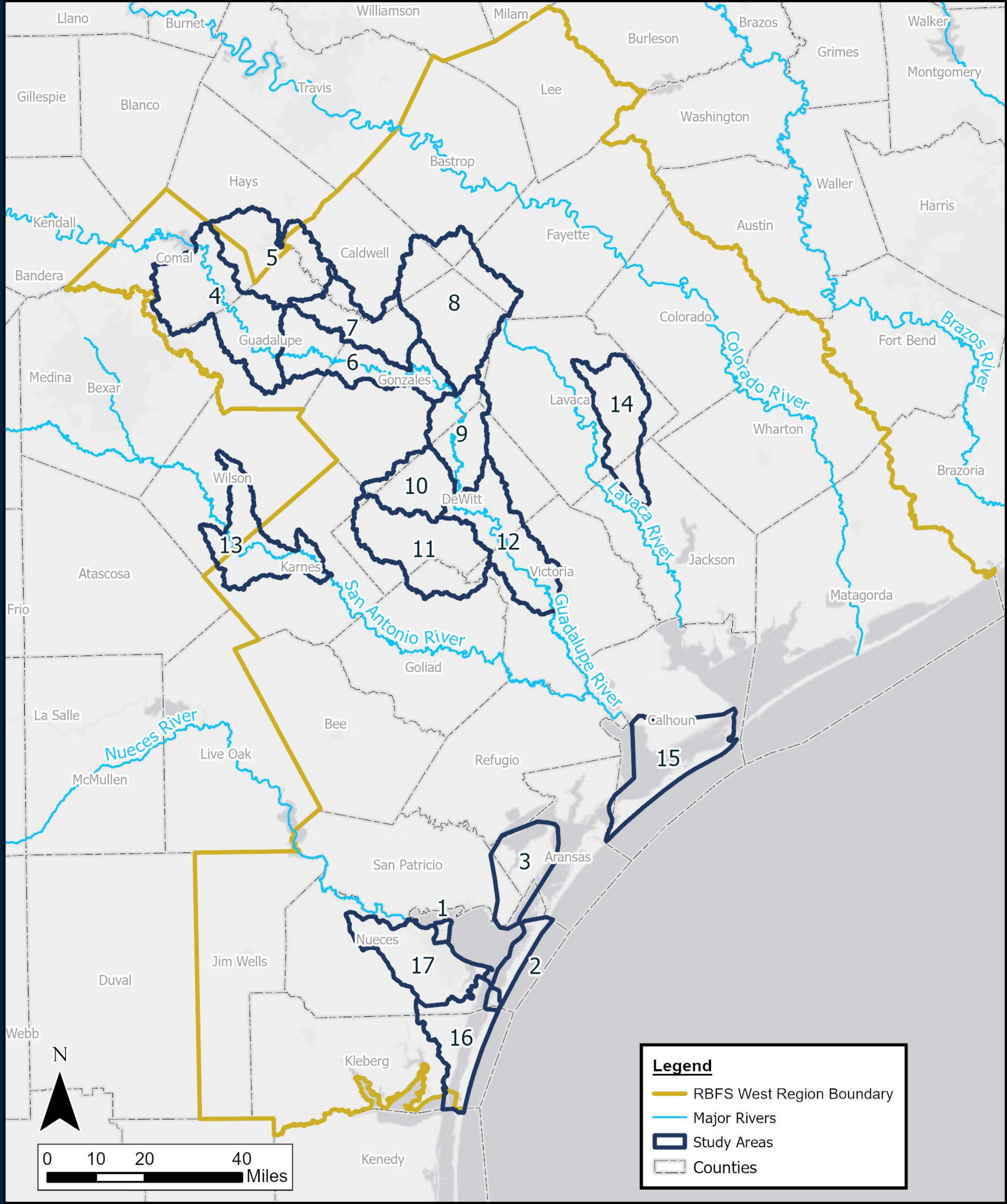
GLO River Basin Flood Study

TIFF Integrated Flood Modeling Brown Bag Series
West Region Modeling Overview

Commissioner Dawn Buckingham, M.D.

Agenda

- Selection of Watersheds for Evaluation & Watershed Level of Detail
- Modeling Methodologies:
  - Riverine Watersheds
  - Coastal Watersheds
- Key Findings & Lessons Learned
- Phase 4 Alternatives Analysis & Next Steps



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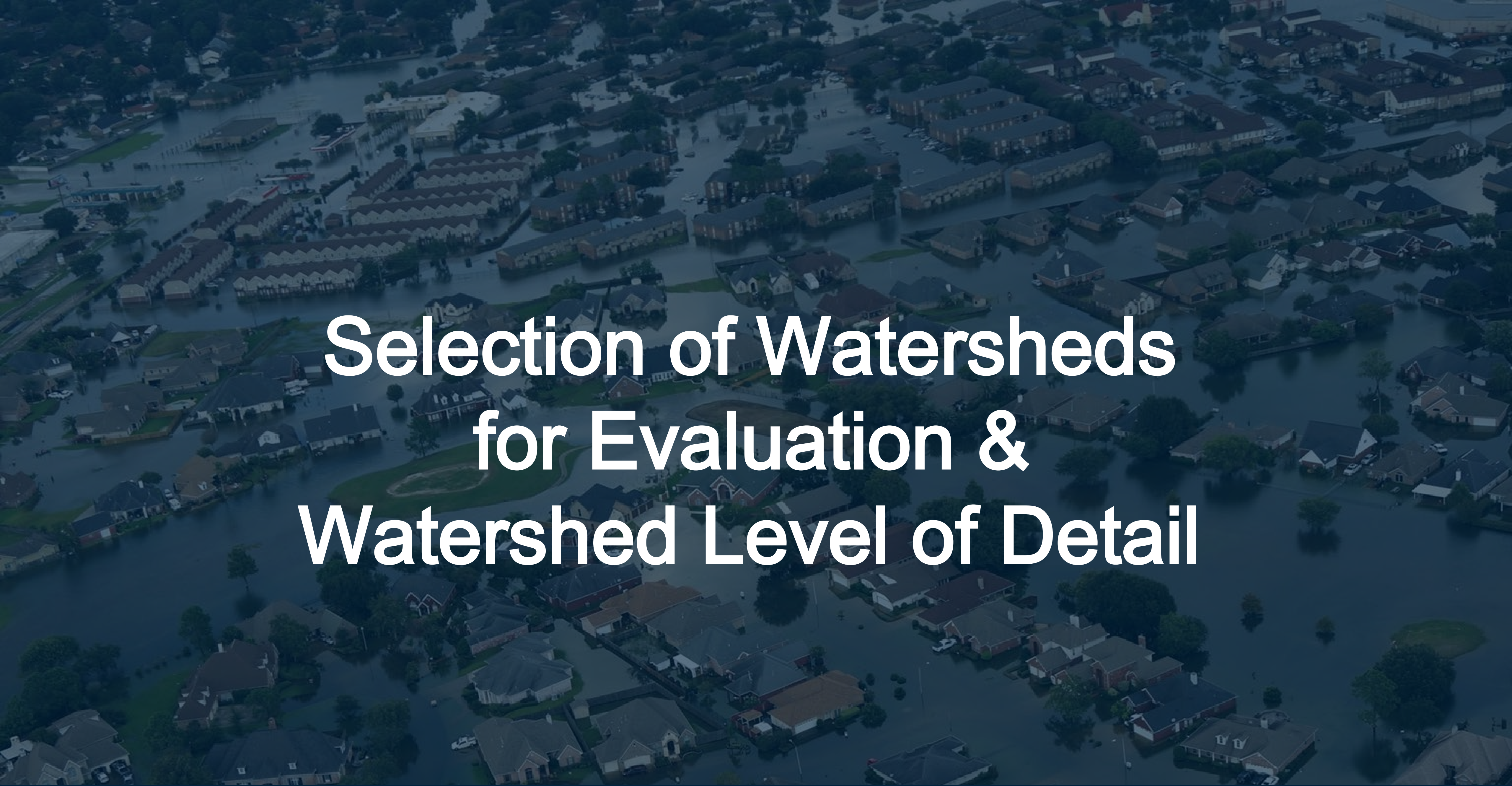

Selection of Watersheds for Evaluation & Watershed Level of Detail

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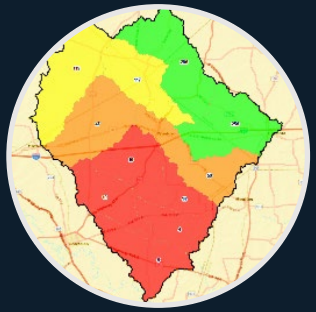
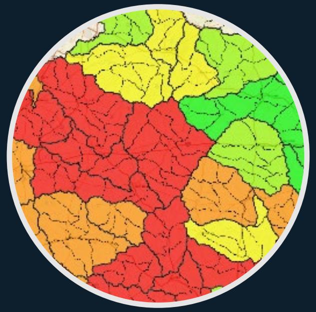
Watershed Prioritization (Guiding Areas of Study)



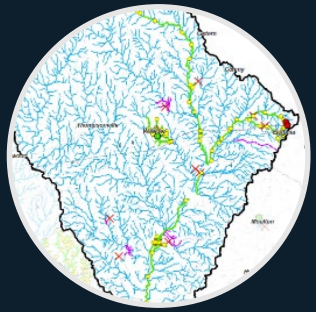
STEP ONE

HUC12 EVALUATIONS



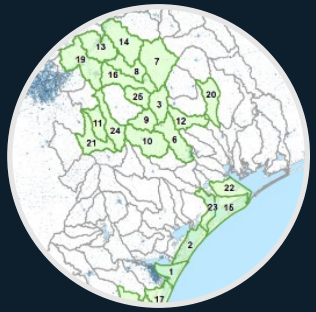
STEP TWO

HUC10 EVALUATIONS



STEP THREE

STREAM LEVEL EVALUATIONS



RESULT

PHASE 3 STUDY AREAS

HUC10 Prioritization Formula:

- 80% Flood Vulnerability (NRI)
- 10% SoVI
- 10% Community Engagement

Stream Level of Detail (Guides Level of Evaluation)

Data Inputs

- Texas Water Development Board (TWDB) Floodplain Quilt
- U.S. Geological Survey National Hydrography Plus (NHDPlus) High Resolution Stream Flowlines
- Microsoft's Texas Building Footprints Dataset
- Redacted National Flood Insurance Program (NFIP) and Individual Assistance (IA) Claims
- Redacted FEMA Severe Repetitive Loss and Repetitive Loss Structures
- Critical Infrastructure
- Texas Department of Transportation (TxDOT) Roadway Overtopping History

High Risk –

Primary flooding source for a watershed. Expected High severity and frequency of flooding

Modeling: Detailed survey, smaller sub -basins, more mesh detail, focus for calibration, location of flow inputs.

Medium Risk –

May contribute to community flood hazards, but where the extent of impact is not evident based on available data at this time.

Modeling: Lower -detail survey (field recon), larger meshes, larger sub-basin delineation, location of flow inputs.

Low Risk -

Outside of populated areas with minimal flood hazard. These streams can likely be assessed broadly through low level detail studies.

