Forward Thinking Innovations for Risk Rating and Risk Reduction

ASFPM 2018 – Thursday, June 21, 2018

Introduction

Joined forces

On July 3 2017, SNC-Lavalin and Atkins joined forces

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- A leading engineering and construction group in the world offering services in oil and gas, mining and metallurgy, infrastructure and power
- Major player in the ownership of infrastructure

- One of the world's most respected design, engineering and project management consultancies serving infrastructure, transportation and energy sectors

Atkins is now part of SNC-Lavalin's Engineering, Design and Project Management Sector

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Increased geographic reach

- An established and balanced footprint
- Greater “at-scale” European and Middle Eastern presence

APPROXIMATELY **50,000** EMPLOYEES

SPEAKS **70** LANGUAGES

WORK FROM OFFICES IN OVER **50** COUNTRIES

REPRESENTS SOME **130** NATIONALITIES

- Atkins Energy segment allocated 41% Europe, 46% North America, 9% Middle East & Africa and 4% Asia Pacific
- Atkins segmentation based on fiscal year ended March 31, 2016 applied to twelve month period ended September 30, 2016
- Pro forma financials based on SNC-Lavalin fiscal year ended December 31, 2016 and Atkins twelve month period ended September 30, 2016

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- Flood mitigation and mapping services
- 2-D Riverine Hydraulic Modelling and Levee Design Services
- FEMA RiskMAP PTS
- Rapid Post-fire Flooding Risk Mapping
- Rapid 1D hydraulic Engineering & Mapping
- Dam breach inundation studies
- Scour protection and erosion control design
- 2-Dimensional hydraulic modelling of urban areas
- Strategic Stormwater Master Planning

LET'S GO CAPS

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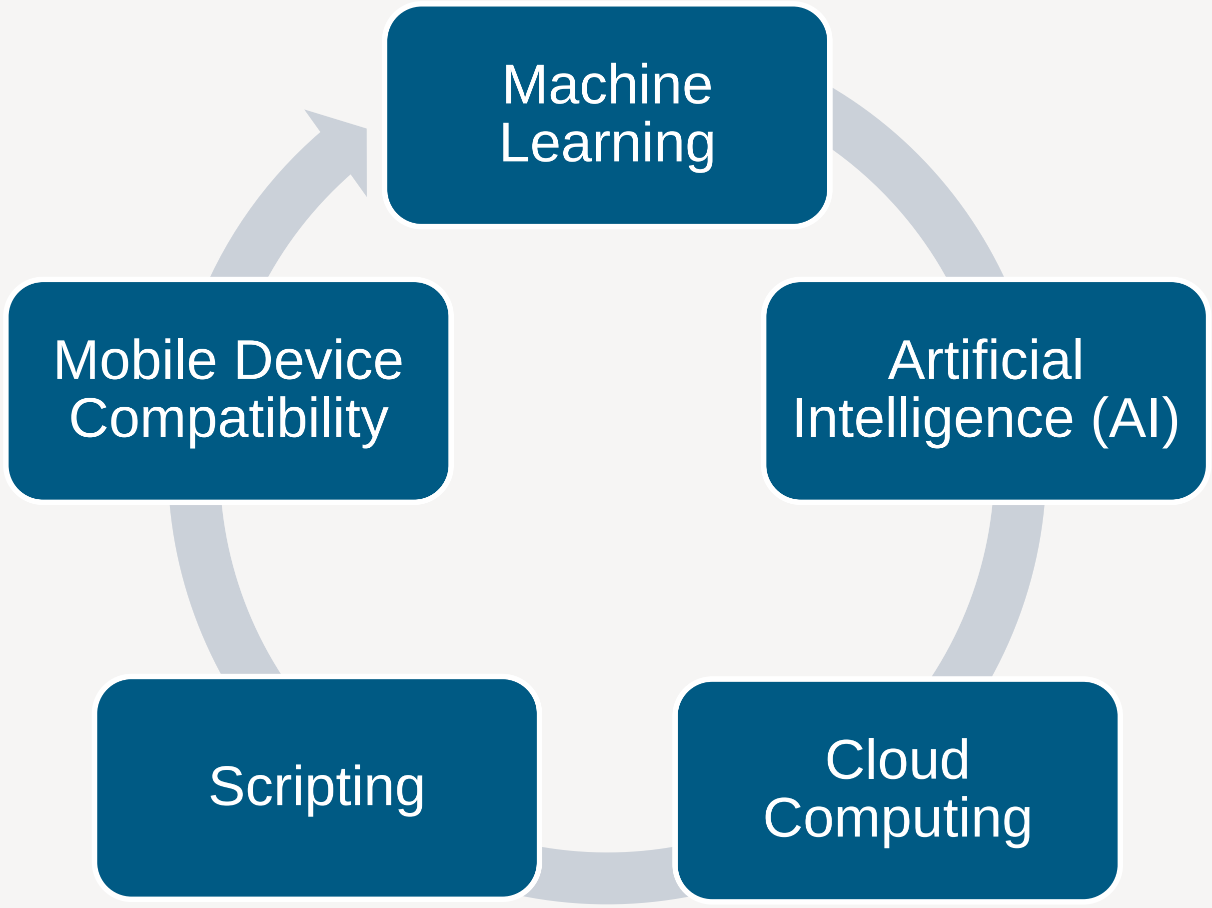
Our Innovations Buzz Words



FLOODMAP
DESKTOP

2001

FloodMap Desktop application to automate DFIRM mapping, first released

Free to everyone, Atkins release the first publicly available DFIRM mapping software to create DFIRM maps and database.

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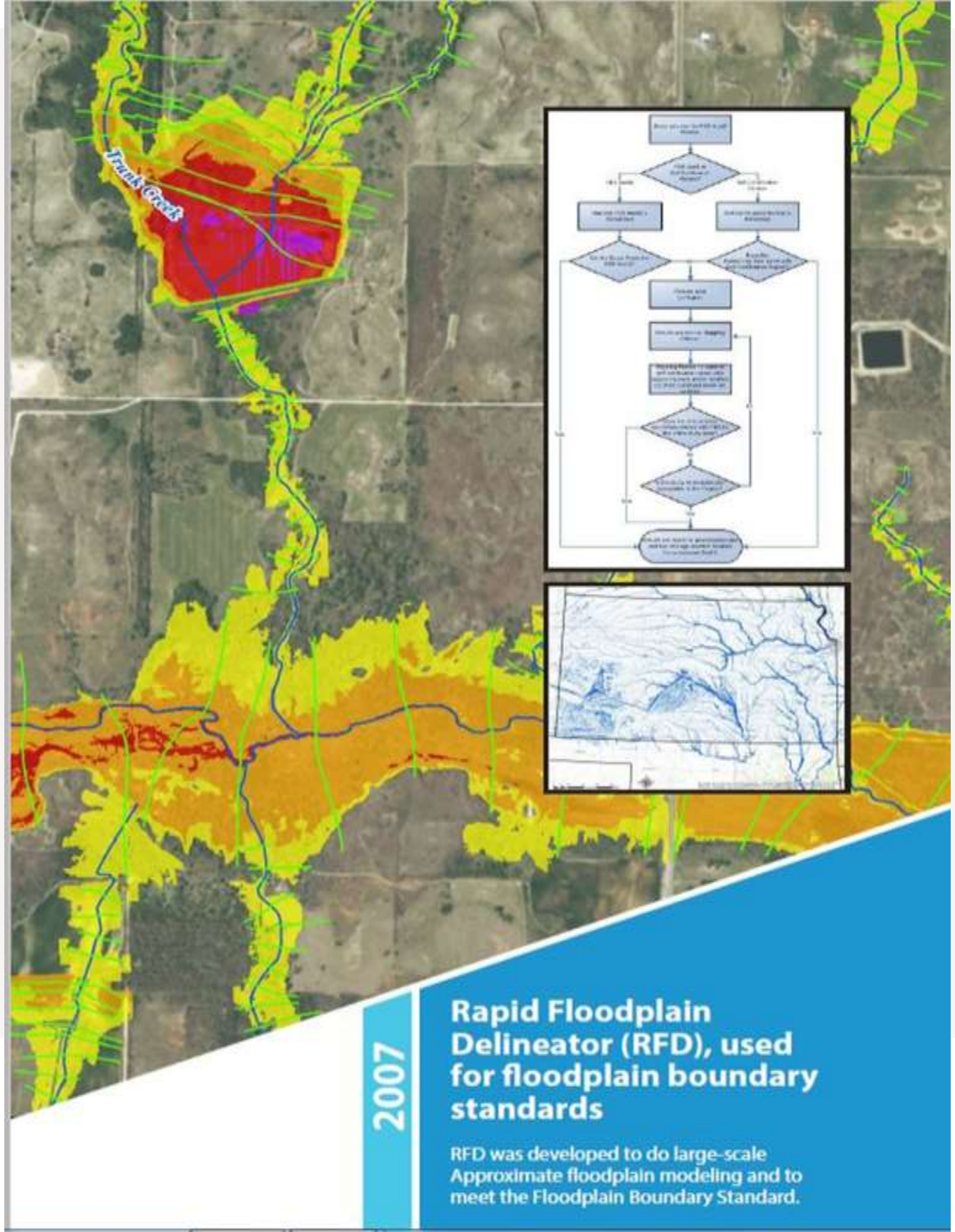

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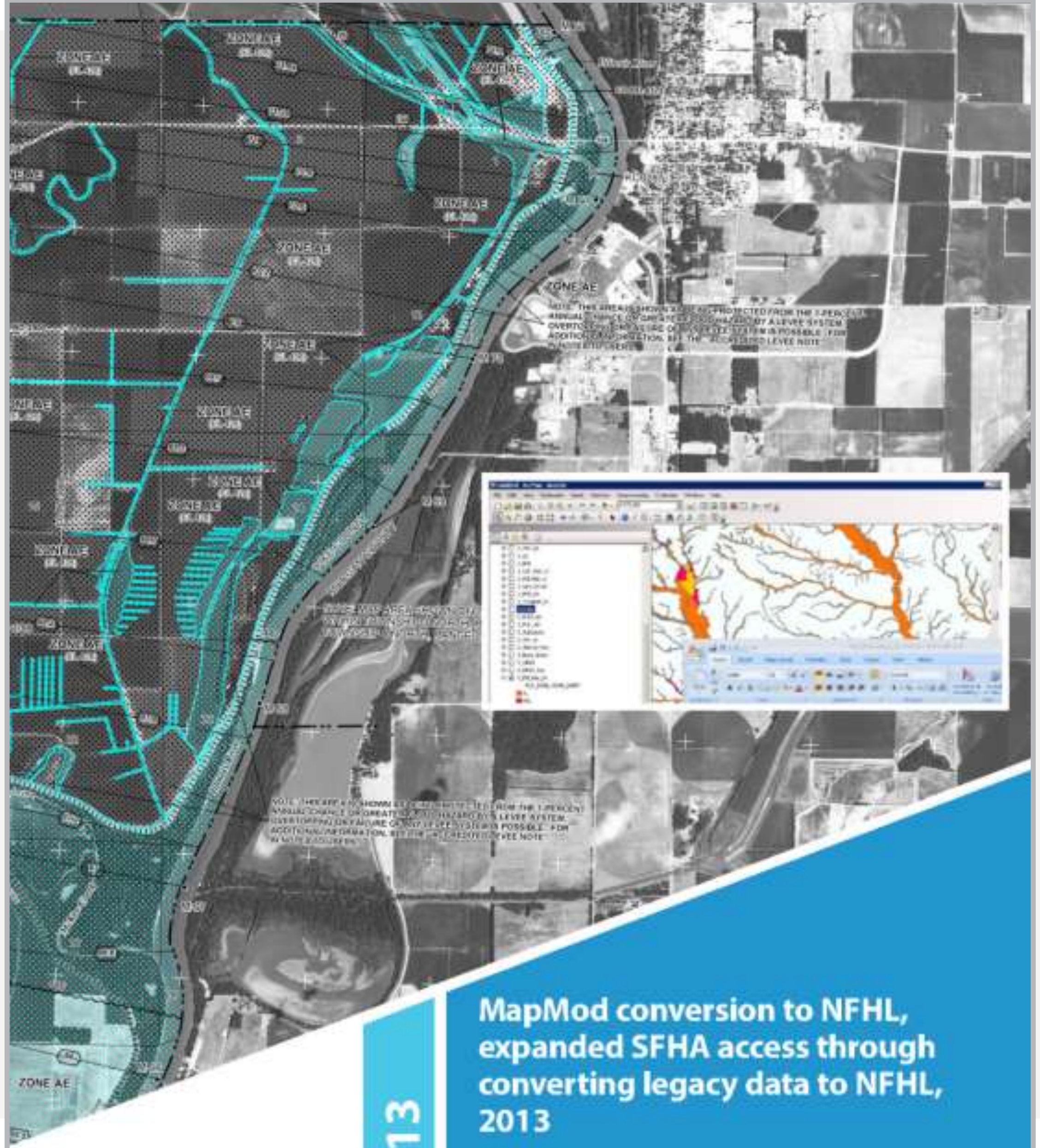

MapMod

2013

MapMod conversion to NFHL, expanded SFHA access through converting legacy data to NFHL, 2013

Converted the legacy DFIRM databases into the new seamless National Flood Hazard Layer format and standard.

