Flood and Sea Level Rise

Mapping Updates

Petaluma City Council Meeting
January 8, 2024

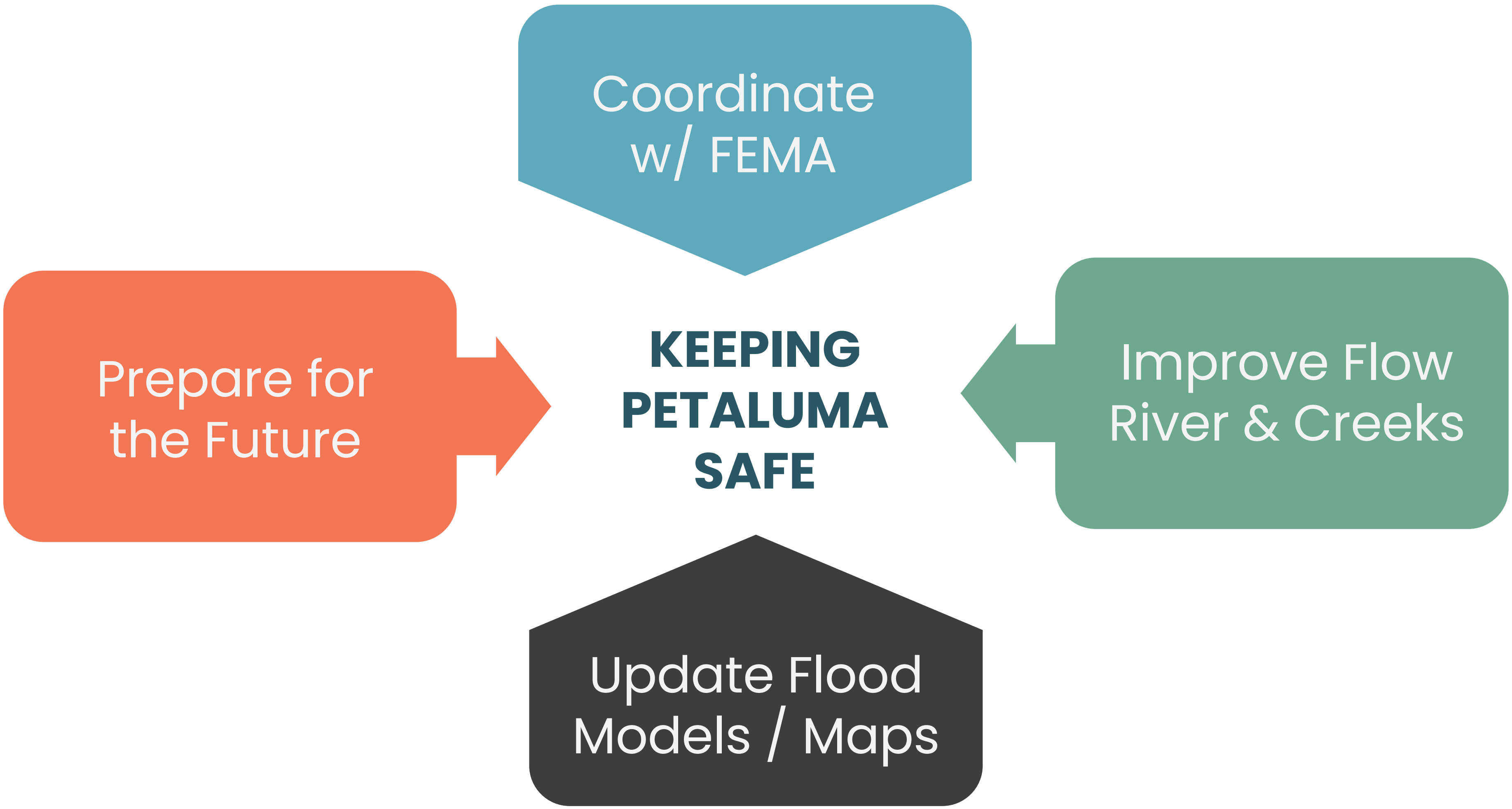
Informational Workshop

Today: Understanding Flood Hazard Areas

- Today we are talking about flood hazards
  - From rain
  - From the Bay
- Flood risk planning will impact land use decisions and policy making
- Today we are focusing on how we understand hazard areas for the General Plan (mapping)
- Next meeting we will look at impacts

Flood and Sea Level Rise Modeling and Map

FLOODPLAIN MANAGEMENT

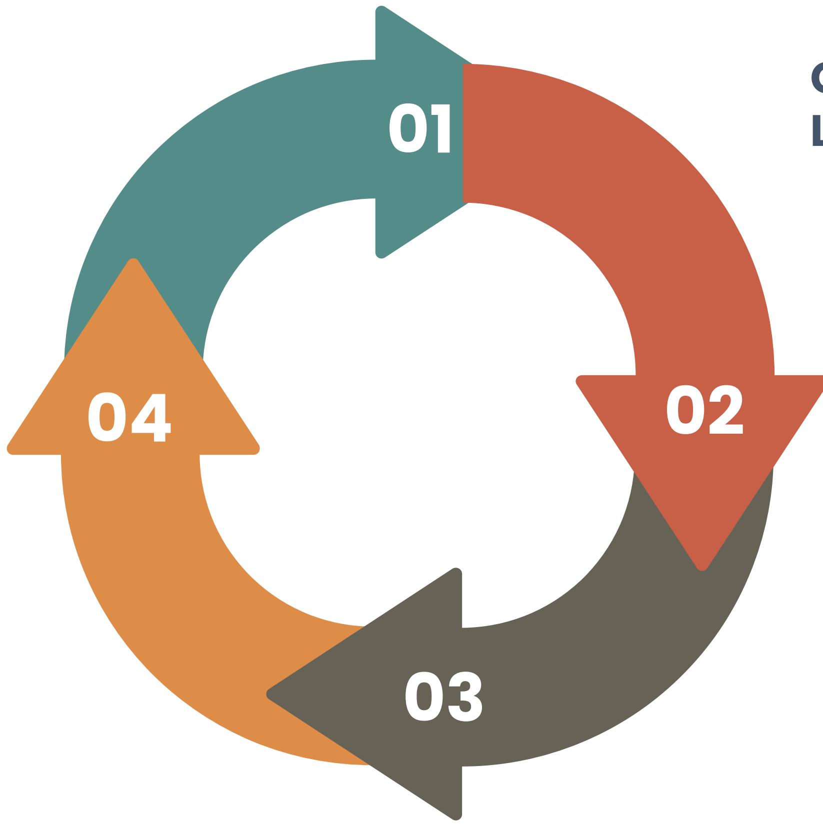


FLOOD MAPPING UPDATE PROCESS

FOLLOWS BEST GUIDANCE

- FEMA
- NOAA
- CA OPC

COMPLEX AND LOCALLY FOCUSED



UPDATED RAINFALL

PREDICTIVE SEA LEVEL RISE DATA

WEST CONSULTANTS

WATER | ENVIRONMENTAL | SEDIMENTATION | TECHNOLOGY

EXPERIENCED TECHNICAL PROFESSIONALS

- 60 w/ advanced degrees in water resources engineering
- 14 w/ a PhD

LEADERS AND TEACHERS

- We teach nationwide - American Society of Civil of Engineers & Floodplain Managers

MANAGER - DAVE SMITH

- P.E., CFM, D.WRE – 20 Years experience performing / managing hydrologic and hydraulic modeling in Petaluma since 2005

SHERWOOD
DESIGN ENGINEERS

CIVIL ENGINEERING FIRM

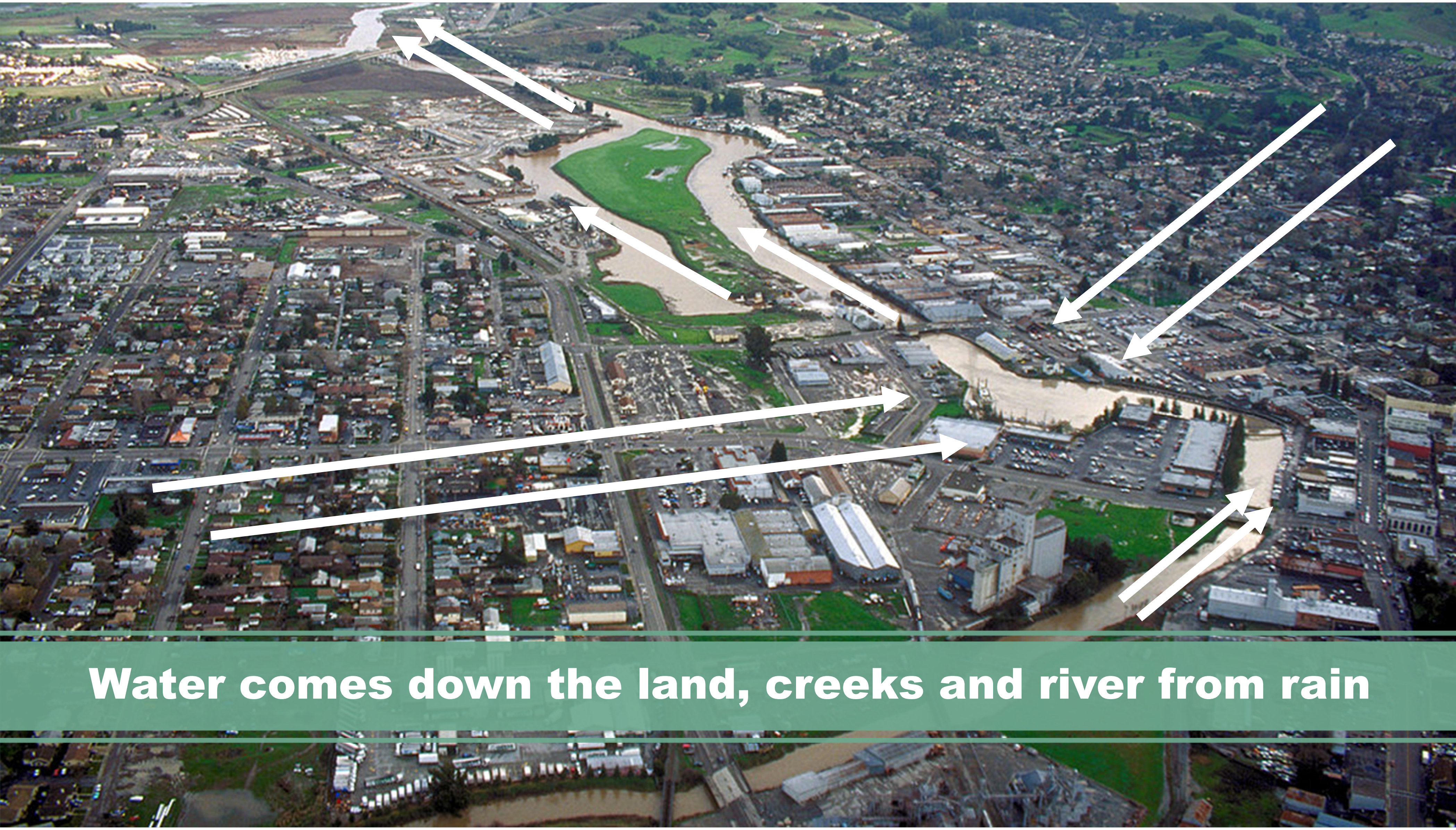
- International, regional, Petaluma
- 110 + Staff

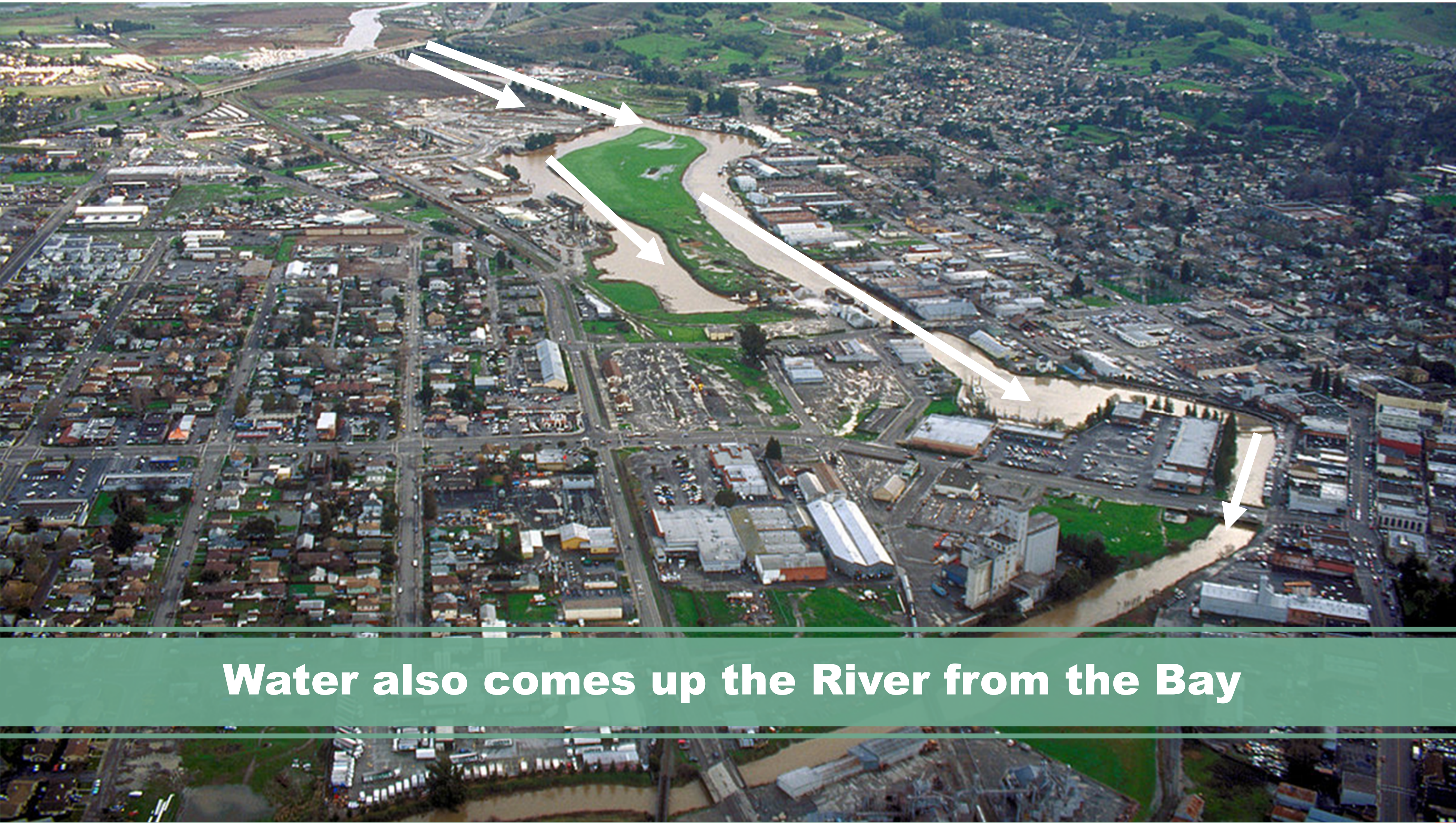
HYDROLOGY MODELING, STORM WATER MANAGEMENT, WATERSHED RESTORATION, INFRASTRUCTURE PLANNING

- Recent SLR projects include multiple Bay Area Jurisdictions

PROJECT MANAGER - SEBASTIAN BERTSCH

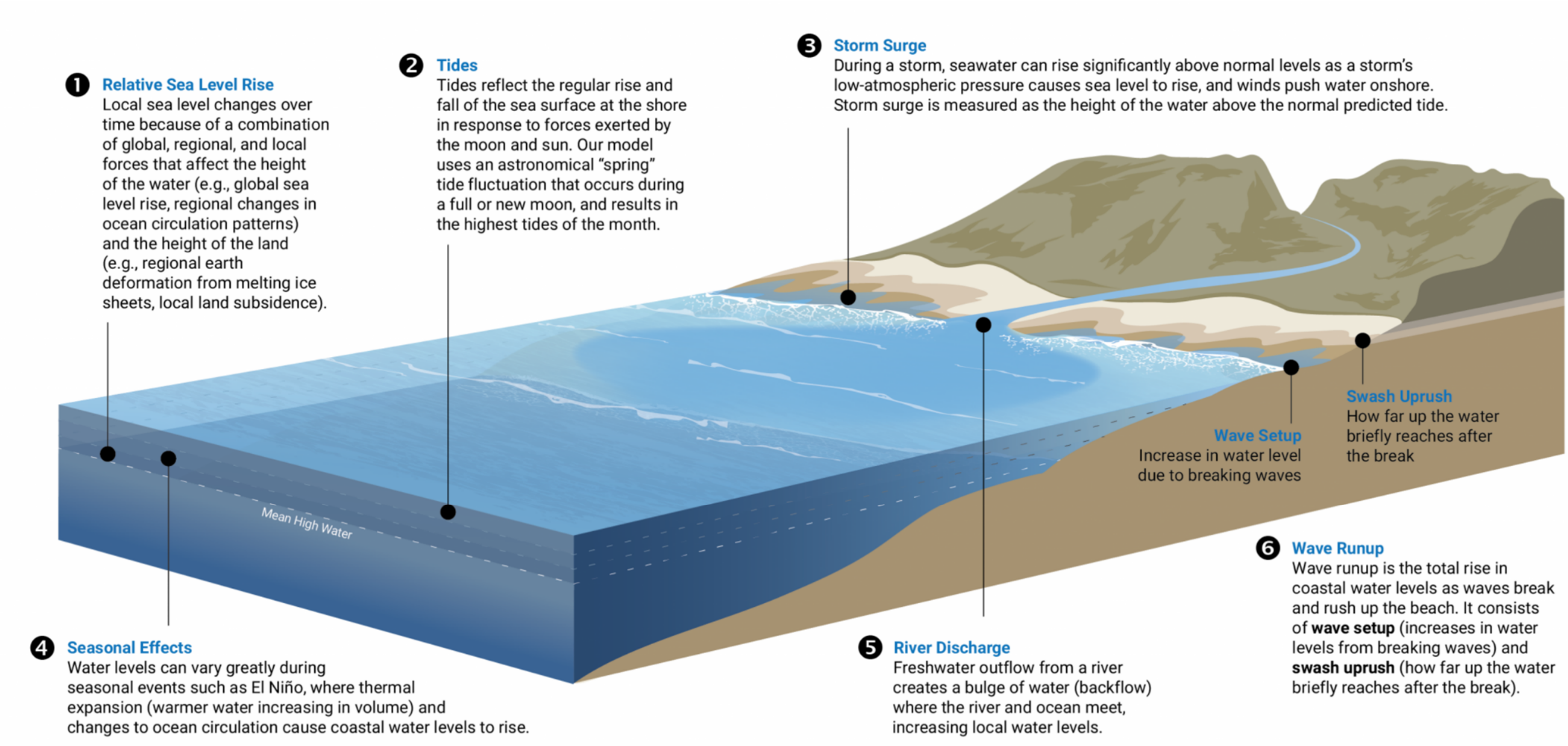
Where does flood water come from?