Modeling: No survey, larger sub -basins, upstream low detail may not have flow input.

Model Tiers

Tier 1

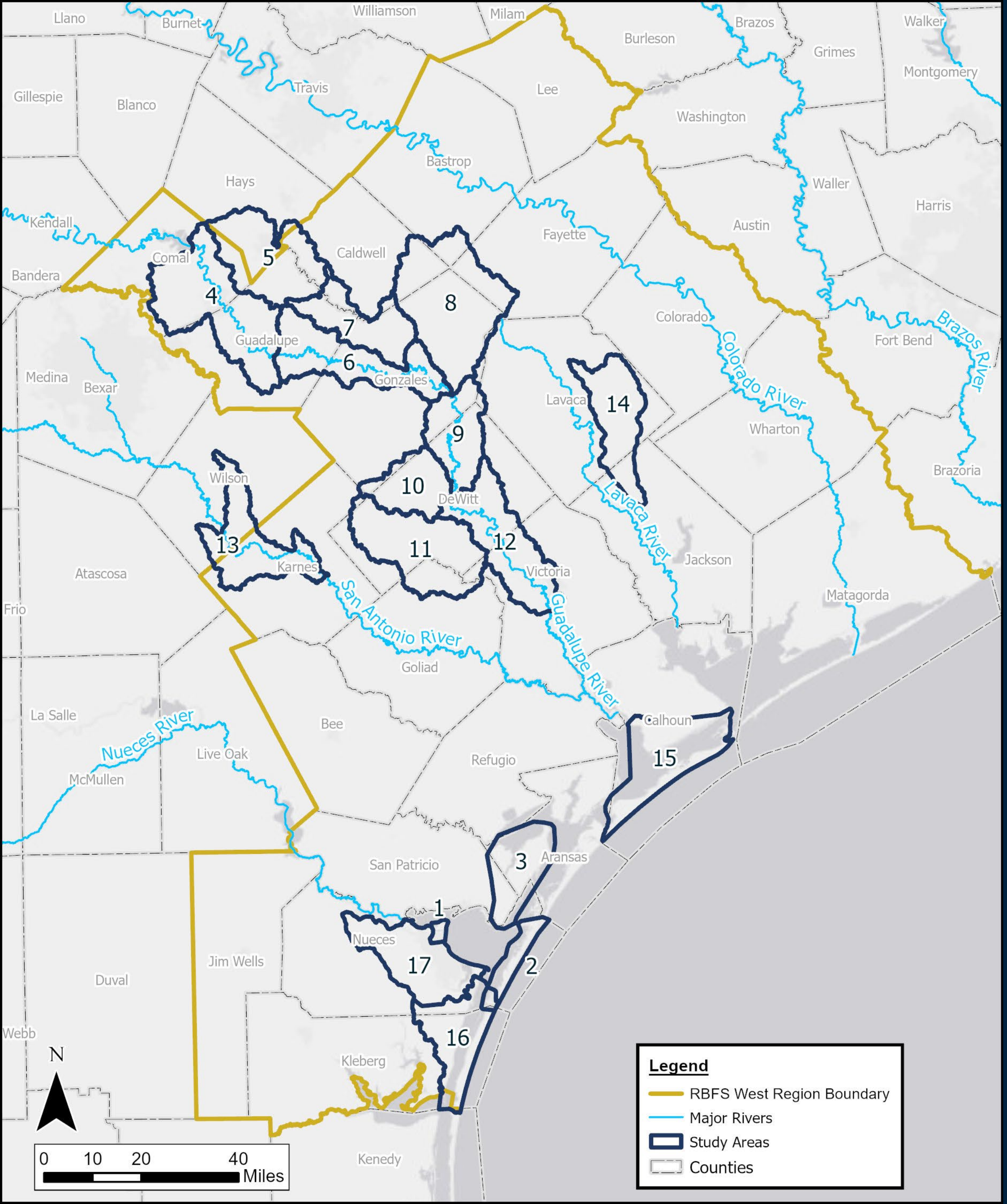
Tier 1 represents study locations of the highest risk and highest level of detail study. These studies represent locations that have the most potential for future large-scale flood mitigation projects that may warrant federal efforts.

Tier 2

Tier 2 represents the majority of potential studies, which are modeling efforts in locations having sufficient detail for evaluating mitigation project alternatives, but not likely for large federal (USACE) type of projects.

Tier 3

Tier 3 represents the remainder of the region that does not qualify for Tiers 1 or 2 and is expected to be served by BLE data. **West Region did not model any watersheds using Tier 3 approaches.**

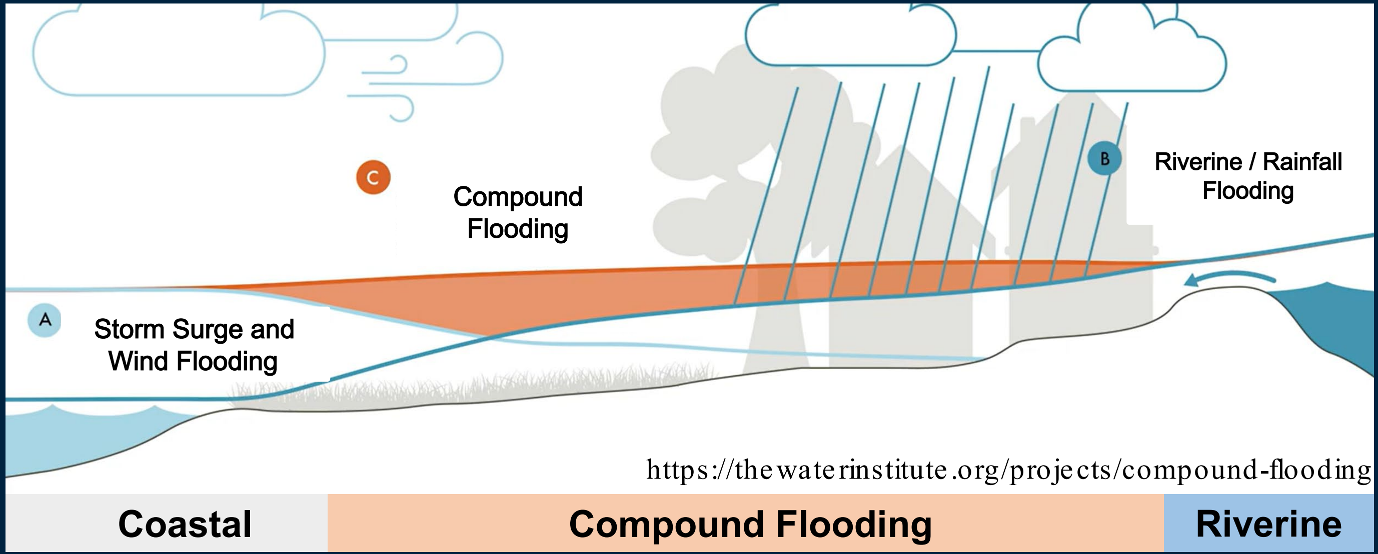


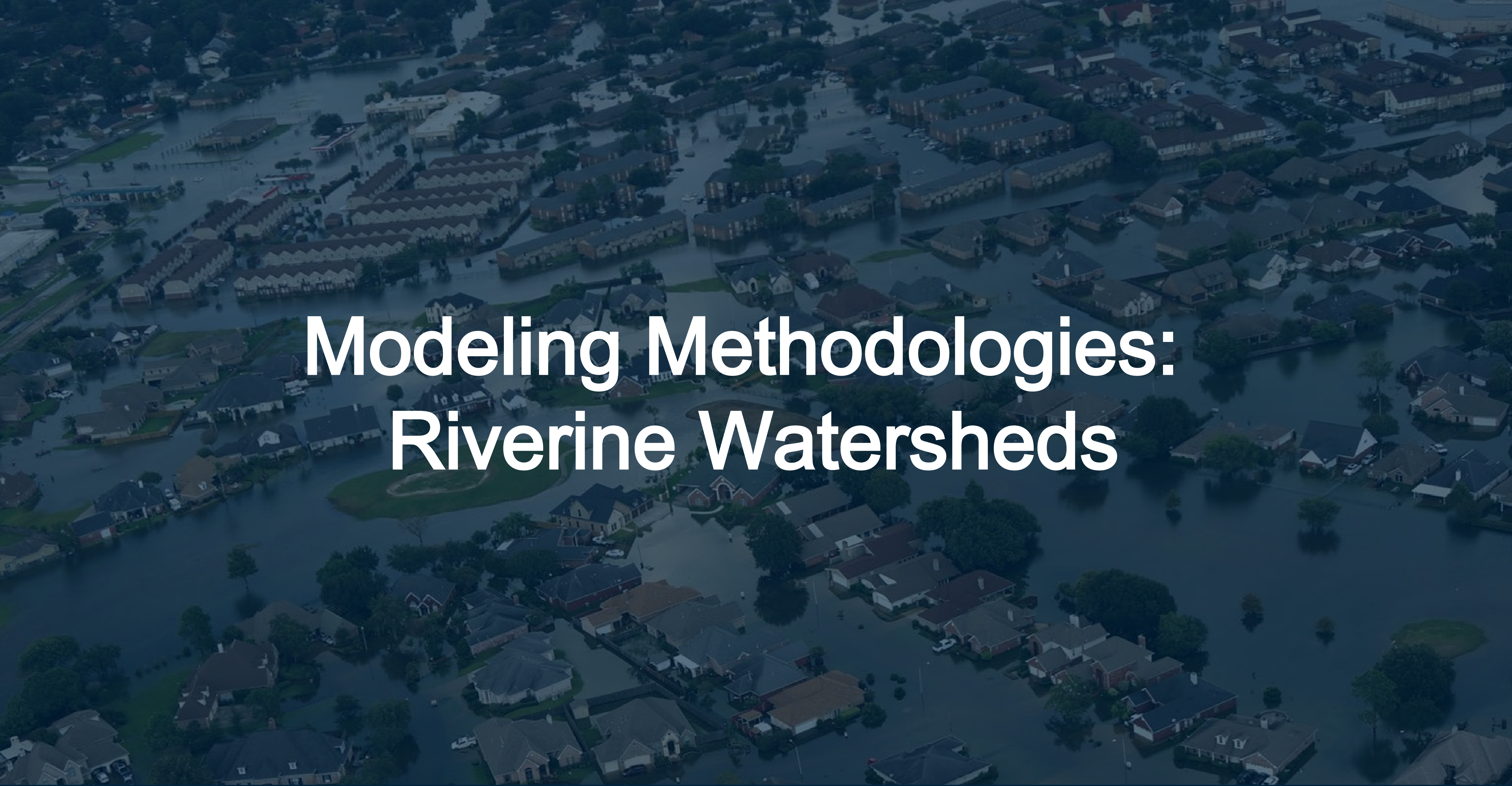
West Region Modeling

ID Number	Tier	Study Name
1	1	City of Corpus Christi
2	1	Mustang Island
3	1	Aransas Bay / Rockport
4	2	Comal River- Guadalupe River
5	2	Upper San Marcos River
6	2	Mill Creek - Guadalupe River
7	2	Lower San Marcos River
8	2	Peach Creek
9	2	McCoy Creek - Guadalupe River
10	2	Lower Sandies Creek
11	2	Twelvemile Creek
12	2	Spring Creek - Guadalupe River
13	2	Marcelinas Creek- San Antonio River
14	2	Ragsdale Creek- Lavaca River
15	2	San Antonio Bay- Espiritu Santo Bay
16	2	Upper Laguna Madre
17	2	Oso Creek