Value: Greatly increasing the area and amount of FEMA Special Flood Hazard data available in the NFHL data set. Allowing access of this data to geospatial tools in a seamless layer.

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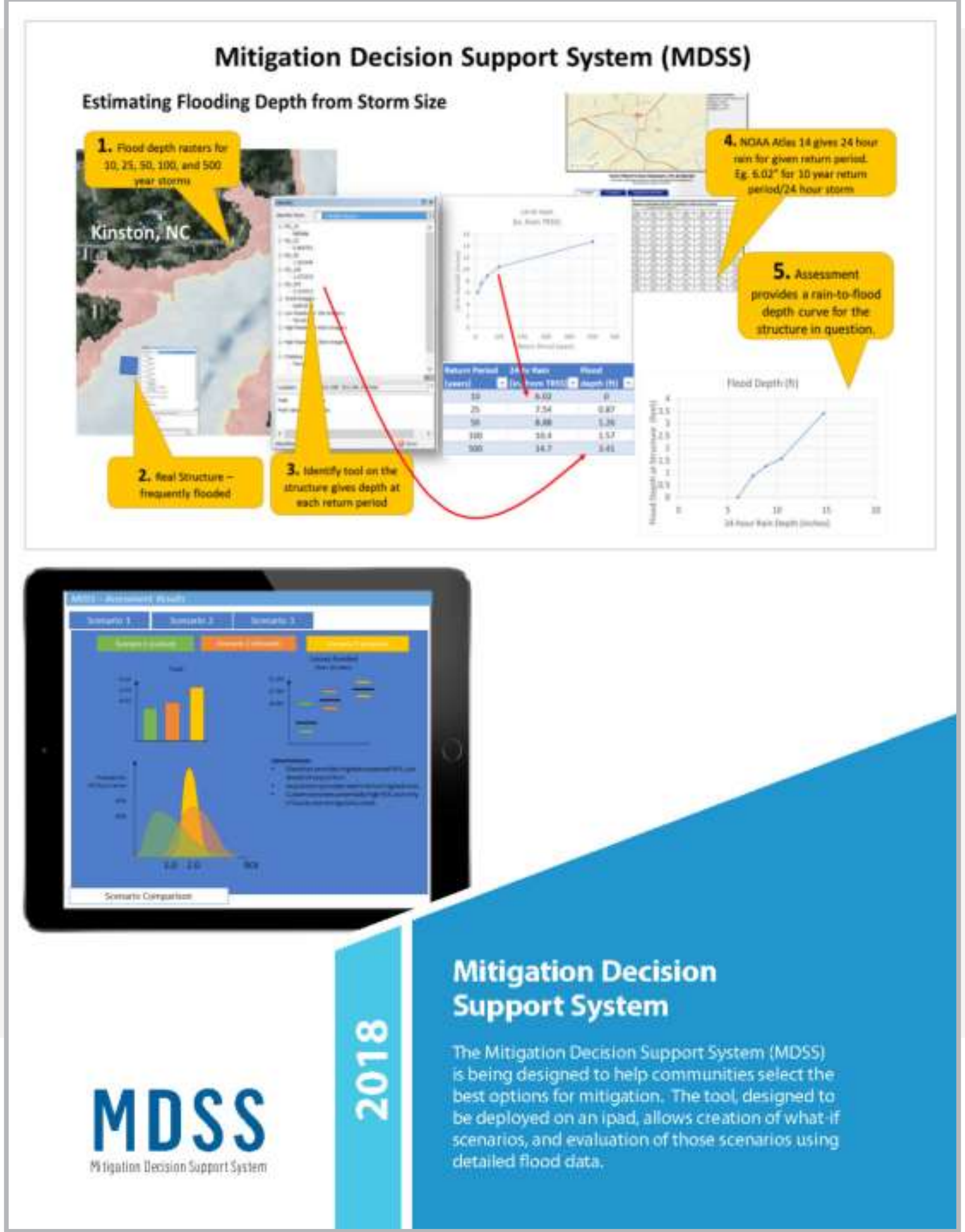
2-D Pluvial Modeling

2018

2-D Pluvial and Riverine Watershed Mapping

STARR II has developed high-speed, Google Cloud-based engineering analysis tools to identify riverine and pluvial (rainfall) flood risk. These tools allow the evaluation of very complex flow scenarios. Pluvial analysis, while a major insured risk in the NFIP, is not currently mapped, and this tool will allow FEMA to quantify this risk for the public.



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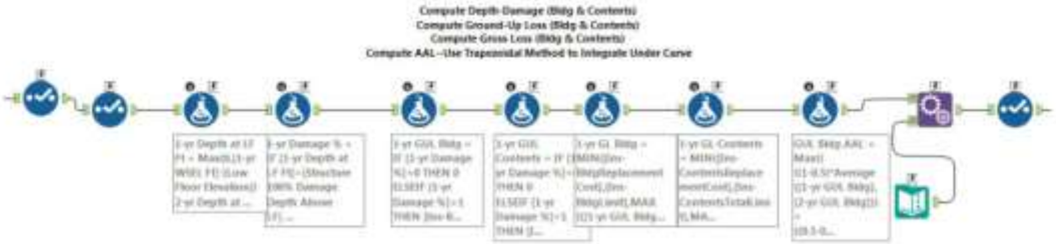
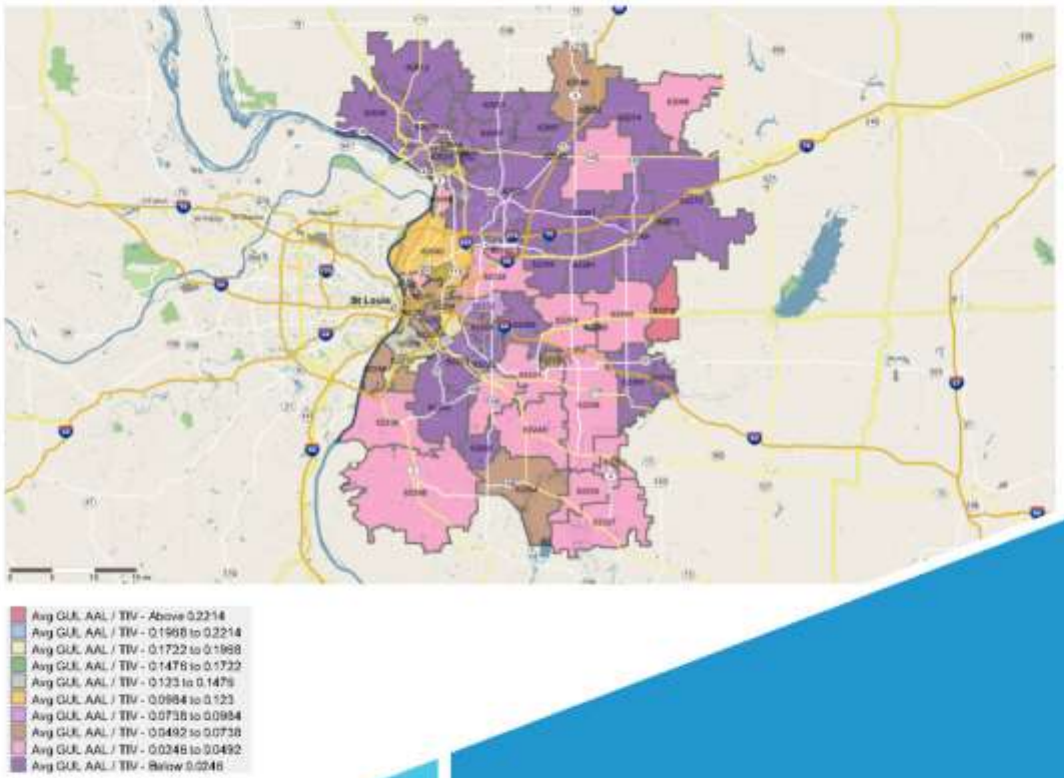


Average GUL AAL / TIV By Zip Code



MDI
Map Data Integration

2018

Map Data Integration (MDI)

The Map Data Integration (MDI) workflow was developed to assist FEMA in the Risk Rating 2.0 process, and maximizes the use of existing FEMA and Other Federal Agency flood data. The tool extends the existing flood data to cover very small storms to truly massive 10,000-year events. This enables FEMA actuaries to more accurately price flood insurance by location.

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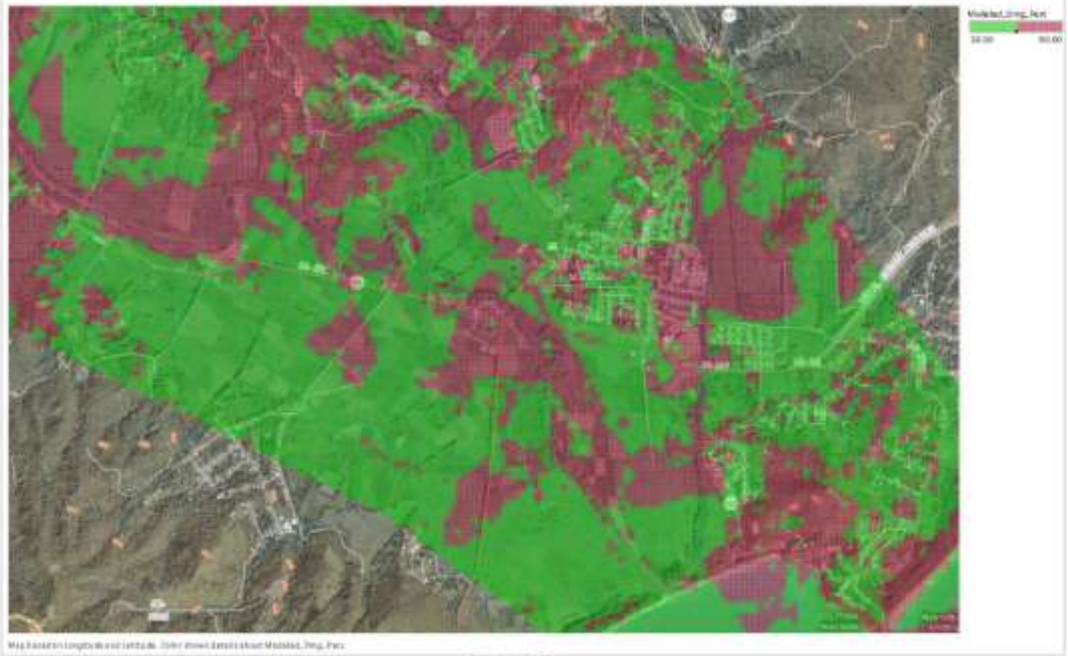

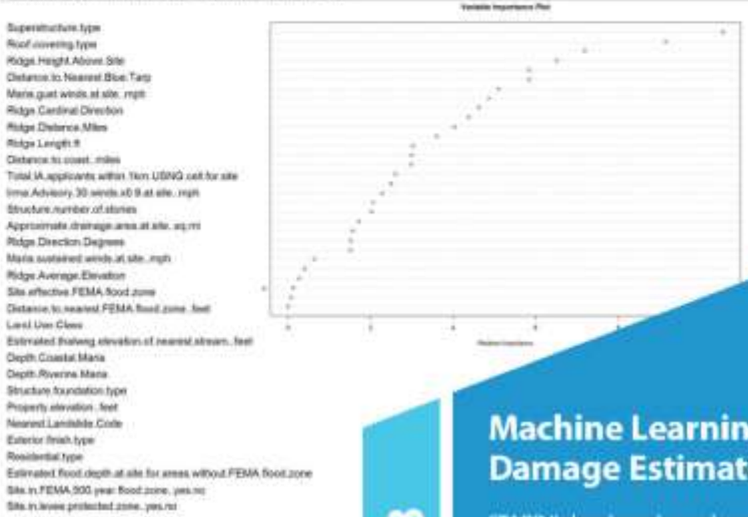

Substantial Damage Estimation (SDE)

2018

Machine Learning for Substantial Damage Estimation (SDE)

STARR II developed an advanced machine learning (artificial intelligence) estimation of flood and wind damage in Puerto Rico and the U.S. Virgin Islands following Hurricanes Irma and Maria. This process utilized dozens of complex variables to fully capture complex disaster impacts, including wind patterns in valleys and along ridges, to provide a highly granular estimate of damage to individual structures. Field verification is underway.