Water comes down the land, creeks and river from rain



Water also comes up the River from the Bay

Flooding comes from many places



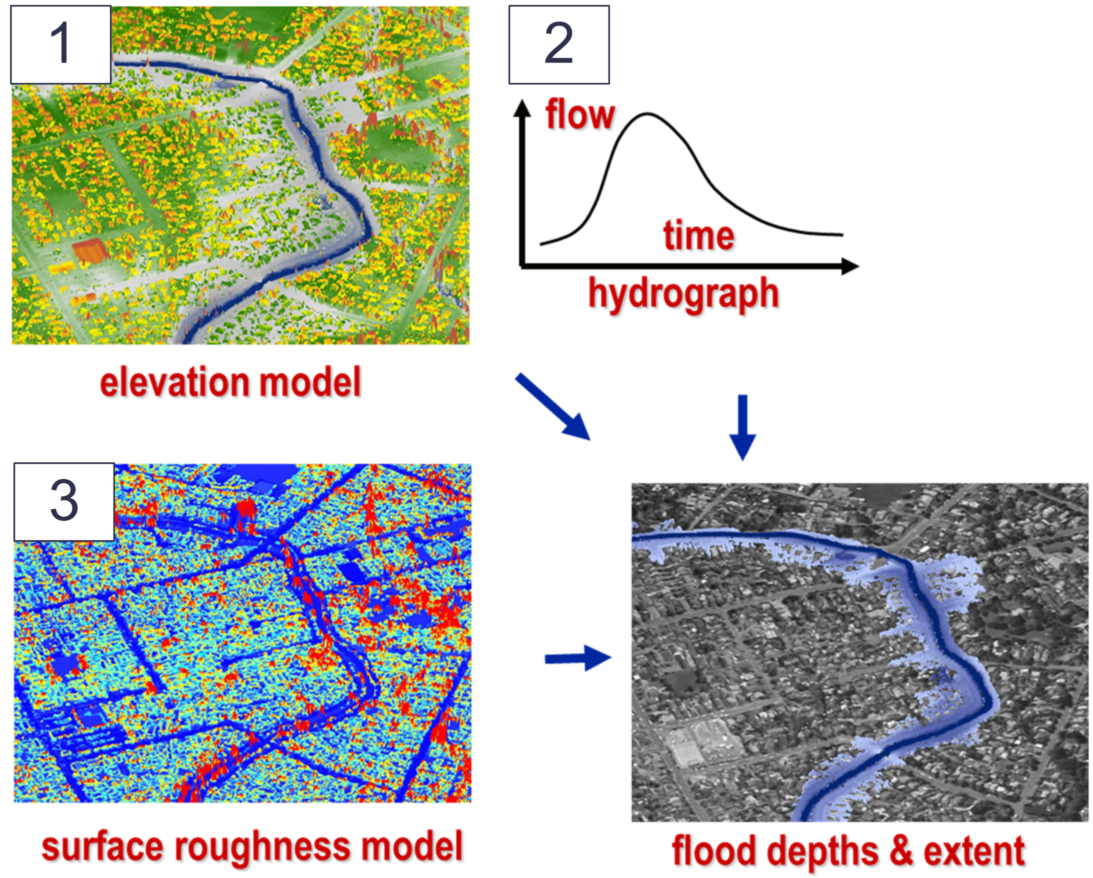
Source: Science and Modeling – Our Coast, Our Future (ourcoastourfuture.org)

3 Flood Types to Consider

- King Tide
  - The highest tides of the year
  - Happen every year
  - Tide gauges tell us this water level
- Rainfall
  - Rain falling on the city and watershed, trying to move down river
  - 1% chance of happening every year
  - Flood models tell us what floods
- Storm Surge
  - Extreme high water in the river due to atmospheric events, separate from rain
  - 1% chance of happening every year
  - Tide gauges/the US Army Corp of Engineers tells us this water level

What is a flood model?

- A software flood model considers 4 main factors
  - 1: The shape of the land and creeks
  - 2: Rainfall amount and location
  - 3: Amount and speed of run off
  - 4: Height of the River/Bay
- 1% Annual Flood Risk = 1% chance every year = 100 year flood
  - Common standard for Flood Planning

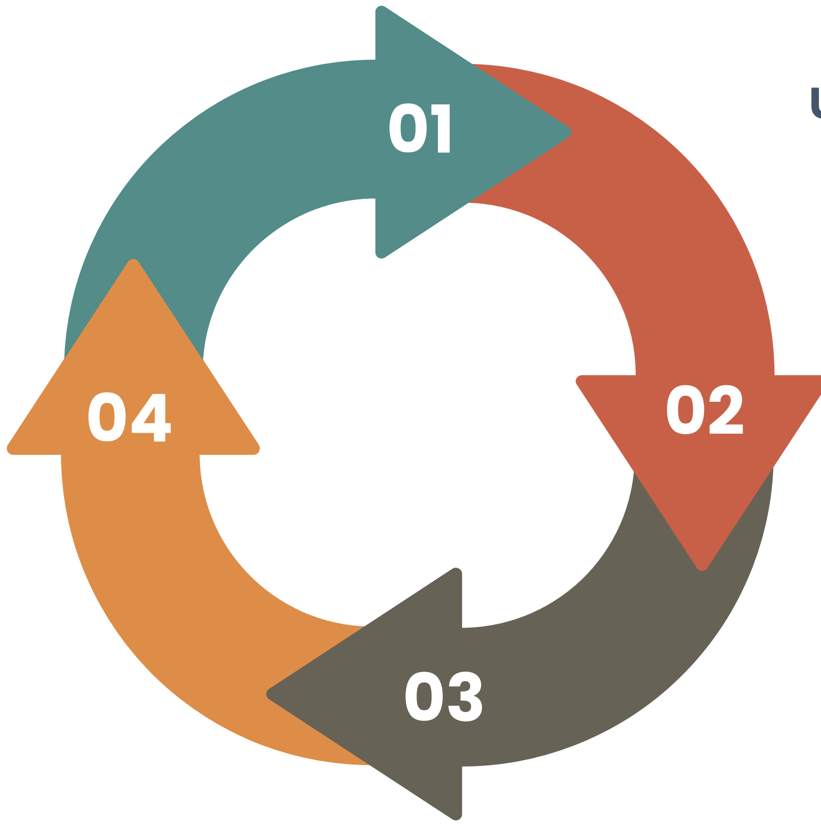


Niwa.co.nz

WE USED THE BEST MODEL

MODEL FEATURES	HEC HMS and HEC RAS 2D	XPSTORM
Great for out of bank flows	✓	✗
Most up to date	✓	✗
Can model outside Petaluma	✓	✗
Used regionally	✓	✓
Economical	✓	✗
Developed by Army Corps	✓	✗

MODEL PROCESS WAS PRECISE, PETALUMA FOCUSED



USED BEST MODEL

HEC-HMS and HEC-RAS 2D

USED BEST, PETALUMA DATA

Rainfall data, terrain data (ground surface), structure data

GOT AS GRANULAR AS POSSIBLE

We walked the streams to determine roughness values, hundreds of culverts/bridges

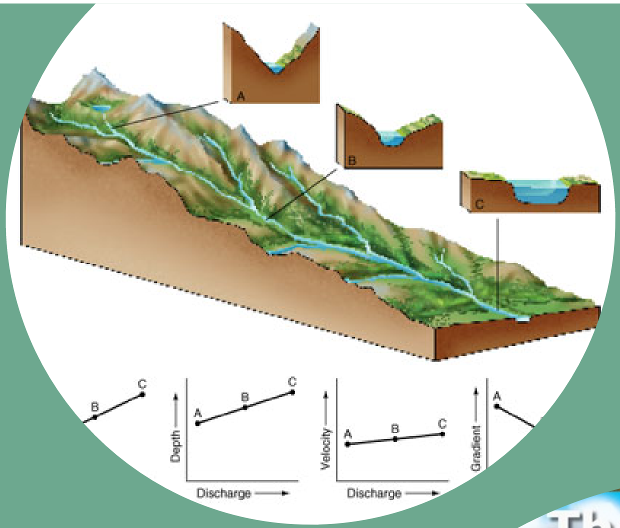
RAN MODEL, COMPARED TO DATA, DOUBLE CHECKED

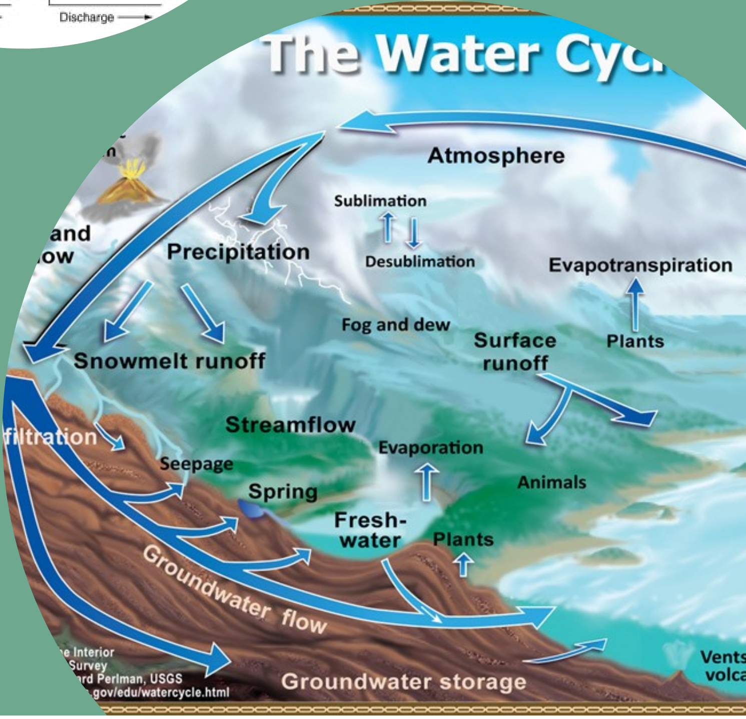
Calibrated to the three largest events of record, checked model results carefully for reasonableness stream by stream, reach by reach

Model Background

What is hydrology?

What is hydraulics?





PETALUMA FLOOD MODELING

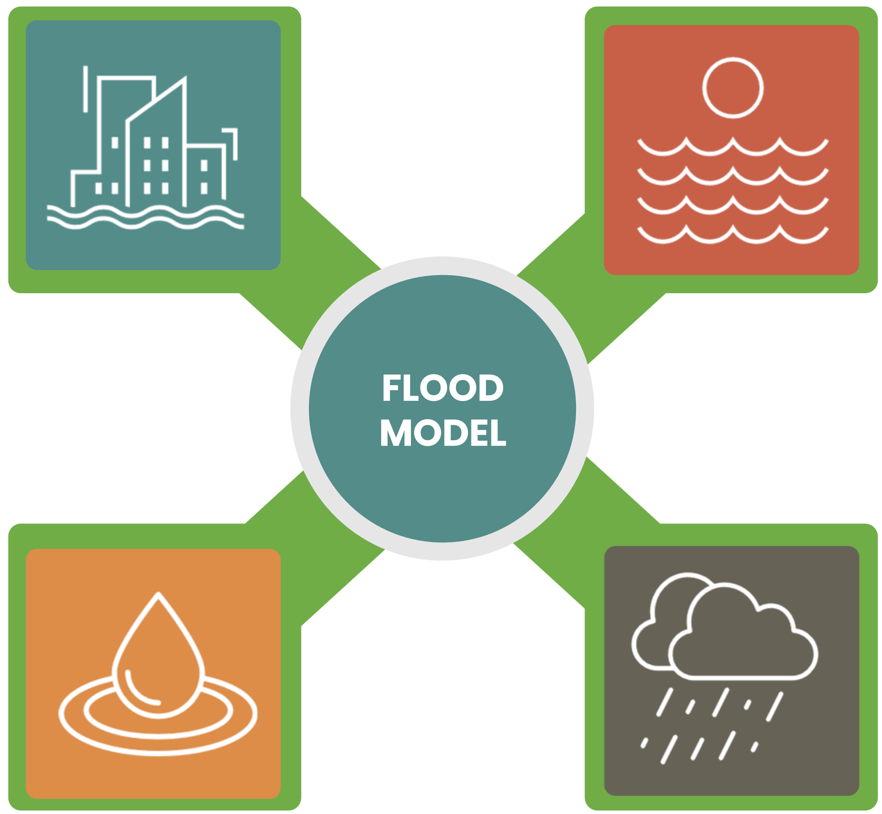
Includes Climate Change Impacts, Uses Petaluma Specific Data

SEA LEVEL RISE

Based on current science

MEAN HIGHER HIGH TIDE

The average of the highest tides each year as provided by NOAA.



HYDROLOGY and HYDRAULICS

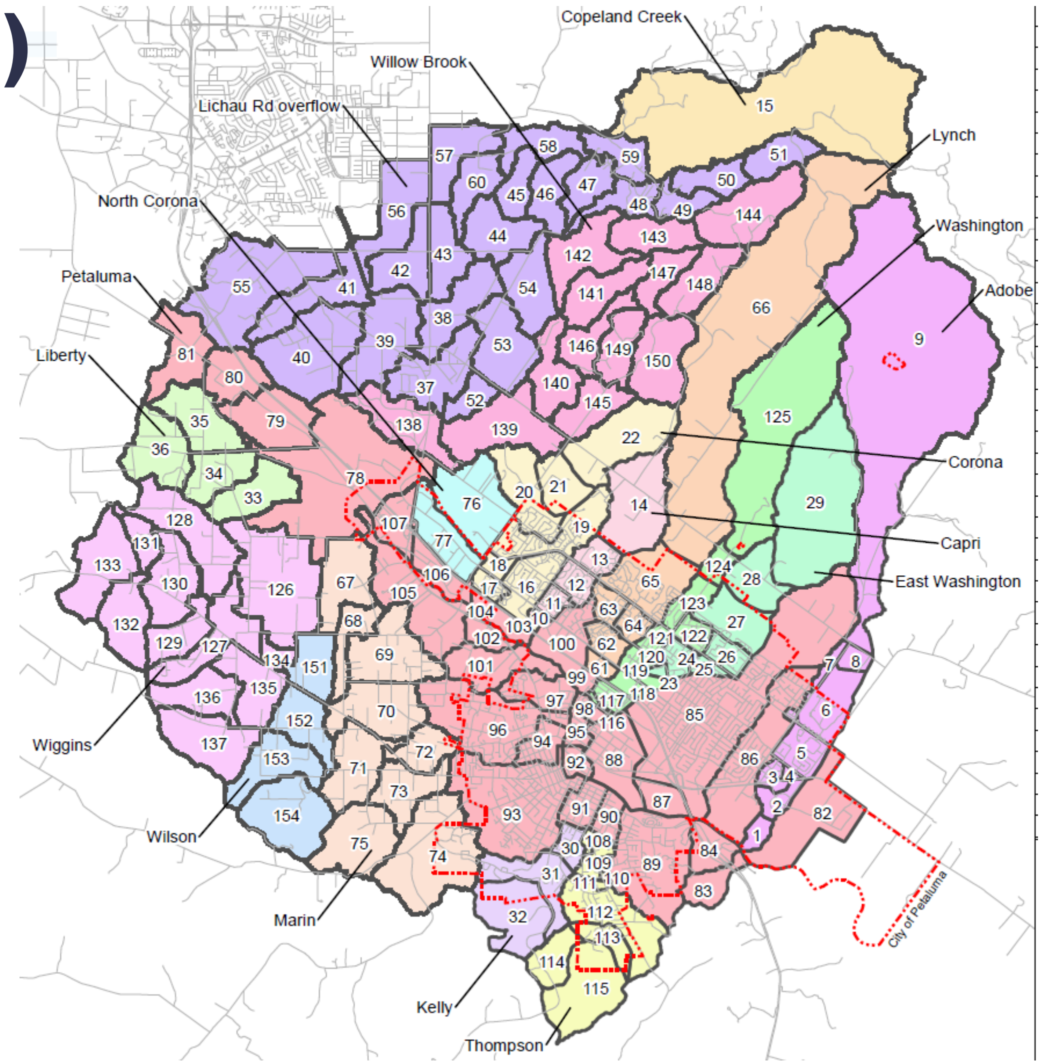
Ground Surface Terrain, Field Surveys, Land Uses, Vegetation levels

RAIN

Custom rain study specific to Petaluma in 2023. Considered how much rain is reasonable, where it falls in the watershed heaviest, and how quickly it falls.

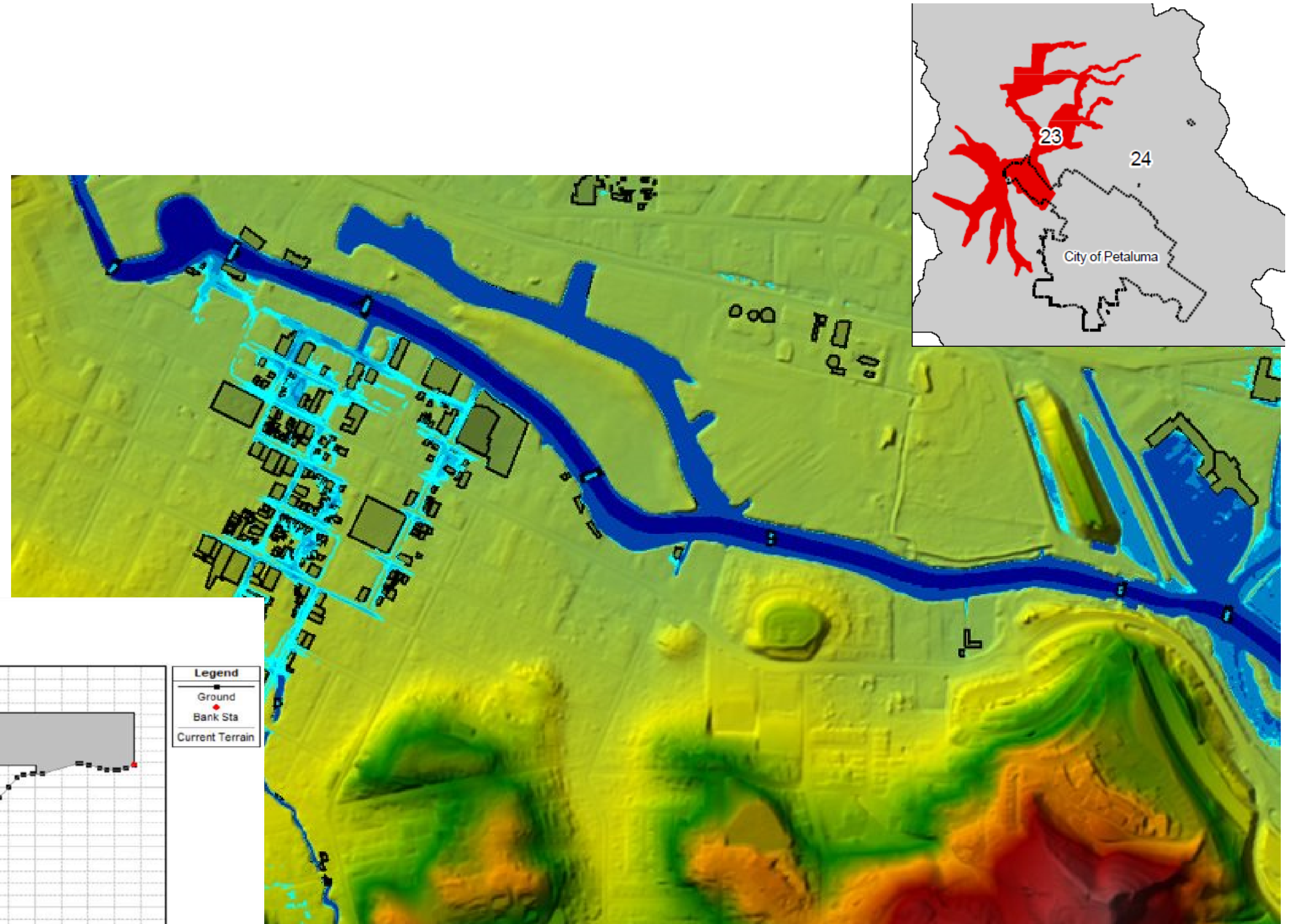
Hydrology (HEC-HMS)

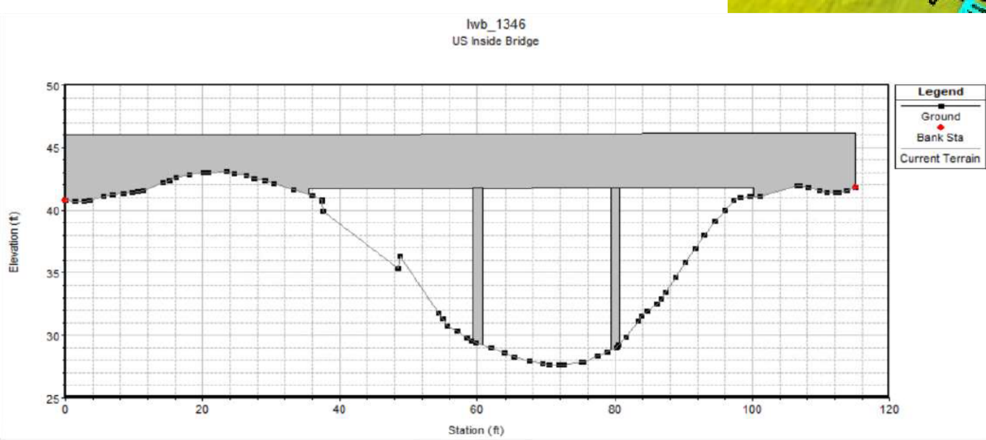
- This is the Petaluma River watershed
- Flow estimated in each drainage area
- 154 subbasins