Modeling Overview

- All watersheds / study areas were modeled using **2-dimensional (2D)** flood modeling in HEC-RAS
  - Coastal areas: rain-on-mesh
  - Riverine area: subbasin flows
- Best **available data** (leveraged models, newly collected survey, etc.)
- Models are **calibrated** for major flood events, but calibration data is limited for some watersheds.
- Modeled events: 50% AEP (2-year) through 0.2% AEP (500-year)
- Coastal Areas: Risk from **Coastal**, **Rainfall**, and **Compound** Events (coastal surge + rainfall) was analyzed for several flood frequencies





Modeling Methodologies: Riverine Watersheds

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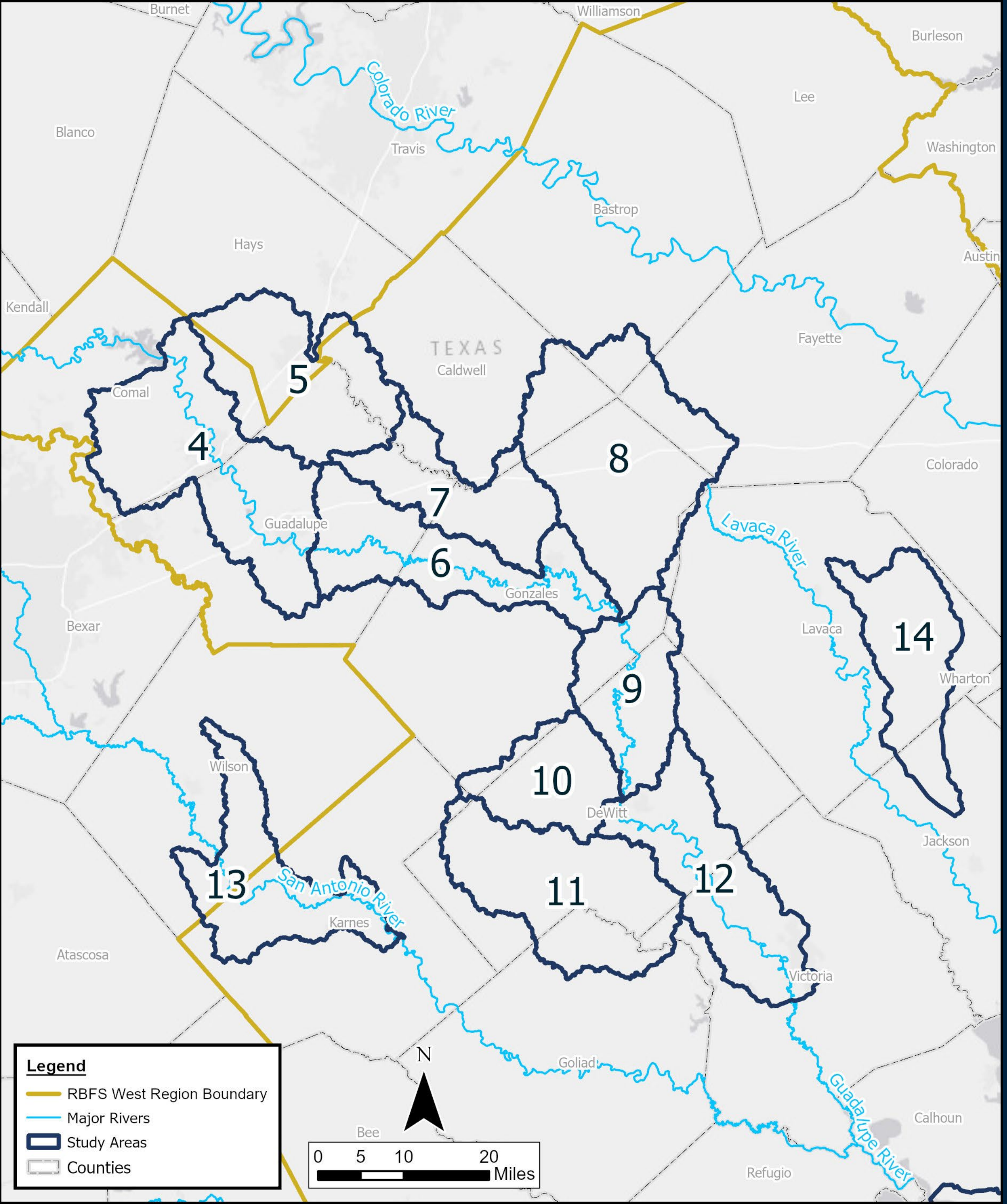


West Region Riverine Modeling

ID Number	Tier	Study Name
4	2	Comal River- Guadalupe River
5	2	Upper San Marcos River
6	2	Mill Creek - Guadalupe River
7	2	Lower San Marcos River
8	2	Peach Creek
9	2	McCoy Creek - Guadalupe River
10	2	Lower Sandies Creek
11	2	Twelvemile Creek
12	2	Spring Creek - Guadalupe River
13	2	Marcelinas Creek- San Antonio River
14	2	Ragsdale Creek- Lavaca River

Hydrologic Approaches - Leveraging InFRM

InFRM
INTERAGENCY FLOOD RISK MANAGEMENT

INFRM Overview

Interagency Flood Risk Management (InFRM) is comprised of FEMA, USACE, USGS, and NWS. The Watershed Hydrology Assessment (WHA) for the Guadalupe River Basin was completed in September 2019. It includes detailed hydrologic analysis (considering both uniform rainfall and elliptical storms) of the entire Guadalupe River Basin. The goal is to provide consistent frequency flows across the river basin, based on all available hydrologic information.

Leveraging InFRM for RBFS

- InFRM used for **upstream inflows.**
- Provided initial flows and basin parameters.
- **Hydrologic methods** selected were consistent with those from InFRM study.
- Peak flows were **compared** to InFRM flows at reference locations.
- Where possible, **calibration event selection** used events also calibrated

Benefits of Using InFRM

- **Regional calibration** already completed.
- **Consistency** with previous basin-wide modeling.
- Ensures model performance aligns with historical flood characteristics.

Hydrologic Approaches - Prelim Flows & Statistical Hydrology

Preliminary Frequency Flows

- Existing **studies (InFRM, GBRA, BLE, Effective FIS)** leveraged for initial estimations of frequency flows in the watershed
- Comparisons performed at key locations for the 50% AEP to 0.2% AEP storm events

Statistical Hydrology

- Visual comparison was made to evaluate USGS rating curves to historical field measurements to better understand the change in channel hydraulic characteristics over time. Additional rating curves derived from InFRM model.
- Comparisons made between the USGS rating curve and the InFRM derived rating curve used to confirm the quality of the USGS rating curve and helped inform the selection of Manning's n values.
- *USGS Bulletin 17C Guidelines for Determining Flood Flow Frequency* performed for watersheds with gages with sufficient period of records in HEC-SSP

EXAMPLE Preliminary Frequency Flow Comparison (McCoy)

Node Description	Drainage Area (sq. mi.)	Existing Study	50% AEP	20% AEP	10% AEP	4% AEP	2% AEP	1% AEP	0.2% AEP
Guadalupe River below Peach Creek	2582.8	InFRM	16,400	50,200	93,300	173,100	259,100	378,600	718,600
	NA[1]	BLE	-	-	97,500	155,000	218,000	295,000	482,000
	2582	GBRA	18,000	45,900	76,500	130,900	187,600	258,400	497,900
Guadalupe River above McCoy Creek	2705.2	InFRM	15,300	47,500	87,900	165,500	248,800	367,100	700,800
	NA[1]	BLE	-	-	93,900	148,000	208,000	281,000	458,000
Guadalupe River below McCoy Creek	2737.8	InFRM	15,400	47,600	88,200	165,900	249,300	367,700	701,600
	NA[1]	BLE	-	-	93,900	148,000	208,000	281,000	458,000
Guadalupe River above Sandies Creek	2786.2	InFRM	15,100	44,300	81,000	154,600	236,600	354,800	689,100
	NA[1]	BLE	-	-	93,900	148,000	208,000	281,000	458,000
Guadalupe River below Sandies Creek at Cuero (USGS 08175800)	3497.4	InFRM	15,100	45,900	88,500	173,000	264,600	401,500	787,100
	NA[1]	BLE	-	-	94,100	148,000	210,000	291,000	490,000
	3502	GBRA	16,900	42,500	70,100	121,000	174,000	242,000	481,000

EXAMPLE Bulletin 17C Results (McCoy)

Station	Peak Streamflow (cfs) by Annual Exceedance Probability						
	50%	20%	10%	4%	2%	1%	0.2%
08175800 Guadalupe River at Cuero, TX							
Lower 95%-CI	12,994	33,547	55,960	96,350	136,798	187,395	354,433
Estimate	16,881	44,737	78,125	146,967	225,720	336,788	789,392
Upper 95%-CI	21,938	63,604	126,903	313,737	625,206	1,251,603	6,308,859

Hydrologic Approaches - Rainfall Runoff

Subbasin Delineation

Basin breaks at gages, confluences, and major structures

Average sub-basin size per SOP can be up to 10 sq miles

InFRM subbasins: 30-120 sq miles (more detailed delineation was needed)

Losses

Loss Method: Initial and Constant Loss

Losses based on USACE Fort Worth District percent sand methodology

Sand percentage determined per subbasin using a geospatial sand grid

Transform

Transform Method: Snyder Unit Hydrograph method

Sensitivity testing performed on lag time and peaking coefficients

Channel Routing

Modified-Puls routing method was used to align the HEC-HMS model with the HEC-RAS model

Precipitation

Variable precipitation by subbasin was applied based on NOAA Atlas-14 precipitation-frequency grids

Local rainfall truncated or shifted in timing to better match modeled InFRM flows

Areal Reduction & Elliptical Storms

TP-40 uniform areal reduction can be applied for contributing drainage areas up to 1,000 square miles. Elliptical storms applied for contributing drainage areas greater than 1,000 square miles

While some West Region watersheds met the cumulative drainage area criteria for consideration per the SOP, the highly undeveloped nature of the study area did not warrant use. InFRM flows took both areal reduction and elliptical storms into account.

