-regulatory product
- **Benefits**
  - Better understanding of the risk from extreme precipitation events
  - Infrastructure design, bridges, culverts, wastewater, water supply
  - Floodplain mapping (NFIP), where can we safely construct new neighborhoods
  - Preparedness or mitigation planning
- **Ongoing studies**
  - NOAA Atlas 14 (September 2018)
  - Extreme storm HHT & Extreme storm DB

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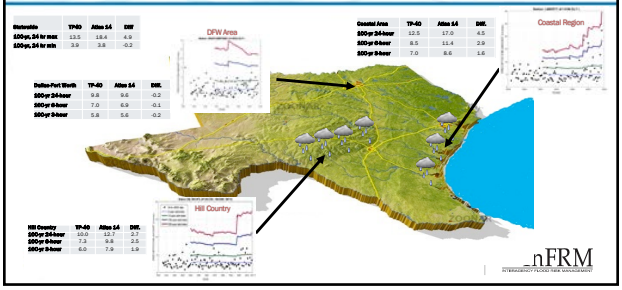
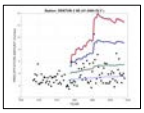
InFRM - NOAA Atlas 14 Precipitation Results

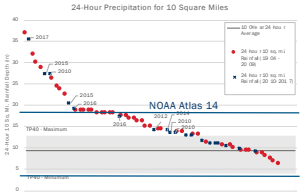


InFRM – NOAA Atlas 14, Are We Done?

- Statistical Hydrology
  - Flood Frequency Analysis of stream gage records using Bulletin 17C
- Precipitation Frequency Estimates
  - NOAA Atlas 14 just released in Texas, Area Reduction Factor studies
- Rainfall Runoff Modeling
  - Storm Calibrations, Uniform Rainfall, Elliptical Storms
- Reservoir (Period of Record) Simulations
  - Development of regulated/unregulated flows & extension of gage records
- Reservoir Studies
  - Pool & Outflow Frequency Estimates using USACE Dam Safety procedures



Storms Exceeding Infrastructure and NFIP Standards



Watershed Hydrology Assessments What is the 100-Year Flow (Planning and Mitigation)

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Purposes of the InFRM Watershed Hydrology Assessments (WHAs)

- Update Flood Risk Estimates in Large, Complex River Basins
- Start with suites of models developed by USACE (i.e. CWMS) to extend resources
- Employ a range of hydrologic methods and compare their results
- Consider non-stationary factors
  - Regulation, land use, climate variation
- Recommends 1% annual chance (100-yr) and other frequency flows
- Suggests areas where FEMA flood hazard information may need to be updated

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Selected River Basins

Basis for Selection:

- Where sufficiently detailed USACE modeling products are available as a starting point
- Where FEMA has future floodplain mapping activities scheduled
- Limited to FEMA Region 6

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Methods Used in the Watershed Assessments

- **Statistical Hydrology**
  - Flood Frequency Analysis of stream gage records using Bulletin 17C
- **Precipitation Frequency Estimates**
  - NOAA Atlas 14 just released in Texas, Area Reduction Factor studies
- **Rainfall Runoff Modeling**
  - Storm Calibrations, Uniform Rainfall, Elliptical Storms
- **Reservoir (Period of Record) Simulations**
  - Development of regulated/unregulated flows & extension of gage records
- **Reservoir Studies**
  - Pool & Outflow Frequency Estimates using USACE Dam Safety procedures

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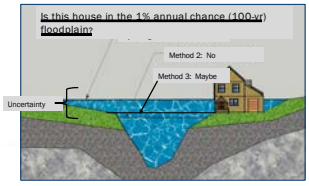
The Problem of Hydrology

- **Single largest source of uncertainty in flood risk estimation**
  - Variation equals up to 20-feet of Depth in Texas
- **Many commonly used and accepted hydrologic methods**
- **Every method will give a different answer**