Hydraulics (HEC-RAS 2D)

- Ground elevation data
- Structures
- Roughness (streets vs. vegetation)



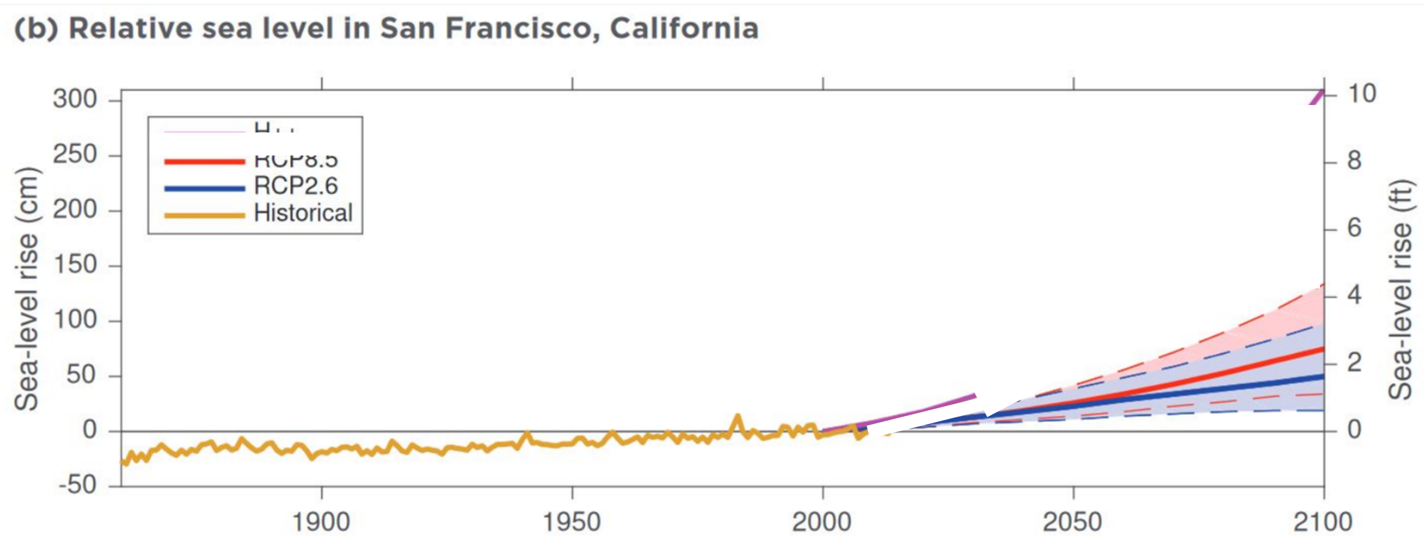


Predicting the Future

- Data will guide General Plan with predictions of potential future floods
  - Many variables were considered: Precipitation, Bigger Surge, Urban Cover
  - Sea Level Rise (SLR) will also have a significant impact, as it impacts River drainage

Source for SLR Predictions

- California Ocean Protection Council Guidance (OPC2018)
  - Used by numerous state and local agencies and counties/cities
  - Provides ranges of SLR, and how likely they are to happen in future decades
  - Recommends which predictions are appropriate for different planning efforts
  - Recommends assuming continued High Emissions (RCP)



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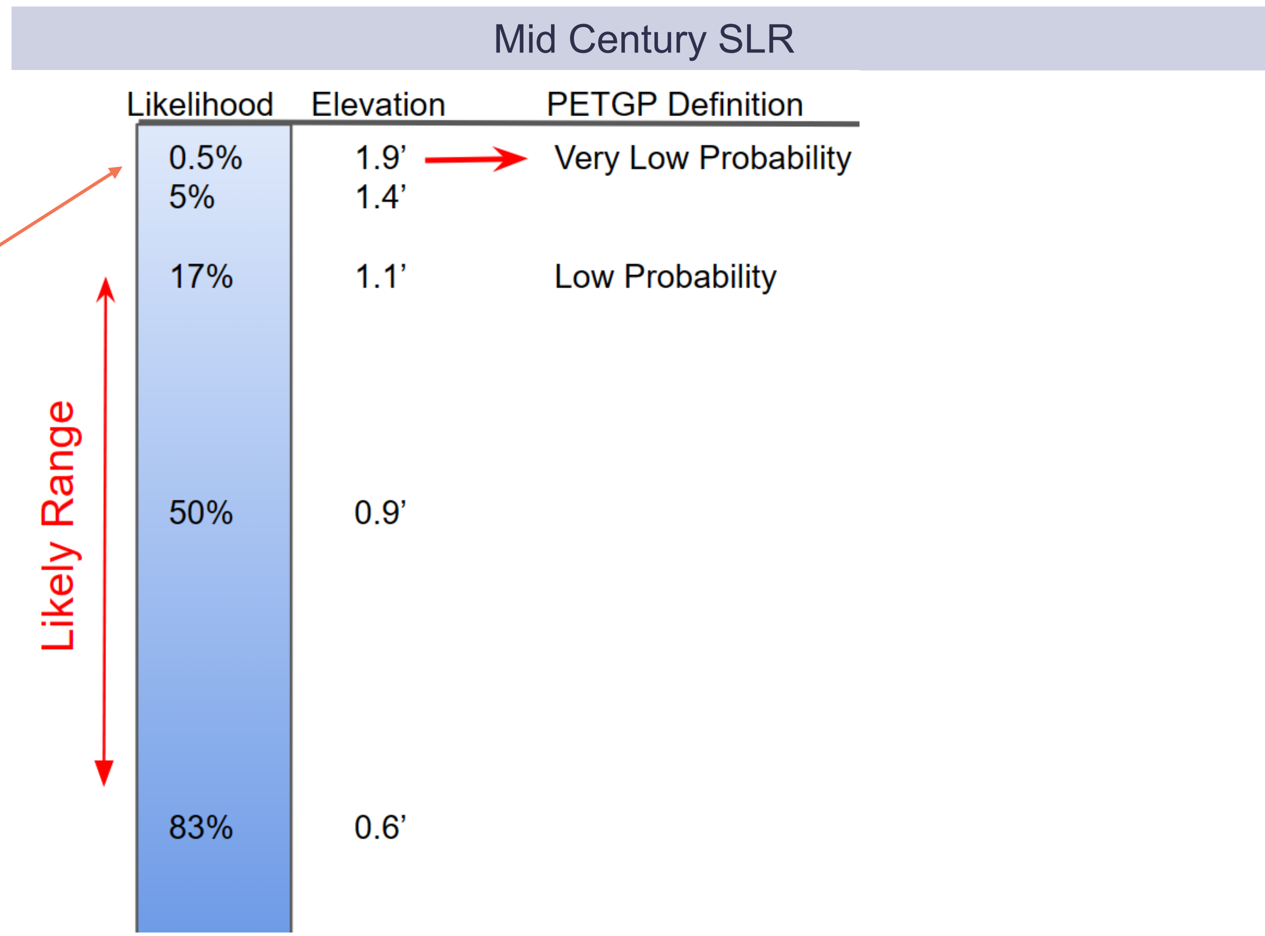
  - Recommends which predictions are appropriate for different planning efforts

Sea Level Rise (SLR) Selections

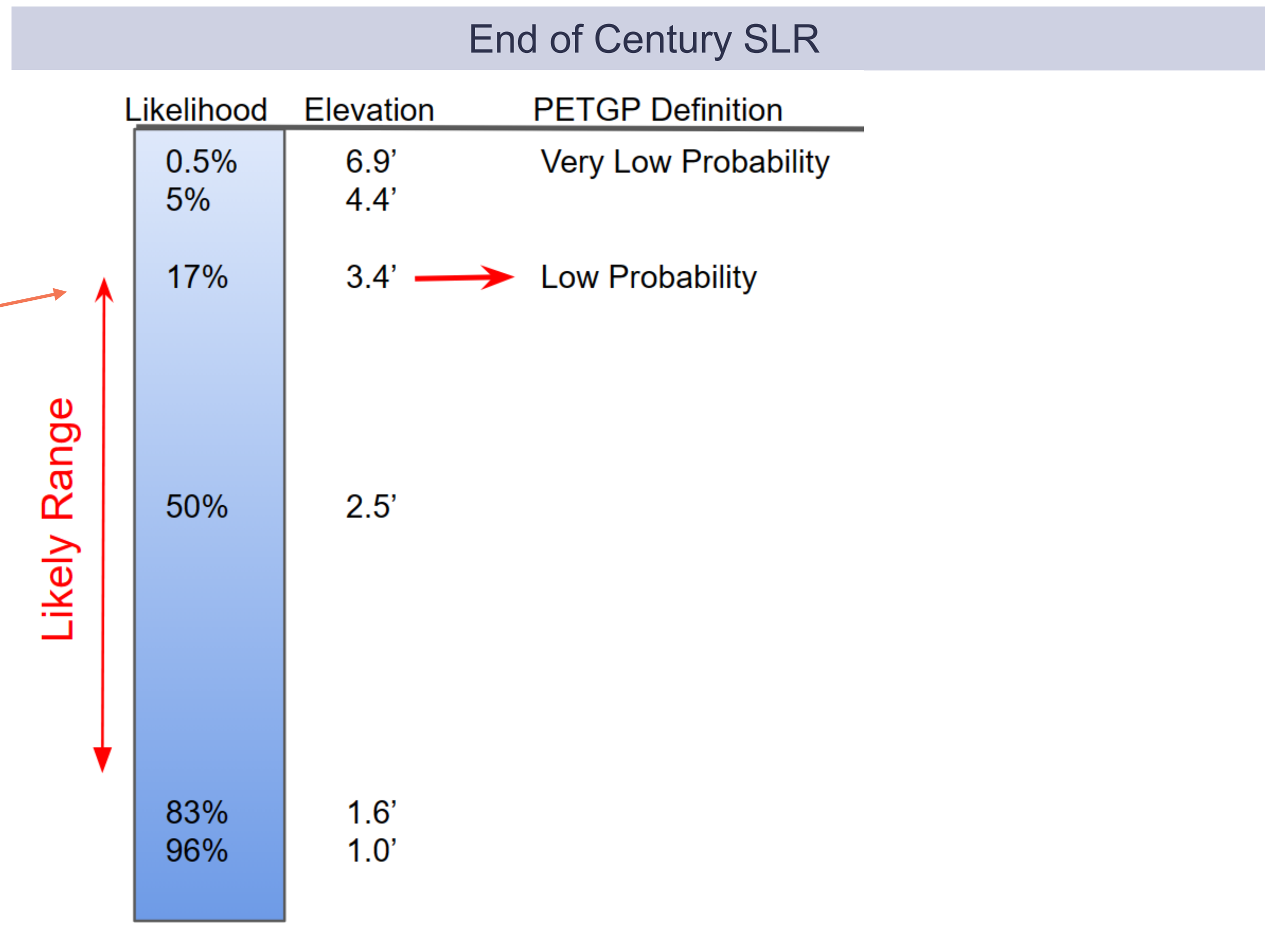
- Mid-Century
  - Roughly 2050
  - Very low probability SLR
  - 0.5% chance
  - **1.9 feet**
  - Short planning horizon, so the worst case was selected



Sea Level Rise (SLR) Selections

- End-of-Century
  - Roughly 2100
  - Low probability SLR
  - 17% chance
  - **3.4 feet**

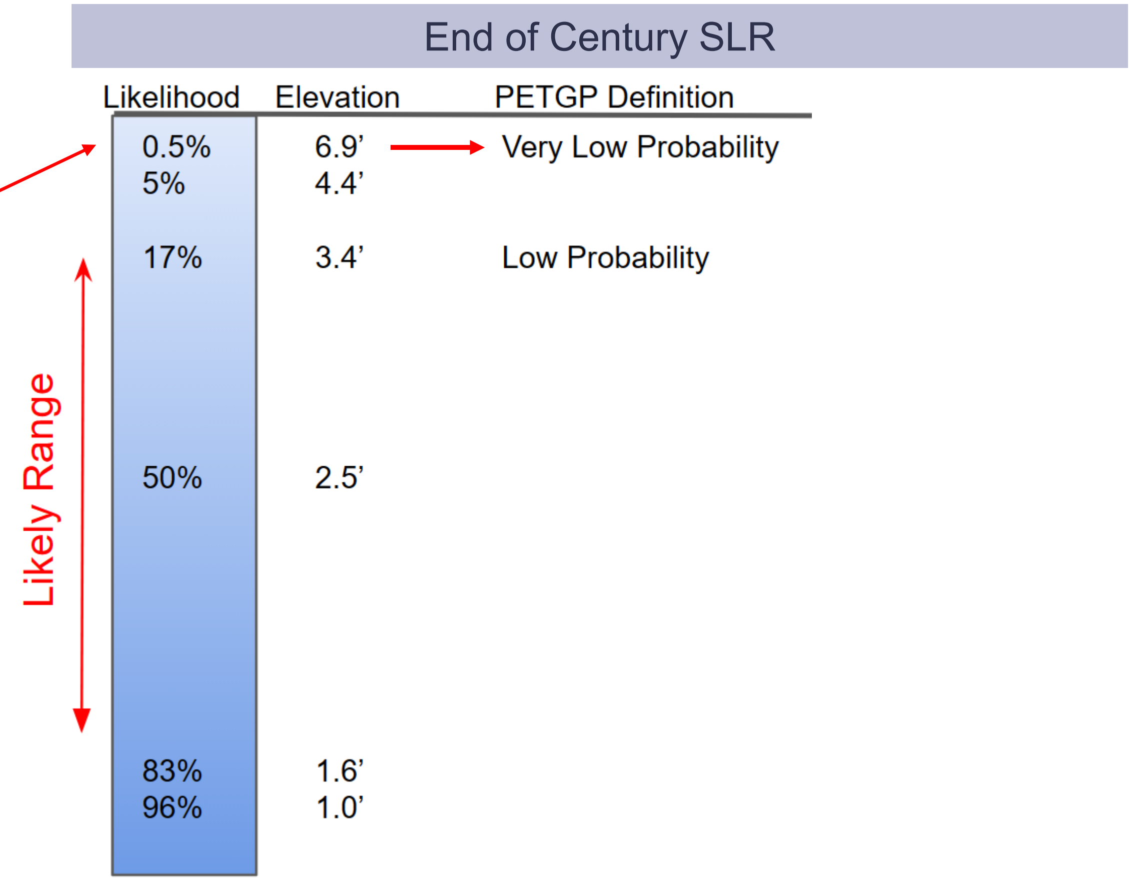
  - Longer planning horizon gives us more time to prepare
  - Appropriate for most planning efforts



Sea Level Rise (SLR) Selections

- End-of-Century
  - Roughly 2100
  - Very Low probability SLR
  - 0.5% chance
  - **6.9 feet**

- Longer planning horizon gives us more time to prepare
- Appropriate for isolated critical or high risk infrastructure and uses

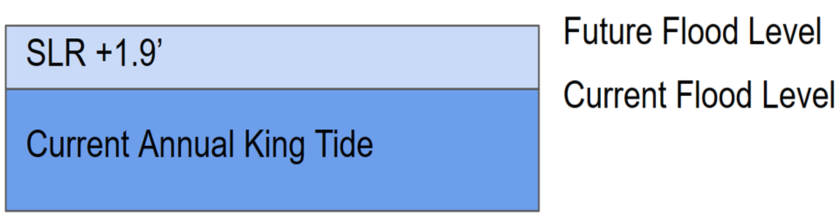


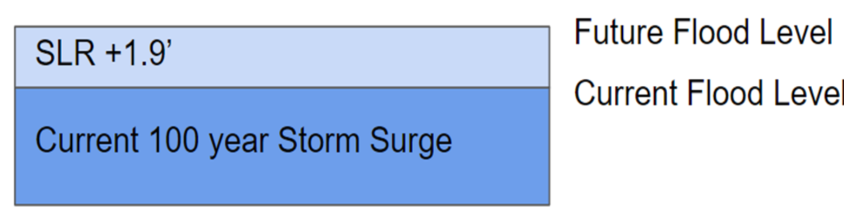
Using SLR in flood maps

- The maps most relevant for long term planning are 1.9' of SLR in Mid-Century and 3.4' in the End-of-Century
  - It is straightforward to explore how SLR affects King Tide and Storm Surge flooding
  - Considering how SLR affects Rainfall flooding requires our new model

King Tide and Storm Surge

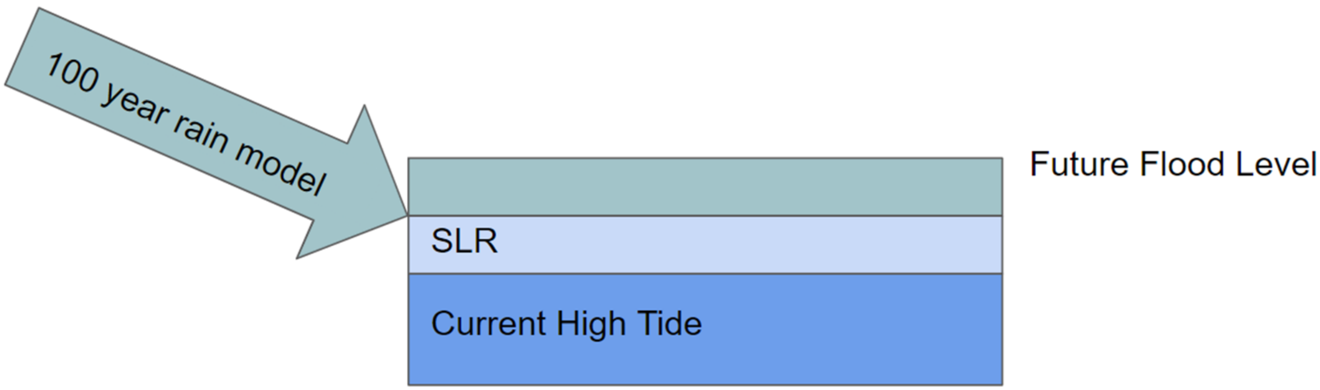
- Current King Tide and Storm Surge patterns are layered on top of Sea Level Rise to predict what will flood in the future





SLR effects on Rainfall flooding

- Considering how SLR impacts rainfall flooding requires updated rain model
  - Model Method
    - 1: Add SLR amount to current MHHW tide level
    - 2: Run the rain flood model, now with rainfall needing to "fight" the higher river elevation
    - 3: Model results may show extra flooded areas

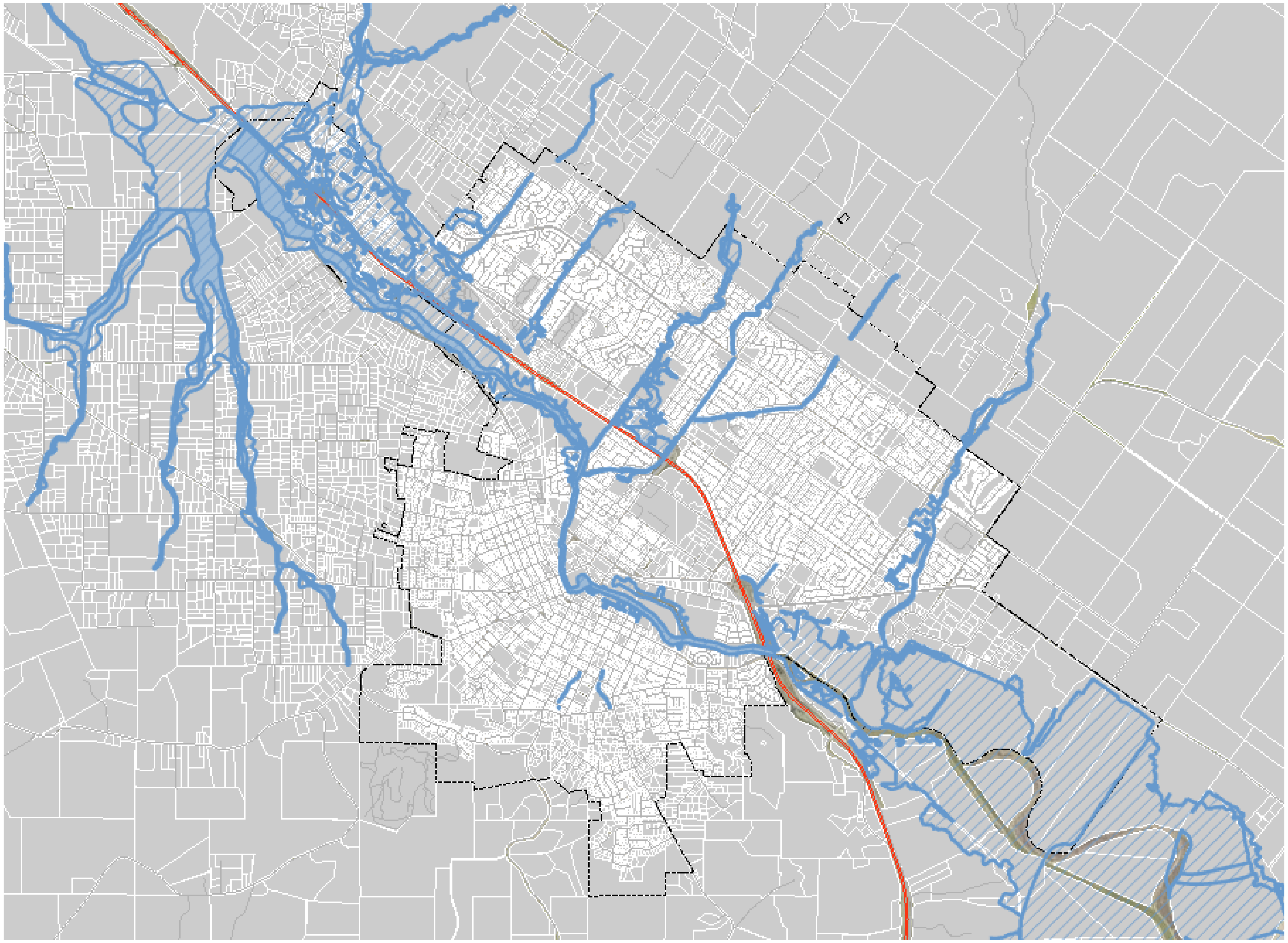


What did we model?