Hydrologic Calibration

- Historical events selected for calibration runs in the InFRM model
- Typically 3 calibration & 2 validation events selected

Example List of Parameters tested:

- Lag Time
- Peaking Coefficients
- Modified-Puls routing parameters
- Baseflow
- Initial & Constant Losses

Calibration Challenges:

- Lack of stream gages in some watersheds, or gages with low period of record
- Disparity in flows between hydraulic model and hydrologic model, despite HMS routing

EXAMPLE Statistical Hydrologic Model Performance Metrics (Spring Creek)

Historical Event	Gage Location	NSE	PBIAS	RSR
May-15	Guadalupe Rv at Victoria; TX	0.831	7.98	0.87
May-16	Guadalupe Rv at Victoria; TX	0.883	-0.66	0.89
Dec-18	Guadalupe Rv at Victoria; TX	0.889	-2.96	0.91
Oct-21	Guadalupe Rv at Victoria; TX	0.301	35.51	0.80
May-23	Guadalupe Rv at Victoria; TX	0.702	29.58	0.96

Performance Rating	NSE	PBIAS	RSR
Very Good	0.80 ≤ NSE < 1.00	PBIAS < ±15	0.00 < RSR ≤ 0.60
Good	0.70 ≤ NSE < 0.80	±15 ≤ PBIAS < ±20	0.60 < RSR ≤ 0.70
Satisfactory	0.50 ≤ NSE < 0.70	±20 ≤ PBIAS < ±30	0.70 < RSR ≤ 0.80
Unsatisfactory	NSE ≤ 0.50	±30 ≤ PBIAS	RSR > 0.80

Hydraulic Approach Overview

Overview

- 2D HEC-RAS v 6.4.1
- Modeled Events: 50%, 20%, 10%, 4%, 2%, 1% and 0.2% AEP
- Flow hydrographs from HMS applied at subbasin outlets.
- Future conditions not assessed for Tier 2s (All West Region Riverine Watersheds)

Terrain / Bathymetry & Land Use

- 3.3 ft grid resolution / Based on LiDAR from TNRIS (2018-2019).
- Bathymetry updates on best available data (GBRA cross-section surveys, coastal survey data, RBFS bathymetric survey)
- Land use: (1) Local data sources, (2) NLCD 2019

Structure Data

- RBFS Detailed Hydraulic survey (high risk streams)
- Leveraged Structure Data from existing studies (GBRA)
- Field Reconnaissance (medium risk streams)
- Approximation for lower-detail areas based on Google Earth/ Street view

Mesh Generation

Custom West Region ArcGIS Tools Used for Mesh Generation:

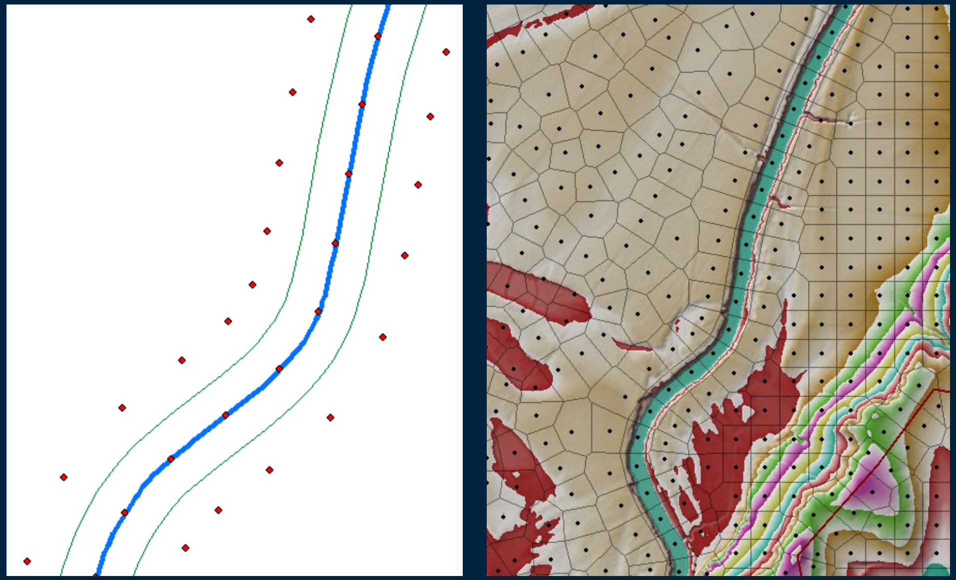
1. Shapefiles were specifically placed and edited in ArcMap with certain attributes to specify the cell spacing along, around, or within shapefile points, lines, and polygons;
2. The tools used these shapefiles as inputs and produced points that could be imported to HEC-RAS;
3. Breaklines and 2D Connections were added to the HEC-RAS geometry; and
4. HEC-RAS created the final mesh using the cell centers and breaklines/2D Connections in the model.

Example Mesh Tool Input & Output

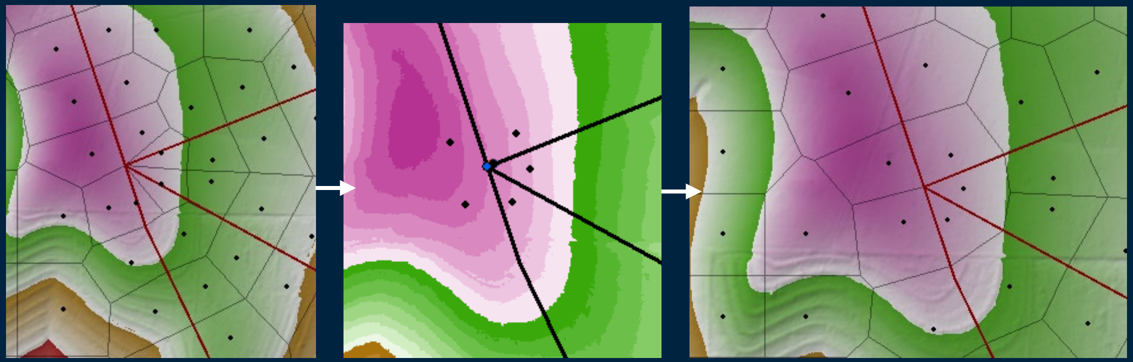
- **Curb & Gutter Streets:** Tool generated cells along centerline
- **Breaklines**: Tool generates cells parallel to line
- **Streams:** Tool generated cells along centerline of channel
- **Rural Areas**: Contour Based Cells or Rectangular Grid
- Tools to help with tricky intersections

- **Cell Spacing** defined by user
  - Generally larger coarser mesh sizes used in less developed areas, very coarse mesh outside of 500-year floodplain
  - Smaller cell sizes used along streams, developed areas, within floodplains
- **Goal:** Minimize # of cells while achieving reasonable level of model detail

Example: Streamline Centerline mesh tool and a Contour/Grid based rural area



Example: Breakline Intersections mesh tool



Hydraulic Approach - Calibration & Other Comparisons

Hydraulic Calibration

- Updates to Mannings n (using ranges of land use values provided by SOP)
- Addition of calibration override regions where appropriate
- Bridge/Culvert parameters updates

- Stream gages, high-water marks, and road closures used where available for comparisons

Other Result Checks/Comparisons

- Comparisons performed at boundary for **adjacent RBFS watersheds**
- **Comparisons of RBFS results to other recent or relevant studies (example: InFRM, FIF study models, RBFS, BLE, etc.)**

EXAMPLE Calibration Comparisons at Gage Locations

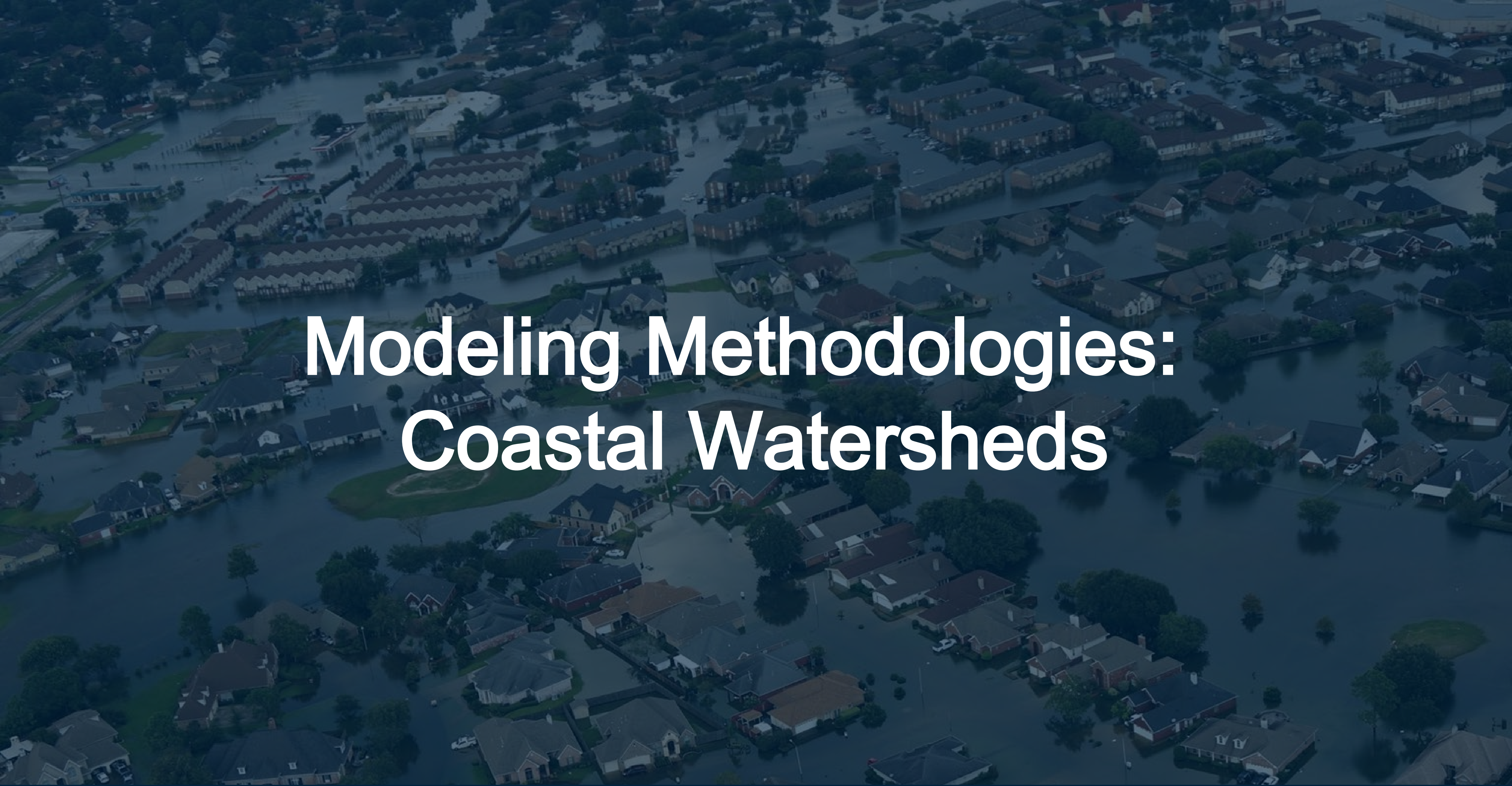
Table 25. (HEC-HMS) August 2017 Calibration – Modeled vs. Observed Peak Flow, Hydrograph Volume, and Time to Peak Comparisons at Gage Locations

Reference Name	Plan Name	Model Q/WSE (cfs/ft)	Obs. Q/WSE (cfs/ft)	Diff.	Model Vol. (ac-ft)	Observed Vol. (ac-ft)	% Diff.	Model Peak Time (hr)	Observed Peak Time (hr)	Diff. (hr)
08169792 FLOW	2017-08	7,441	7,430	0%	35,103	35,740	-2%	8	6.5	1.5
08169845 FLOW	2017-08	13,960	15,300	-9%	73,218	70,988	3%	6.5	5.5	1
08173900 FLOW	2017-08	46,288	47,100	-2%	264,928	247,726	7%	23.75	17.75	6