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Data Driven Hurricane Irma and Maria Recovery

Michael DePue, P.E., CFM

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Post – Disaster Inspection

Substantial Damage Assessment

Post Disaster Risk Assessment

Actionable Mitigation Support

Risk Communication

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Hurricane Maria PR+USVI Damage

Hurricane Maria PR+USVI Damage – Structure Level

Concrete structure with newer metal roof survived intact

Concrete structure with older metal roof and wood rafters lost roof

Foundation failure might be visible from aerial image

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SDE Requirements, Challenges & Solution

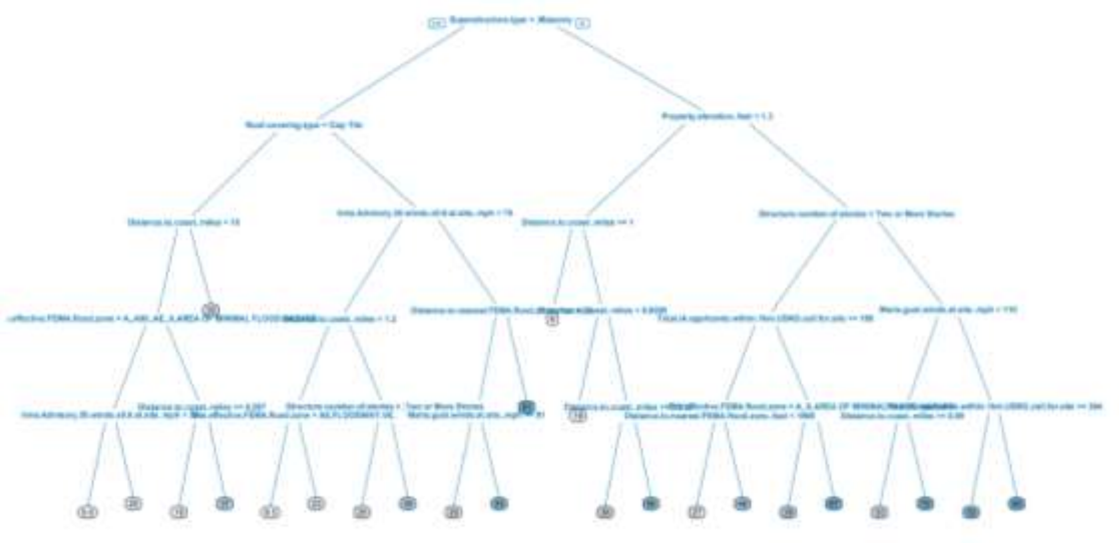
Challenges:

- Maria and Irma Events
  - Two hurricanes in close sequence
  - Damage was very widespread
  - Combined wind and flood event
  - Severe logistical barriers:
- Building style is different than on mainland, less data on performance
- Highly geographic differences in damage (both vertical and horizontal)

Requirement:

- Needed a way to predict damage to structures with confidence
  - Minimize need for human inspection

Solution: Boosted Regression Decision Tree Model



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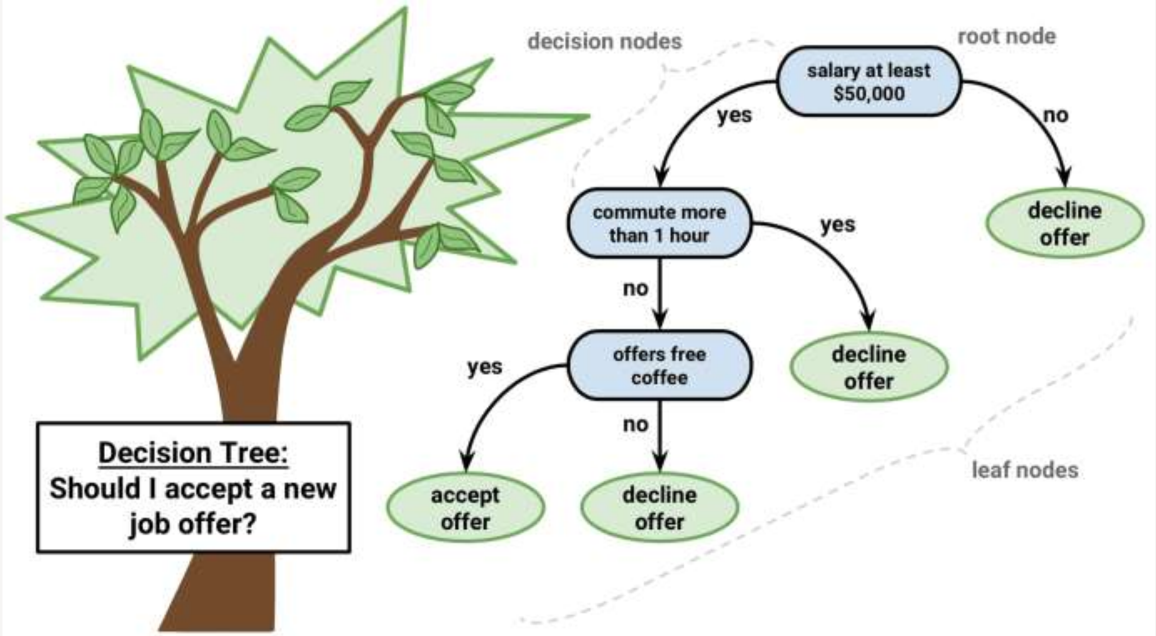
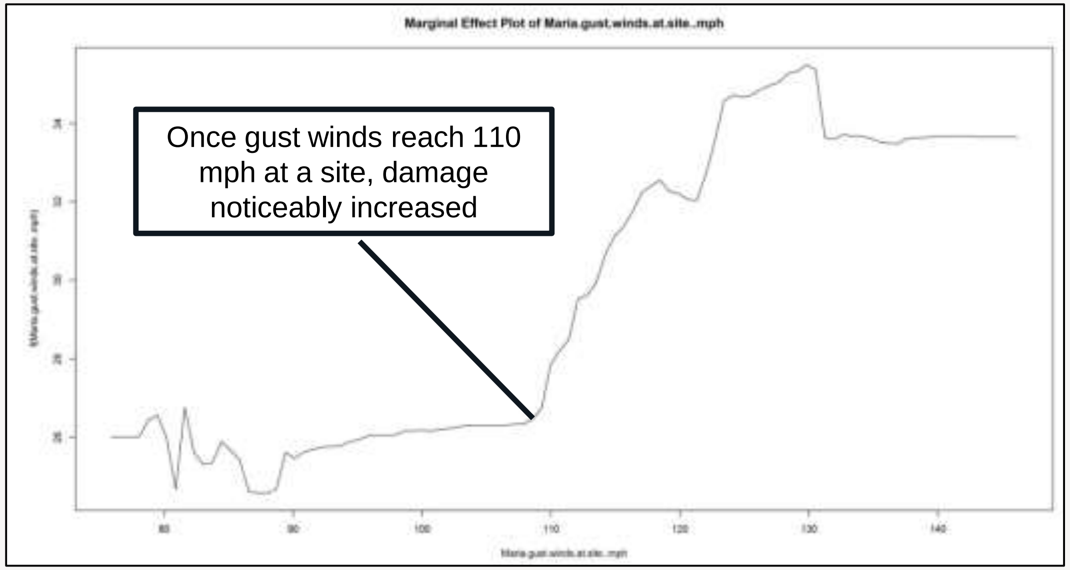
Boosted Regression Decision Tree Model

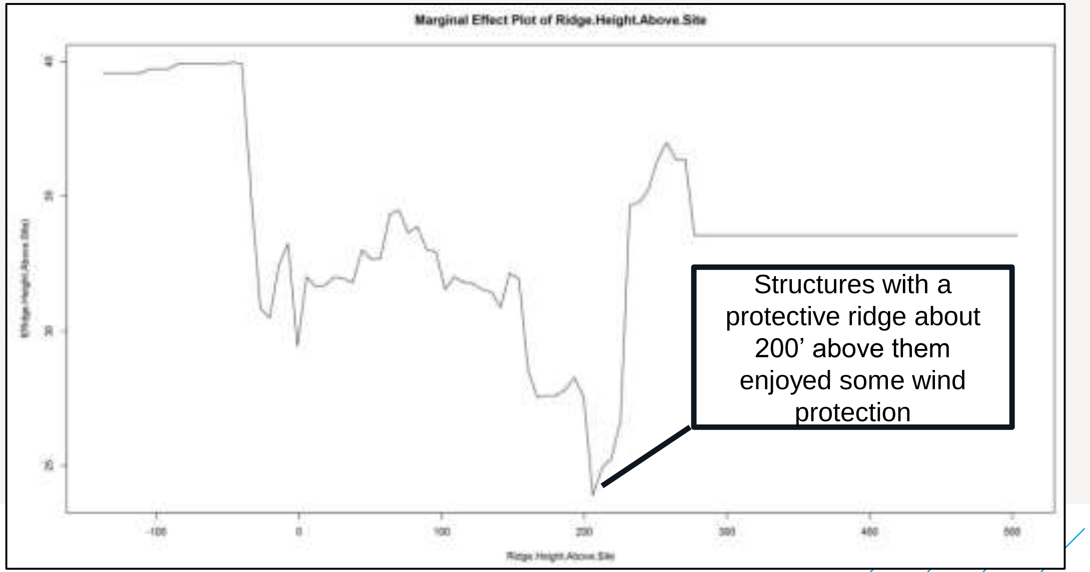
- A form of Machine Learning
- Good technique for dealing with incomplete or missing data
- Looks for patterns in the data
- Model preforms thousands of iterations to discern patterns
- High degree of control over number of decision trees tested and used
- Cross-validation or data sampling used to determine final number of decision trees needed in model to meet specified criteria



Model Results

- Of the 146,039 in the SFHA for PR+USVI
  - Sorted structures into groups as noted, 0-29%, 30-70%, 71%+
  - Theoretically, all of these could have required inspection
  - Net “Inspect” decision for 30,640 of these, approximately 21% of total
- Model accuracy varied by geography, but was generally good, with average of ±8.8% difference in predicted damage percentage





Looking Forward

Model results directly contributed to rebuilding PR & USVI

- Model can easily be refined using newly gathered data, or new types of data
  - One possible way to aid in wood vs. concrete issue: use infrared imagery

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Santa Barbara Fire Disaster Recovery

Selena Forman, PhD, P.E

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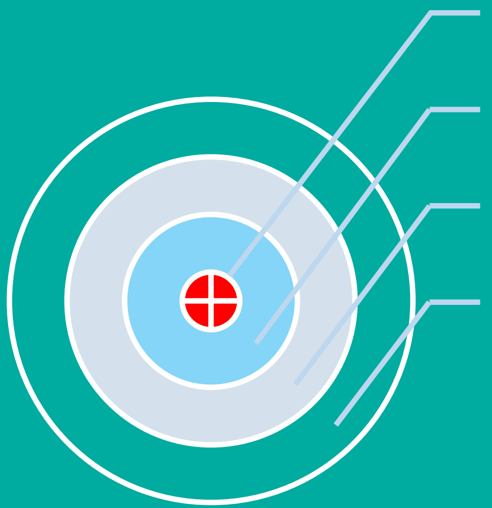

Risk Identification

Rapid Post Disaster Fire Analysis

Risk Communication

Actionable Mitigation Support

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Introducing Recovery Maps

- The Thomas Fire scorched land and eliminated vegetation causing increases in runoff during storm events
- January 2018 debris flows significantly changed ground conditions
- Recovery Maps reflect increased risks