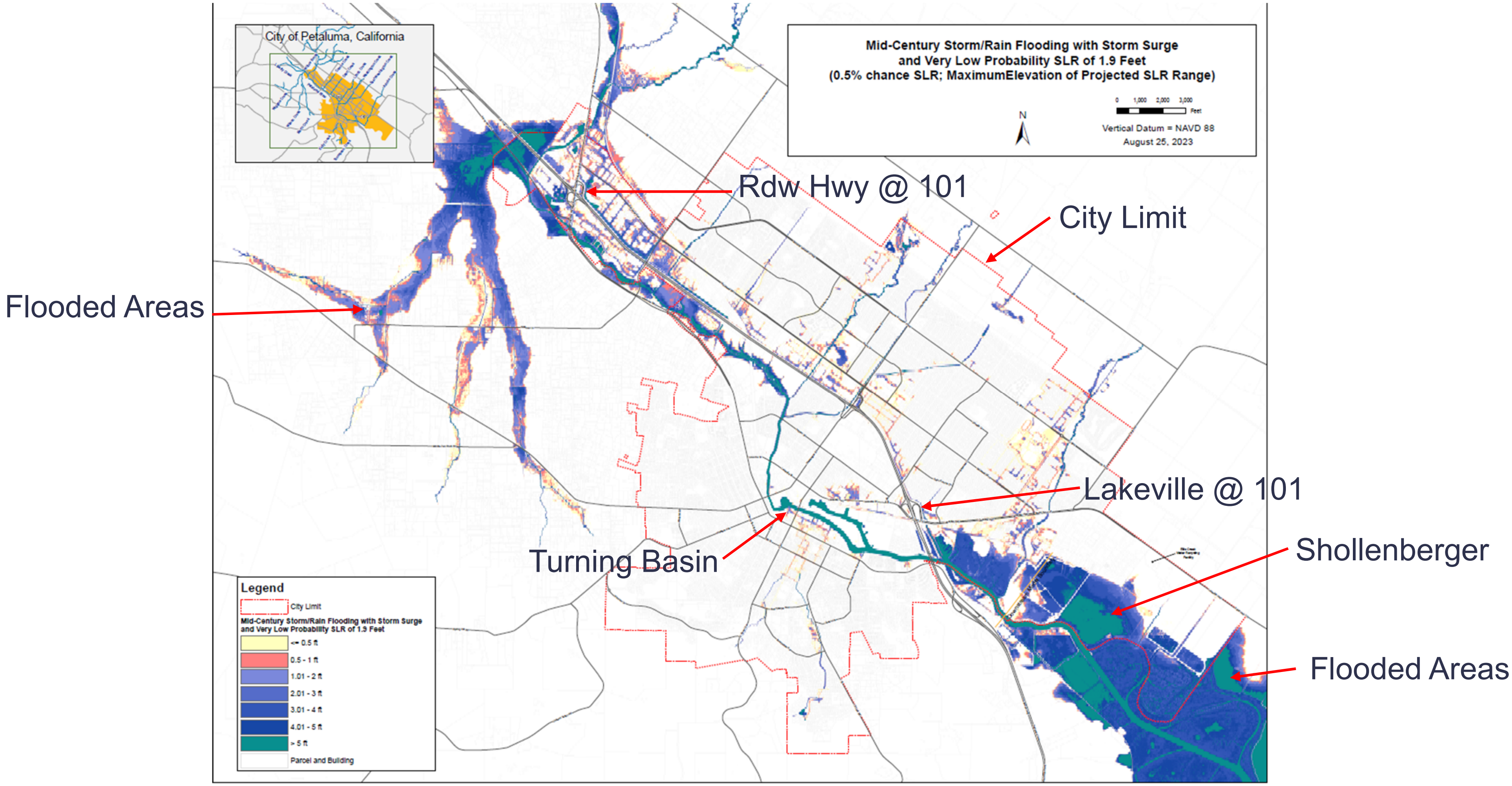
- What are flood risks at mid-century (around 2050), if we look at
  - Rain and storm surge (Map 1)
  - King tides (Map 2)
- What are flood risks at the end of the century (around 2100), if we look at
  - Rain and storm surge (Map 3)
  - King tides (Map 4)
- What could the very low probability flood risks at the end of the century
  - Rain and storm surge (Map 5)
  - King tides (Map 6)
- Maps are next! First, questions?

Clarifying Questions

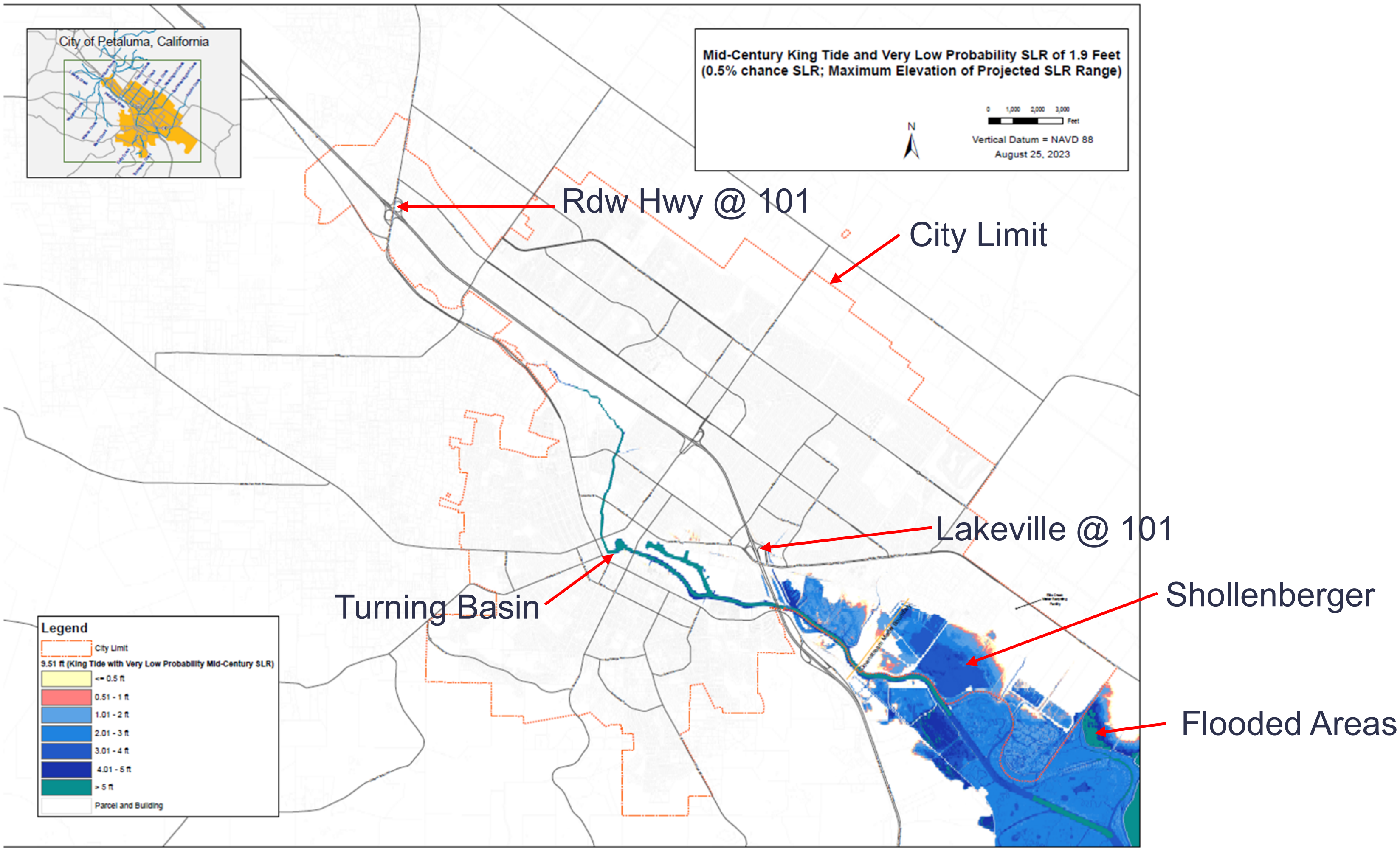
Current FEMA 100 Yr (1% Chance) Floodplain



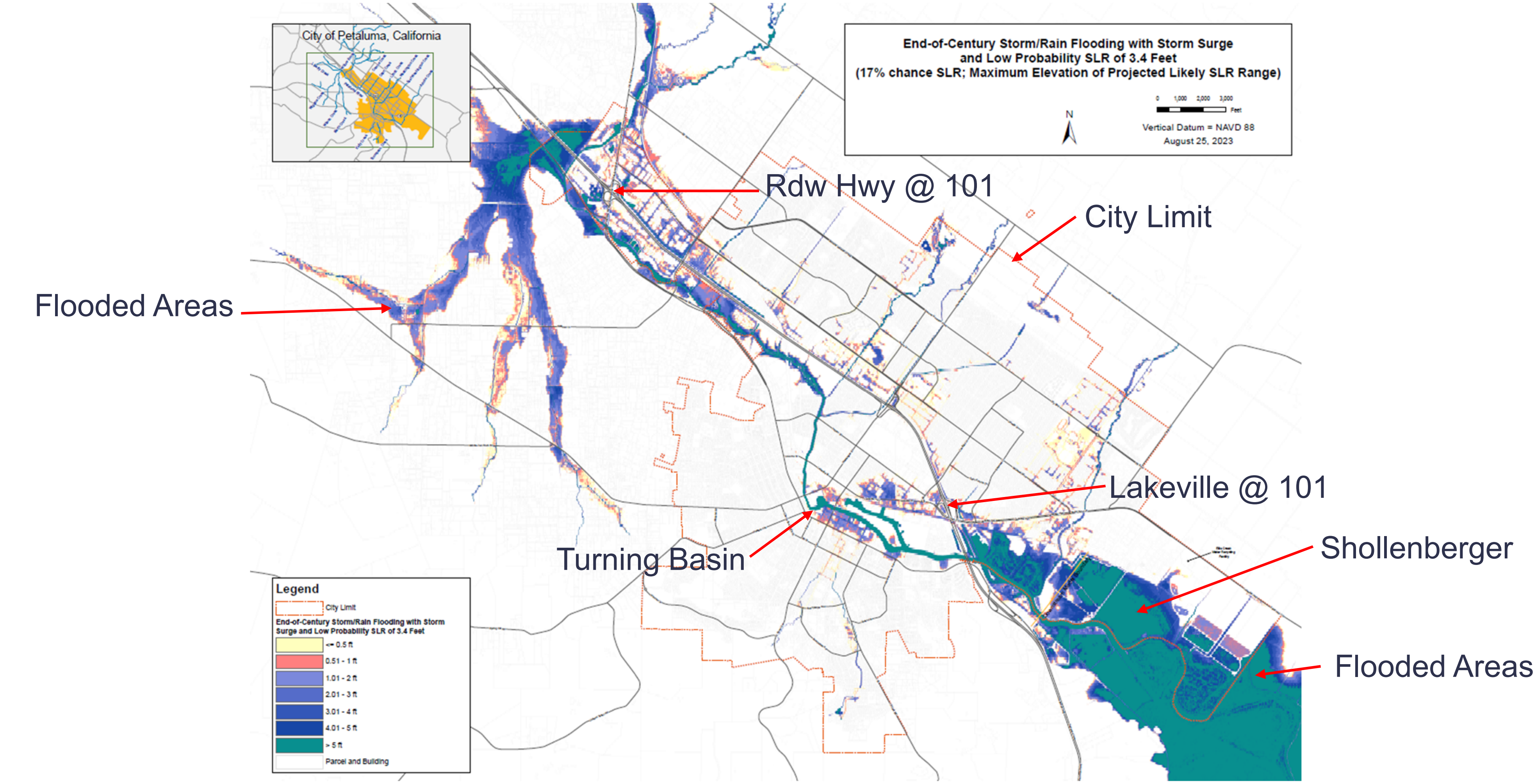
Mid-Century SLR (1.9 feet), Rain and Storm Surge



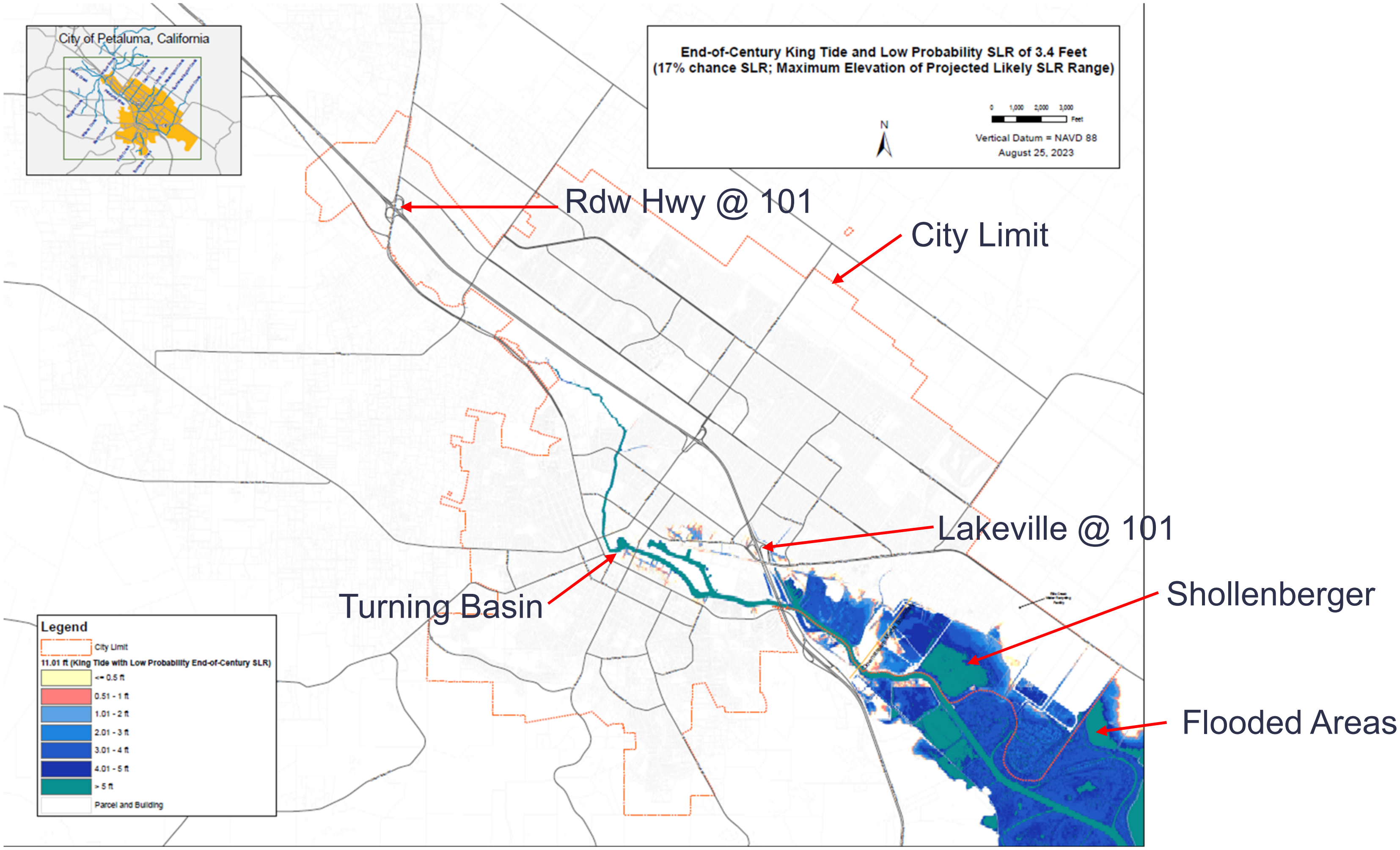
Mid-Century SLR (1.9 feet), King Tide



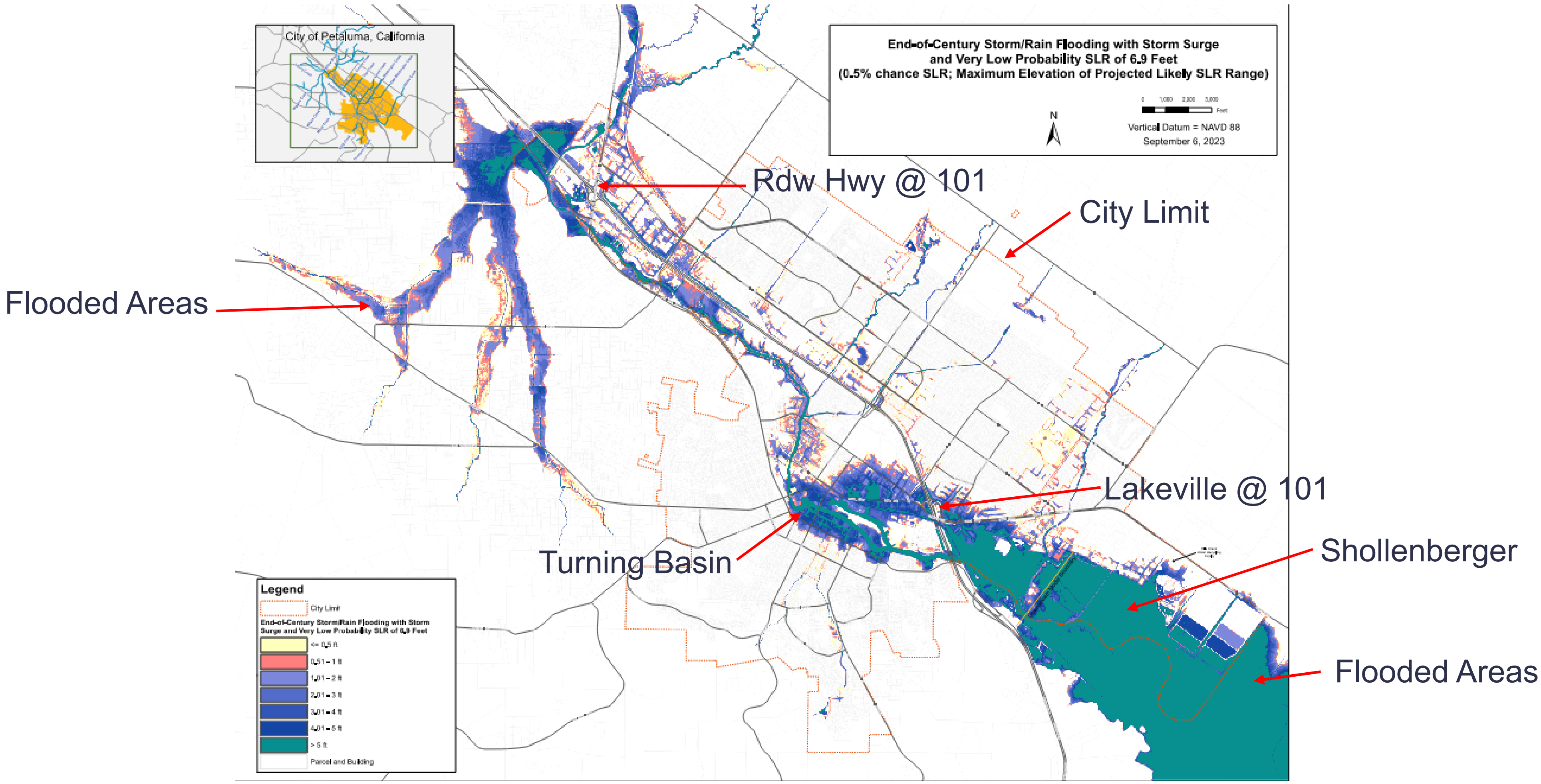
End-of-Century SLR (3.4 feet), Rain and Storm Surge