EXAMPLE WSE Comparison to Adjacent Watershed

Table 24: Spring Creek and McCoy Creek WSE Comparisons

Location	WSE (ft)						
	2Yr	5Yr	10Yr	25Yr	50Yr	100Yr	500Yr
McCoy Creek Downstream	156.49	167.4	173.31	178.91	183.29	187.48	193.42
Spring Creek Upstream	157.24	167.82	173.3	178.99	183.25	187.09	192.01
McCoy - Spring (US - DS)	-0.75	-0.42	0.01	-0.08	0.04	0.39	1.41



Modeling Methodologies: Coastal Watersheds

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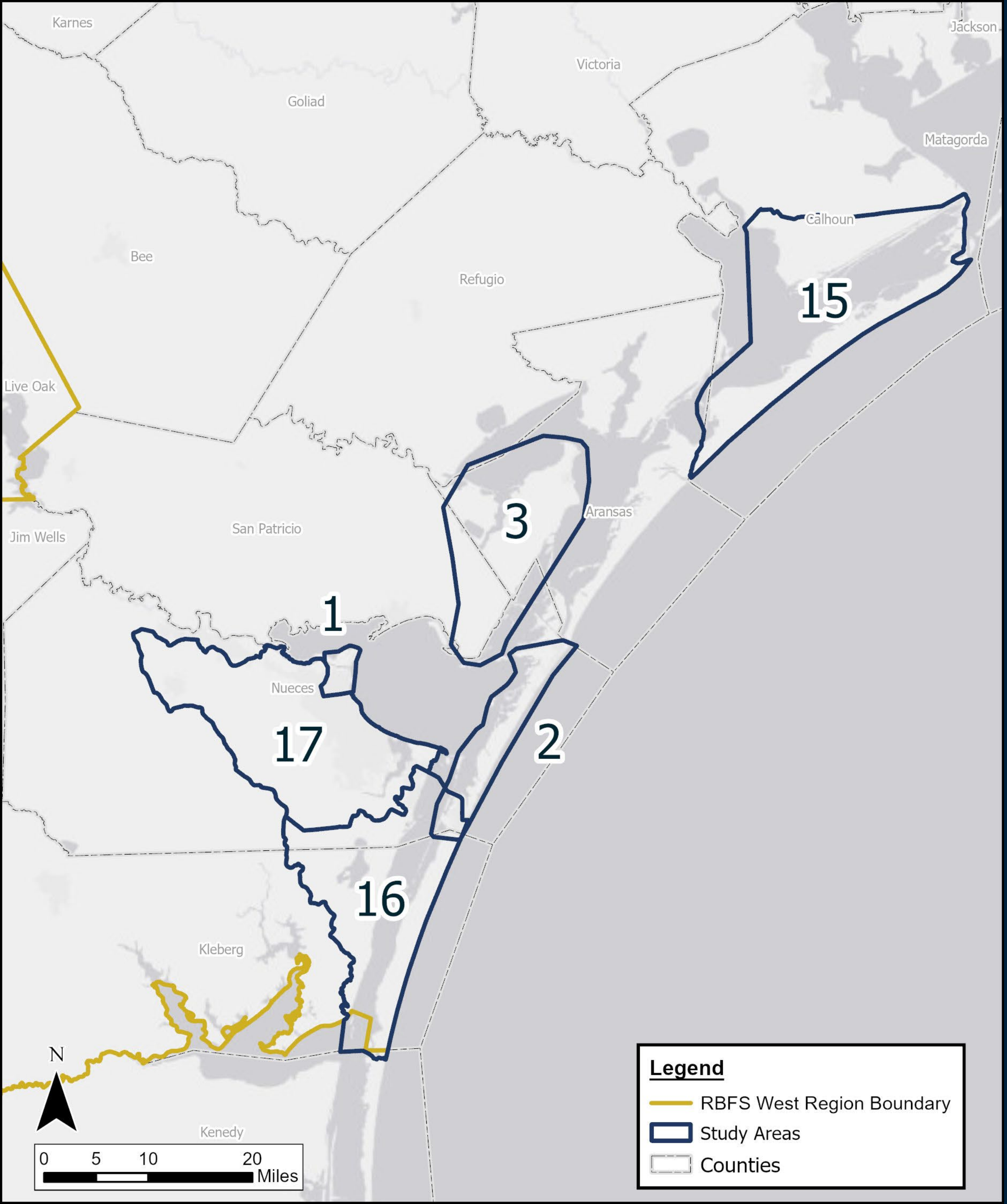


West Region Coastal Modeling

ID Number	Tier	Study Name
1	1	City of Corpus Christi
2	1	Mustang Island
3	1	Aransas Bay / Rockport
15	2	San Antonio Bay- Espiritu Santo Bay
16	2	Upper Laguna Madre
17	2	Oso Creek

Hydrologic Approaches

Rain-on-Mesh Justification

Watersheds lack clear watershed divides and flow paths which makes traditional routing and sub-basin delineation difficult and inaccurate. Flow exchange across sub-watersheds and the resulting flow patterns can be better captured with a 2D ROM model.

Losses

Loss Method: Initial and Constant Loss

Losses based on USACE Fort Worth District percent sand methodology. Sand percentage determined per subbasin using a geospatial sand grid.

Losses calculated directly in RAS through infiltration layers.

Transform, Areal Reduction & Elliptical Storms

Not applicable.

Channel Routing

Not applicable.

Precipitation

Precipitation was applied directly to the HEC-RAS model mesh. For return period event simulations, NOAA Atlas 14 gridded precipitation data was applied uniformly. A HEC-HMS model was used to generate basin-average rainfall depths and a precipitation time series dataset.

Calibration

The calibration of flow data is not applicable for the coastal watersheds. However, loss parameters were adjusted during the calibration process.

Hydraulic Approach Overview

Overview

- 2D HEC-RAS v 6.4.1
- **Surge boundary conditions created from USACE Coastal Texas Study and NOAA tidal gages**
- Modeled Events: 50%, 20%, 4%, 2%, 1% and 0.2% AEP rain-fall only, **10% 2%, 1%, 0.2% surge-only, Joint probability high/low/most likely surge with high/low/most likely rainfall**
- **Precipitation & losses applied directly in HEC-RAS**
- **Future conditions assessed for Tier 1s**

Terrain / Bathymetry & Land Use

- 3.3 ft grid resolution / Based on LiDAR from TNRIS (2018-2019).
- Bathymetry updates on best available data (GBRA cross-section surveys, coastal survey data, RBFS bathymetric survey)
- Land use: (1) Local data sources, (2) **SLAMM Land Cover**, (3) NLCD 2019
- **Future Land Use (Tier 1s only): USGS' Conterminous US Land Cover Projections and SLAMM future projections**

Structure Data

- **Tier 1s: RBFS detailed hydraulic survey throughout model domains along major drainage channels**
- **Tier 2 Coastal: no survey data collected**
- Approximation for lower-detail areas based on Google Earth/ Street view

Mesh Generation

Custom West Region ArcGIS Tools Used for Mesh Generation.

*Note: Differences from riverine areas are **bolded above**.*

Application of Future Conditions (Tier 1s)

Land Cover

- Local future land cover projections (Corpus area only)
- Sea Level Affecting Marshes Model (SLAMM) Landcover Model from the GLO's 2019 Texas Coastal Resiliency Master Plan
- USGS' Conterminous US Land Cover Projections

Rainfall

- Future Rainfall was **not assessed** as part of River Basin Flood Study.
- **Atlas 14 rainfall data was used for all present and future events.**

Surge

- 2085 Surge from USACE Coastal Texas Study (4.92 Feet Sea Level Rise Scenario)
- **Future Surge-only Modeling Performed using USACE 2085 Coastal Texas Study Boundary Conditions.**
- **Future Tides Based on 4.92 Feet Above Current MHHW. Applied as Boundary Condition for Rainfall Simulations.**

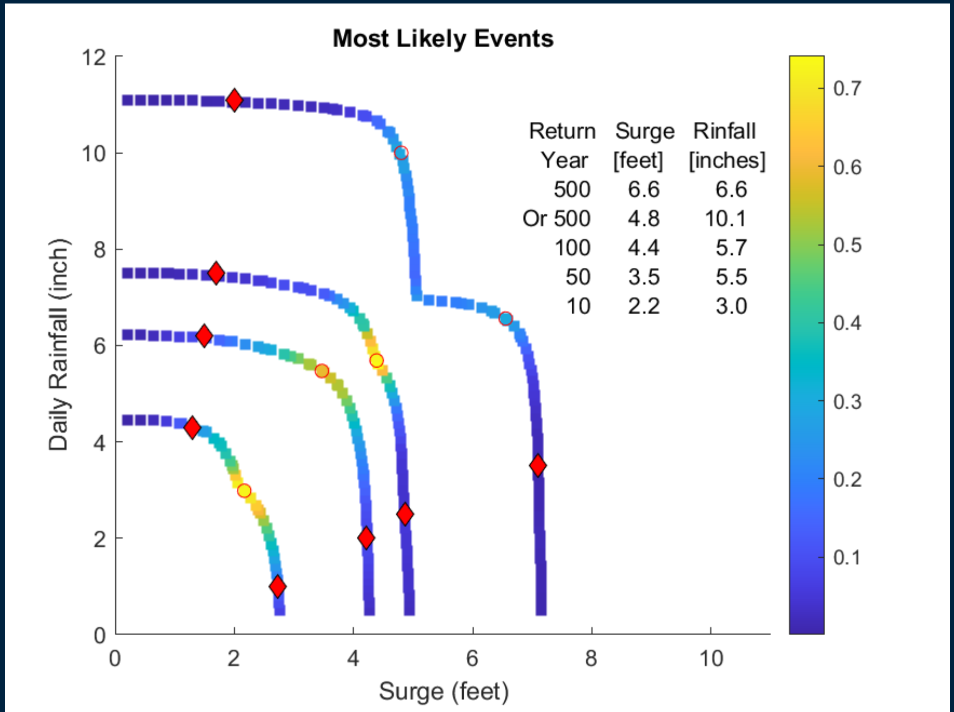
Coastal Modeling

Leveraging USACE Coastal Texas Study (CTXS)

- Used for coastal surge and wind boundary conditions.
- Spatially variable boundary conditions were applied to coastal models using CTXS simulation results
- Wave overtopping for levees: the wave and water level time series used in the overtopping calculation were extracted from the CTXS simulations.

Compound flooding

- Precipitation and tidal gage data was used to perform a joint probability analysis.
- A peak-over-threshold (POT) approach was selected to select extreme events.
- For each POT pair event (surge-precipitation), a coincidence analysis was conducted to determine statistical significance.
- The 10-, 50-, 100-, and 500-year joint return period events were simulated with a combination of high and low rainfall with high and low surge conditions.
- Joint simulation results were processed to extract the maximum flood hazard of the three events. Joint events were mapped through defining three flooding zones – hydrologic, transition, and coastal as defined by Bilskie, 2021.