Photo by David McNew/Getty Images

Overview of Damage and Purpose of Recovery Maps

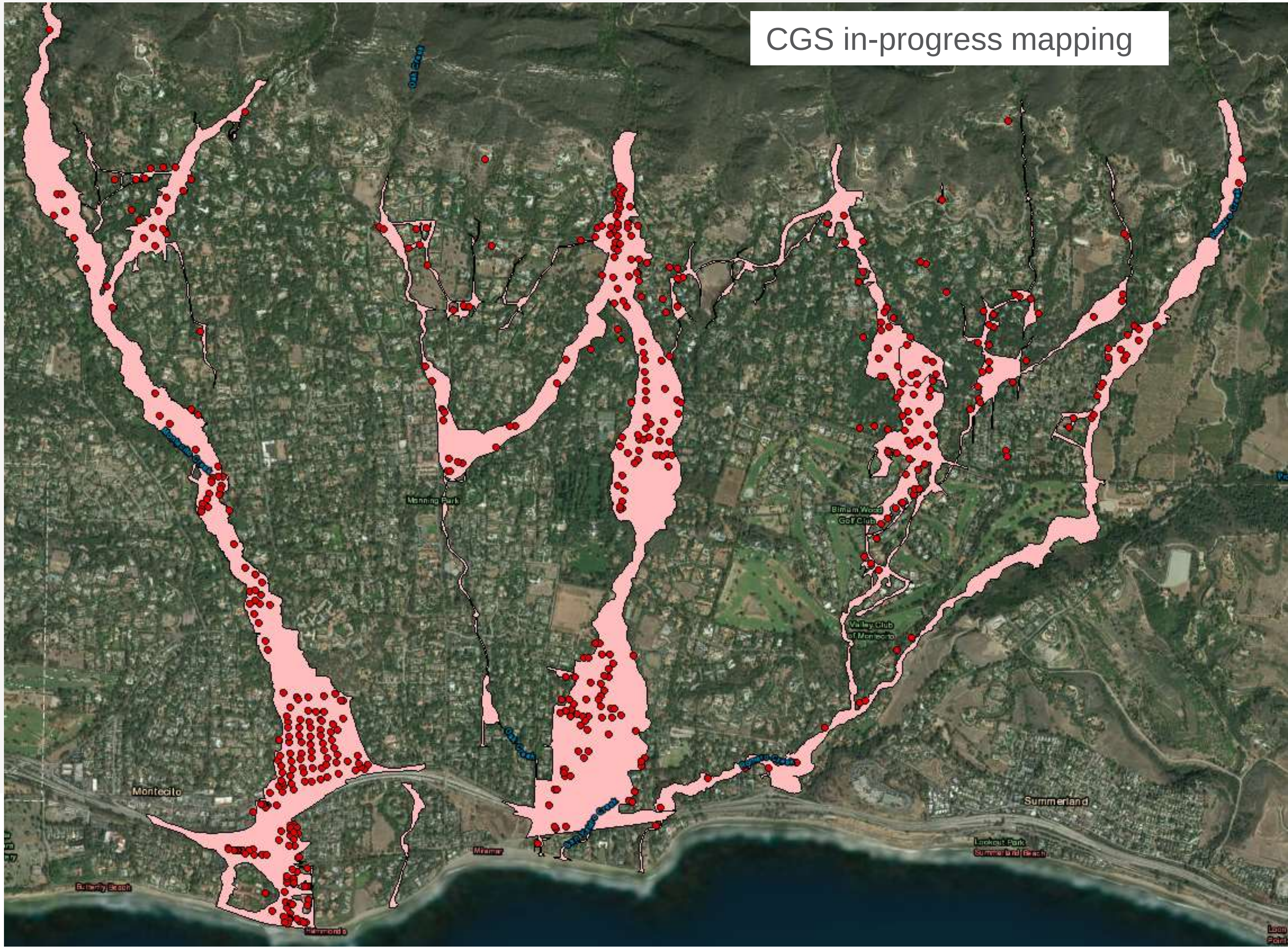
- Mileage - 45 miles
- # of Communities Effected – 4

COUNTY OF SANTA BARBARA CALIFORNIA

Cal OES
CA Office of Emergency Services

FEMA

Partners



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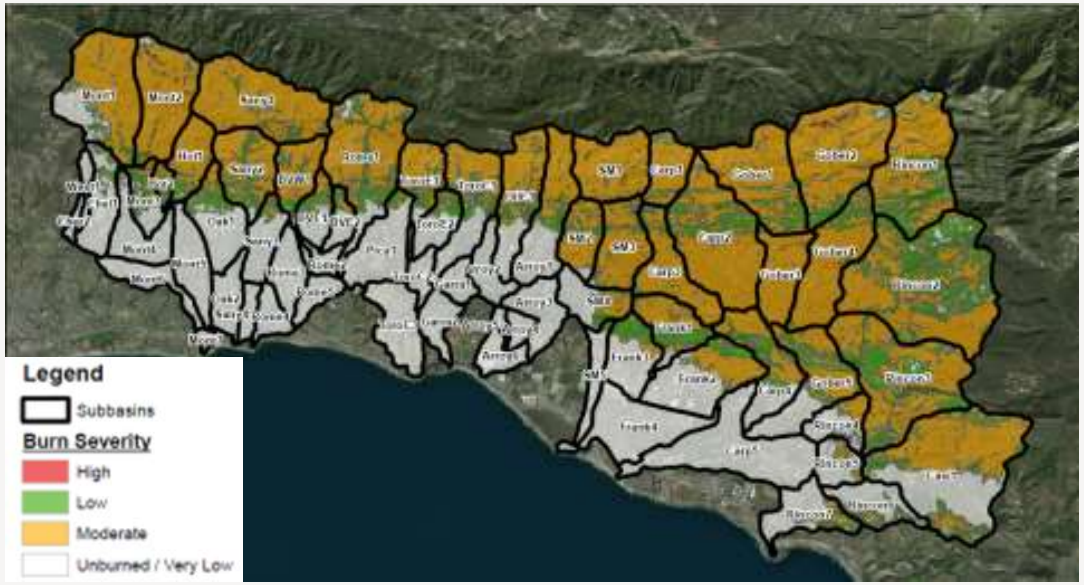
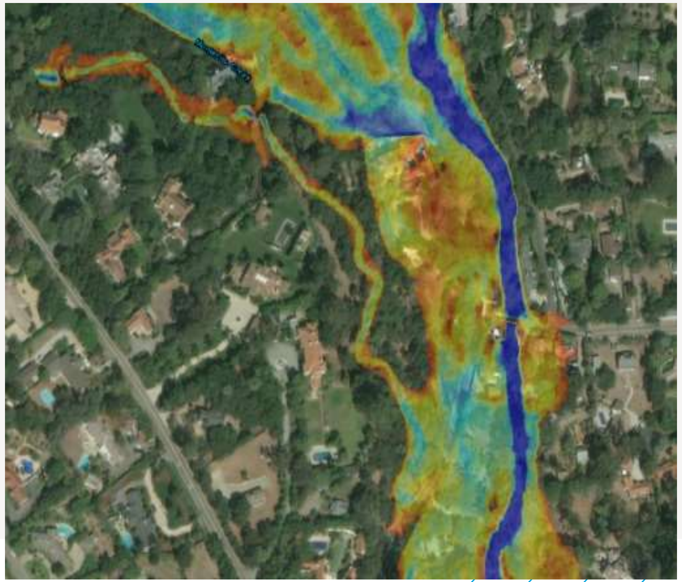
Technical and Outreach Approach



- Develop post-burn hydrologic models based on 1% chance rainfall
- Develop 2-dimensional (2D) hydraulic models utilizing post-burn flows
  - Define hazard boundaries
  - Produce water surface elevation grids & contours
  - Produce depth grids
- Develop Recovery maps
- Multiple opportunities to share findings, address concerns, and answer questions at public meetings



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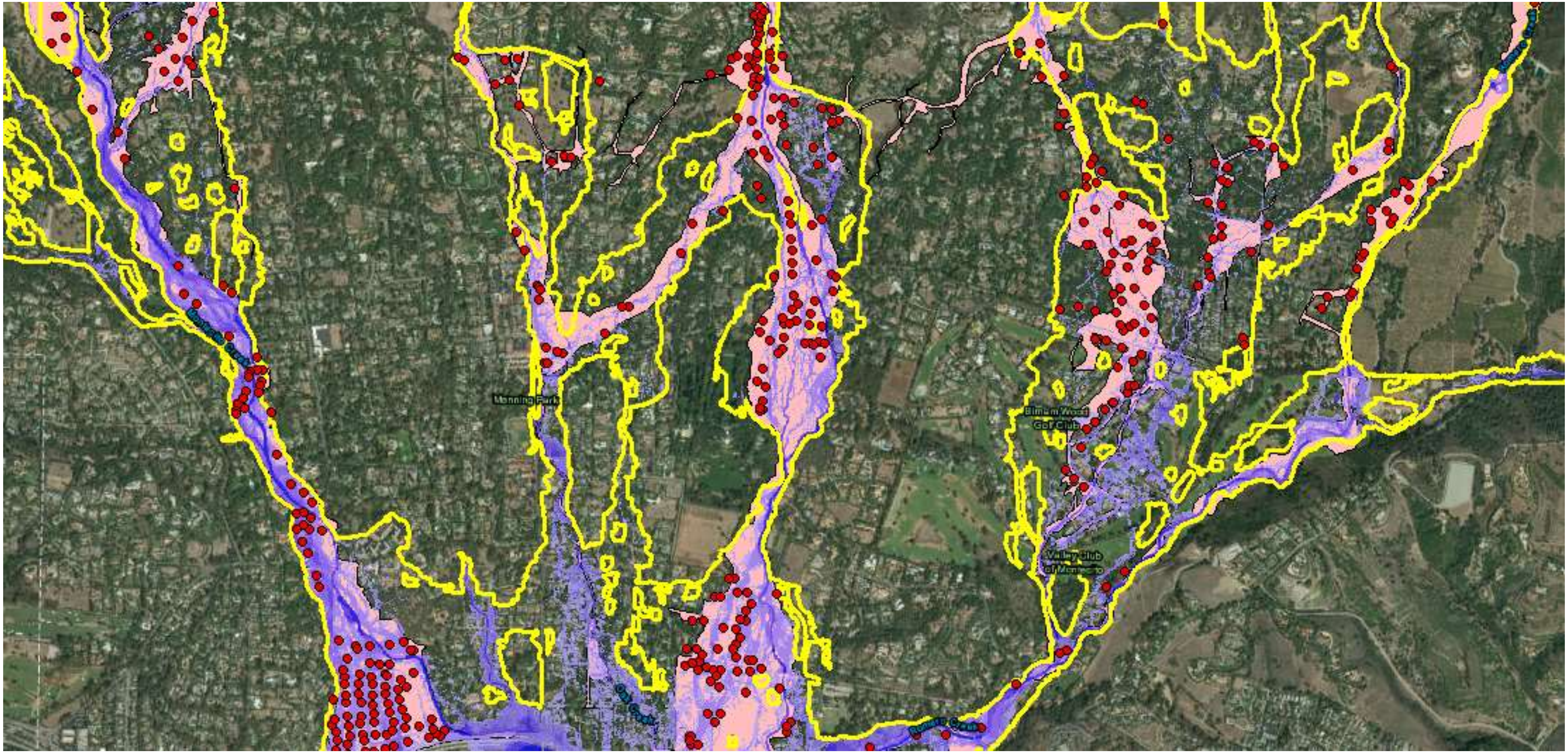

CGS in-progress mapping

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Mitigation: A Fundamental Shift in Approach

- Distinguish lessons learned to employ mitigation actions that ensure structures are
  - Rebuild Stronger,
  - Safer, and
  - Less vulnerable in the future

- Community Actions
  - Pursuing debris basin projects from Hazard Mitigation Grant Program (HMGP)
  - HMGP is now available after Fire Management Assistance declarations (FY 17 and 18)
  - One potential project is code enforcement augmentation

- Individual Actions
  - In rebuild, follow recovery maps which better reflect current hazard risk

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Rapid Floodplain Delineation (RFD) and Its Applications

Sarada Kalikivaya, P.E., CFM

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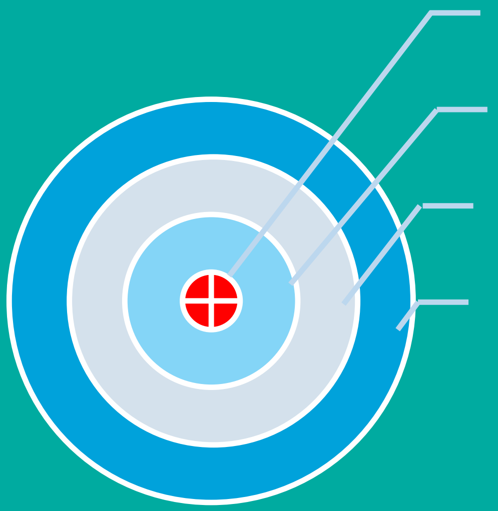

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Rapid Floodplain Delineation (RFD) – Highlights

Introduction

- In-house Technology tool
- Philosophy
  - *Keep it simple*
    - *Desktop-based, extremely small system footprint*
    - *Exceptionally fast computations*
    - *Only features needed for accurate computations, no bloat*
    - *GIS required only to setup data and view results*
  - *Not a black-box program*
    - *Meant to allow engineer to use time effectively*
    - *Lots of meaningful output for QA/QC*
    - *Speed allows issues to be detected and fixed quickly*

Features

- Topography
  - *Tiled data for most efficient usage*
  - *No complicated different sources merging*
- Hydrology
  - *Gridded hydrology uses updated flow at every cross-section*
- Hydraulics
  - *Highly-intelligent XS placement and bending*
  - *Automated determination of ineffective flow areas*
  - *Use of either in-program step-backwater or HEC-RAS back end*
  - *Ability to automatically read structures from standard roads dataset along National Bridge Inventory*
  - *Enforce good H&H at confluences*
  - ***Full backwater computation***