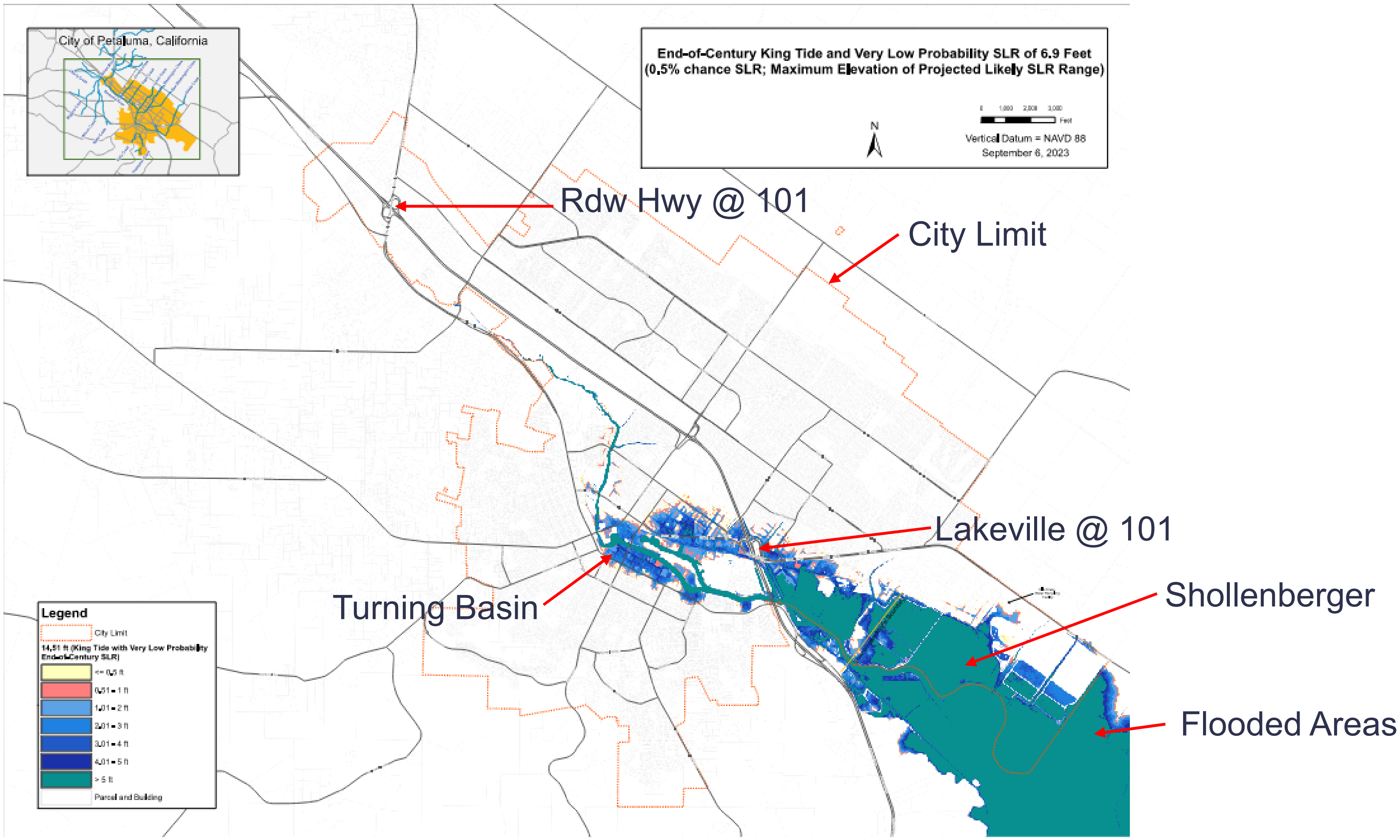
End-of-Century SLR (3.4 feet), King Tide



End-of-Century SLR (6.9 feet), Rain and Storm Surge



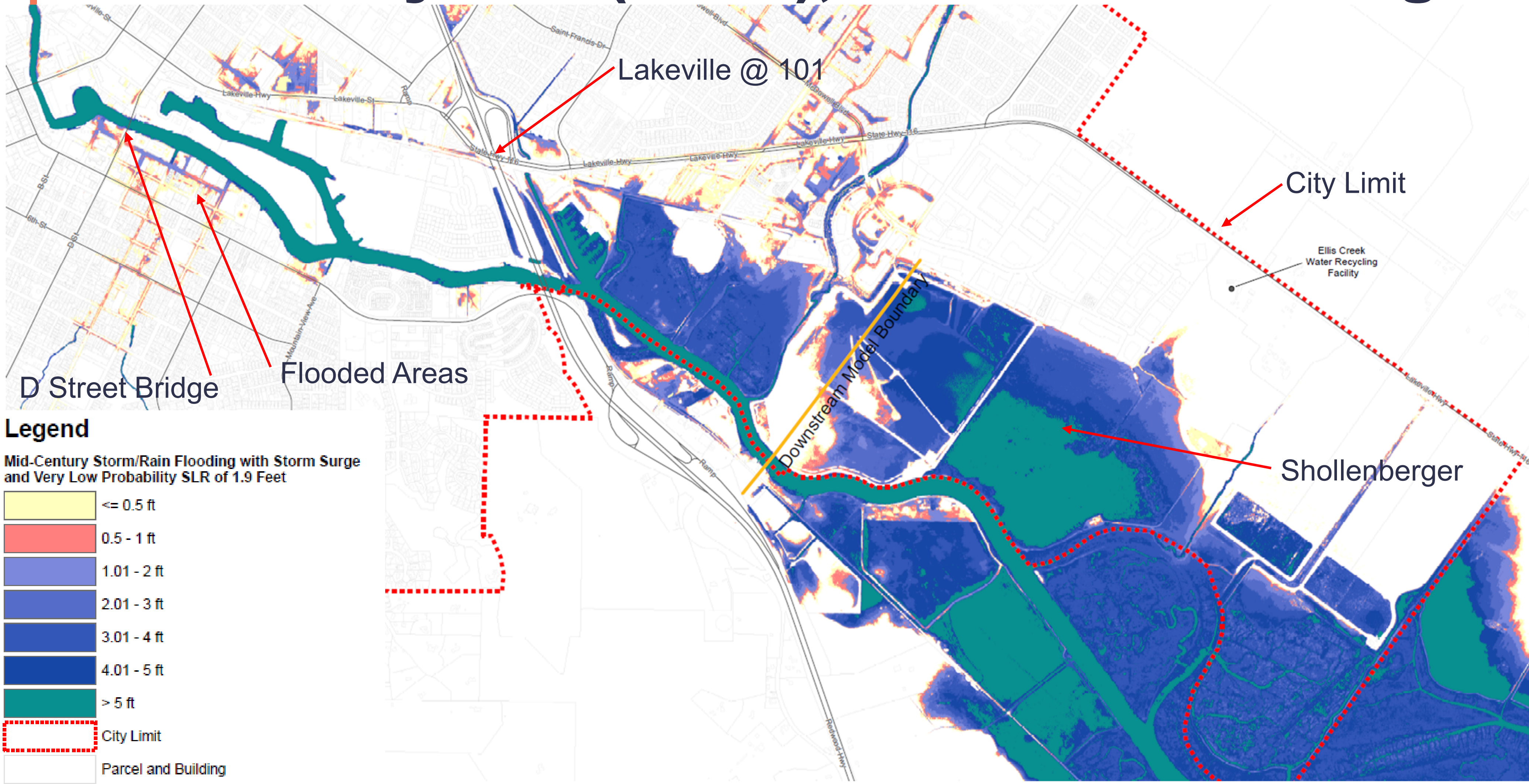
End-of-Century SLR (6.9 feet), King Tide



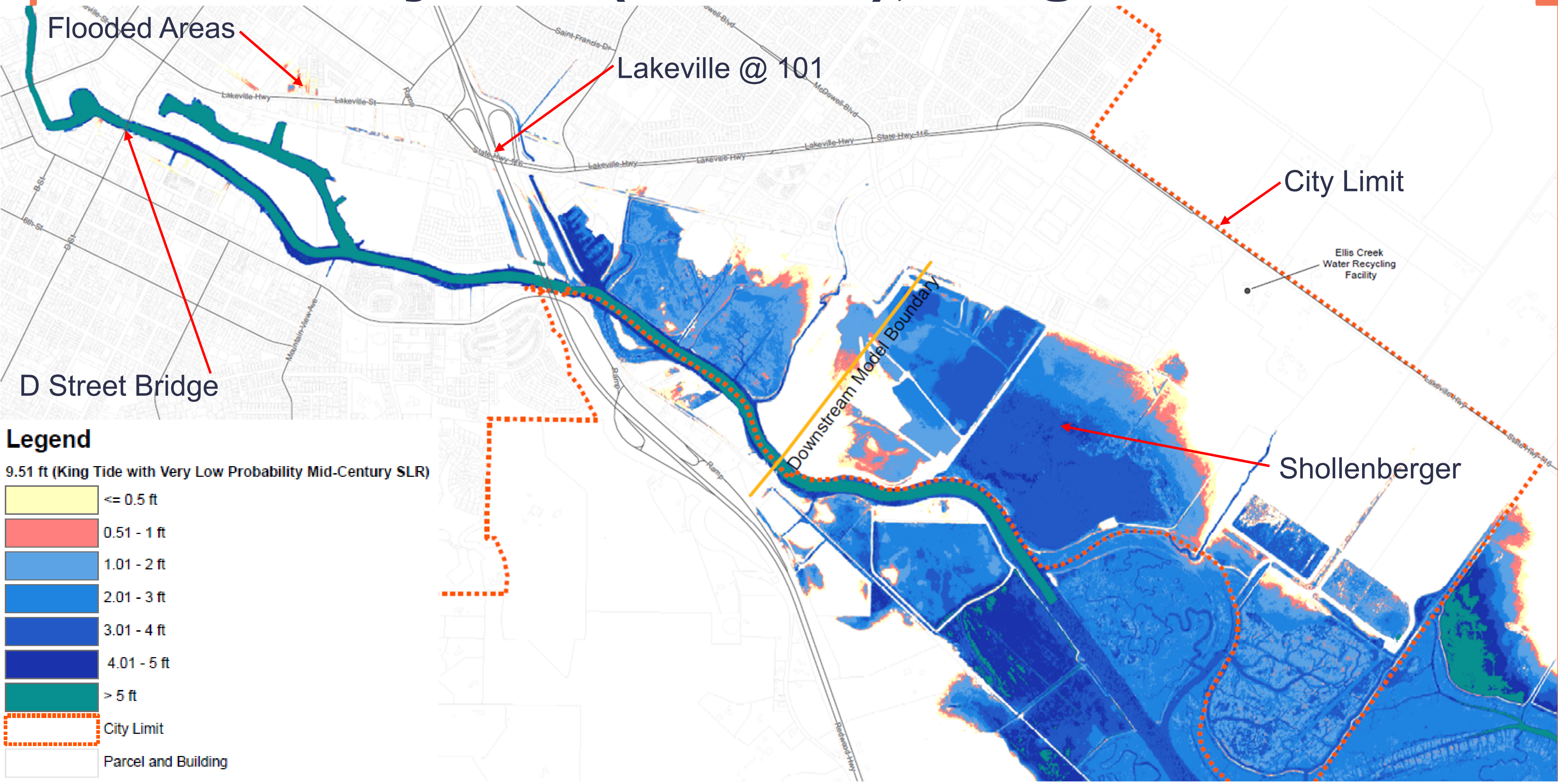
Where can SLR affect the City in the Future

- Let’s zoom in to the same maps

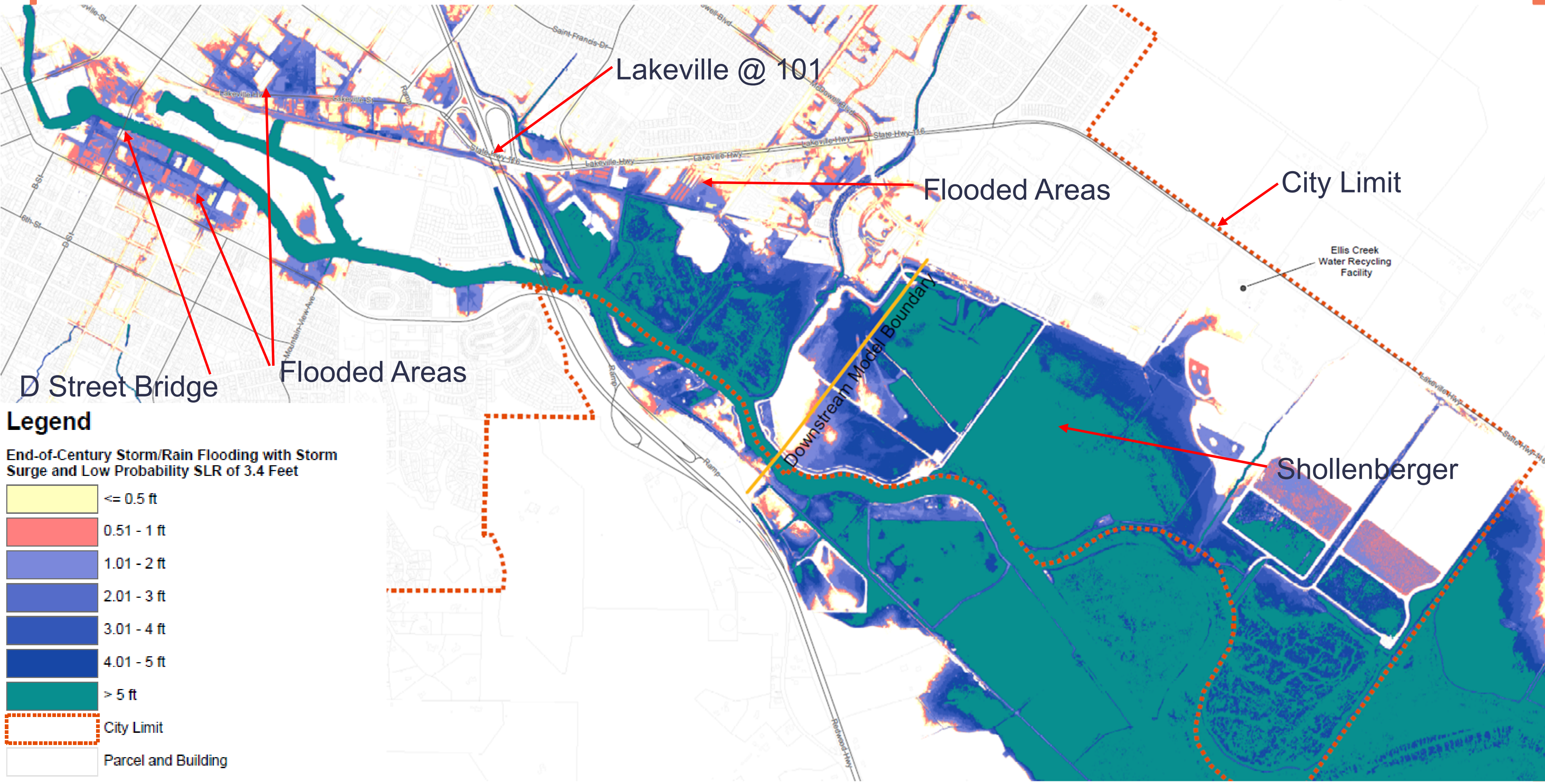
Mid-Century SLR (1.9 ft), Rain + Storm Surge