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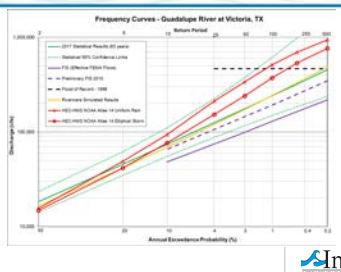
Compare Results from Multiple Methods

- **Compare Results early and often**
- **Investigate Reasons for the Differences**
- **Elicit Feedback from multiple Subject Matter Experts**
- **Select Recommended Methods and Frequency Flows**



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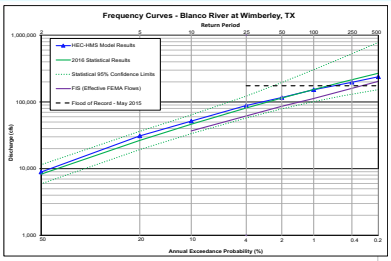
Why WHA's - Uncertainty Associated with Single Method Approach



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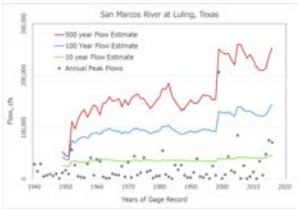
Plotting How Statistical Estimates Have Changed Over Time

- Useful in communicating uncertainty and effects of new floods to stakeholders
- Demonstrate that even with 100 years of record, the 100-yr (1% ACE) flow estimate is still a moving target
- Need to look carefully and compare statistical results to other methods before adopting them
- Change over time plots are being added to HEC-SSP



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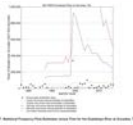
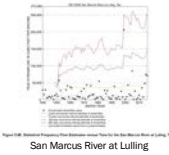
InFRM – Why WHA's, Non-Stationary Trends In Flood Flow Frequency Estimates, Guadalupe River, TX

- Additional non-stationarities Guadalupe River system



Guadalupe River at Gonzales

Guadalupe River at Victoria



San Marcus River at Lulling

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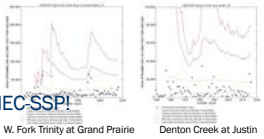
InFRM – Why WHA's, Non-Stationary Trends In Flood Flow Frequency Estimates, Trinity River, TX

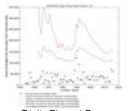
- Additional non-stationarities Trinity River system

This capability has been added to HEC-SSP!

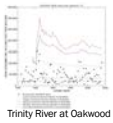


W. Fork Trinity at Grand Prairie

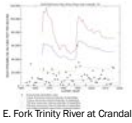
Denton Creek at Justin



Trinity River at Rosser



Trinity River at Oakwood



E. Fork Trinity River at Crandall

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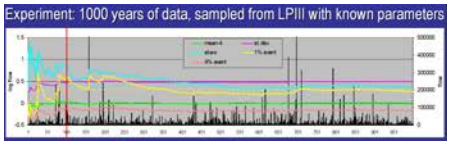
How Much Gage Record Do You Need to Estimate the 100-yr Discharge?



Dashed Yellow Line = Actual 100-yr (1%) Discharge
Solid Yellow Line = Estimate of 100-yr (1%) Discharge based on previous years of record

300 to 400 years of Record before 100-yr Estimate Converges

Credit: Beth Faber at USACE-HEC

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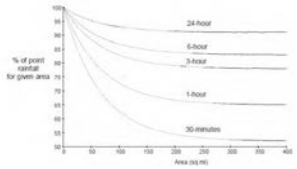
Limitations of the Uniform Rainfall Method for Flood Risk Estimation

- Published Depth Area Reduction Factors are limited
- Figure 15 from NWS TP-40
- Published in 1961
- Programmed into HEC-HMS Depth-Area Analyses