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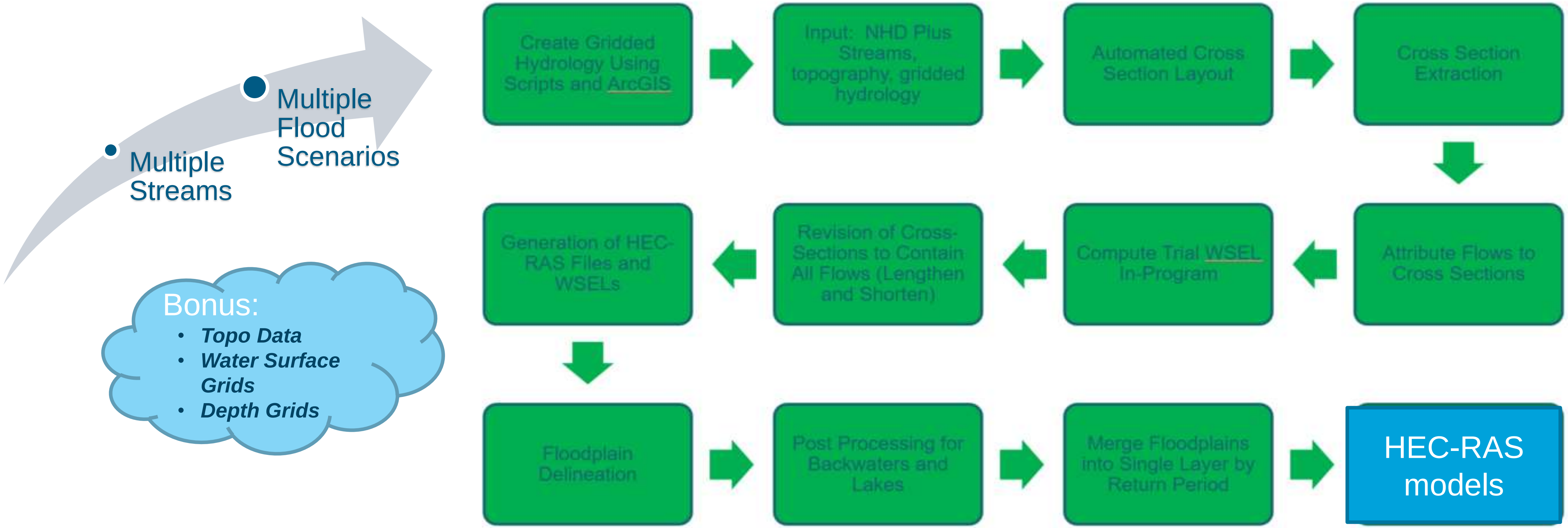
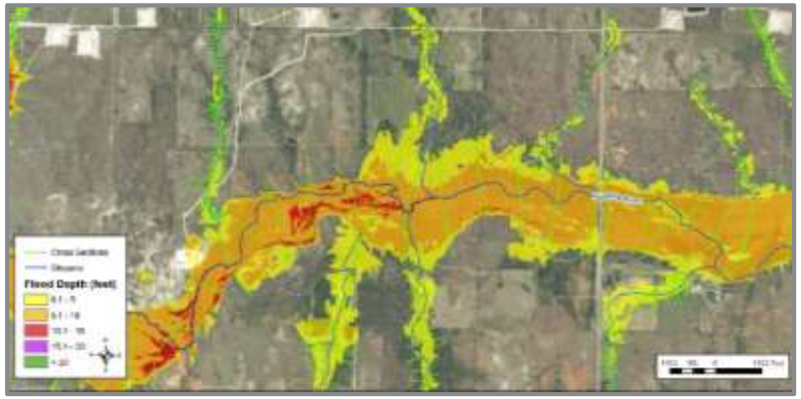
What is the typical Process?

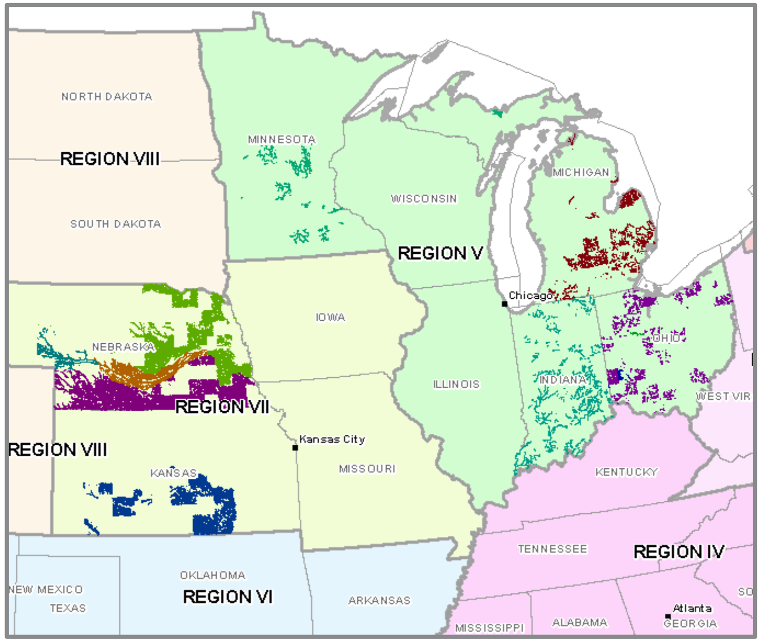


Tool Application Examples

- Strong history of use since 2006:
  - **Over 10,000 miles of use for Flood Insurance Rate Map production**
  - **Over 60,000 miles of use for validation of existing study flooding sources in 9 months**
  - **Over 30,000 miles of new miles of Flooding Sources**

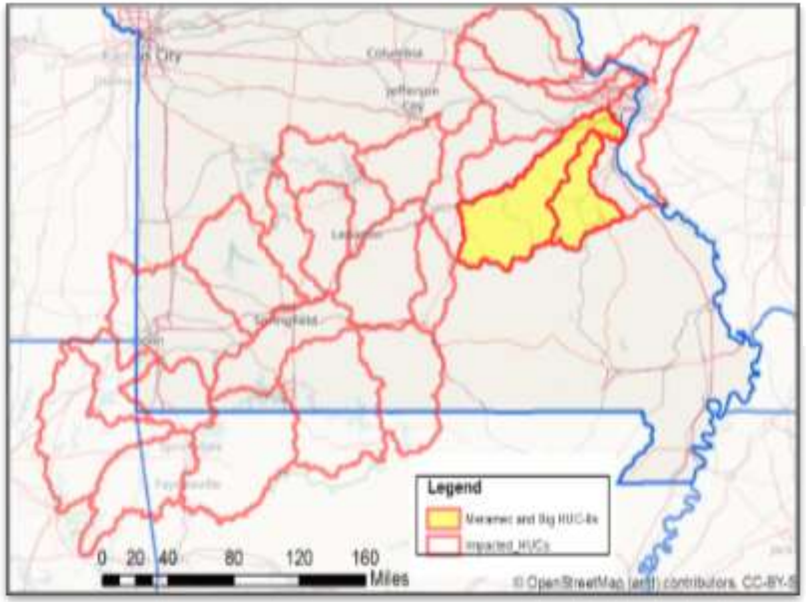


BLE Analysis



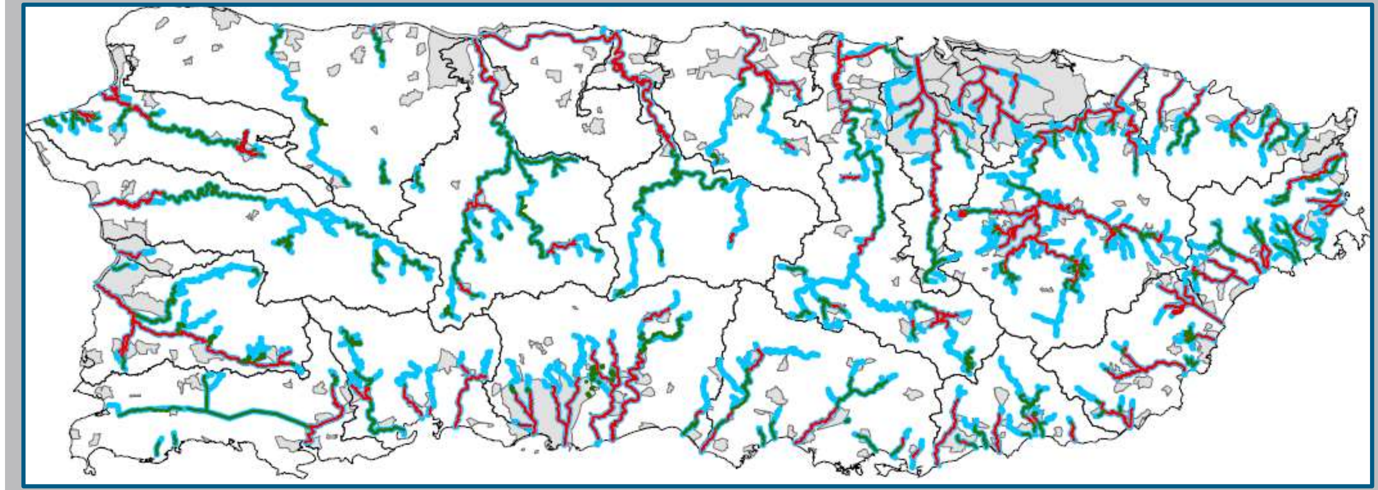
Leader in the Nation

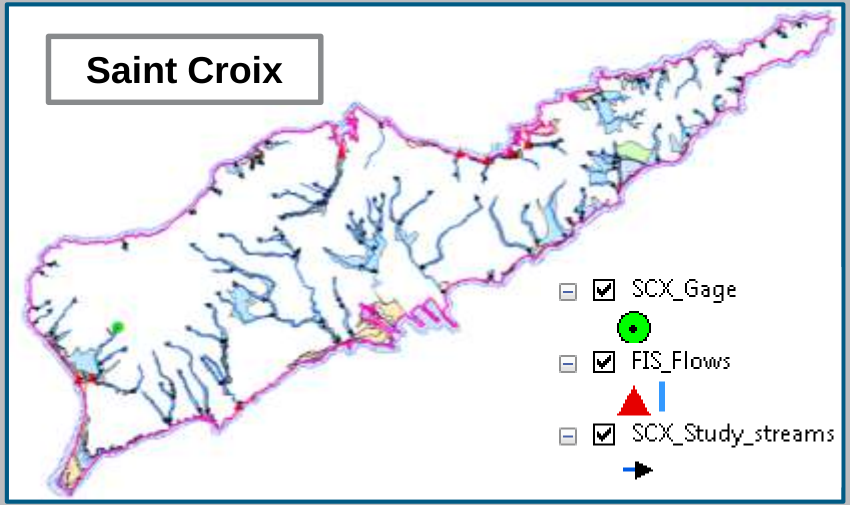
CNMS Validation with FOA

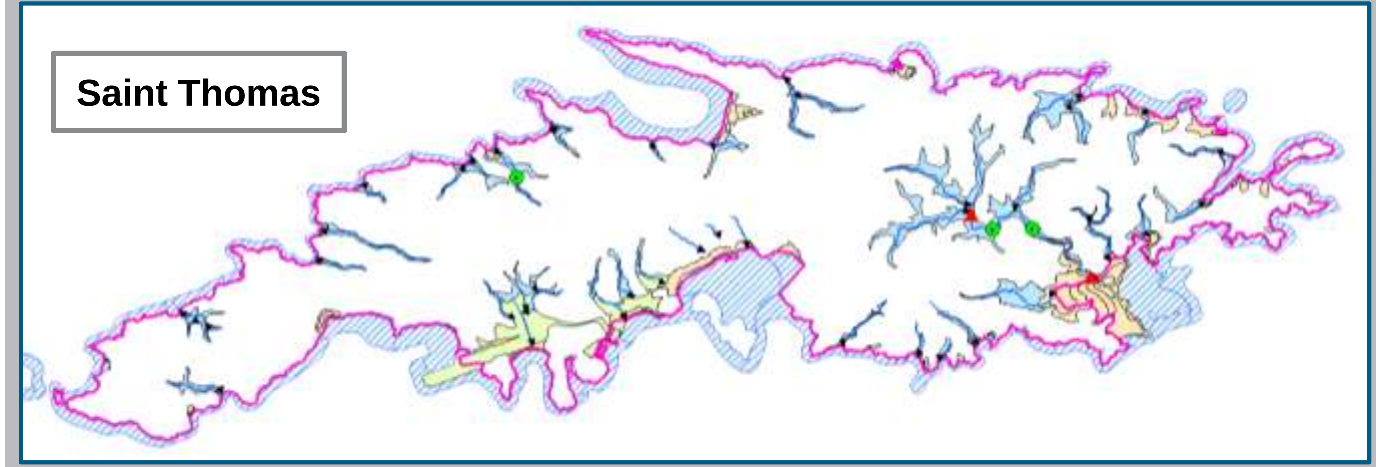


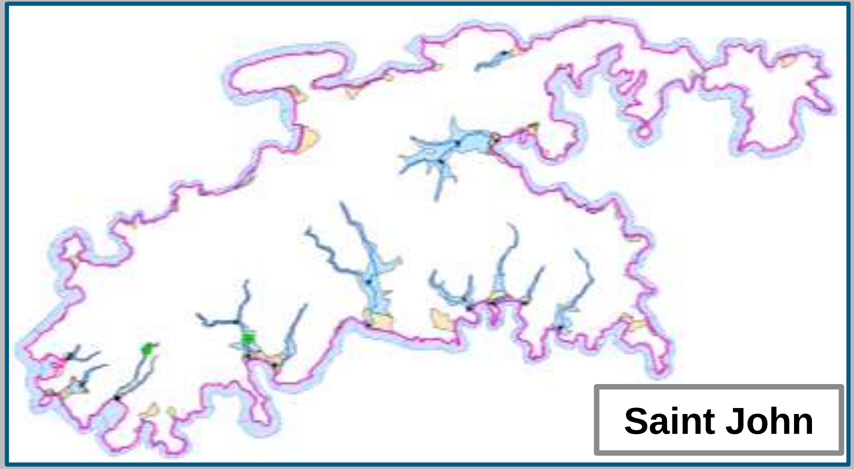
Flood Forecasting

Tool Application Examples: ABFEs in Puerto Rico & USVI









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How Are We Making FEMA Successful?