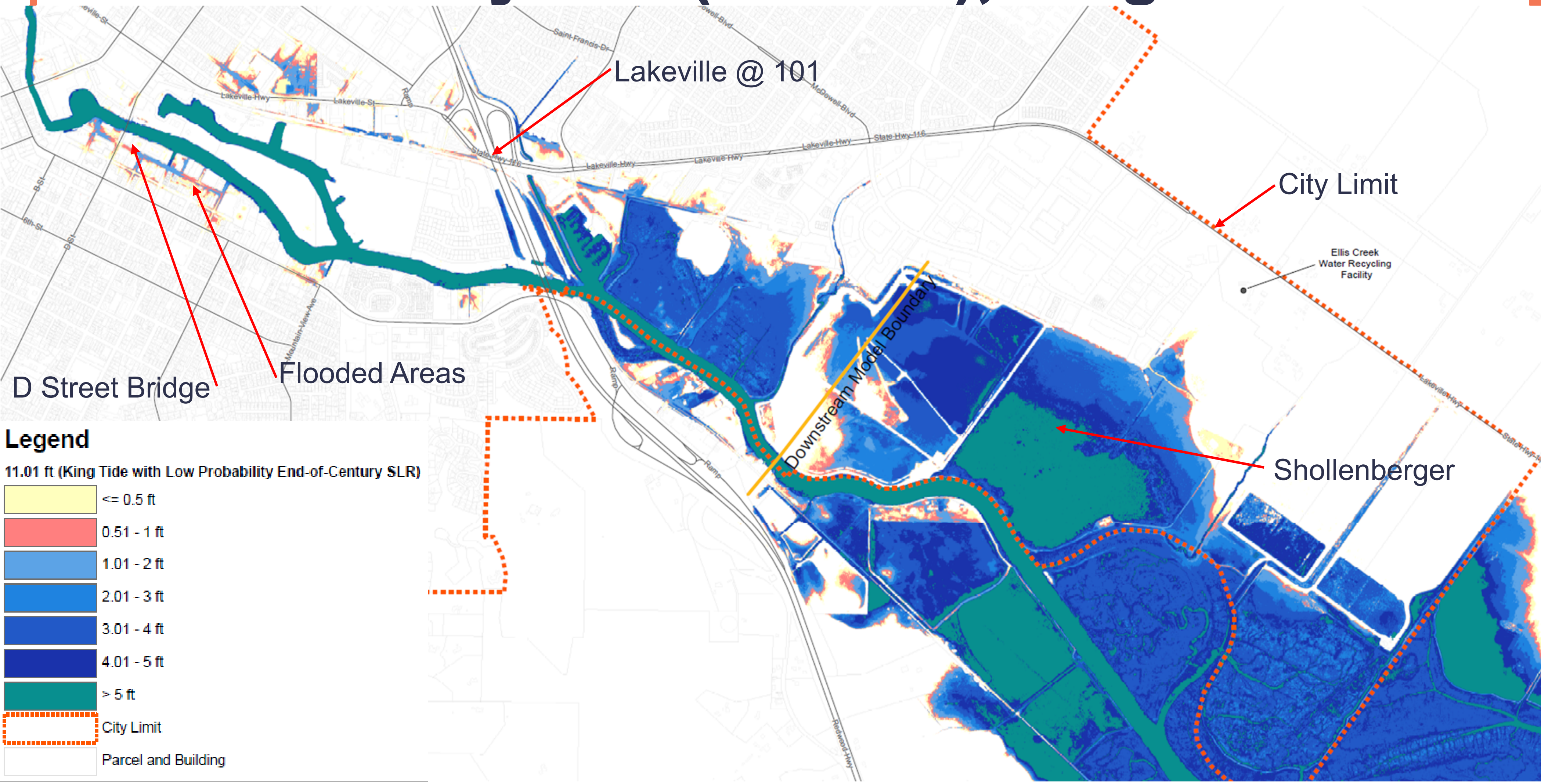
Mid-Century SLR (1.9 feet), King Tide



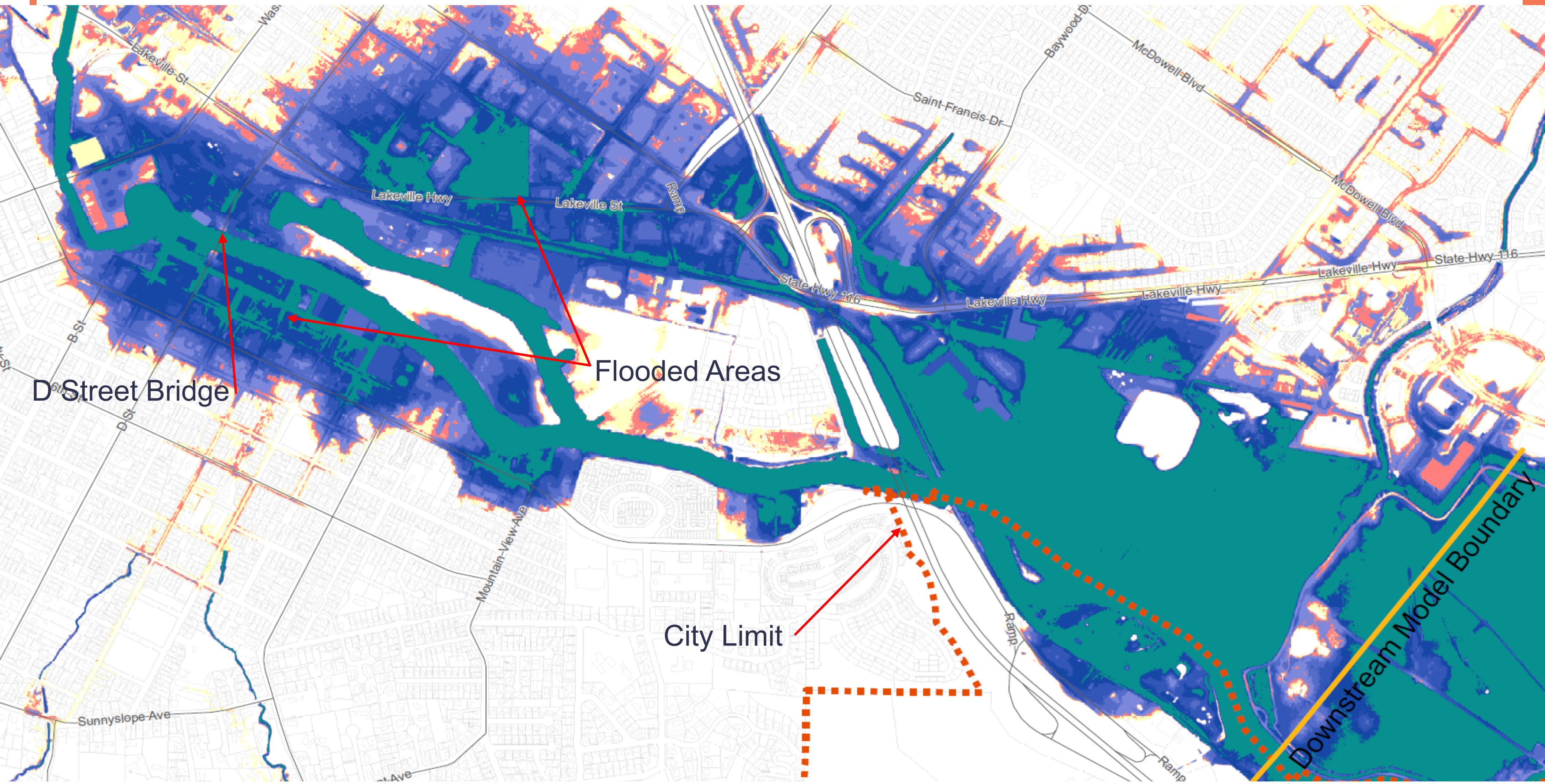
End-of-Century SLR (3.4 ft), Rain + Storm Surge



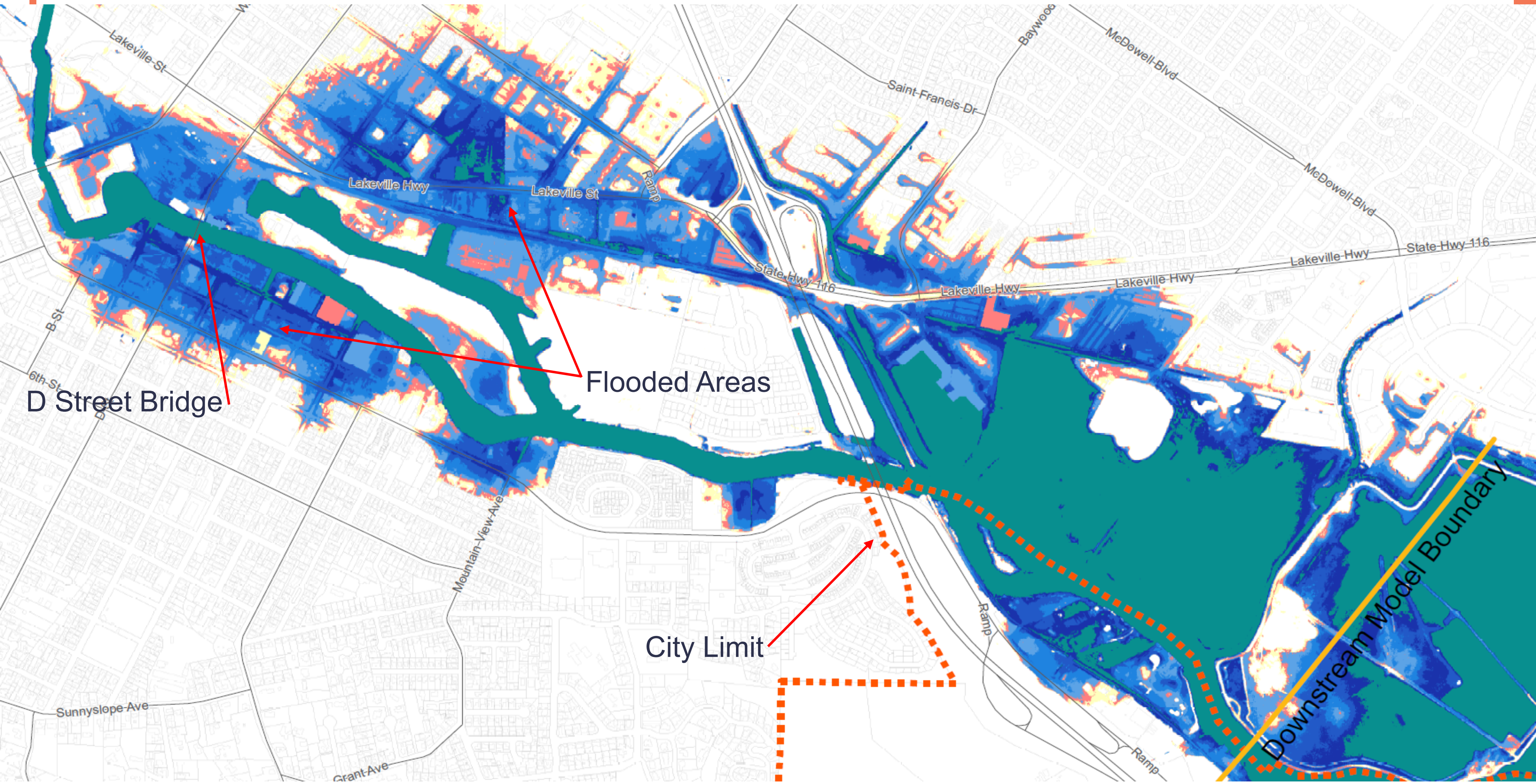
End-of-Century SLR (3.4 feet), King Tide



Very Low Probability, End of Century SLR, Storm Surge

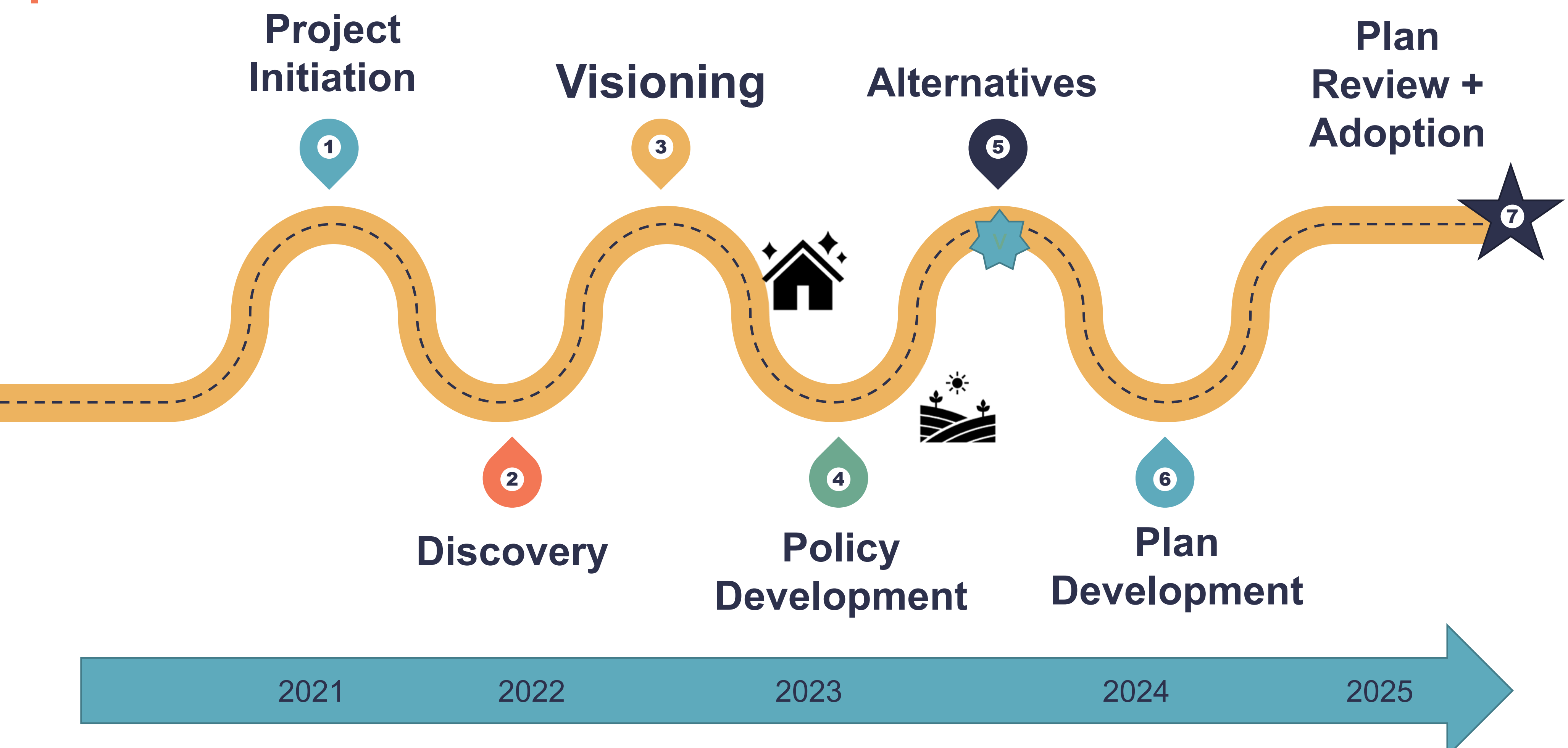


Very Low Probability, End-of-Century SLR, King Tide



Flood Mapping in the General Plan Update

General Plan Update Roadmap



GPAC Meetings

GPAC meetings are the 3rd Thursday of the month @ 6:00 pm

- ✓ Introduction of Updated Flood & Sea Level Rise Modeling & Maps - September 21, 2023
- ✓ Discussion of Flood Resilience Planning - October 19, 2023
- ✓ Discussion of Land Use Alternatives I - November 16, 2023
- ❑ **Discussion of Land Use Alternatives II – January 18, 2023.**

WHERE WE ARE NOW

JANUARY 2024

NEXT STEPS

MORE PUBLIC ENGAGEMENT

2024

THE ROAD AHEAD

2024-2025

CONTINUED ROBUST PUBLIC ENGAGEMENT

- Public Review of Alternatives
- Development and Analysis of Preferred Alternative
- Public and Council Review of Preferred Alternative
- Admin Draft General Plan & Environmental Review
- Public Draft General Plan & Admin Draft EIR
- Final General Plan & Final EIR

Summer 2025

FEMA Map Update Process

- The City will soon begin the process to update our flood maps with FEMA
- Led by Public Works
- Including:
  - Technical review with FEMA
  - Community Engagement
- 1-2 year timeline to completion

Floodplain Management in Petaluma

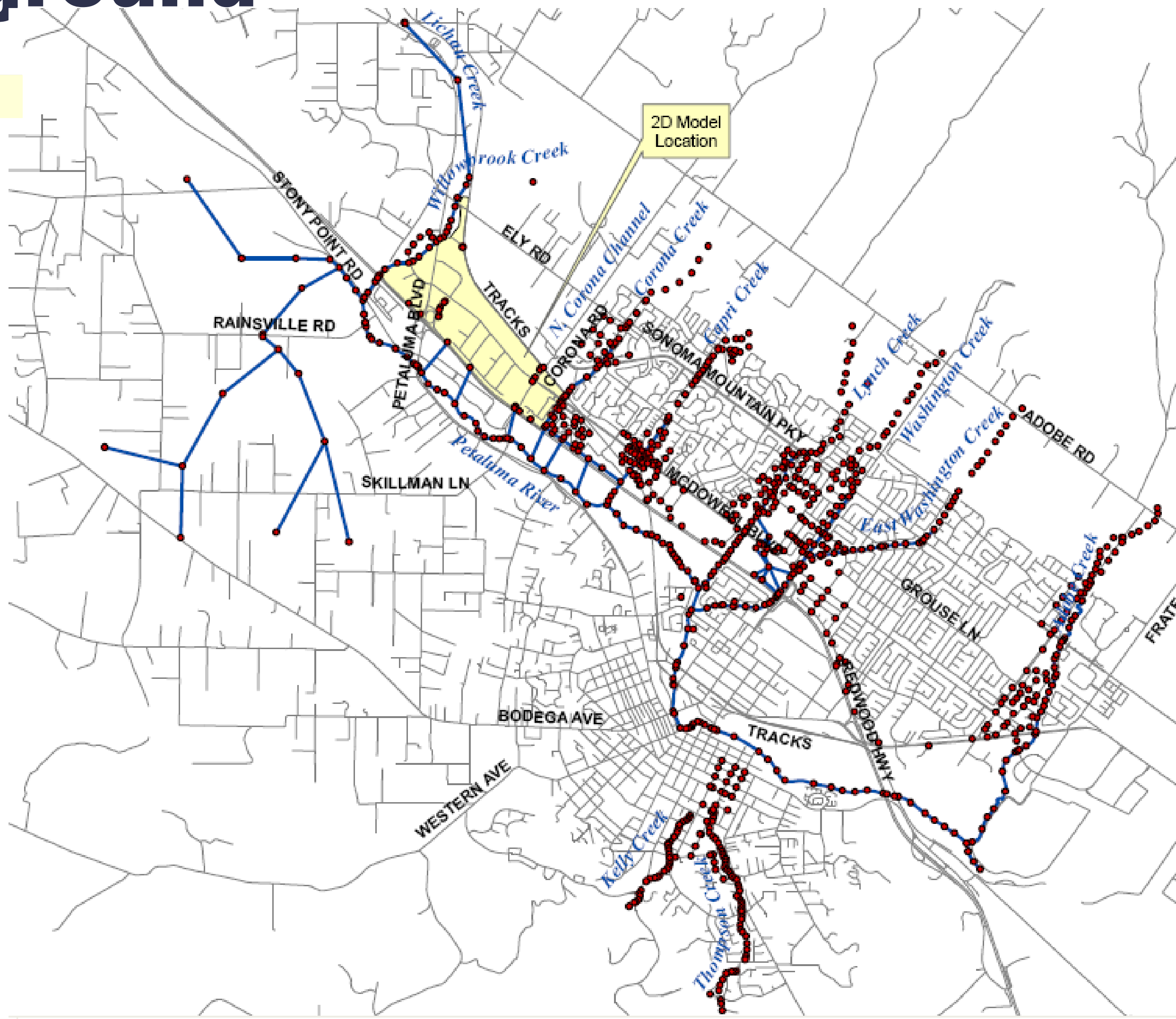
- Floods can happen anywhere and wreak havoc quickly
- Keep our community safe by minimizing flood risk and damage
- Community Rating System (CRS)
- Projects to manage the flow of water through our river and creeks.
    - Payran Reach Flood Walls,
    - Denman Reach Detention Ponds/Terracing
    - Capri Creek improvements
- **Floodplain Maps & Sea Level Rise Maps**
- Updated models will help inform General Plan policies as well as provide critical information to inform upcoming flood management projects.