- Limited to 400 square miles
- Study River Basins are up to 10,000 square miles

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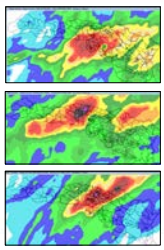
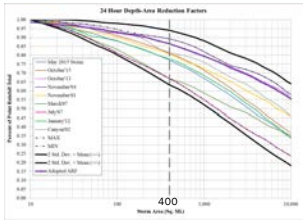
Calculate Area Reduction Factors from Observed Storms





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Advantages of the InFRM Watershed Hydrology Assessments

- Multi-Agency Approach → One Federal Answer
  - Leverage unique expertise within each agency
  - Leverage models & funding from multiple programs
  - Strengthens Collaboration between Federal Agencies
- Update the Hydrology for Large, Complex River Systems
- Account for How the 100-yr Flow Changes Over Time
- Consider impacts of non-stationary factors in the watershed
- Incorporate Latest Methods and Technology
- Reduce the Uncertainty in the 1% annual chance (100-yr) Flow by Comparing Results from Multiple Hydrologic Methods

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Pre-generated Inundation Mapping Libraries (Mitigation and Response)

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Estimated Base Flood Elevation (estBFE) Viewer

- Purpose
  - Provide engineering data in a format that allows immediate use by public.
  - Federal, State and local officials to estimate a Base Flood Elevation consistently.
- Version 2.0 – Updated Report, Point-Click-Download all datasets

Flood Inundation Mapper (FIM) Viewer

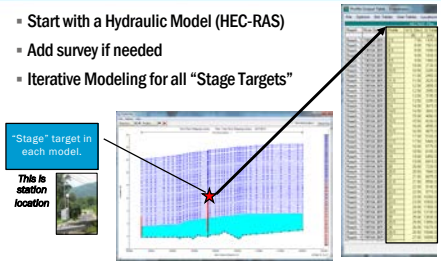
- Purpose
  - House inundation information from all partners
    (InFRM is working collectively to build the digital platform)
  - Pre-position datasets in "peace time"
  - Using IWRSS standards for modeling submittals
  - Libraries built with other federal resources

Why Inundation Mapping?

- **Map showing area that would be flooded from a particular flood event.**
  - Planning and Mitigation (Emergency preparedness)
    - Frequency Based
      - 100-year, 500-year
    - Historical and transposed storms
      - What if?
      - Can be from another location in the region
  - Emergency response
    - Real-time in advance or during the event
    - 2015-2017 TDEM requested 1000's of miles

How do you make one?

- Start with a Hydraulic Model (HEC-RAS)
- Add survey if needed
- Iterative Modeling for all "Stage Targets"



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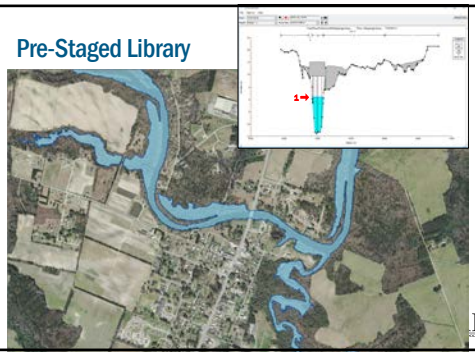
Pre-Staged Library



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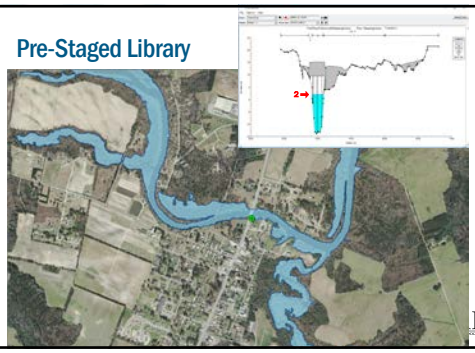

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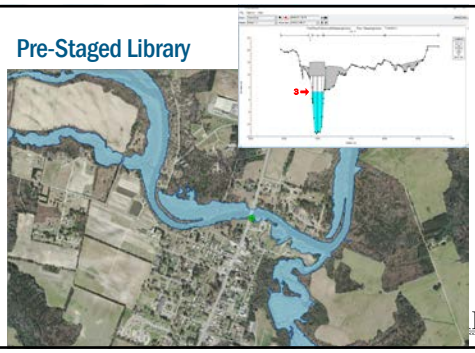