- ✓ Model Backed Datasets
  - › Provide credible flood risk data to help communities implement higher floodplain management standards
- ✓ Multiple H&H Model Result Formats
  - › Not just regulatory floodplains
- ✓ Multiple Uses Outside Regulatory Process
  - › Ex: ABFEs / Grant Applications / Risk Assessments
- ✓ Cautiously Increasing Flood Risk Data Coverage
  - › Cost effectively produce flood risk data in unmapped (or under mapped) areas

2D Monte - Carlo Probabilistic Modeling Uncertainties

Cameron Jenkins, PE

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**TMAC – Technical Mapping Advisory Council*
** NAS – National Academy of Sciences*

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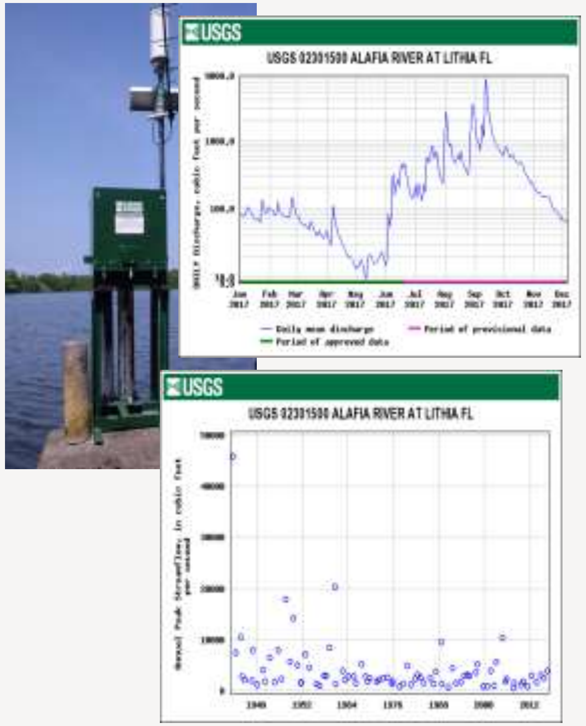
Deterministic Approach (Current) – Flood Modeling



Collect Gage Data

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	<-- FOR BULLETIN 17B ESTIMATES --> VARIANCE OF EST.	95% CONFIDENCE INTERVALS LOWER	UPPER
0.9950	487.6	579.5	----	363.4	618.7
0.9900	548.4	631.7	----	414.5	688.5
0.9500	786.7	840.3	----	620.2	958.5
0.9000	978.2	1011.	----	789.2	1173.0
0.8000	1305.	1306.	----	1082.0	1538.0
0.6667	1753.	1719.	----	1485.0	2042.0
0.5000	2455.	2380.	----	2110.0	2849.0
0.4292	2846.	2755.	----	2452.0	3311.0
0.2000	5157.	5062.	----	4386.0	6198.0
0.1000	7960.	8023.	----	6592.0	9969.0
0.0400	13110.	13810.	----	10420.0	17190.0
0.0200	[illegible]	20210.	----	[illegible]	[illegible]
0.0100	25490.	29040.	----	19030.0	36790.0
0.0050	[illegible]	41150.	----	[illegible]	[illegible]
0.0020	50940.	64180.	----	35440.0	80760.0

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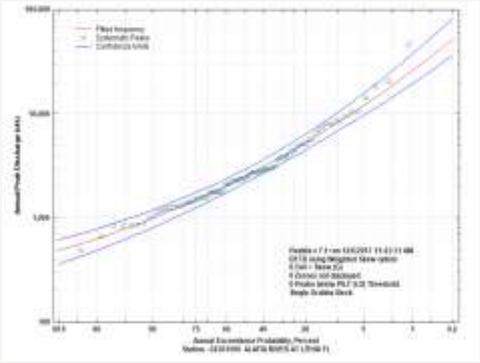
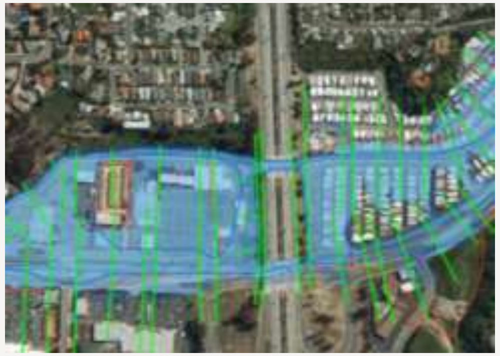
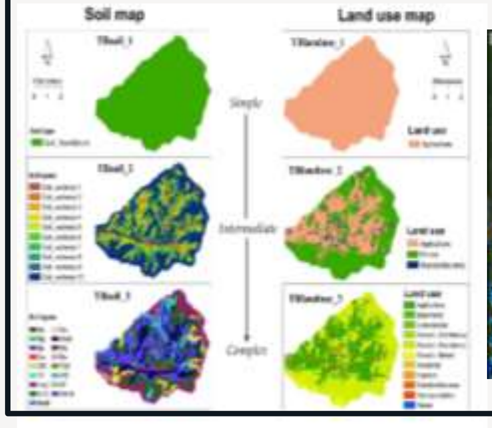
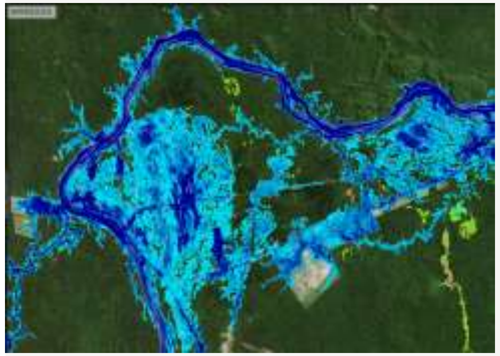


Flood Frequency Analysis





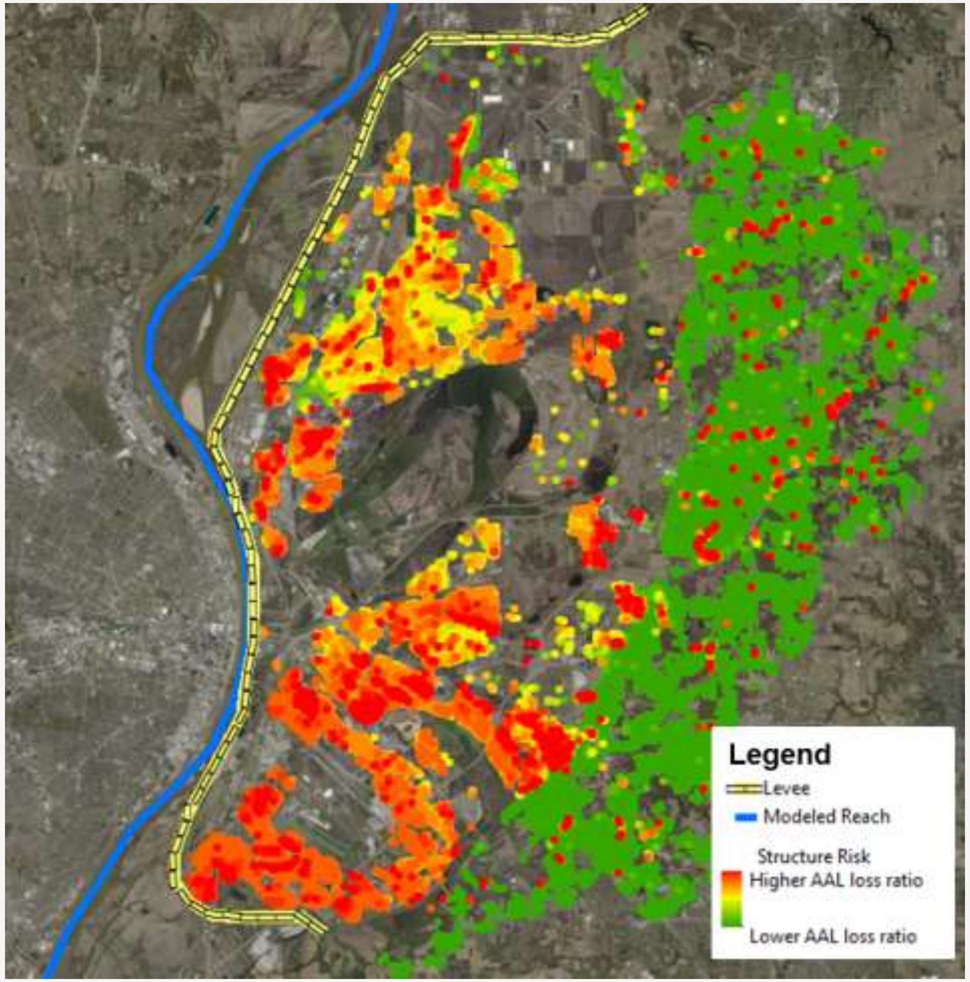


1D or 2D Hydraulic Modeling

Need for Probabilistic Modeling

- In Deterministic Approach - No consideration of uncertainty
- More than 25% of NFIP claims are for structures outside the SFHA (about 60% of losses)
- Need structure-level risk assessment
- Graduated risk within 0.2% floodplain
- Risk behind levees and ultimately performance based levee analysis
- Future conditions
- Risk-informed decision making process
- Residual and Pluvial risk
- Total flood risk (Fluvial + Pluvial)

$$\text{AAL Loss Ratio} = \frac{AAL}{Structure\ Value}$$



Hot Spot Map of AAL Loss Ratio (Combined Fluvial and Pluvial)