Return Year	Surge [feet]	Rinfall [inches]
500	6.6	6.6
Or 500	4.8	10.1
100	4.4	5.7
50	3.5	5.5
10	2.2	3.0

Example Joint Probability (10-, 50-, 100-, and 500-year isolines) of non-tidal residual and daily precipitation. The red circles represent the most likely events for a given return year. The red diamonds represent two additional design events. (Aransas Bay Watershed)

List of Modeled Events for Coastal Watersheds (1 of 2)

Event	Rainfall	Coastal Boundary Condition
1-year Rainfall-Only Current-Day*	Atlas 14 1-Year, 24-Hour	Current-Day MHHW
2-year Rainfall-Only Current-Day*	Atlas 14 2-Year, 24-Hour	Current-Day MHHW
5-year Rainfall-Only Current-Day*	Atlas 14 5-Year, 24-Hour	Current-Day MHHW
10-Year Rainfall-Only Current-Day	Atlas 14 10-Year, 24-Hour	Current-Day MHHW
25-Year Rainfall-Only Current-Day	Atlas 14 25-Year, 24-Hour	Current-Day MHHW
50-Year Rainfall-Only Current-Day	Atlas 14 50-Year, 24-Hour	Current-Day MHHW
100-Year Rainfall-Only Current-Day	Atlas 14 100-Year, 24-Hour	Current-Day MHHW
200-Year Rainfall-Only Current-Day*	Atlas 14 200-Year, 24-Hour	Current-Day MHHW
500-Year Rainfall-Only Current-Day	Atlas 14 500-Year, 24-Hour	Current-Day MHHW
1000-Year Rainfall-Only Current-Day*	Atlas 14 1000-Year, 24-Hour	Current-Day MHHW
10-Year Rainfall-Only 2085 Land Use*	Atlas 14 10-Year, 24-Hour	2085 MHHW
50-Year Rainfall-Only 2085 Land Use*	Atlas 14 50-Year, 24-Hour	2085 MHHW
100-Year Rainfall-Only 2085 Land Use*	Atlas 14 100-Year, 24-Hour	2085 MHHW
500-Year Rainfall-Only 2085 Land Use*	Atlas 14 500-Year, 24-Hour	2085 MHHW
10-Year Surge-Only 2017	None	2017 10-Year Synthetic Storm
50-Year Surge-Only 2017	None	2017 50-Year Synthetic Storm
100-Year Surge-Only 2017	None	2017 100-Year Synthetic Storm
500-Year Surge-Only 2017	None	2017 500-Year Synthetic Storm
10-Year Surge-Only 2085*	None	2085 10-Year Synthetic Storm
50-Year Surge-Only 2085*	None	2085 50-Year Synthetic Storm
100-Year Surge-Only 2085*	None	2085 100-Year Synthetic Storm
500-Year Surge-Only 2085*	None	2085 500-Year Synthetic Storm

** Applicable for Tier 1s only*

List of Modeled Events for Coastal Watersheds (2 of 2)

Event	Rainfall (Downtown Corpus Christi)	Coastal Boundary Condition (Downtown Corpus Christi)
10-Year Joint 2017– High Precipitation / Low Surge	Atlas 14 10-Year, 24-Hour	2017 1-Year Synthetic Storm
10-Year Joint 2017 – Low Precipitation / High Surge	Atlas 14 1-Year, 24-Hour	2017 10-Year Synthetic Storm
10-Year Joint 2017 – Most likely	Atlas 14 2-Year, 24-Hour	2017 5-Year Synthetic Storm
50-Year Joint 2017 – High Precipitation / Low Surge	Atlas 14 50-Year, 24-Hour	2017 1-Year Synthetic Storm
50-Year Joint 2017 – Low Precipitation / High Surge	Atlas 14 1-Year, 24-Hour	2017 50-Year Synthetic Storm
50-Year Joint 2017 – Most likely	Atlas 14 5-Year, 24-Hour	2017 10-Year Synthetic Storm
100-Year Joint 2017 – High Precipitation / Low Surge	Atlas 14 100-Year, 24-Hour	2017 1-Year Synthetic Storm
100-Year Joint 2017 – Low Precipitation / High Surge	Atlas 14 1-Year, 24-Hour	2017 100-Year Synthetic Storm
100-Year Joint 2017 – Most likely	Atlas 14 10-Year, 24-Hour	2017 10-Year Synthetic Storm
500-Year Joint 2017 – High Precipitation / Low Surge	Atlas 14 500-Year, 24-Hour	2017 1-Year Synthetic Storm
500-Year Joint 2017 – Low Precipitation / High Surge	Atlas 14 1-Year, 24-Hour	2017 500-Year Synthetic Storm
500-Year Joint 2017 – Most likely	Atlas 14 10-Year, 24-Hour	2017 50-Year Synthetic Storm

Key Findings & Lessons Learned

Commissioner Dawn Buckingham, M.D.

Key Findings

Key Findings - Riverine Watersheds

- Flooding in most watersheds is **dominated by major rivers** (e.g., Guadalupe, Comal, San Antonio, Blanco, Navidad).
- **Smaller tributaries** present localized risks, especially in **urbanized or low-lying areas** —further analysis is recommended where development is planned.
- Several watersheds lacked full calibration due to **limited observed data**, especially in rural areas

Key Findings - Coastal Watersheds

- Storm surge is the dominant hazard in shoreline areas, while rainfall dominates further inland.
- Current FEMA maps may underrepresent rainfall-only hazards in coastal watersheds.
- Bivariate and joint probability analyses show surge and rainfall are generally independent but can coincide.
- Transition zones between surge- and rainfall-dominant areas are limited; most areas are clearly influenced by one dominant source
- Future sea level rise scenarios indicate significant increases in 100-year water surface elevations (WSEs).

Modeling Strengths & Weaknesses

Strengths

- **Leveraged existing modeling** where available to efficiently use RBFS funding.
- Higher level of model detail for **higher risk** /more developed areas.
- Hydraulic **survey data** collected for higher-risk streams.
- Mesh tools used helped **minimize model run times** (under 30 min for majority of watersheds).
- Generally **best available regional modeling** for all watersheds where modeling was performed.

Weaknesses / Limitations

- West Region is a more rural / data limited region. Several watersheds had **limited calibration data** available for use. Particularly an issue in coastal watersheds.
- Models do not include **storm sewer systems**.
- **Stability challenges** associated with 2D modeling.
- Challenges w/ integrating bathymetry used for Guadalupe River (from GBRA modeling). Lack of bathy for some areas

Coastal Modeling:

- The model is also limited by uncertainties in the surge boundary conditions and spatial wind fields extracted from regional-scale models
- Overland waves are also a limitation in areas close to the shoreline for storm events that include high wind speeds

Lessons Learned

Coordination with Ongoing Studies

- Several FIF and many CDBG projects across West Region. Challenges with data sharing and parallel timelines. Goal was for RBFS baseline reports to include result comparisons with other recently developed models but was not possible in all cases.

File Sizes of Modeling Packages

- Large number of result files (WSE and depth rasters) led to large file sizes for especially coastal watersheds. These result files were required to meet programmatic standards.

Stakeholder Engagement

- Met with all stakeholders upon completion of baseline modeling to discuss baseline modeling results. Meeting with stakeholders during development of the baseline models to share draft results could have better confirmed draft results or indicated areas the models were not properly capturing.

Hot Spot Analysis

Commissioner Dawn Buckingham, M.D.

Hot Spot Analysis

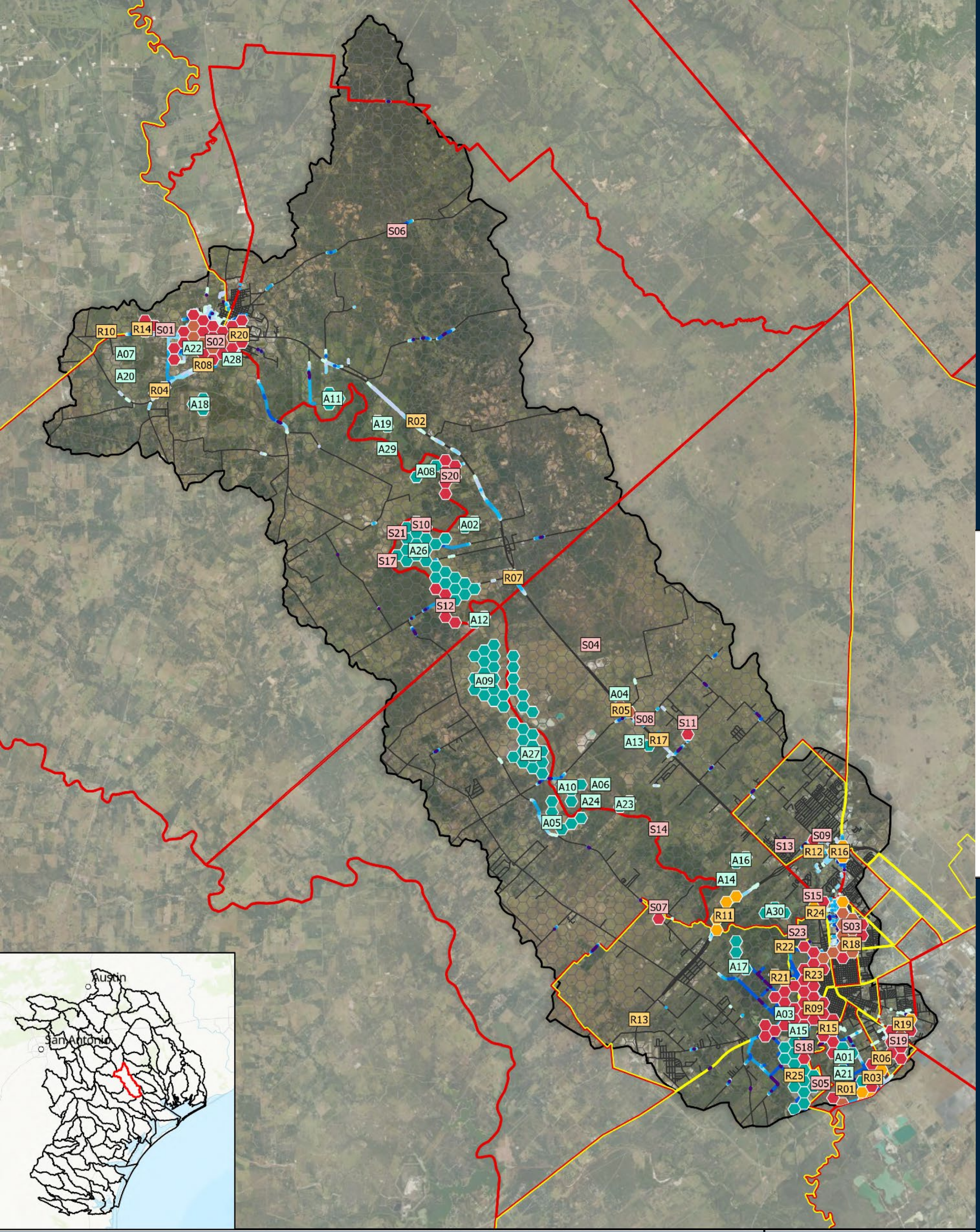
Data Directly Applied in Hot Spot Methodology

1. Modeling Data
   - Riverine Areas
     - 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% AEP events
   - Coastal areas
     - 10%, 2%, 1%, and 0.2% AEP existing rainfall-only
     - 10%, 2%, 1%, and 0.2% AEP future rainfall-only
     - 10%, 2%, 1%, and 0.2% AEP surge-only
     - NOTE: Coastal Tier 2s used existing surge, coastal Tier 1s used future surge
2. USACE National Structure Inventory
3. TxDOT Roadway Inventory
4. USDA National Cropland Data

Other Data Used to Interpret Hot Spots / Select Draft Areas of Focus

1. Related Study data (FIF, CDBG)
2. Stakeholder engagement data
3. SoVI (VMAP)
4. LMI (HUD)
5. Flood-related fatalities (NOAA)
6. Critical Infrastructure (TWDB)
7. Flood Mitigation Projects/Strategies/Evaluations recommended by TWDB's State Plan

Example Watershed HSA Output



Spring Creek - Guadalupe River

Hexagons (2000-ft Diameter)

Roadway

SoVI (3 Classes)

Low

Medium

High

Inundated Roadway Per Storm Event

50% AEP

20% AEP

10% AEP

4% AEP

2% AEP

1% AEP

0.2% AEP

Flood Exposure Hot Spots

Structures

Road + Structures

Road

Road + Ag.