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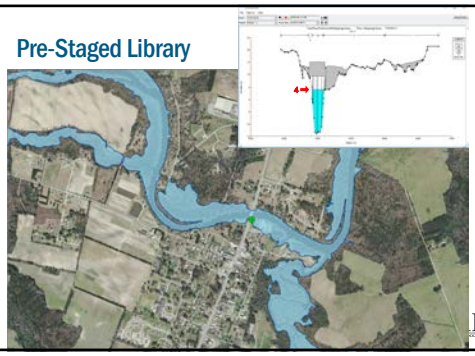
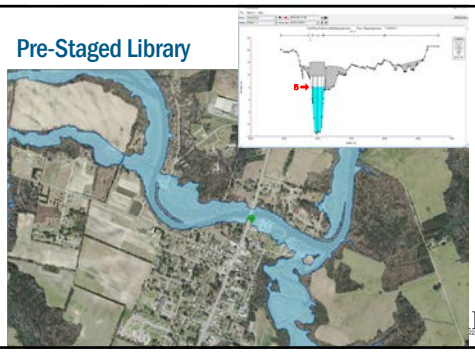


Pre-Staged Library



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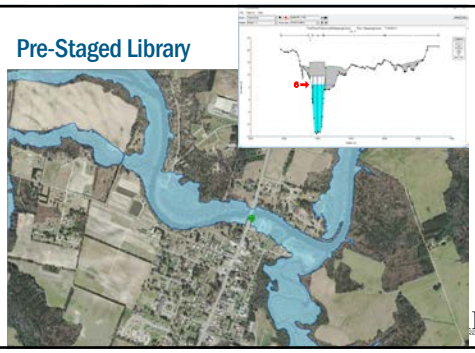

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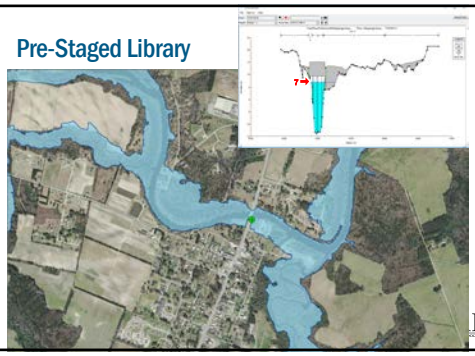

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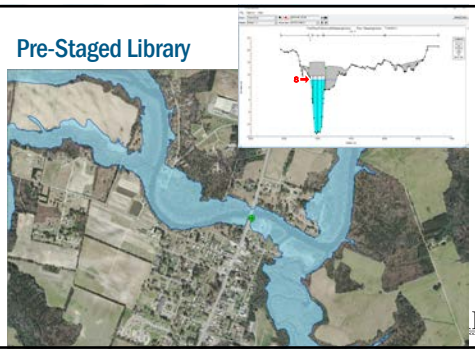