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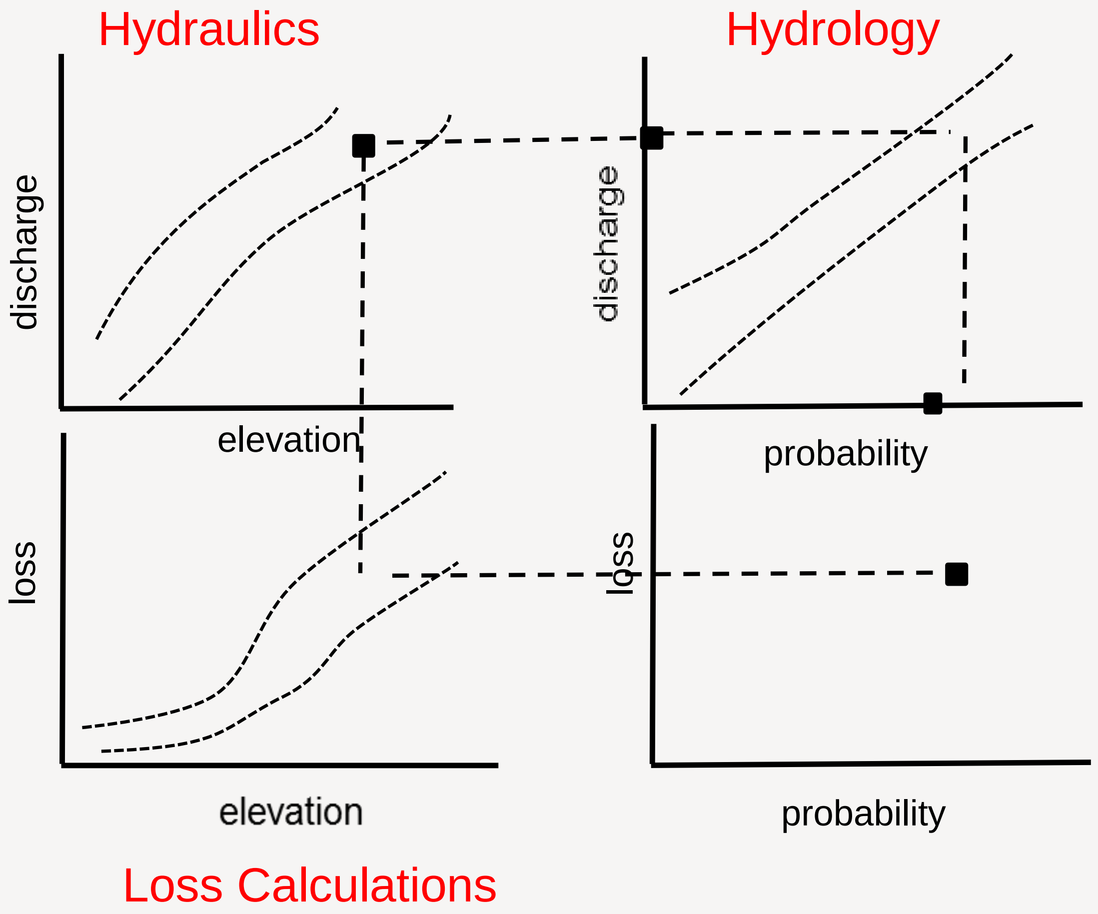
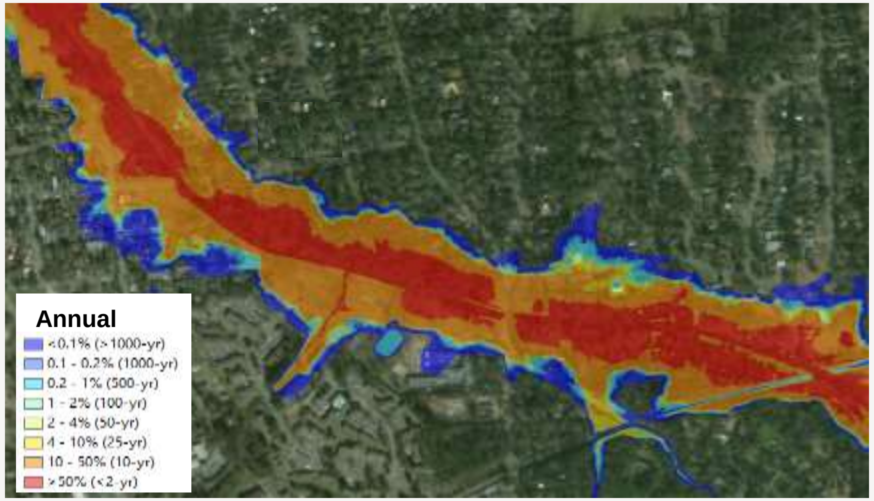
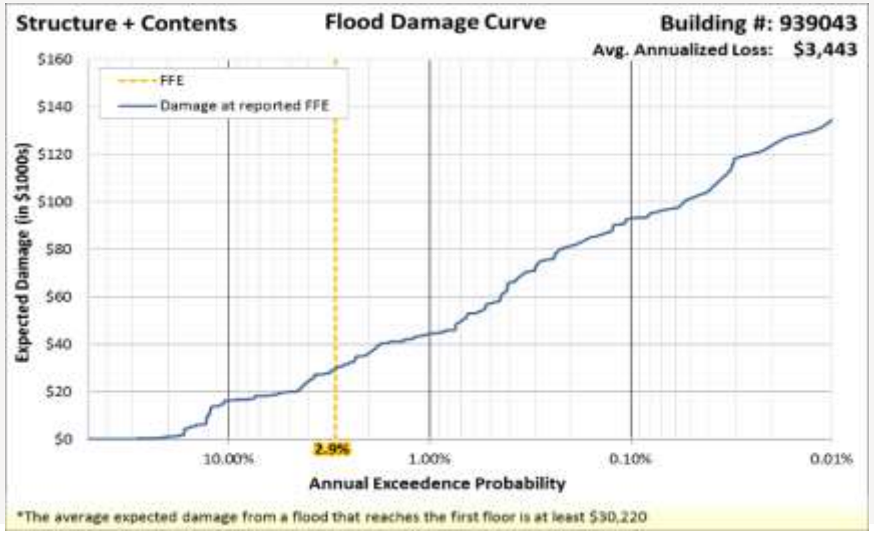
Probabilistic Approach







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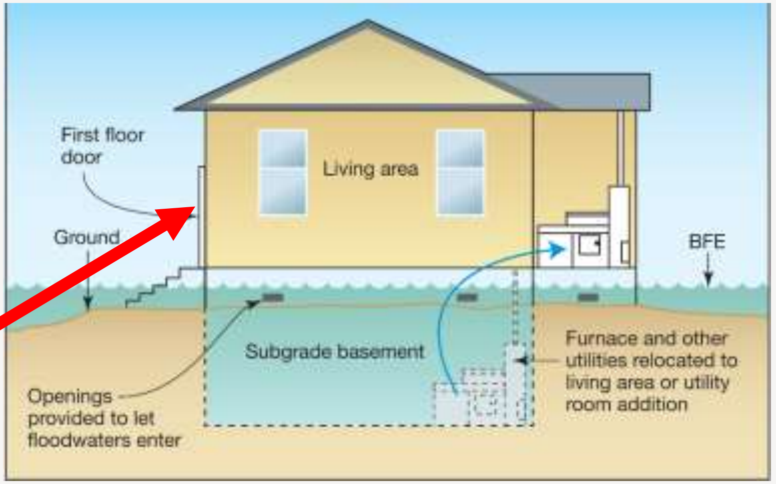
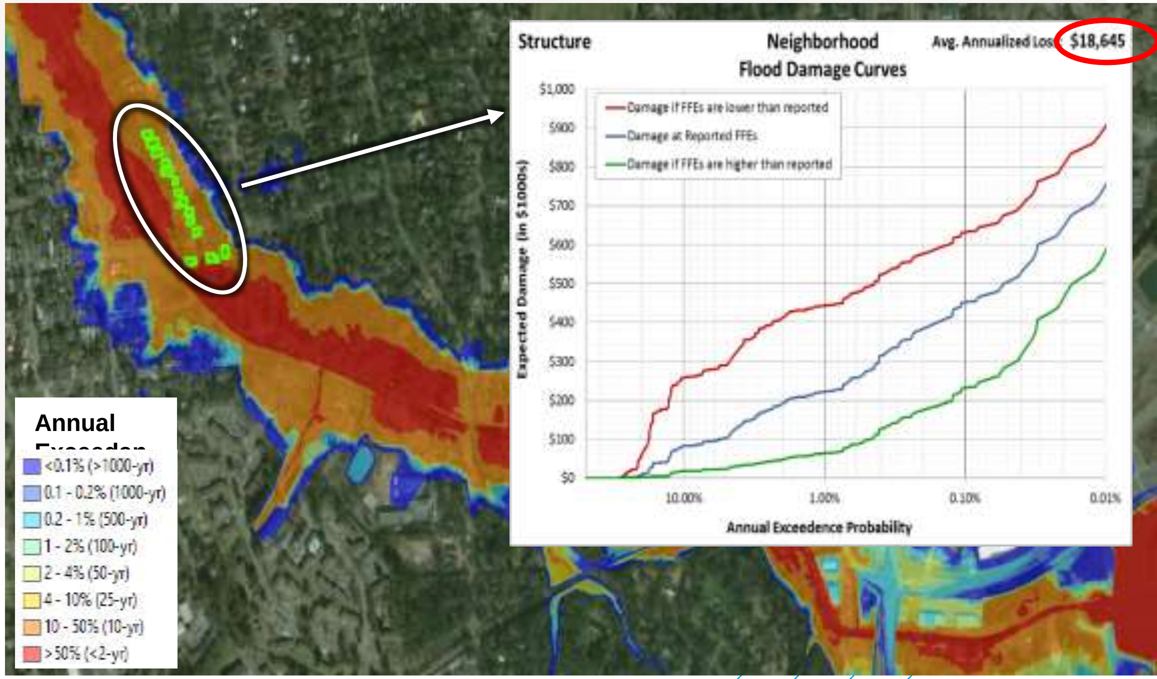
Probabilistic Mapping – Benefits

- ✓ More comprehensive analysis of the flood hazard –
  - ✓ *50% (2-yr) to the 0.05% (2000-yr) annual chance or greater*
- ✓ More credible analysis of the flood hazard –
  - ✓ *modeled scenarios consider multiple uncertainties*
- ✓ Increased confidence in the probability at which a flood would reach a structure's first floor elevation
- ✓ More accurate flood risk and annualized loss estimates
- ✓ True multi-frequency grid outputs
  - ✓ *WSEL, depth, velocity, and depth * velocity*
  - ✓ *Applications in both pre- and post-disaster environments*





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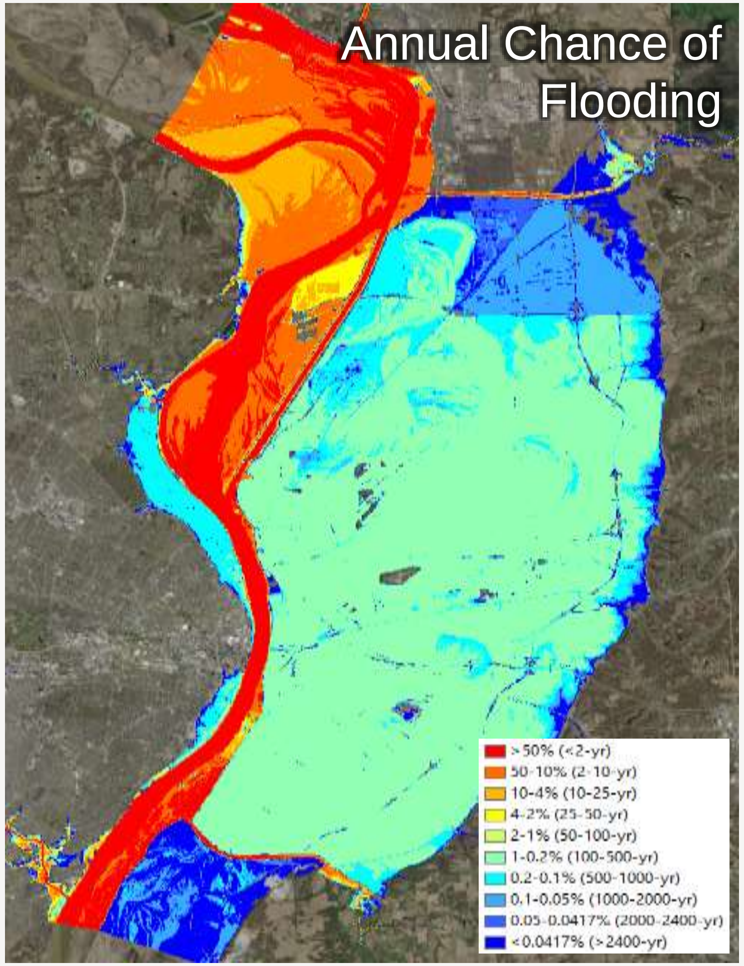
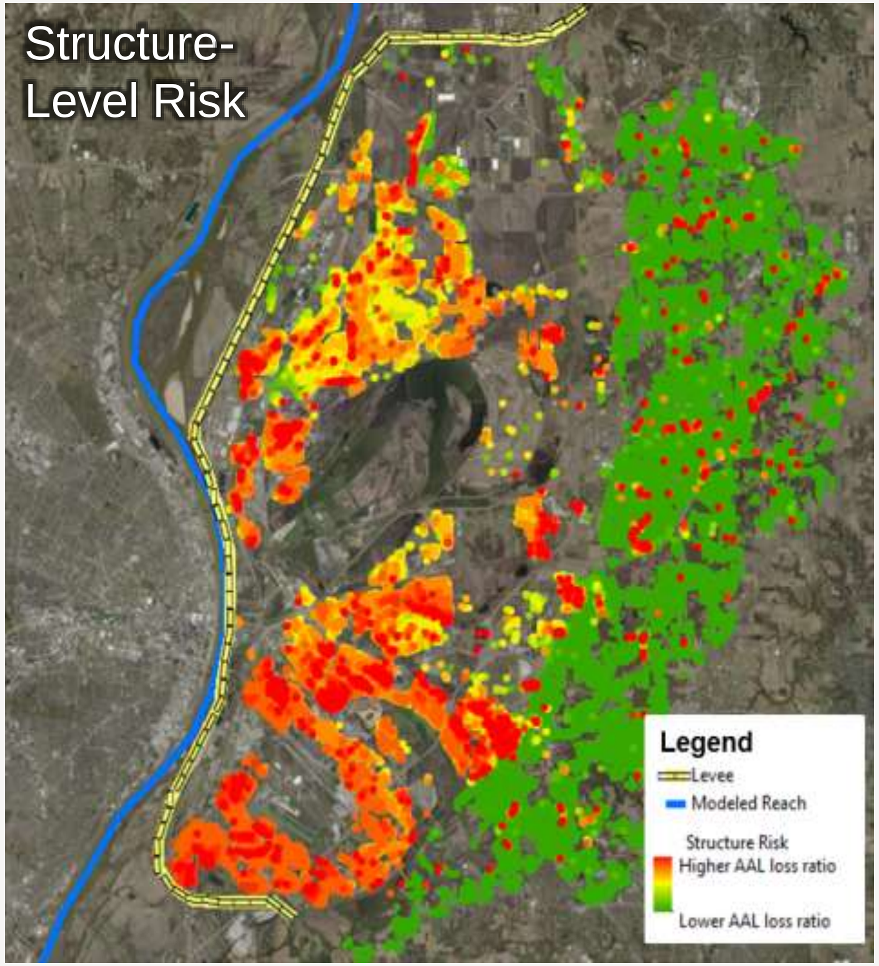
Probabilistic Modeling Pilots & Outputs