Ag.

Structures + Ag.

Structures + Ag. + Road

GLO RBFS Model Report

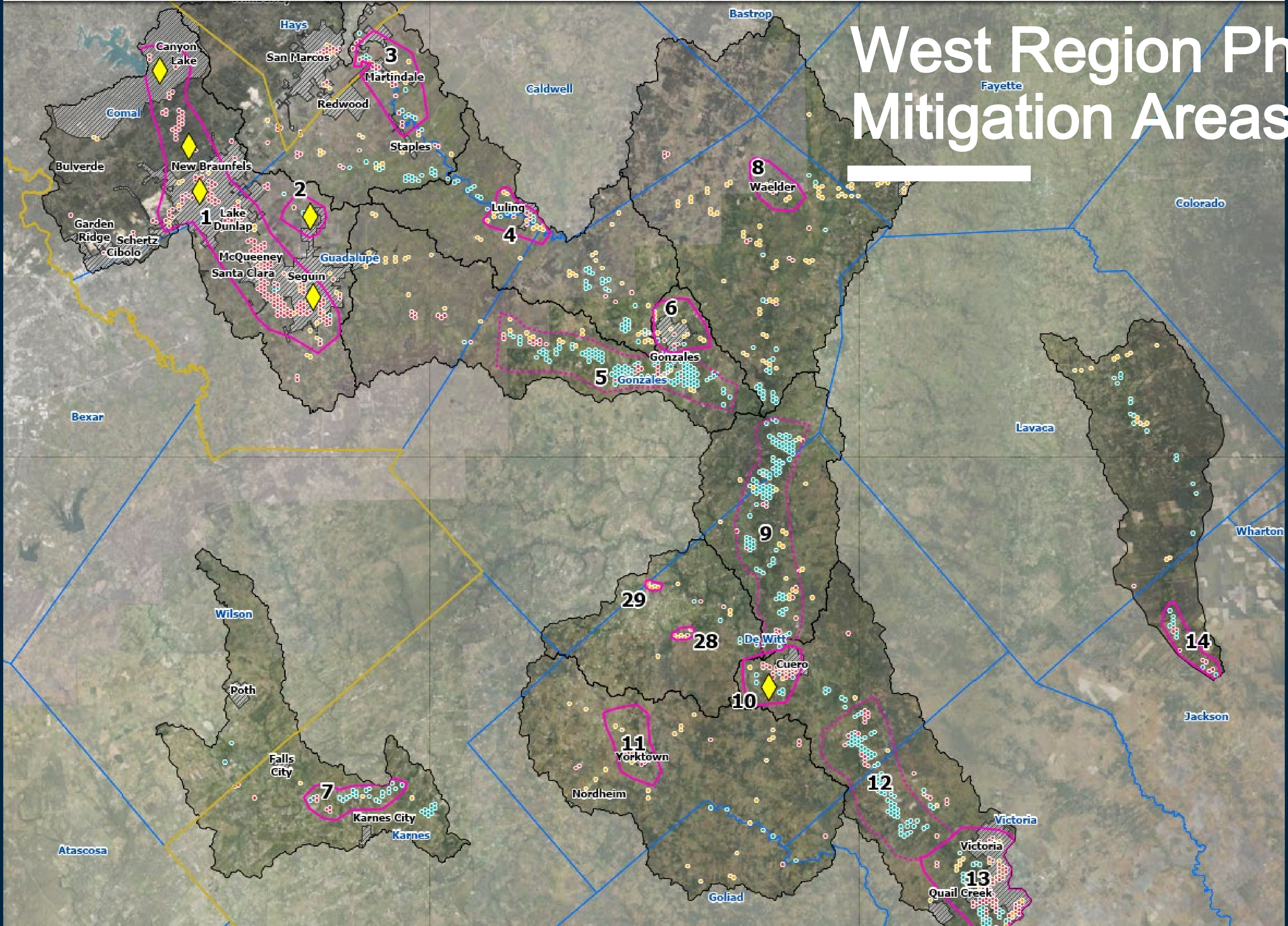
Spring Creek-Guadalupe River

Hot Spot Analysis

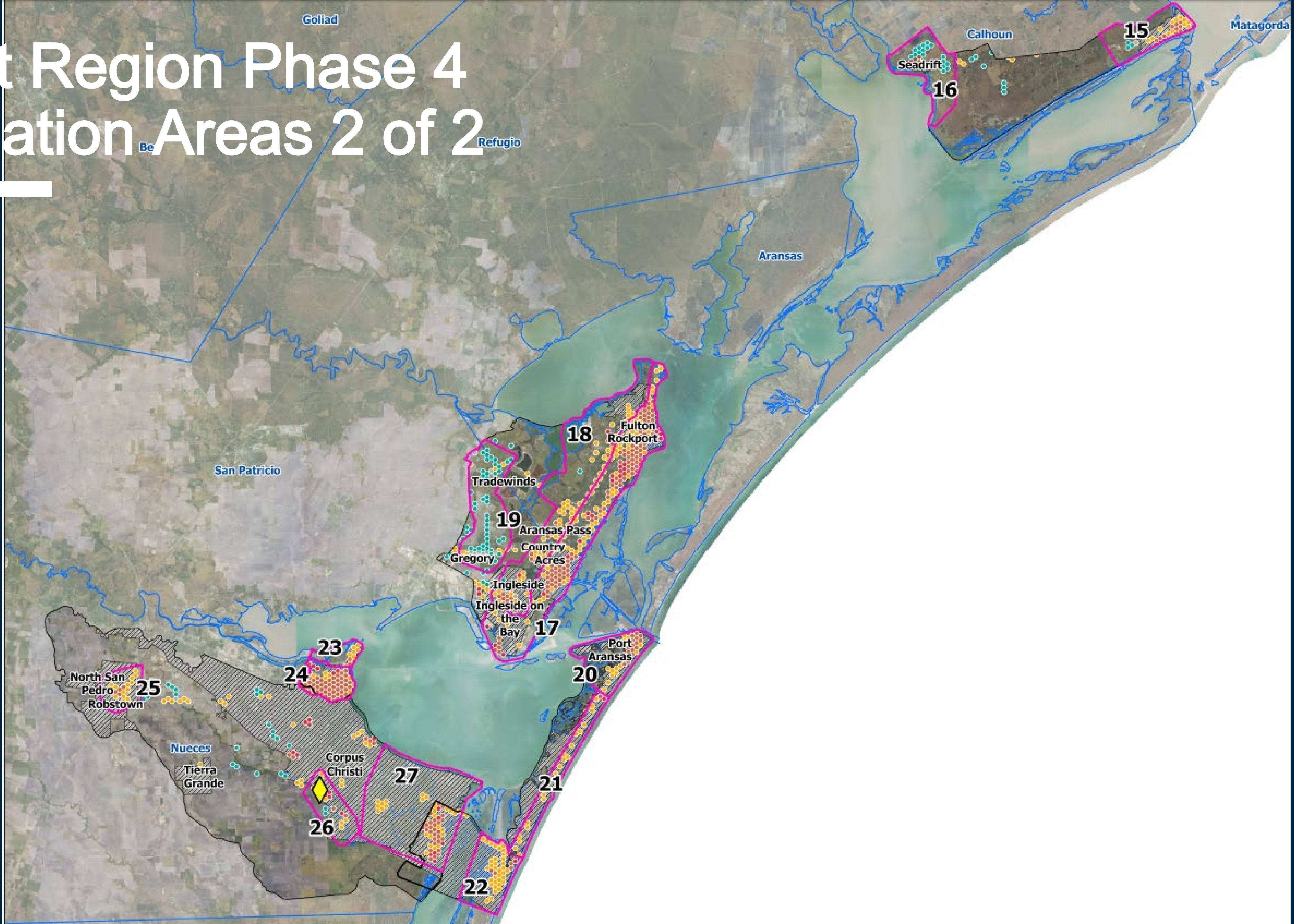
RIVER BASIN FLOOD STUDY

WESTERN REGION

West Region Phase 4 Mitigation Areas 1 of 2



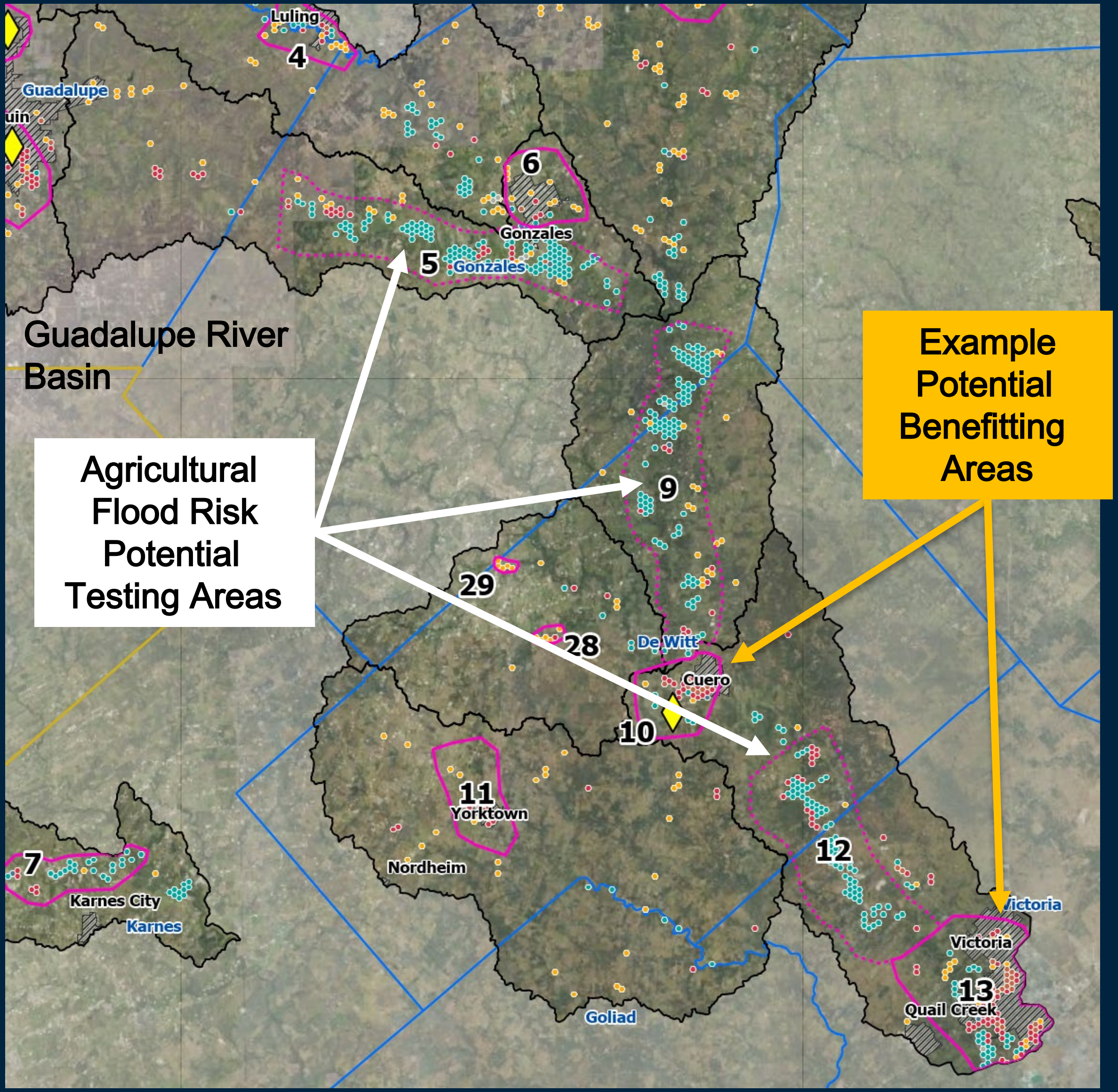
West Region Phase 4 Mitigation Areas 2 of 2



West Region Regional Study: Agricultural Hotpots

- West Region did not prioritize **agricultural hot spots** when advancing Mitigation Areas, but we are looking at agricultural flood risk as part of a regional effort in Phase 4.

- Will proof-of-concept test ecosystem restoration for flood mitigation benefit within agricultural watershed(s).



Phase 4 Alternatives Analysis & Next Steps

Commissioner Dawn Buckingham, M.D.

Alternatives Analysis (Ongoing Work & Next Steps)

25%

- Strategizing suite of projects
- Preliminary costs & screening
- Utility/ Environmental Investigation
- Stakeholder Check-in #1

Project Strategizing & Screening
(Completed)

50%

- Alternatives Analysis Modeling

Modeling
(Summer - Fall)

75%

- Finalize modeling
- Benefits & costs
- Stakeholder Check-in #2

BCA