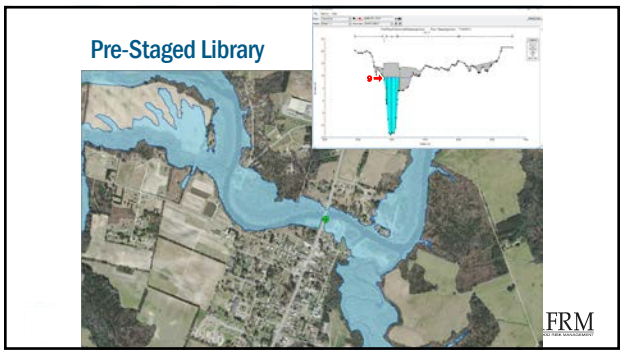
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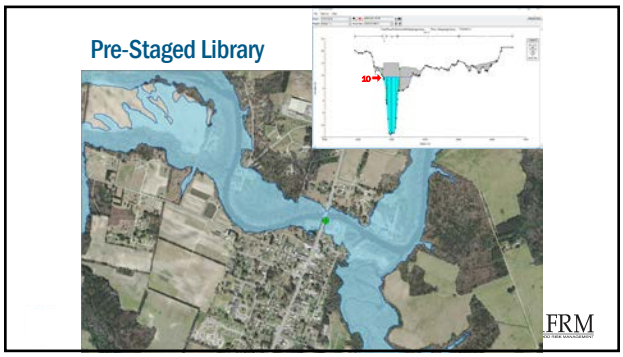
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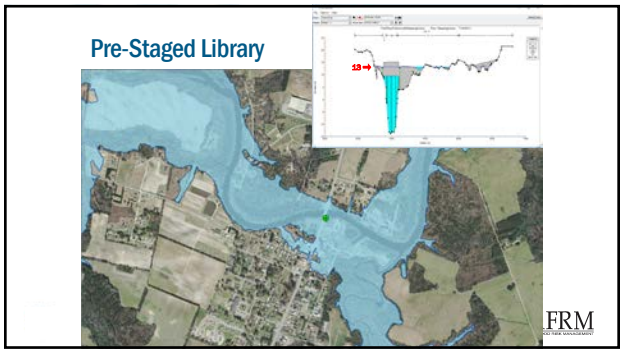
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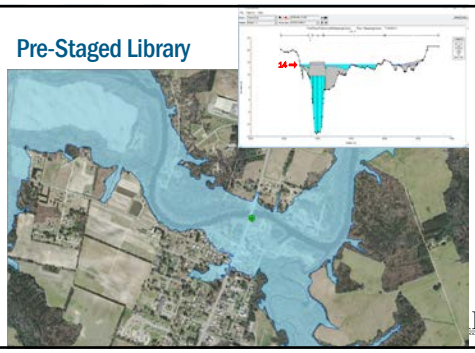

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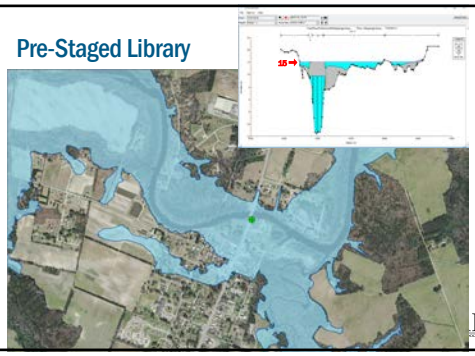

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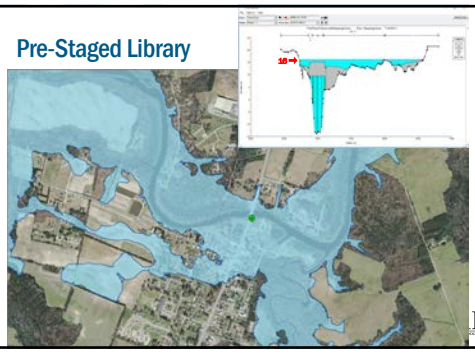
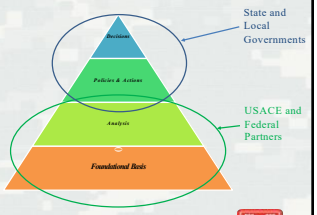


Flood Risk Products and Uses

- Analysis and foundational basis
  - ► Numerical models (CWMS, FEMA NFIP)
  - ► Data (Cooperative stream gage program)
  - ► Products (NOAA Atlas 14)
  - ► Storm transpositions
- Benefits
  - ► Better policy decisions
  - ► Actions
    - Plan stormwater infrastructure
  - ► Emergency preparedness
  - ► What-if scenarios
  - ► Emergency response
  - ► Basis for real-time inundation mapping



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Questions?

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