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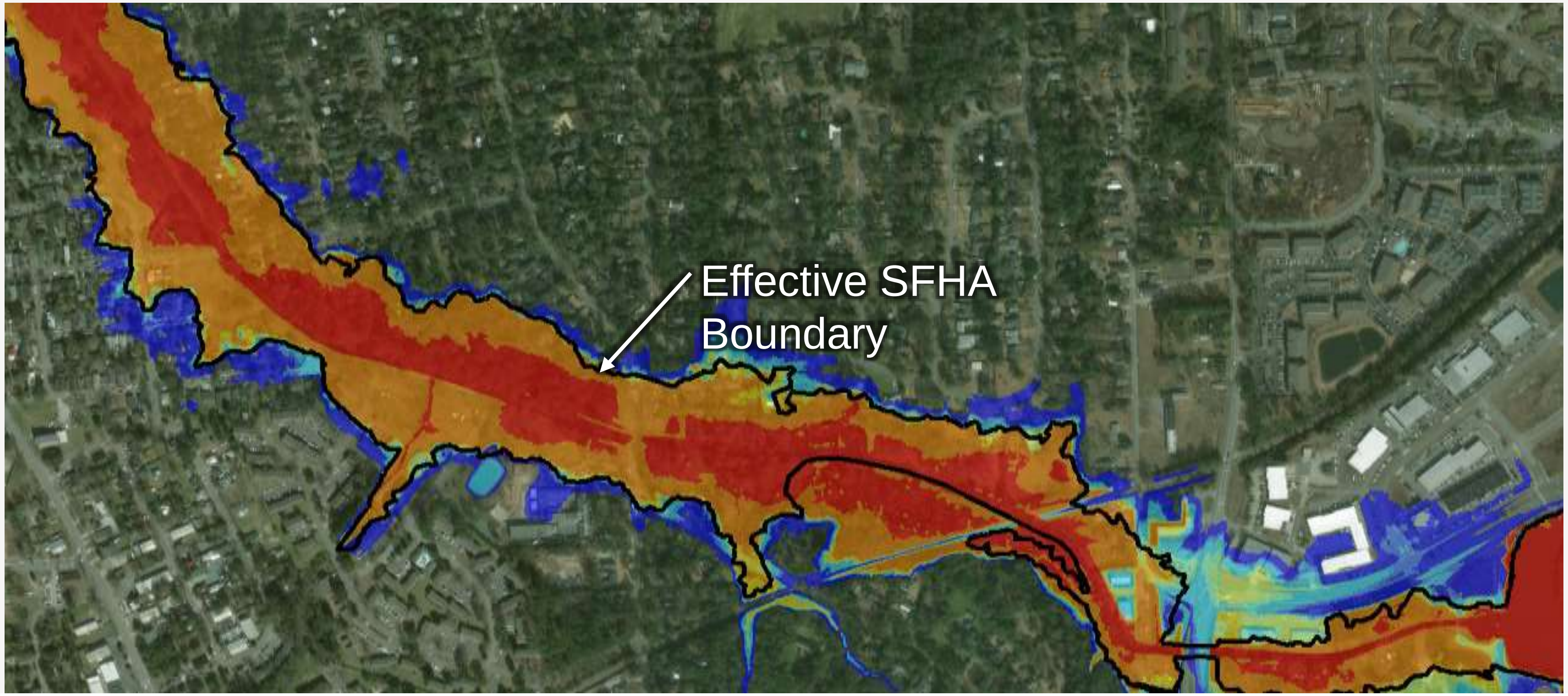
Probabilistic Mapping – Looking to the Future

- ✓ 5 locations being currently analyzed
- ✓ Refine pluvial and levee analyses
- ✓ Define the process to develop levee fragility curves
- ✓ Create procedure document
- ✓ Publish procedure in Journal



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Improving Mitigation Decision-Making through Local Data and Tools – Jefferson Parish, LA

Jamelyn Trucks, CFM, CGM

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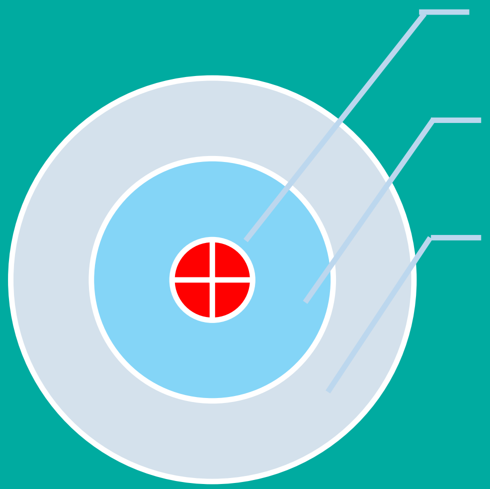

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Informing the Mitigation Plan Process

Usually involves 3 major components

- Risk Assessment (what are the risks/problems?)
- Capability Assessment (what could we do about them?)
- Mitigation Actions (what will we do about them?)

How do we make the best decisions about what we should do to mitigate?

- Creating better tools and data
- Increasing collaboration across departments
- Bringing it all together in one place

"If you just keep haphazardly going around doing one project that doesn't feed into the next, you may be hurting yourself in the end"

Michelle Gonzales, director of floodplain management and hazard mitigation for Jefferson Parish

Source: The Economist INTELLIGENCE UNIT

Innovation for better Communication, Risk Assessment and Decision Making

Hazard Event Capture Tool

Collector App

Asset Inventory

Collector App

Repetitive Loss Analysis Tool

Collector App

Grant Application Development Tool

Collector App

Adopt a Catch Basin

Public Facing Website

Decision Support Tool

Final End Product

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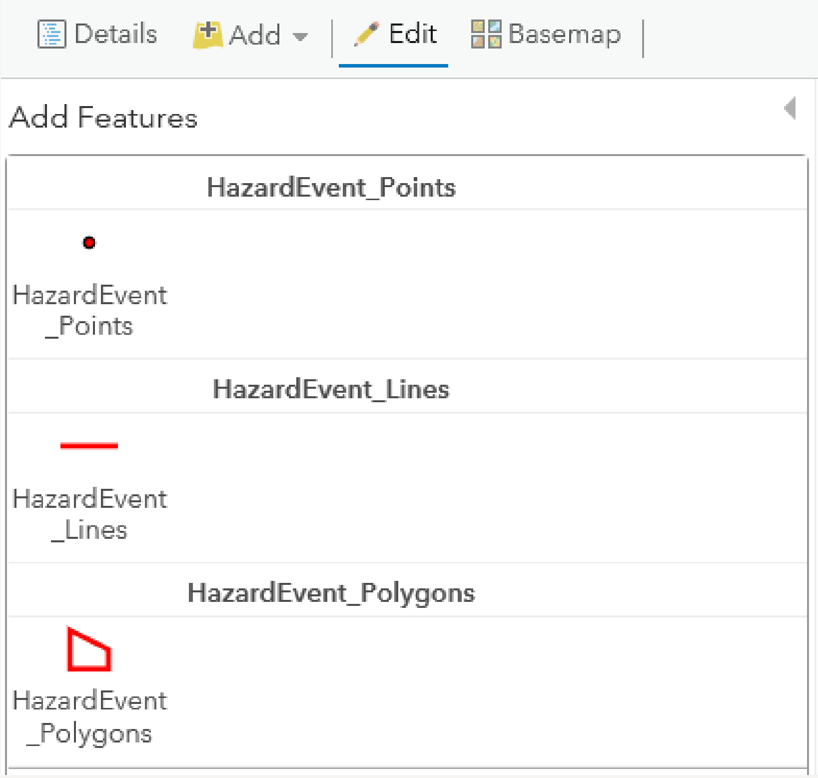
Hazard Event Capture Tool

When events happen, field staff can record from mobile application and office staff can take calls from citizens

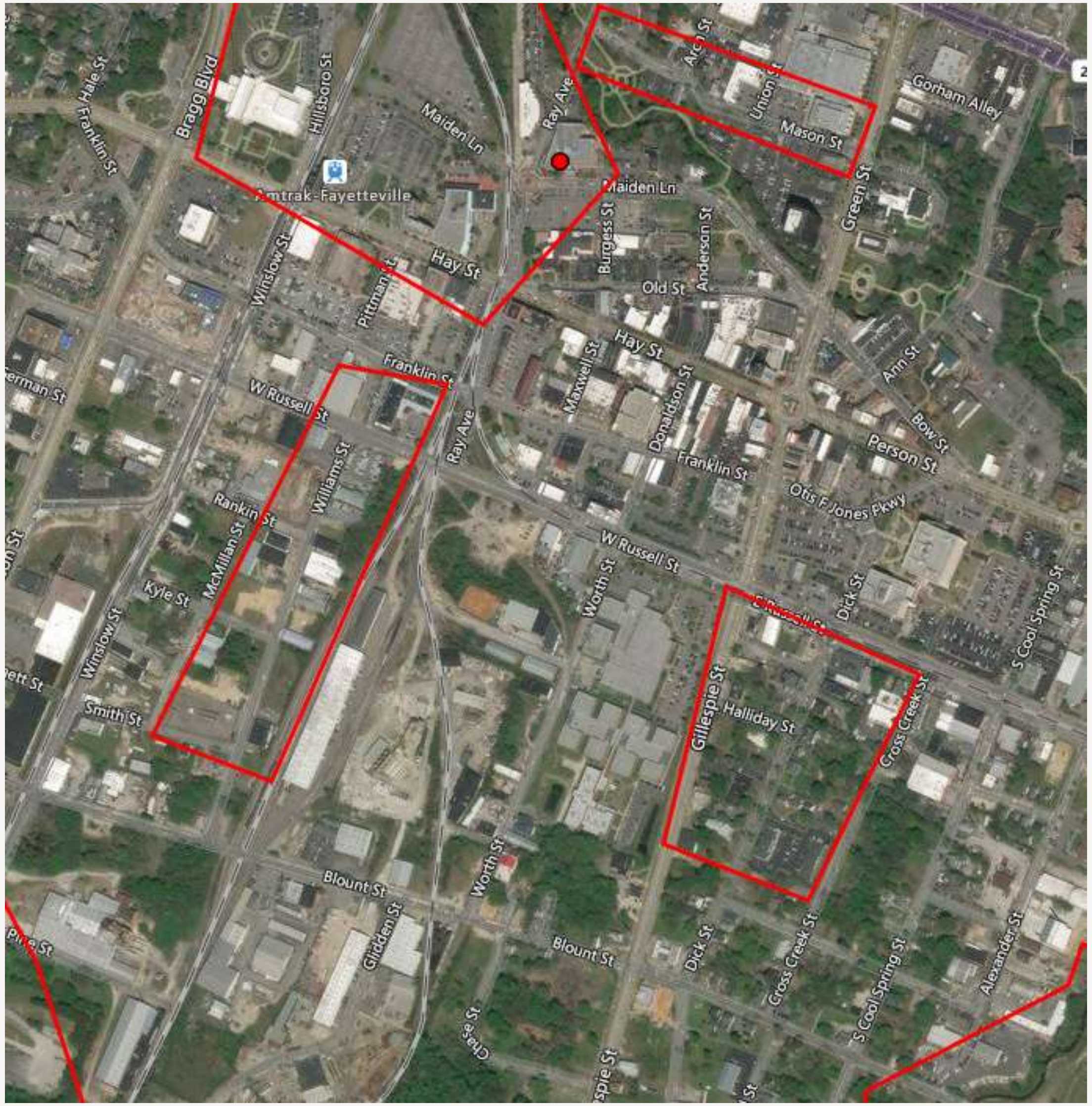


Can add information like:

Date

Magnitude

Duration



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Repetitive Loss Analysis Tool

Identifies all repetitive loss properties in parish and is a starting point for determining areas where mitigation is needed

- ✓ Repetitive loss properties can be low hanging fruit for mitigation
- ✓ These can be a jumping off point when thinking about applying for mitigation grants

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Support FEMA Strategic Plan at a Community Level

Better learn from past disasters, improve continuously, and innovate

Use Collector App to record and gather Localized and Reported Hazard Event Data in real time.

Strengthen grants management, increase transparency, and improve data analytics

Grants Development supported by field collection tools and integration with Maps to expedite process and develop data layers.

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Looking Forward - Decision Support Tool

Policy-makers can be assured of getting the right information to make the right decisions

- ✓ Better Identification and Communication of Risks through Maps
- ✓ Based largely on the inputs of all of the collector apps and tools
- ✓ End tool will provide local staff with information on the advantages and disadvantages of different projects
- ✓ Key part of the mitigation planning process!

Next steps:

Parish is looking to put together a more collaborative GIS effort to support collaboration between departments and municipalities

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Key Takeaways

Innovations that support FEMA and other partners with

- Post – Disaster Inspection
- Substantial Damage Assessment
- Post Disaster Risk Assessment
- Actionable Mitigation Support
- Risk Communication

- Risk Identification
- Flood Forecasting
- Structure level Risk Assessment
- Rapid Post Disaster Fire Analysis

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Key Takeaways – Your Input

Which Innovation resonated well with you?

In your opinion, Which Innovations are needed for future ?

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