(Fall - Winter)

100%

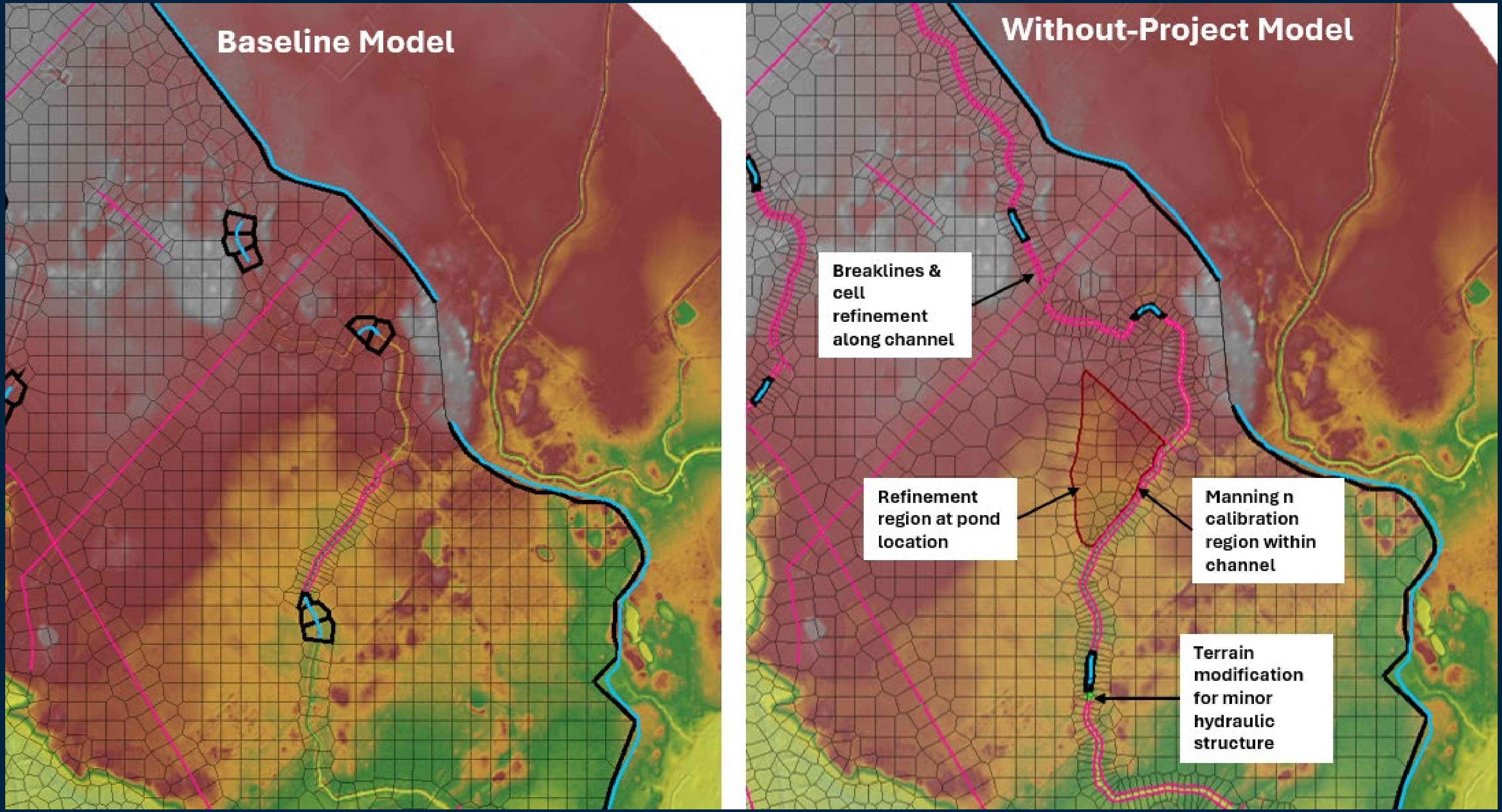
- Finalization of BCAs
- Final Recommended Plan

Final Recommendation
(Winter – Spring 2026)

Without -Project Modeling Updates in Phase 4

- Updates to the Baseline Phase 3 model are **limited to refinements needed to model project alternatives appropriately**

- Models will **not be truncated** / trimmed to project extents (West Region decision)



With-Project Modeling in Phase 4

SA/2D Connections

Can be used to model upsized culverts, raised bridges and/or larger bridge embankment openings, and seawalls

Terrain Modifications

Can be used to model any excavation, channel widening or deepening, detention, levees, and dams

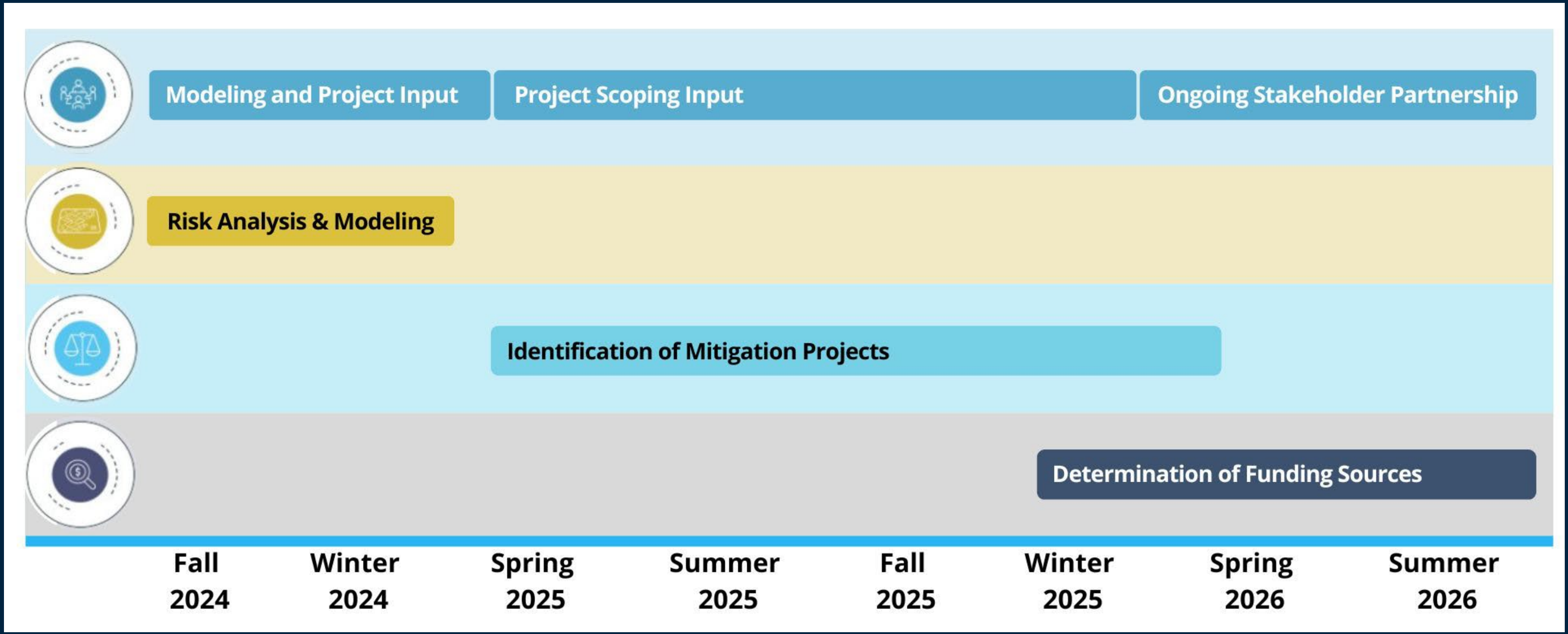
Update proposed conditions inputs

Updates to Manning's n calibration regions or infiltration layer to show proposed changes to land cover

No Adverse Impact Analysis

Perform a no adverse impact analysis to ensure modeled project results do not cause unintended impacts

West Region Study Timeline & Next Steps



QUESTIONS?

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Texas General Land Office | CDR
Commissioner Dawn Buckingham, M.D.