Clarifying Questions

Appendix

Model Background

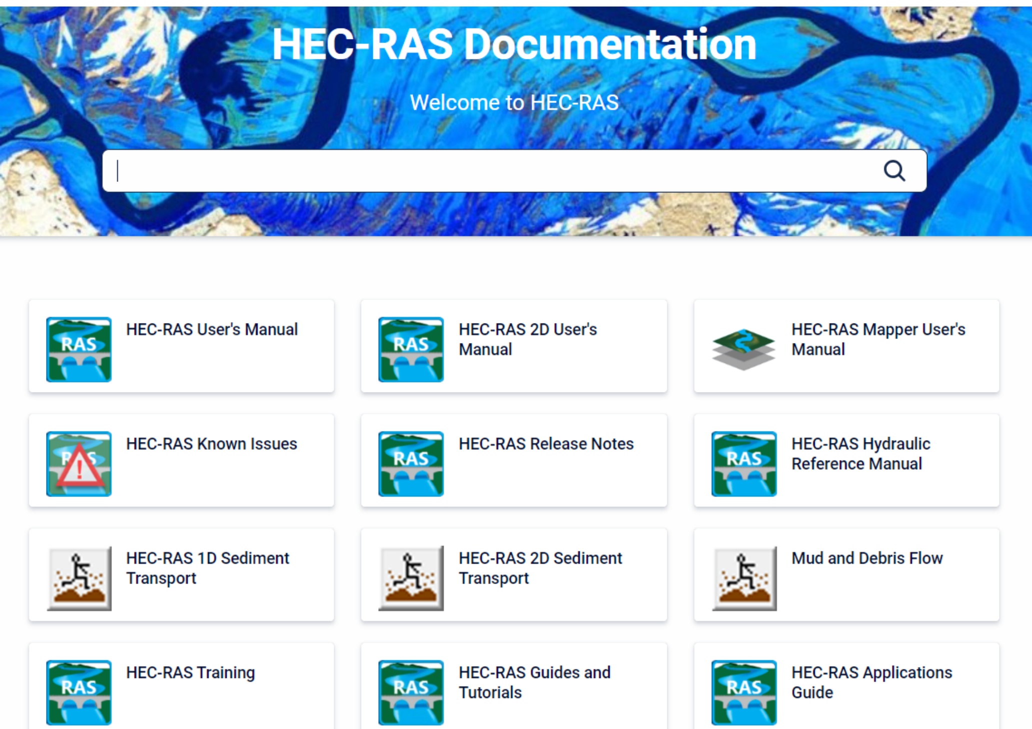
- City's current model updated in 2012 for General Plan
- "XP Storm"

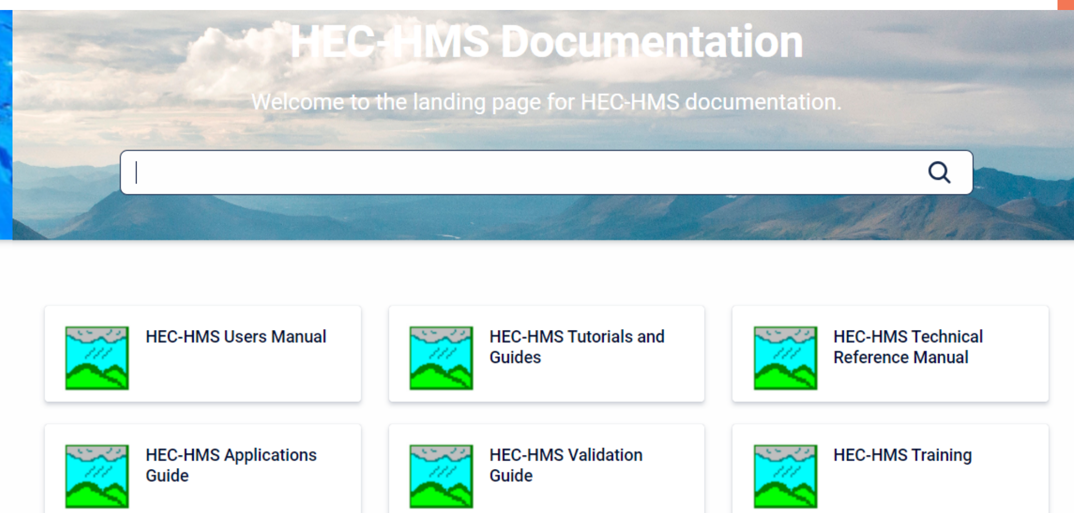


Model Background

Model Background

- New Model: HEC-RAS (River Analysis System) 2D for hydraulics and HEC-HMS (Hydrologic Modeling System) for hydrology.





Model Background

- What is hydrology?
- Hydrology analyses how rainfall turns into runoff. How much of the rain sinks in and how much runs off?
  - HEC-HMS inputs include:
    - Rainfall depth for a given storm (how deep), rainfall spatial distribution (where is it falling), and rainfall temporal pattern (how quickly it falls).
    - Loss rates (rate that water sinks into the ground)
    - Watershed/subbasin geometry (are the basins long and skinny for example, or more rounded). The basin response forms the shape of the discharge/flow hydrograph (flow vs. time).
  - HEC-HMS outputs include:
    - Flow hydrographs for each subbasin

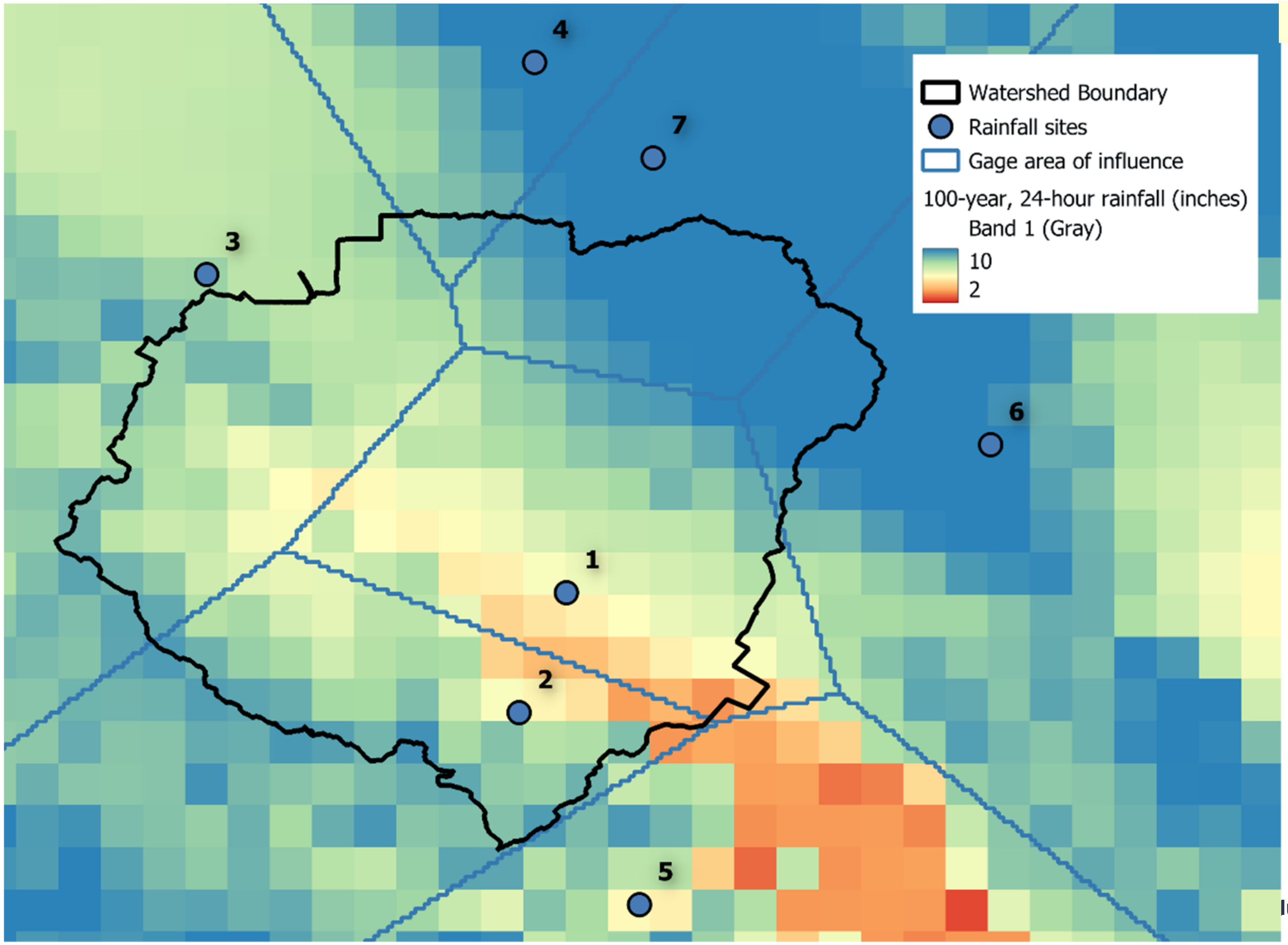
SB

Model Background

SB0

- What is hydraulics?
- Hydraulics tells us how high the water gets in channels and overbanks.
  - HEC-RAS inputs include:
    - Flow hydrographs from HEC-HMS at each subbasin outlet.
    - Downstream boundary conditions (tide levels assumed)
    - Channel roughness (vegetation, roads/parking lots—not just where but how rough/smooth)
    - Topography (ground surface data excluding buildings/structures—"bare earth")
    - 2D grid limits
    - Structure data (bridges, culverts, floodwalls, weirs)
  - HEC-RAS outputs include:
    - Depth, velocity, and water surface elevations...everywhere within the 2D grid limits.

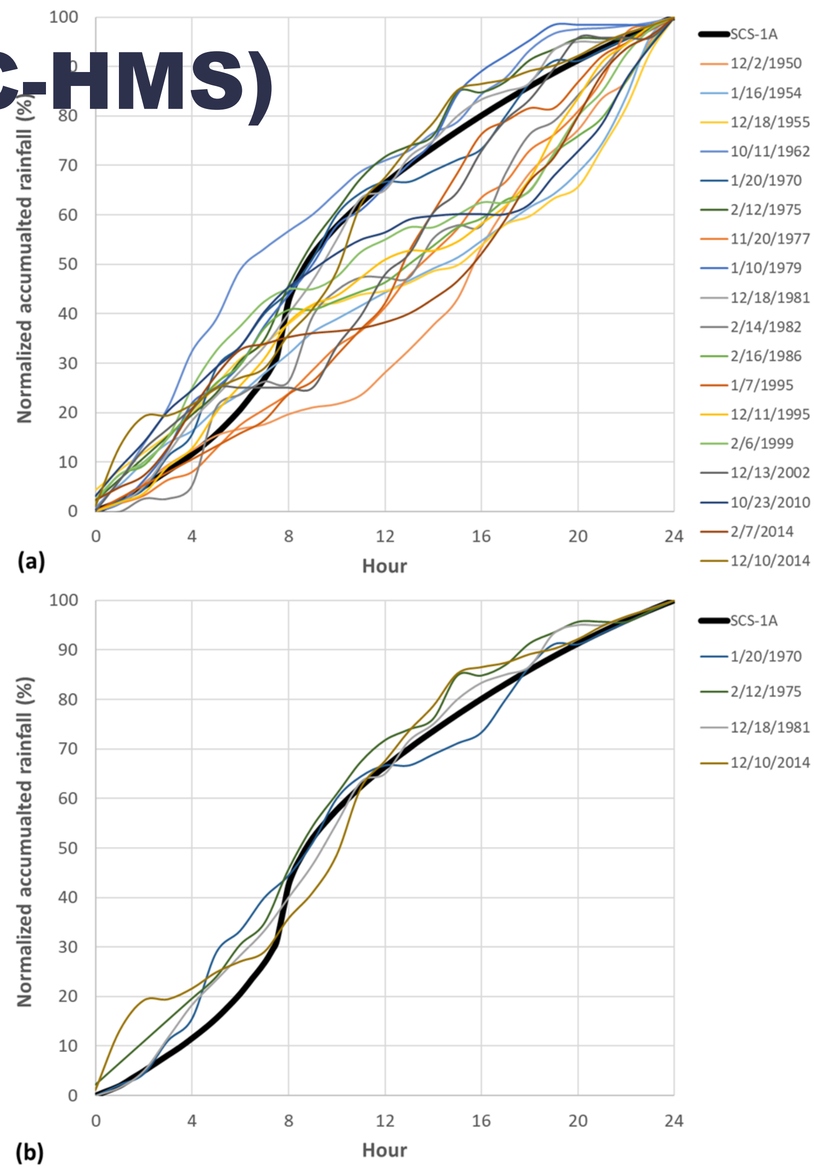
Hydrology (HEC-HMS)



- Rain falls unevenly on the Petaluma Watershed
- Every storm is different
- Recent data provided averages

Hydrology (HEC-HMS)

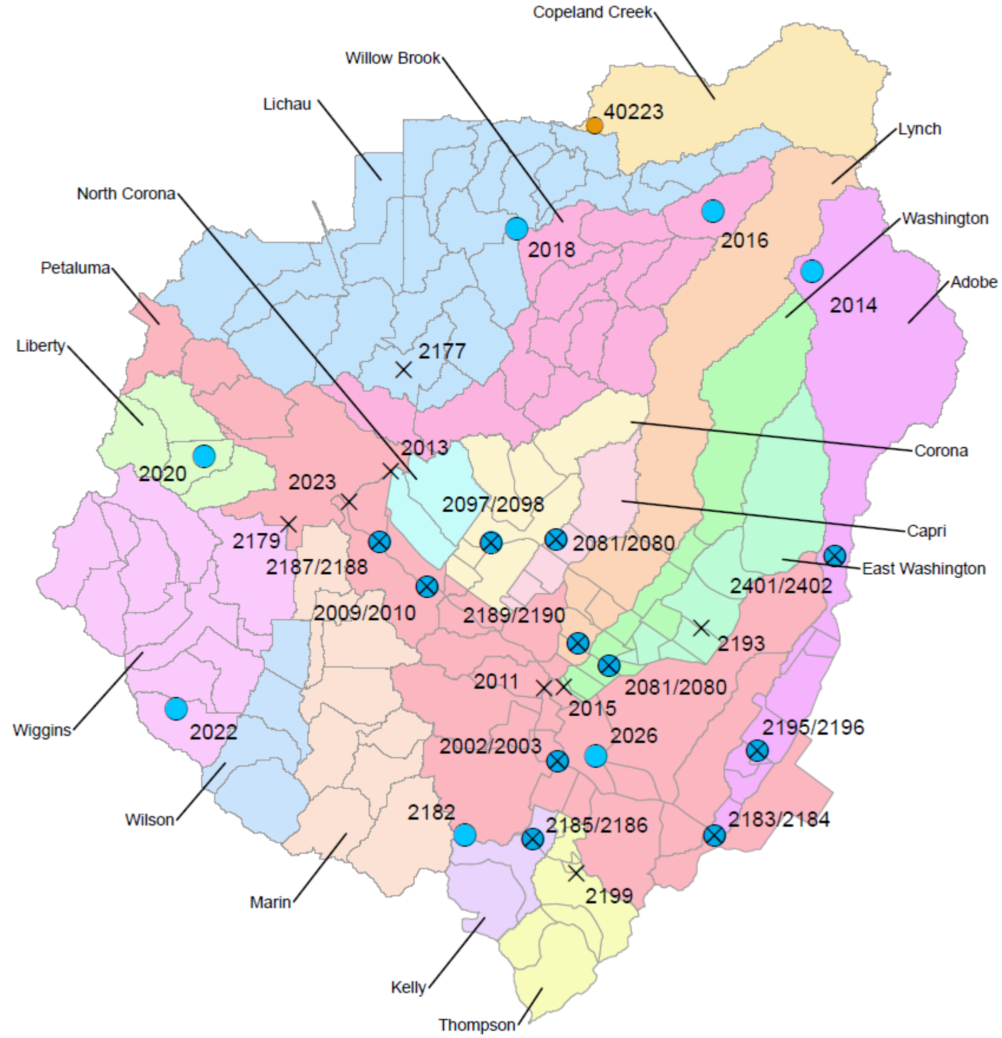
Instead of modeling the rainfall pattern of
specific historical storms an "average" 100-year storm is modeled

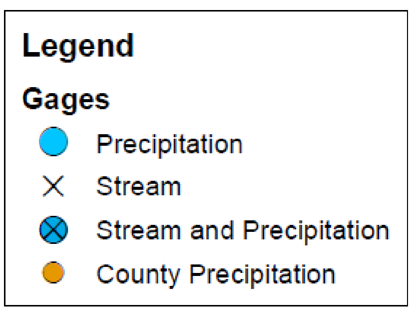


SB0

Hydraulics (HEC-RAS 2D)

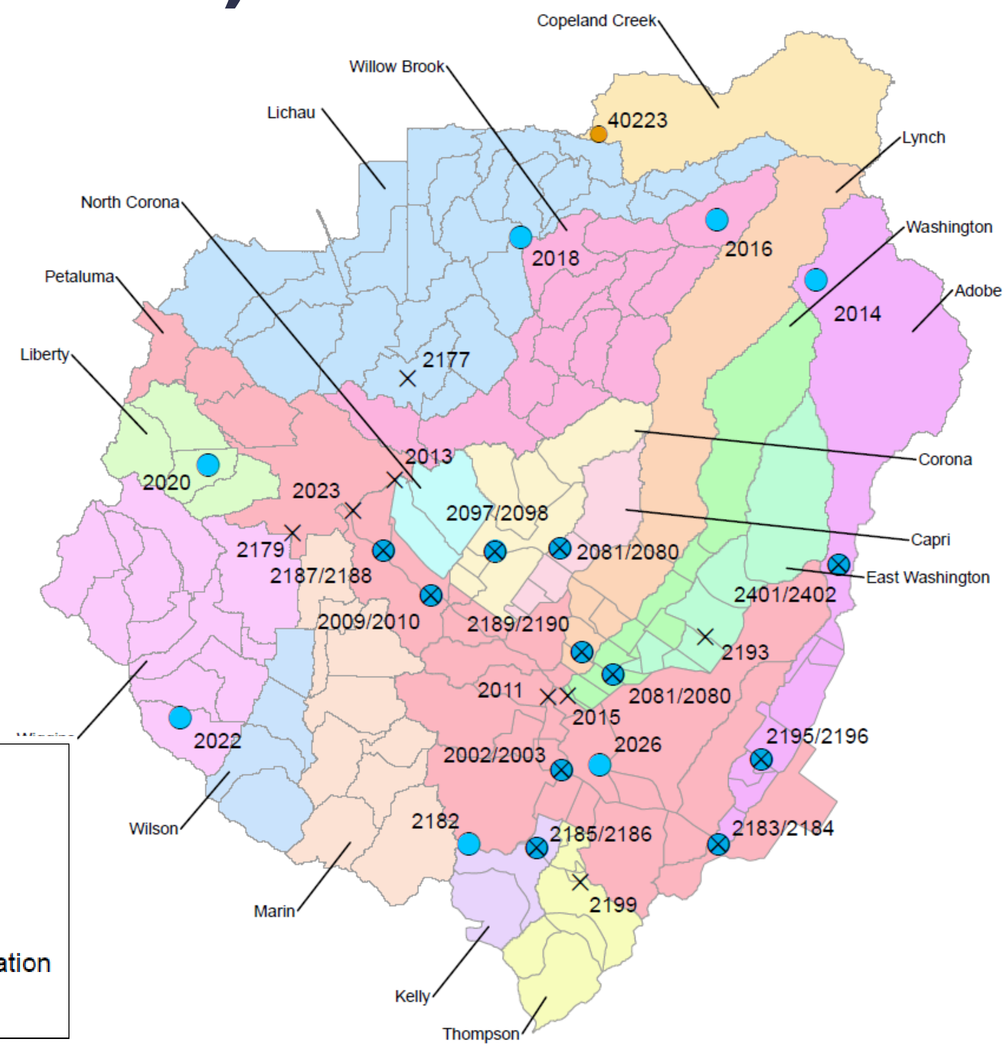
- Calibration—what is it? SB0
- We can compare the model to past storms
- Precipitation gages and stream gages

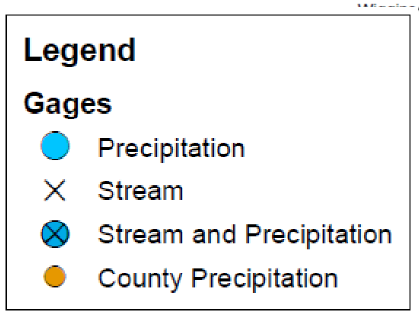




Hydraulics (HEC-RAS 2D)

- Model calibration was performed for the largest rain events of record:
  - December 2005 (the “New Year’s Flood”)
  - January 2017
  - February 2019





Hydraulics (HEC-RAS 2D)

- Calibration results at Payran:

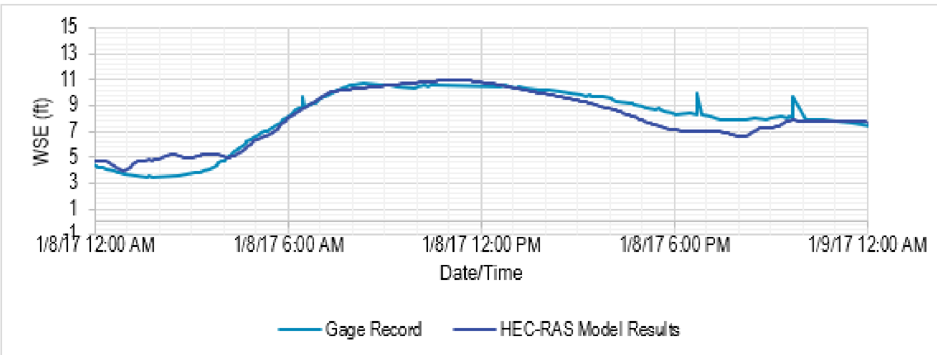


Figure 4-14. 2017 Stream Gage Data Comparison: Petaluma R @ Payran St (ID:2011)¶

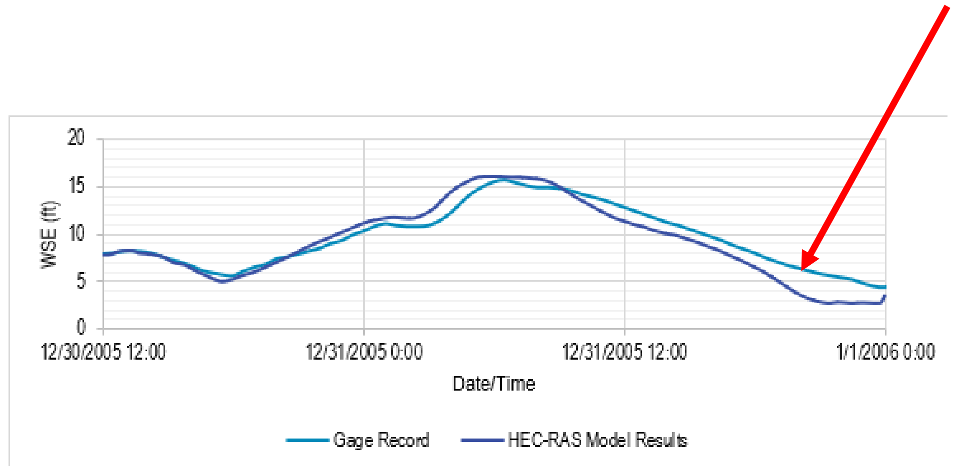


Figure 4-7. 2005 Stream Gage Data Comparison: Petaluma R @ Payran St (ID:2011)¶

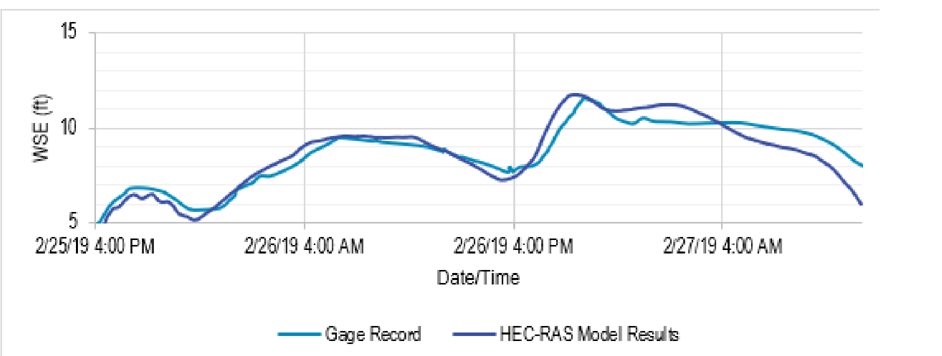


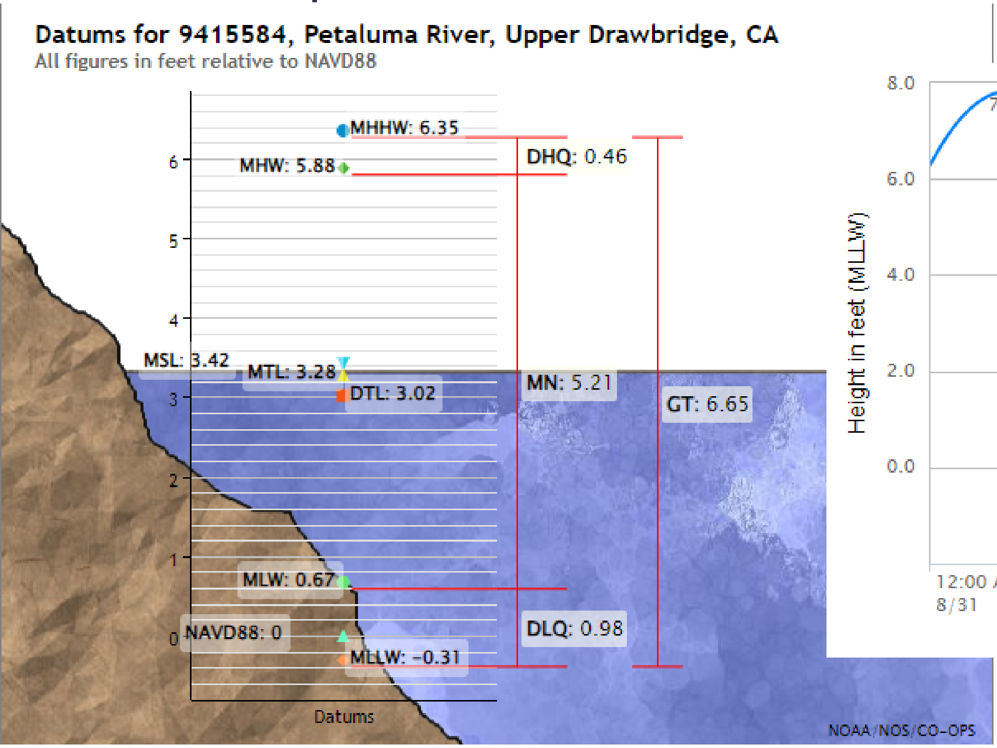
Figure 4-23. 2019 Stream Gage Data Comparison: Petaluma R @ Payran (ID:2011)¶

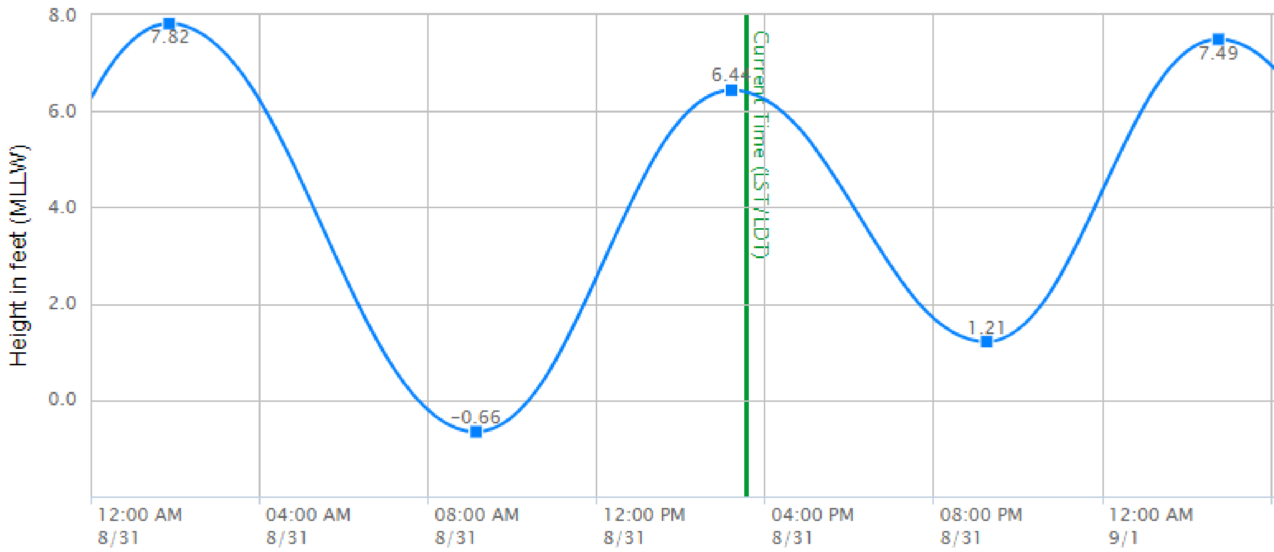
- Model predicts floods very similar to historical storms


The Bay level impacts how much water
can flow down the River

How high is the river during a rain event?

- The model must make an assumption about the height of the River near the railroad drawbridge (near 101 bridge) during a storm
  - The river elevation is assumed to be the Mean Higher High Water (MHHW), as in previous models

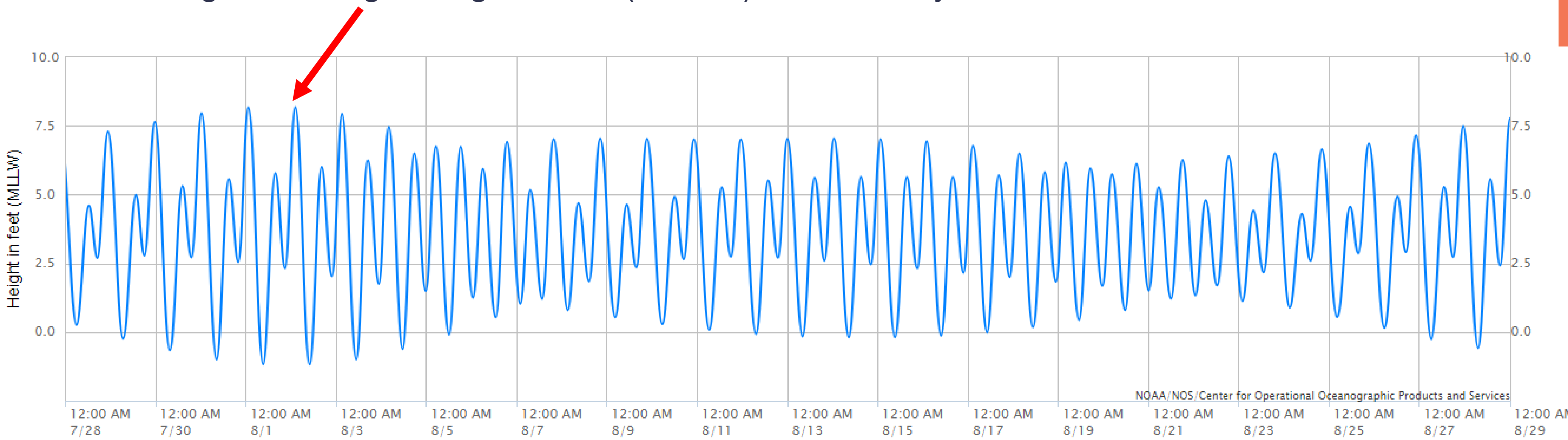




SB0

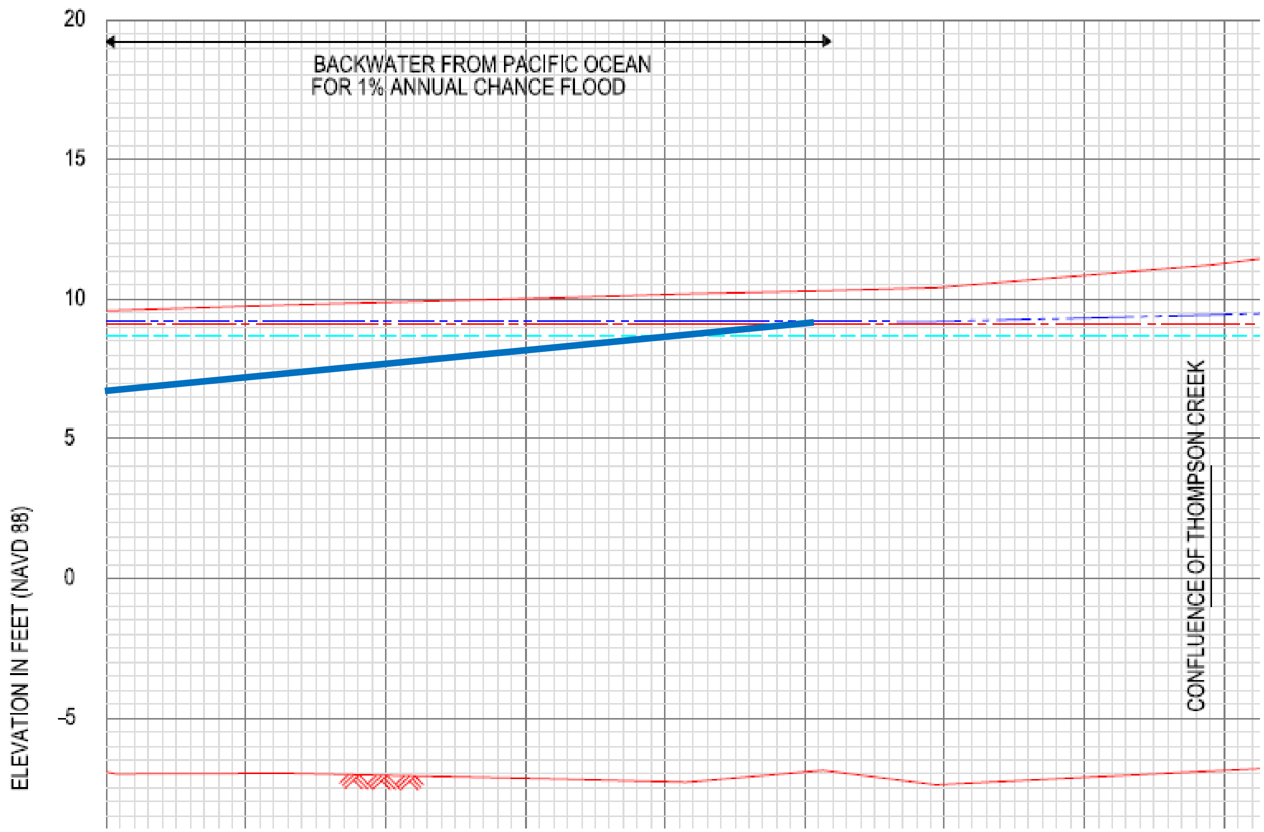
What about King Tides?

- Why not assume the river is at King tide during the rain event?
  - King tide is an exceptionally high tide (typically during new or full moon around the Equinox)
  - It is very unlikely for 1%ACE Rain to happen during King Tide
  - Using “Mean Higher High Water” (MHHW) is sufficiently conservative



Downstream Boundary Assumptions/Definitions

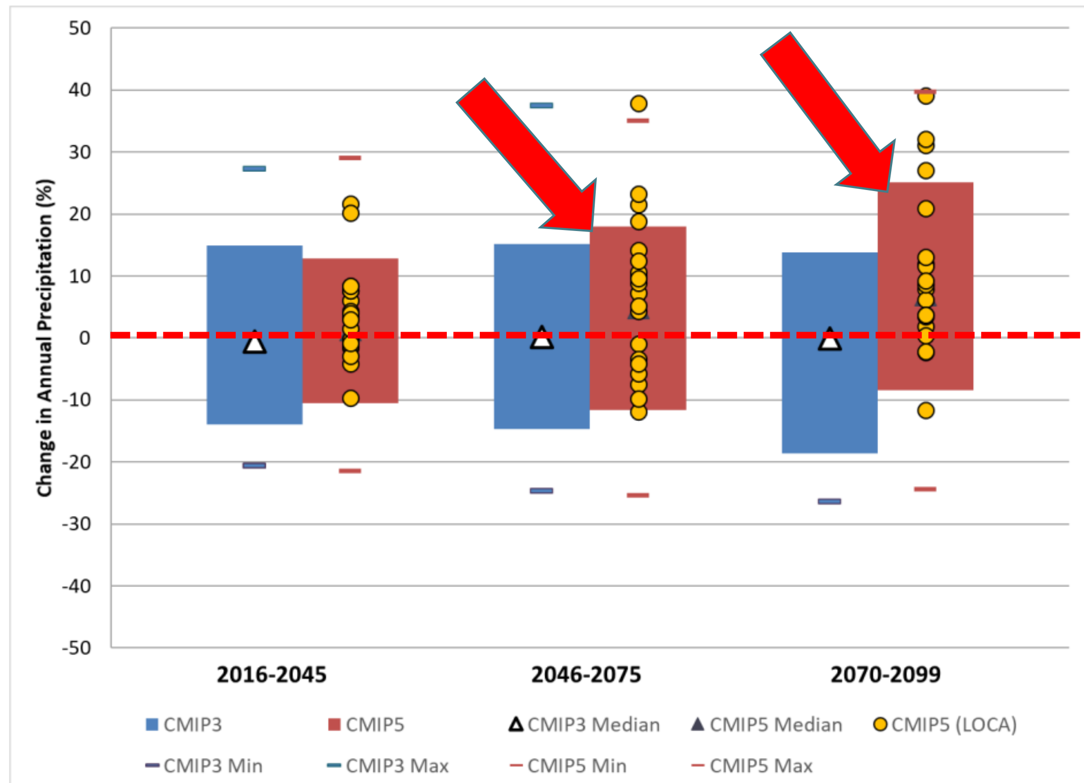
- The model doesn't assume a storm surge (ocean water moving upriver) happens at the same time as rainfall (rain moving down river)
- US Army Corps standards were followed.



Possible Changes to Precipitation and Storms

- Limited state guidance or local precedence to factor in changes
- Rain is expected to get more intense, and storms surge to get higher
- Available data in 2022 wasn't sufficient to include in model
- Draft policy to incorporate estimates in future flood model

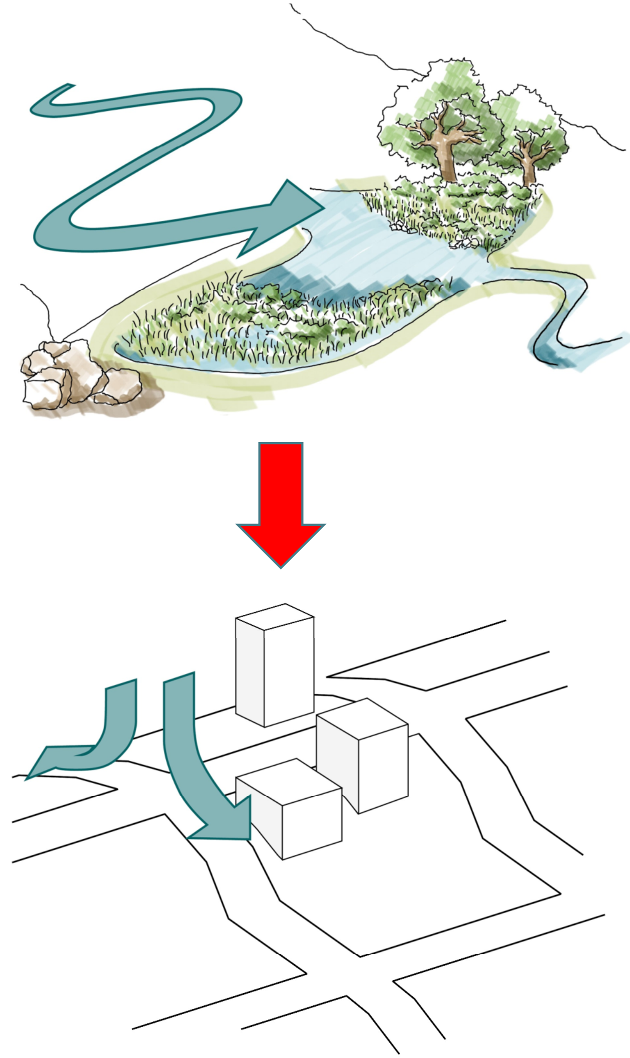
Figure A-6. Projected Changes in Mean Annual Precipitation for the Sonoma County Region based on CMIP3 and CMIP5 Projections



Sonoma Water: Climate Resilience Efforts Appendix A

Changes to Urban Cover

- Impervious surfaces = added pavement & buildings which cause more runoff
  - Issues include pollution, groundwater depletion, erosion, urban heat island, etc
  - Cause more flooding in small rain events
  - Model was stress tested
    - Not sensitive to higher impervious cover in city



Sherwood Design Engineers

Hazard + Likelihood + Impact = Risk

RISK EXPOSURE MATRIX		IMPACT				
		Insignificant	Minor	Moderate	Major	Catastrophic
LIKELIHOOD	Almost Certain	Low	Medium	High	Critical	Critical
	Likely	Low	Medium	High	Critical	Critical
	Possible	Insignificant	Low	Medium	High	High
	Unlikely	Insignificant	Low	Low	Medium	Medium
	Rare	Insignificant	Insignificant	Insignificant	Low	Low